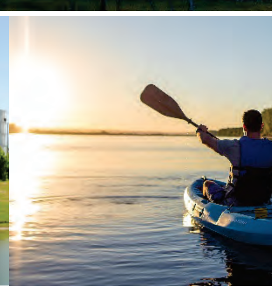
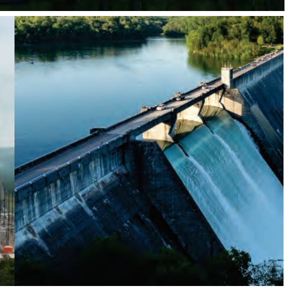
2019 Integrated Resource Plan

VOLUME II - DRAFT ENVIRONMENTAL IMPACT STATEMENT





TENNESSEE VALLEY AUTHORITY

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Abstract: The 2019 Integrated Resource Plan (IRP) is a long-term plan that provides direction on how TVA can best meet future demand for power. It will shape how TVA provides low-cost, reliable electricity; supports environmental stewardship; and fosters economic development in the Tennessee Valley for the next 20 years. TVA's IRP is based upon a "scenario" planning approach that provides an understanding of how future decisions would play out in future scenarios. A wide variety of resource options and business strategies are considered in this IRP. TVA identified six scenarios: (1) The Current Outlook, (2) Economic Downturn, (3) Valley Load Growth, (4) Decarbonization, (5) Rapid Distributed Energy Resources (DER) Adoption, and (6) No Nuclear Extensions. Five planning strategies were evaluated against the backdrop of these scenarios: (A) Base Case, (B) Promote Distributed Energy Resources (DER), (C) Promote Resiliency, (D) Promote Efficient Load Shape and (E) Promote Renewables. The modeling process applied each strategy to each scenario, resulting in 30 resource portfolios. The model analyzed how to achieve the lowest-cost portfolio with each strategy in each scenario, looking for the optimal solution within that particular combination.

The EIS assesses the natural, cultural and socioeconomic impacts associated with the implementation of the 2019 IRP. The Base Case serves as the No-Action Alternative, and the remaining four strategies are the Action Alternatives. The draft EIS analyzes and identifies the relationship of the natural and human environment to each of the five strategies considered in the IRP. Under all the portfolios, there is a need for new capacity in all scenarios modeled, in part to replace expiring or retiring capacity. Uncertainty around future environmental standards for CO_2, along with lower loads and gas prices, are key considerations when evaluating potential coal retirements.

Emissions of air pollutants, the intensity of greenhouse gas emissions and generation of coal waste decrease under all strategies. Strategies focused on resiliency, load shape and renewables have the largest amounts of solar and storage expansion and coal retirements, resulting in lower environmental impact overall but higher land use. For most environmental resources, the impacts are greatest for Strategy A (the No Action alternative) except for the land area required for new generating facilities, which is greater for the action alternatives, particularly Strategies C, D, and E.

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1 Introduction

The Tennessee Valley Authority (TVA) has developed the Integrated Resource Plan (IRP) and associated programmatic Environmental Impact Statement (EIS) to address the demand for power in the TVA power service area (PSA), the resource options available for meeting that demand, and the potential environmental, economic and operating impacts of these options. The IRP will serve as a roadmap for meeting the energy needs of TVA's customers over the next 20 years.

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). TVA's PSA includes virtually all counties in Tennessee and portions of Alabama, Georgia, Kentucky, Mississippi, North Carolina, and Virginia.

TVA's generating assets include: six fossil plants, three nuclear plants, 29 conventional hydroelectric plants, one pumped storage hydroelectric plant, nine natural gas combustion turbine (CT) gas plants, eight natural gas combined cycle (CC) gas plants, one diesel generator site and 14 solar energy sites. TVA has gas-co-firing potential at one coal-fired site as well as biomass co-firing potential at its coal-fired sites. In total, these assets constitute a portfolio of 33,500 megawatts (MW).

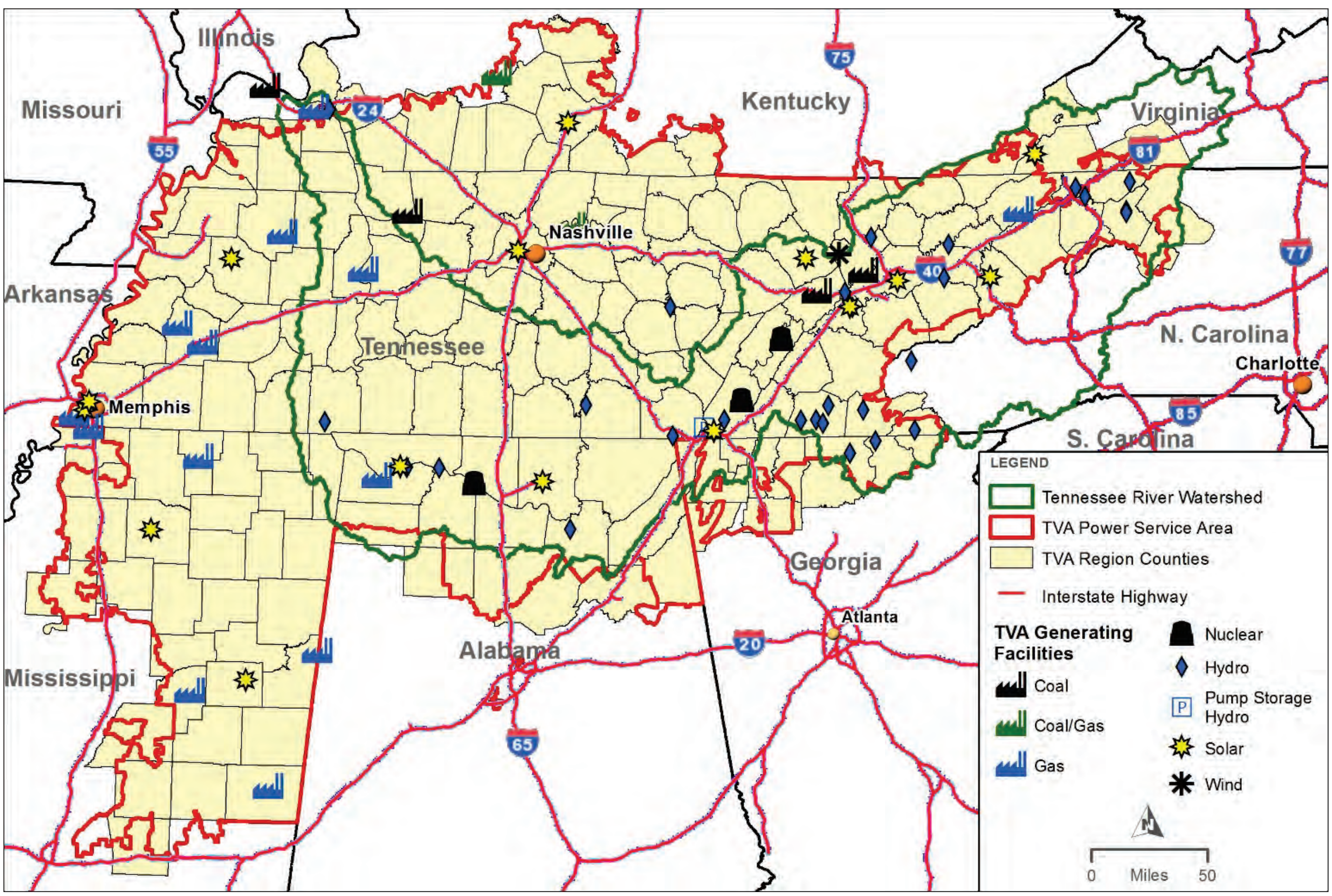

Figure 1-1: Power Service Area and Tennessee River Watershed, herein the TVA region.

1.1 Purpose and Need for Integrated Resource Planning

TVA is developing this new IRP and associated EIS to proactively address regional and national changes within the utility marketplace, including the expansion of distributed energy resources (DER) in the Tennessee Valley. Upon adoption by the TVA Board, the new IRP will replace the 2015 IRP (TVA 2015a). The purpose of the IRP and EIS is to provide TVA with direction on how to best meet future electricity demand. The IRP process evaluates TVA's current energy resource portfolio and alternative future portfolios of energy resource options on a "lowest system cost" basis to meet the future electrical energy needs of the TVA region while taking into account TVA's mission of energy, environmental stewardship and economic development.

1.2 Statutory Overview

In addition to Section 113 of the Energy Policy Act of 1992 (now the least-cost, system-wide planning provision of the TVA Act), several federal laws and executive orders are relevant to TVA's integrated resource planning. Those that are specific to the natural, cultural and socioeconomic resources potentially affected by the TVA power system are described below. This section begins with a detailed description of the National Environmental Policy Act and then lists other potentially applicable laws and executive orders.

1.2.1 National Environmental Policy Act

This EIS has been prepared by TVA in accordance with the National Environmental Policy Act (NEPA) of 1969 (42 United States Code [U.S.C.] §§ 4321 *et seq.*), regulations implementing NEPA promulgated by the Council on Environmental Quality (CEQ) (40 Code of Federal Regulations [C.F.R] Parts 1500 to 1508), and TVA NEPA procedures. TVA's Board of Directors will consider the analyses in this EIS and IRP when it selects the resource plan to be implemented.

NEPA requires federal agencies to consider the impact of their proposed actions on the environment before making decisions. 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. For major federal actions with significant environmental impacts, NEPA requires that an EIS be prepared. This process must include public involvement and analysis of a reasonable range of alternatives.

According to CEQ regulations, a programmatic EIS is appropriate when a decision involves a policy or program, or a series of related actions by an agency over a broad geographic area. Due to the comprehensive nature of the IRP, this EIS meets that criterion. The environmental impacts of the alternative actions are, therefore, addressed at a regional level, with some extending to a national or global level. The more site-specific effects of actions that are later proposed to implement the IRP will be addressed in subsequent tiered environmental reviews.

The IRP and EIS are developed with public input. TVA is using the input from the scoping period, summarized below, in developing the draft EIS and the draft IRP. The draft IRP and draft EIS are being distributed to interested individuals; groups; and federal, state and local agencies for their review and comment. During the public comment period for the draft EIS and draft IRP, TVA plans to conduct public meetings throughout the Tennessee Valley region. Following the public comment period, TVA will respond to the comments received on the draft IRP and draft EIS and incorporate any necessary changes into the final IRP and final EIS.

The completed final EIS will be placed on TVA's website, and notice of its availability will be sent to those who received the draft EIS or submitted comments on the draft EIS. TVA also will send the final IRP and final EIS to the U.S. Environmental Protection Agency (EPA), which will publish a notice of its availability in the Federal Register. TVA intends to publish the final EIS and final IRP during the summer of 2019.

The TVA Board of Directors will make the final decision on the IRP no sooner than 30 days after the publication of the Federal Register notice of the filing of the final EIS and final IRP. The TVA Board of Directors will consider the analyses in the EIS and IRP when it selects the resource plan to be implemented. Following a decision by the TVA Board of Directors, TVA will then issue a Record of Decision (ROD), which will include (1) the decision; (2) the rationale for the decision; (3) alternatives that were considered; (4) the alternative that was considered environmentally preferable; and (5) associated mitigation measures and monitoring, and enforcement requirements.

1.2.2 Other Laws and Executive Orders

Several other laws and executive orders are relevant to the construction and operation of TVA's electric power system (Table 1-1). These laws and executive orders may affect the environmental consequences of an alternative plan, or measures needed during its implementation. Most of these laws also have associated implementing regulations.

Chapter 4 (Affected Environment) describes the regulatory setting for each resource in more detail. Chapter 5 (Anticipated Environmental Impacts) discusses applicable laws and their relevance to this analysis.

Table 1-1: Laws and Executive Orders relevant to the environmental effects of power system planning, construction and operation.

Environmental Resource Area	Law / Executive Order
Water Quality	Clean Water Act
Groundwater	Safe Drinking Water Act Resource Conservation and Recovery Act Comprehensive Environmental Response, Compensation, and Liability Act Federal Insecticide, Fungicide, and Rodenticide Act
Air Quality	Clean Air Act
Wetlands and Waters	Clean Water Act Executive Order 11990 – Protection of Wetlands Executive Order 13778 – Restoring the Rule of Law, Federalism, and Economic Growth by Reviewing the "Waters of the United States" Rule
Floodplains	Executive Order 11988 – Floodplain Management
Endangered and Threatened Species	Endangered Species Act
Cultural Resources	National Historic Preservation Act Archaeological Resources Protection Act Native American Graves Protection and Repatriation Act
Environmental Justice	Executive Order 12898 – Federal Actions to Address Environmental Justice in Minority and Low-Income Populations
Land Use	Farmland Protection Policy Act
Coal Mining	Surface Mining Control and Reclamation Act
Waste Management	Resource Conservation and Recovery Act Comprehensive Environmental Response, Compensation, and Liability Act Toxic Substances Control Act

1.3 Relationship with Other NEPA Reviews

Several environmental documents and reviews are relevant to TVA's IRP and are briefly discussed in the sections below. They are arranged by the type of action.

1.3.1 Programs, Plans and Policies

Diesel-fueled Generation in TVA Demand Response Program Environmental Assessment (February 2017)
Evaluated the potential use of diesel-fueled generators by participants in TVA demand response programs to provide backup generation during certain demand response events (TVA 2017a).

2015 Integrated Resource Plan (August 2015)
Provides direction for how TVA will meet the long-term energy needs of the Tennessee Valley region. This document and the associated supplemental EIS evaluated scenarios and strategies for providing electricity through 2033.

Natural Resource Plan (July 2011)
Guides TVA's natural resource stewardship efforts over the following twenty years. This document and the associated EIS evaluated the resource management programs and activities, alternative approaches to TVA's resource management efforts, and the environmental impacts of the alternatives.

Reservoir Operations Study Environmental Impact Statement (May 2004)
Evaluated changes in TVA's policy for operating its reservoir system.

TVA Solar Photovoltaic Projects Programmatic Environmental Assessment (September 2014)
Evaluated the potential impacts of constructing and operating small solar photovoltaic (PV) systems providing power for the TVA system.

1.3.2 Power Generation – Coal and Gas

Ash Impoundment Closure Programmatic EIS (June 2016)
Evaluated the closure of ash impoundments containing coal combustion residuals (CCR) at fossil fuel plants across the Tennessee Valley to support the implementation of TVA's goal to eliminate all wet CCR storage at its coal plants (TVA 2016e).

Bull Run Fossil Plant Ash Impoundment Closure Project Environmental Assessment (October 2017)
This environmental assessment (EA) tiers from the 2016 Ash Impoundment Closure Programmatic EIS, which evaluated the closure of the Bull Run Fossil Plant (herein, Bull Run) Sluice Channel and Fly Ash Impoundment. TVA expanded the closure area at BRF and determined a long-term need for wastewater treatment at Bull Run. The new proposed action included a plan to repurpose the Stilling Impoundment and possibly a portion of the Fly Ash Impoundment to be used as part of wastewater treatment at Bull Run.

Bull Run Fossil Plant Landfill Environmental Impact Statement (November 2016)
Addressed the continued disposal of CCR from the Bull Run Fossil Plant by constructing and operating a new landfill for storage of CCR on TVA property adjacent to the plant (TVA 2017b).

Colbert Fossil Plant Decontamination and Deconstruction Environmental Assessment (November 2016)
Evaluated the future disposition of the retired coal-fired plant, including the powerhouse, coal handling facilities, and support buildings.

Cumberland Fossil Plant Coal Combustion Residuals Management Operations Environmental Impact Statement (April 2018)
Evaluated the construction and operation of a bottom ash dewatering facility, an onsite CCR landfill, and process water basins at the Cumberland Fossil Plant.

Flue Gas Desulfurization System at Kingston Fossil Plant Supplemental Environmental Assessment (February 2018)
Supplemented a 2006 EA to evaluate changes to the proposed construction support areas and environmental conditions within the area of the Phase 2 part of the landfill.

Gallatin Fossil Plant Bottom Ash Process Dewatering Facility Environmental Assessment (July 2017)
Evaluated the construction of a bottom ash process dewatering facility and sluice water recirculation system at Gallatin Fossil Plant.

Gallatin Fossil Plant—Installation of Air Pollution Control Equipment and Associated Facilities (March 2013)
Evaluated the construction and operation of air pollution control equipment and associated facilities at Gallatin Fossil Plant. The EA also evaluated the construction and operation of a landfill on the Gallatin plant site for the dry storage of the coal combustion residues.

Johnsonville Cogeneration Plant Environmental Assessment (June 2015)
Evaluated the addition of a heat recovery steam generator to an existing combustion turbine at the Johnsonville Fossil Plant. The steam generator would provide steam to an adjacent industrial customer that was previously provided by now-retired coal-fired units.

Johnsonville Fossil Plant Decontamination and Deconstruction Final Environmental Assessment (December 2018)
Evaluated the future disposition of the physical structures associated with the retired coal-fired plant units, including the powerhouse, coal handling facilities, and surrounding support buildings at Johnsonville Fossil Plant.

Johnsonville Fossil Plant Proposed Actions (December 2018)
Evaluating closure of the coal yard and coal yard runoff pond, construction and operatation of a process water basin for the Johnsonville CT plant site, and development of a borrow site to facilitate closure of the coal yard and coal yard runoff pond (TVA 2018m).

Paradise Coal Combustion Residuals Management Operations Environmental Assessment (June 2017)
Evaluated the implementation of projects proposed to support dry storage and CCR Rule compliance at Paradise Fossil Plant, including the construction and operation of a gypsum dewatering facility, a dry fly ash handling system, and an onsite CCR landfill. The EA also included the closures of the gypsum disposal area, slag impoundment 2A/2B and stilling impoundment 2C, and the Peabody ash impoundment.

Potential Retirement of Bull Run Fossil Plant Environmental Assessment (February 2019)
Evaluation of the potential retirement of a single-generator coal-fired plant in Anderson County, Tennessee.

Potential Retirement of Paradise Fossil Plant Environmental Assessment (February 2019)
Evaluation of the potential retirement of operating Unit 3 at a coal-fired plant in Muhlenberg County, Kentucky. Units 1 and 2 were replaced with natural gas generation in spring 2017.

Shawnee Fossil Plant Coal Combustion Residuals Management Environmental Impact Statement (December 2017, August 2018)
Evaluated the closure of an existing landfill and ash impoundment and the construction and operation of a new onsite CCR landfill. The 2017 EIS was supplemented in 2018 to include the construction and operation of two process water basins.

Widows Creek Fossil Plant Deconstruction Environmental Assessment (June 2016)
Evaluated the future disposition of the physical structures associated with the retired coal-fired plant, including the powerhouse, coal handling facilities and surrounding support buildings.

1.3.3 Power Generation – Nuclear

Watts Bar Nuclear Plant Unit 2 Replacement of Steam Generators Environmental Assessment (December 2017)
Evaluated the replacement of steam generators in Watts Bar Nuclear Plant Unit 2, which would allow TVA

to operate the plant more efficiently and maintain the generating capacity of Unit 2.

Sequoyah Nuclear Plant Units 1 and 2 License Renewal Environmental Impact Statement (2011)
Evaluated the operation of the two units for an additional 20 years to 2014-2014.

1.3.4 Power Generation – Solar and Other Renewables

Cumberland Solar Project Environmental Assessment (January 2018)
Evaluated the construction and operation of a proposed 20- MW solar PV facility on approximately 140 acres in Limestone County, Alabama. This solar facility would connect to the existing adjacent 161-kilovolt (kV) TVA Ardmore Substation. TVA proposed to enter into a power purchase agreement (PPA) with Cumberland Land Holdings, LLC to purchase the electric power generated by the solar facility.

Latitude Solar Center Project Environmental Assessment (August 2016)
Evaluated the construction and operation of a proposed 20 MW solar PV facility on approximately 135 acres near Whiteville, Tennessee. The facility would connect to the TVA transmission system through a power line to an existing nearby Bolivar Electric Authority substation. TVA proposed to enter into a PPA with Latitude Solar Center, LLC.

Millington Solar Project Environmental Assessment (December 2017)
Evaluated the construction and operation of a proposed 53 MW solar PV facility on approximately 390 acres in Millington, Tennessee. The facility would connect to the TVA electrical transmission network via a new onsite substation and a new TVA 161-kV transmission line. TVA proposes to enter into a PPA with SR Millington, LLC (TVA 2017c).

Naval Air Station Meridian Solar Farm Environmental Assessment (April 2017)
Evaluated the construction and operation of a proposed 6 MW solar PV facility on approximately 45 acres on Naval Air Station Meridian in Lauderdale County, Mississippi. The facility would connect to the existing substation located approximately one mile away, which would transmit the power to the TVA network. TVA proposed to enter into a PPA with SR Meridian, LLC.

Providence Solar Center Environmental Assessment (March 2016)
Evaluated the construction and operation of a proposed 20 MW solar PV facility on approximately 118 acres in Madison County, Tennessee. The facility would tie into a nearby Southwest Tennessee Electric Membership Corporation substation. TVA proposed to enter into a PPA with Providence Solar Center, LLC.

River Bend Solar Project Environmental Assessment (November 2015)
Evaluated the construction and operation of a proposed 80 MW solar PV facility on approximately 645 acres in Lauderdale County, Alabama. The facility would be connected to TVA's Colbert Fossil Plant - Selmer 161-kV transmission line. TVA proposed to enter into a PPA with River Bend Solar, LLC, a subsidiary of NextEra Energy Resources, LLC (TVA 2015c).

Selmer North I Solar Project Environmental Assessment (October 2016)
Evaluated the construction and operation of a proposed 20 MW solar PV facility on approximately 99 acres near Selmer in McNairy County, Tennessee. The facility would connect to the TVA transmission system through a connection to an existing nearby Pickwick Electric Power Cooperative power line which would be rebuilt. TVA proposed to enter into a PPA with Selmer North I, LLC.

Selmer North II Solar Project Environmental Assessment (July 2016)
Evaluated the construction and operation of a proposed 10 MW solar PV facility on approximately 73 acres near Selmer in McNairy County, Tennessee. The facility would connect to the TVA transmission system through a connection to an existing nearby Pickwick Electric Cooperative power line. TVA proposed to enter into a PPA with Selmer North II, LLC.

Wildberry Solar Center Project Environmental Assessment (June 2016)
Evaluated the construction and operation of a proposed 20 MW solar PV facility on approximately 135 acres in Fayette County, Tennessee. The facility would tie into an existing nearby Chickasaw Electric Cooperative substation. TVA proposed to enter into a PPA with Wildberry Solar Center, LLC.

1.4 Overview of Volumes I and II

Volume I of this document contains the draft 2019 IRP along with descriptions on the methodology and development of the recommendation. This works in conjunction with Volume II of this document, which contains the draft EIS. The EIS is a document required by NEPA which describes the environmental effects of proposed actions that may have a significant effect on the quality of the human environment.

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2 TVA Power System

2.1 Introduction

This chapter describes the Tennessee Valley Authority's (TVA) existing power system, including power sales and purchases; generating facilities; energy efficiency and demand response programs; and the transmission system.

As of September 30, 2018, TVA's power system had a summer net generating capability of 37,514 megawatts (MW). Approximately 33,526 MW of the total capability was provided by TVA facilities and the remainder was provided by non-TVA facilities under long-term power purchase agreements (PPAs). Power generation by these facilities for the 2015 – 2018 fiscal years is summarized in Table 2-1. TVA operates a network of approximately 16,200 miles of transmission lines and 508 substations, switching stations and switchyards. This system transmits power from TVA and non-TVA generating facilities to 1,321 customer connection points. TVA's power system is described in more detail in the remainder of this chapter. Unless stated otherwise, the capacity of energy resources described in this EIS is the net summer dependable capacity.

Table 2-1: Fiscal year 2015–2018 generation by type from both TVA facilities and purchased power.

	Generation in gigawatt-hours			
Type of generation	FY 2015	FY 2016	FY 2017	FY 2018
Nuclear	54,543	52,897	58,742	64,194
Coal	58,854	48,811	41.422	34,026
Natural Gas	26,639	37,494	36,597	43,481
Hydroelectric	16,453	15,018	13,250	16,399
Wind	4,171	4,129	4,245	4,055
Solar	202	350	534	491
Biomass	240	171	136	287
TOTAL	161,102	158,871	154,926	162,933

2.2 TVA Customers, Sales, and Power Exchanges

TVA is primarily a wholesaler of power. In fiscal year (FY) 2018, it sold nearly 163 billion kilowatt-hours (KWh) of electricity; total revenue from these sales was $10.6 billion. Wholesale power is delivered to 154 local power companies (LPCs) that, in turn, distribute electricity to residential, commercial and industrial customers within their service areas. These non-profit, publicly owned LPCs are diverse and include municipal systems and rural electric cooperatives. The largest, Memphis Light, Gas and Water Division, serves approximately 421,000 electric customers and accounted for 9 percent of TVA's 2018 operating revenues. Some of the smallest LPCs serve less than 1,500 customers. Many provide only electrical service while others provide water, wastewater, telecommunications and/or natural gas service. Sales to LPCs comprised 87.8 percent of TVA 2018 power sales and 92.6 percent of power sale revenues.

In addition to the LPCs, TVA sells power directly to 58 industries and federal installations. The directly served industries include chemical, metal, paper, textile, data centers, and automotive manufacturers. The federal installations include the Department of Energy (DOE) Oak Ridge Operations in Tennessee and military bases. Sales to directly served industries and federal installations comprised 12.2 percent of 2018 power sales and 7.4 percent of power sale revenues. Since 2015, power sales to federal installations have decreased while sales to directly served industries have increased.

The TVA PSA (Figure 1-1) is defined by the TVA Act. The TVA Act restricts TVA from entering into contracts that would make TVA or its LPCs a source of power outside the area for which TVA or its LPCs were the primary source of power on July 1, 1957. The Federal Power Act prevents the Federal Energy Regulatory Commission (FERC) from ordering TVA to deliver power generated by other entities to customers within the TVA PSA.

The TVA Act authorizes TVA to exchange, buy or sell power with 13 neighboring electric utilities. 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. It also allows TVA to sell power to neighboring utilities when its generation exceeds demand. TVA conducts these exchanges through 69 transmission system interconnections. To the extent allowed by Federal law, TVA offers transmission services to others to transmit or "wheel" power through the TVA PSA.

2.3 TVA-Owned Generating Facilities

TVA owns and/or operates under long-term lease 33,526 MW of summer generating capability (Figure 2-1). These facilities generated about 141,505 million kWh in FY18, a small increase over the preceding two years.

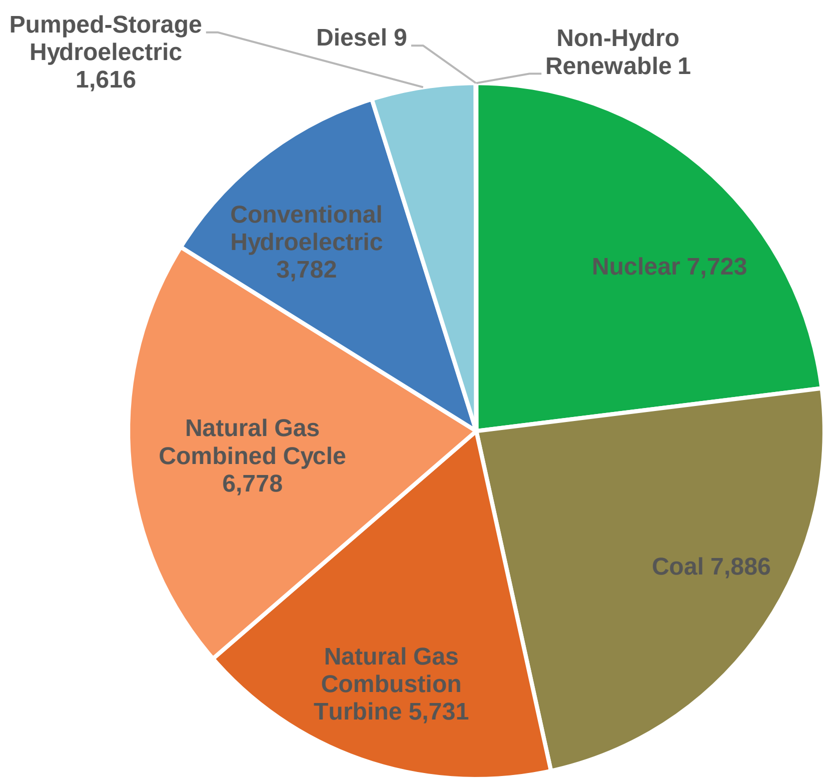

Figure 2-1: Fiscal Year 2018 TVA-owned summer generating capability in megawatts by type of generation.
Source: FY2018 TVA 10-K Report.

2.3.1 Coal-Fired Generation

As of October 2018, TVA had 26 active coal-fired generating units at six plant sites with a total summer net dependable capability of approximately 7,886 MW (Figure 1-1, Table 2-2). The coal-fired units range in size from 134 MW (Shawnee Units 1 – 9) to 1,239 MW (Cumberland Unit 1). The oldest unit was placed in service in 1953 at Shawnee, and the newest is Cumberland Unit 2, which began operation in 1973.

Table 2-2: Characteristics of TVA coal-fired generating facilities.

Facility	Number of Units	2018 Summer Net Capability (MW)	Commercial Operation Date (First and Last Unit)	Boiler Type*	Emissions Controls**
Bull Run	1	865	1967	SCPC	FGD, SCR
Cumberland	2	2,470	1973	SCPC	FGD, LNB, SCR
Gallatin	4	976	1956, 1959	PC	FGD, SCR
Kingston	9	1,398	1954, 1955	PC	LNB (4 units), SCR, FGD
Paradise	1	971	1970	SCPC	FGD, SCR
Shawnee	9	1,206	1953, 1955	PC	DSI, FGD (2 units), LSC, LNB, SCR (2 units), SNCR
Total Coal	26	7,886			

*CF – cyclone furnace; PC – pulverized coal; SCPC – supercritical pulverized coal
**DSI – Dry sorbent injection; FGD – Flue gas desulfurization ("scrubber"); LNB – low-NO_x burner; LSC – low sulfur coal, may be blended with high sulfur coal; SCR – selective catalytic reduction; SNCR – selective non-catalytic reduction.

Since 2010, TVA has retired the 4-unit, 704-MW John Sevier Fossil Plant; the 8-unit, 1,499-MW Widows Creek Fossil Plant; the 126-MW, Unit 10 at Shawnee; the 10 coal-burning units, totaling 2,130 MWs, at Johnsonville Fossil Plant; the five coal-burning units, totaling 1,542 MWs, at Colbert Fossil Plant; Units 1 and 2, totaling 1,176 MW, at Paradise Fossil Plant; and the 3 coal-burning units, totaling 741 MWs, at Allen Fossil Plant. TVA is currently analyzing the potential retirement of the remaining operating unit at Paradise in 2020 and of Bull Run in 2023. These potential retirements were the subject of environmental assessments issued for public review in November 2018, and finalized in February 2019 just prior to the release of this EIS (TVA 2019a, 2019b). Both EAs resulted in a finding of no significant impact.

In April 2011, TVA entered into two agreements to resolve litigation over Clean Air Act (CAA) New Source Review requirements for maintenance and repair of its coal-fired units. The first agreement is a Federal Facilities Compliance Agreement with U.S. Environmental Protection Agency (EPA). The second agreement is a Consent Decree with Alabama, Kentucky, North Carolina, Tennessee, the Sierra Club, National Parks Conservation Association and Our Children's Earth Foundation. Under the terms of these agreements (collectively the "CAA Environmental Agreements"), TVA agreed to either install and operate selective catalytic reduction (SCR), nitrogen oxide emission reduction equipment, and/or flue gas desulphurization (FGD, "scrubber") sulfur dioxide emission reduction equipment; convert to burn renewable biomass fuels, or retire specified units; and operate emission reduction equipment at specified units year-round instead of seasonally. TVA has substantially completed these actions and the coal-fired unit retirements listed above (except those for Paradise

Units 1 and 2, Shawnee Unit 10 and Widows Creek Units 7 and 8) were in response to the CAA Environmental Agreements

In order to maintain adequate generating capacity in the vicinity of some retired coal plants or units, TVA recently constructed and operates natural gas-fired combined cycle (CC) plants at the Allen, John Sevier, and Paradise fossil plant sites. These CC plants are described below.

Fuel Procurement – TVA coal consumption has greatly decreased since 2010 as a result of the coal unit retirements described above, increased generation by other types of power plants and increased energy efficiency. From 2015 through 2018, TVA's coal consumption decreased from 28 to 17 million tons (Figure 2-2). In 2017, the most recent year for which detailed U.S. production data is available (USEIA 2018a), TVA consumed about 2.3 percent of eastern U.S. coal production and 2.1 percent of western U.S. coal production. In recent years, TVA has obtained coal from the Central Appalachians (eastern Kentucky, southern West Virginia, and Virginia) and Illinois Basin (Illinois, Indiana, and western Kentucky) regions in the eastern U.S. and from the Powder River Basin (Wyoming and Montana) and Uinta Basin (Colorado and Utah) regions in the western U.S.

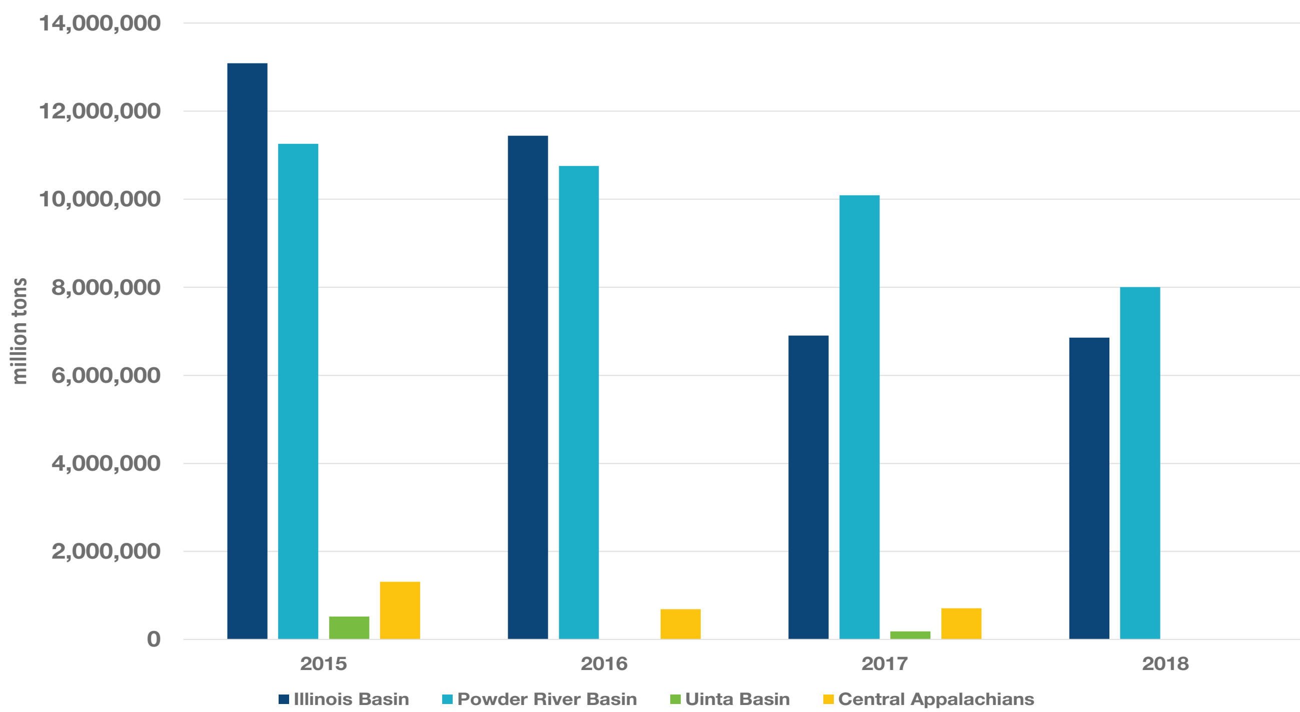

Figure 2-2: Fiscal Year 2015-2018 coal purchases by mining region.

Approximately 43 percent of the 14.9 million tons of coal that TVA contracted to purchase in FY18 was mined by underground mining methods; all of this coal was from the Illinois Basin region (Figure 2-2, Table 2-3). The remaining coal was mined from open pit/area surface mines. The proportion of coal consumed by TVA that is mined by each mining method, as well as the proportion from each of the major mining regions, varies somewhat from year to year due to market conditions and the operating characteristics of TVA coal units. All of the coal that TVA has purchased in recent years from the Powder River Basin was mined by open pit/area mining methods. All of the coal that TVA has recently purchased from the Uinta Basin was mined by underground mining methods, as was over 90 percent of the coal that TVA has recently purchased from the Illinois Basin and Central Appalachians. Surface-mined coal from the Illinois Basin was mined by open pit/area mining methods, and surface-mined coal from the Central Appalachians was mined by contour/highwall mining methods. TVA has not purchased coal from Appalachian mountaintop removal surface mines in recent years.

Table 2-3: TVA coal purchase contracts for FY18, in millions of tons, by mining region and mining method.

Region	Underground	Mining Method: Surface - Open Pit/Area	Surface - Contour/ Highwall	Totals
Illinois Basin	6.4	0.5	0	6.9 (54%)
Powder River Basin	0	8.0	0	8.0 (46%)
Uinta Basin	0	0	0	0
Central Appalachians	0	0	0	0
Totals	6.4 (43%)	8.5 (57%)	0	14.9

TVA purchases coal under both long-term (more than one year) and short-term (one year or less) contracts; 97 percent of 2018 purchases were with long-term contracts. During 2018, 36 percent of TVA's coal supply was delivered by rail, 15 percent was delivered by barge, and 43 percent was delivered by a combination of barge and rail. The remaining 6 percent was delivered by truck. These percentages vary from year to year depending on the coal sourcing areas and other factors.

TVA uses large quantities of limestone to operate the FGD systems at its six coal plants. This limestone is acquired from quarries in the vicinity of the plants and transported to the plants primarily by truck.

2.3.2 Nuclear Generation

TVA operates seven nuclear units at three sites with a total net summer dependable capacity of 7,723 MW (Figure 1-1, Table 2-4). The newest nuclear unit, Watts Bar Unit 2, began commercial operation in 2016 after initial construction efforts were halted in the mid-1980s. In 2017, TVA received approval from the Nuclear Regulatory Commission for an extended power uprate at Browns Ferry. The first of these uprates, completed in July 2018, increased the capacity of Unit 3 by 155 MW. The uprate to Unit 3 was complete January 31, 2019, enabling the unit to generate an additional 155 MW of electricity (up to 1,311 MW electricity total). After the planned completion of the remaining uprate in the spring of 2019, the total generating capacity of Browns Ferry will be increased by 465 MW.

Table 2-4: Characteristics of TVA nuclear generating units.

Facility	Units	2018 Net Summer Capability (MW)	Type	Commercial Operation Date (First and Last Unit)	Operating License Expiration
Browns Ferry	3	3,309	Boiling Water	1974, 1977	2033, 2034, 2036
Sequoyah	2	2,292	Pressurized Water	1981, 1982	2040, 2041
Watts Bar	2	2,122	Pressurized Water	1996, 2016	2035, 2055
Total	7	7,723			

Fuel Procurement - TVA's seven nuclear units use a total of about 4 million pounds of natural uranium equivalent (U_{235}) per year. Natural uranium equivalent is used to make enriched uranium, which has a higher concentration of the uranium U_{235} isotope than natural uranium. This uranium, which comes from uranium producing areas around the world, is processed into enriched uranium and fabricated in North American locations. In October 2018, TVA entered into a DOE program for downblending highly enriched uranium to low enriched uranium for use in TVA nuclear units. TVA currently has sufficient enriched uranium and fabrication in inventory or under contract to provide all of its requirements through 2022.

2.3.3 Natural Gas-Fired Generation

TVA has 87 natural gas-fueled simple-cycle combustion turbine (CT) units at 9 sites (Figure 1-1, Table 2-5). The oldest CTs were completed in 1971 and the newest in 2002. Eight CTs are co-located at the coal-fired Gallatin plant site and 48 are at the sites of three now-retired coal plants (Allen, Colbert, and Johnsonville). The remaining 31 CTs are located at five stand-alone plant sites. The individual CT units range in generating capacity from 15 MW (Allen CT Units 1 – 16) to 180 MW (Gleason CT Units 1 and 2). Eighty of the CT units are capable of using fuel oil and 60 are capable of quick start-up, reaching full generation capability in about 10 minutes. One of the newer CT units at Johnsonville was recently converted to power a steam generator to provide steam to an adjacent chemical plant. This steam was previously produced by now-retired Johnsonville coal plant.

Table 2-5: Characteristics of TVA natural gas-fueled plants.

Facility	Combustion Turbine Units	Steam Turbine Units	2018 Summer Net Capability (MW)	Commercial Operation Date (First and Last Unit)	Oil Fueling Capability
Simple Cycle (CT)					
Allen	20	--	456	1971, 1972	Yes
Brownsville	4	--	468	1999	No
Colbert	8	--	392	1972	Yes
Gallatin	8	--	642	1975, 2000	Yes
Gleason	3	--	500	2000	No
Johnsonville	20	--	1,269	1975, 2000	Yes
Kemper	4	--	348	2002	Yes
Lagoon Creek	12	--	1,048	2001, 2002	Yes
Marshall	8	--	608e	2002	Yes
CT Subtotal	87	--	5,731		
Combined Cycle (CC)					
Ackerman	2	1	713	2007	No
Allen	2	1	1,106	2018	No
Caledonia	3	3	765	2003	No
John Sevier	3	1	871	2012	Yes
Lagoon Creek	2	1	525	2010	No
Magnolia	3	3	918	2003	No

Facility	Combustion Turbine Units	Steam Turbine Units	2018 Summer Net Capability (MW)	Commercial Operation Date (First and Last Unit)	Oil Fueling Capability
Paradise	3	1	1,100	2017	No
Southaven	3	3	780	2003	No
CC Subtotal	21	15	6,778		
Total Gas-Fueled	108	15	12,509		

TVA also has 21 natural-gas fueled CC units at eight sites. At CC plants, electricity is generated by combustion turbines as at simple-cycle CT plants; the hot exhaust from the combustion turbines drives a heat recovery steam generator and the steam drives a steam turbine generator. Two of the CC sites are adjacent to now-retired coal plants (Allen, John Sevier), and two are co-located with CT units (Allen, Lagoon Creek). The Paradise CC plant is near the remaining operating Paradise coal unit. The three-unit Caledonia plant is leased by TVA and the other CC plants are owned by TVA. The arrangement of CTs and steam generators varies, with each steam generator paired with a combustion turbine at some plants while at other plants two or three CTs drive each steam generator. Some of the turbines at the newest CC plants can be operated as quick-start CT units, as well as more efficient CC units. The total net summer dependable capacities are 5,731 MW for the combustion turbine units and 6,778 MW for the combined cycle units.

Fuel Procurement – TVA's consumption of natural gas has greatly increased in recent years as natural gas-fueled generation, particularly from CC plants, has increased and coal-fired generation decreased. In 2014, TVA used about 56 billion cubic feet (BCF) of natural gas to fuel its CT and CC plants and to fuel generating facilities at some non-TVA plants that sell power to TVA under terms of a PPA. Since 2014, natural gas consumption increased to 213 BCF in 2015, 270 BCF in 2016, and 241 BCF in 2017. The consumption in 2018 further increased to 297 BCF with the start-up of the Allen CC plant and the year-long operation of the Paradise CC plant.

TVA purchases natural gas from multiple suppliers under contracts with terms of up to three years. TVA transports the gas across multiple interstate pipelines to gas generating facilities. TVA contracts for natural gas storage to provide peaking supply and balancing services to accommodate changes in generation. Due to the variety of suppliers and characteristics of the pipeline transportation network, it is not possible to break down the natural gas supply by sourcing area or extraction technique.

Fuel oil is purchased on the spot market for immediate delivery to the plants. TVA maintains an inventory of fuel oil at all of its plants with oil fueling capability to provide a short-term backup supply in the event the gas supply is disrupted.

2.3.4 Diesel-Fired Generation

TVA owns one diesel generating facility with a total net summer capacity of 9 MW. This plant, located in Meridian, Mississippi, consists of 5 units completed in 1998. Diesel fuel is purchased on the spot market and transported via TVA tanker trucks from third party terminals and/or other TVA on-site fuel tanks.

2.3.5 Hydroelectric Generation

The TVA hydroelectric generating system consists of 29 hydroelectric dams with 109 conventional hydroelectric generating units. Twenty-eight of these dams are on the Tennessee River and its tributaries and one dam (Great Falls) is on a Cumberland River tributary (Figure 1-1). TVA also operates the four-unit Raccoon Mountain pumped storage hydroelectric facility near Chattanooga, Tennessee. The 85-MW Unit 2 at the Hiwassee hydroelectric plant in southwestern North

Carolina is a reversible turbine-generator with the ability to operate as a pumped storage hydroelectric plant.

The total net summer capability of the TVA hydroelectric system is 5,398 MW; this includes 3,782 MW of conventional hydroelectric generation and 1,616 MW from Raccoon Mountain. Conventional hydroelectric plants range in size from the 4-unit, 11-MW Wilbur plant to the 21-unit, 675-MW Wilson plant. The oldest of the conventional plants, Ocoee No. 1, was completed in 1911 and the newest, Tims Ford, was completed in 1970. In 1992, TVA began its Hydro Modernization Program to replace outdated turbines and other equipment in the hydroelectric plants. At the end of FY18, these modernization efforts had been completed on 60 conventional hydroelectric units and the four pumped hydroelectric units. These efforts resulted in a 444-MW increase in generating capacity of the conventional units and an average efficiency gain of 5 percent. Details about the hydroelectric plants and the operation of the hydroelectric system are available in the *Reservoir Operations Study* (TVA 2004).

2.3.6 Non-Hydro Renewable Generation

TVA owns 14 small photovoltaic (PV) solar installations with a total capacity of about 1,400 kW (Figure 1-1). These include 13 small (<100 kW) installations which generate power marketed through TVA's Green Power Switch program (see Section 2.5) and a recently completed 1-MW facility at the Allen CC plant.

2.4 Purchased Power

For FY 2010 through 2018, purchased power comprised 11 to 16 percent of TVA's total power supply. In FY18, TVA purchased 18,740 million kWh, 13 percent of its total power supply. Approximately 11 percent of this purchased power was purchased on the spot market, one percent through short-term PPAs, and 88 percent through long-term PPAs.

TVA has long-term PPAs for about 3,800 MW of generating capacity; the major PPA contracts/facilities other than those that are part of specific programs, are listed in Table 2-6.

TVA purchases hydroelectric generation from nine U.S. Army Corps of Engineers (USACE) dams on the Cumberland River and its tributaries through a long-term contract with the Southeastern Power Administration (SEPA), a federal power marketing agency. The power generated by the Buffalo Mountain wind farm, completed in 2004, is marketed through the Green Power Switch program (see Section 2-5).

Table 2-6: Major power purchase agreement contracts/facilities.

Facility	Owner/Marketer	Location	Capacity (MW)[1]	Contract End Date
Natural Gas – Combined Cycle				
Decatur Energy Center	Capital Power	Decatur, AL	720	2023
Morgan Energy Center	Calpine	Decatur, AL	615	2026
Lignite Coal				
Red Hills Power Plant	SE Choctaw (Southern Company)	Choctaw County, MS	440	2032
Diesel				
Diesel	various	various	total of 112	various
Wind				
Buffalo Mountain Windfarm	Invenergy	Oliver Springs, TN	27	2024

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Facility	Owner/Marketer	Location	Capacity (MW)[1]	Contract End Date
Lost Lakes Wind Farm	EDP Renewables North America	Dickinson County, IA	101	2030
Caney River Wind	ENEL Green Power North America	Elk County, KS	201	2031
Pioneer Prairie I Wind Farm	EDP Renewables North America	Howard, Mitchell Counties, IA	198	2031
White Oak Energy Center	NextEra Energy Resources	McClean County, IL	150	2031
Bishop Hill Wind Energy Center	Invenergy	Henry County, IL	200	2032
Cimarron Wind Energy Center	NextEra Energy Resources	Gray County, KS	165	2032
California Ridge Wind Energy Center	Invenergy	Champaign County, IL	200	2032
Solar				
West Tennessee Solar Farm	University of Tennessee	Haywood County, TN	5	2032
River Bend Solar Energy Center	NextEra Energy Resources	Lauderdale County, AL	101	2036
Millington Solar Facility	SR Millington (Silicon Ranch Corp.)	Shelby County, TN	69.5	2038
Biomass				
Chestnut Ridge Landfill Gas	WM Renewable Energy	Heiskell, TN	4.8	2031
Hydroelectric				
Cumberland River Hydroelectric Dams (9 dams)	Southeast Power Administration/ USACE	TN, KY	405	2037

[1]Capacities for the Solar PV facilities are direct current; all other capacities are alternating current.

TVA entered into PPAs with the other seven wind farms listed in Table 2-6 in 2009 and 2010, after issuing a request for proposals (RFP) in December 2008 for up to 2,000 MW of electricity from renewable and/or clean sources to be delivered by 2011. The Pioneer Prairie wind farm in Iowa began delivering power to TVA in 2010 and the other six wind farms were delivering power by late 2012. TVA entered into a PPA with an additional wind farm, the 300-MW Streator-Cayuga Ridge wind farm in Livingston County, Illinois, which also began delivering power in 2010. TVA canceled this PPA in May 31, 2016.

Under the Public Utility Regulatory Policies Act (PURPA), TVA is required to purchase energy from qualifying facilities at TVA's avoided cost of either generating this energy itself or purchasing this energy from another source (TVA 2007a). Qualifying facilities are cogeneration or small power production facilities that meet certain ownership, operating, and efficiency criteria. Cogeneration (also known as combined heat and power) facilities produce electricity and another form of useful thermal energy (heat or steam) for industrial or other uses. A qualifying small power production facility has a capacity of between 7 kW and

80 MW and generates power through renewable (hydro, wind or solar), biomass, waste, or geothermal resources. TVA fulfills this requirement through the Dispersed Power Production program. As of December 1, 2018, there were 44 generation sources, with a combined qualifying capacity of 157 MW, whose power TVA purchases through the Dispersed Power Production program. The majority of this power is generated by a 40-MW cogeneration plant operated by International Paper in Lowndes County, MS. and by a 26-MW cogeneration plant operated by DTE Energy in Marshall County, Kentucky. Most of the smaller Dispersed Power Production generation sources are solar PV facilities with a capacity of less than 600 kW installed on or in association with municipal, institutional, and commercial buildings.

The Green Power Providers (GPP) program is an end-user generation program that began in 2003 as the Generation Partners (GP) pilot program. Under the GP pilot program, TVA purchased renewable energy generated by facilities installed by residential, commercial, and industrial customers. TVA purchased qualifying renewable generation at retail plus a premium rate via a generation credit on the participant's monthly bill via a 10 year power purchase agreement. In 2007, the TVA Board adopted a dual metering standard under PURPA that required TVA to make available to its distributors the option to participate in a dual metering program "modeled after" the GP pilot program.

In 2012, the GP pilot program was replaced with the GPP program, which operated similarly to its predecessor and consistent with the dual metering standard TVA adopted in 2007. Qualifying generating systems had a maximum capacity of 50 kW (direct current, DC) and included solar photovoltaic panels, wind turbines, low-impact hydropower, and systems using several types of biomass fuels. A $1,000 incentive for new participants was phased out in 2015 for new non-residential participants and in 2016 for new residential participants. Additionally, the generation credit paid decreased in concert with the significant decrease in the installed cost of solar. For calendar year 2018, the Green Power Providers program capacity for new applicants was capped at 10 MW_{DC}. Generation credit rates for the 20-year contract period were $0.09/kWh for systems with a capacity of up to 10 kW_{DC} and $0.07/kWh for larger systems.

The maximum capacity of individual systems installed under the two programs has varied from a high of 1 MW_{DC} to the current 50 kW_{DC}. As of December 2018, the combined GP and GPP program had over 3,500 generating systems with a total nameplate capacity of about 109 MW_{DC}. Solar PV facilities comprised about 90 percent of this capacity. Biomass (landfill gas, wastewater methane and wood waste and chips) comprised about 10 percent of capacity. Wind generation provided about 96 kW_{DC} and small hydroelectric systems provided 9 kW_{DC}. An additional 171 projects, all solar, with a total capacity of about 4 MW_{DC} have been approved by TVA, under the GPP program, and are in various stages of construction. Additional information on the Green Power Providers program is available at https://www.tva.gov/Energy/Valley-Renewable-Energy/Green-Power-Providers. TVA is evaluating whether the dual metering standard and the GPP program should be updated in response to changes in the utility industry since the dual metering standard and the GPP program were first established in 2007 and 2012, respectively

In October 2010, TVA issued the Renewable Standard Offer (RSO) to promote the development of renewable energy in the TVA PSA. RSO offered set prices to developers of small to mid-size renewable projects under long-term contracts up to 20 years. The generating facilities must be between 50 kW and 20 MW in size and located within the TVA region. Qualifying fuel sources included solar photovoltaic, wind, and biomass from wood waste, agricultural crops or waste, animal and other organic waste, energy crops, and landfill gas and wastewater methane. The RSO program was closed to new proposals in 2015. As of December 2018, 20 RSO facilities with over 157 MW_{DC} of generating capacity were operating (Table 2-7). An additional 2 facilities with a total capacity of 40 MW_{DC} have been approved but are not yet operating.

In February 2012, TVA initiated the Solar Solutions Initiative (SSI), a targeted incentive program aimed to support the existing TVA-region's solar industry and to recruit new industry to the region. In addition to terms similar to those of the RSO, SSI provided incentive payments for solar projects in the RSO program greater than 50 kW and less than or equal to 1 MW that used local certified solar installers. As of December 2018, the program had 56 operating facilities with a total capacity of about 43 MW_{DC} and 1 facility with a total capacity of 1 MW_{DC} approved but not yet operating.

At the end of 2015, TVA closed the SSI program to new proposals and initiated the Distributed Solar Solutions (DSS) program. The DSS program was designed to encourage the TVA-region LPCs to develop and operate solar projects with capacities between 50 kW and 2 MW. The program was offered in 2016 and 2017, and as of December 2018, the program had 2 operating facilities with a total capacity of 3 MW_{DC} and 11 facilities with a total capacity of about 23 MW_{DC} approved but not yet operating.

In September 2017, TVA issued an RFP for the procurement of new renewable energy resources. Qualifying facilities had to be located within the TVA PSA or capable of delivering energy to TVA through TVA's interconnections with neighboring transmission systems. TVA received multiple proposals in response to the RFP. These proposals offered a total capacity of 6,700 MWac of capacity, with 69 percent of this capacity from solar PV facilities, 29 percent from wind facilities, and 2 percent from biomass-fueled facilities. TVA closed the RFP in December of 2017 and, as a result of the proposals received, awarded four contracts to build 674 MWac of new solar power.

Table 2-7: Renewable Standard Offer generating facilities operating in May 2018.

Facility	Owner/Marketer	Location	Fuel	Capacity[1]
West Camden Renewable Energy Facility	Waste Management	Benton County, TN	Landfill gas	4.8
Prairie Bluff Renewable Energy Facility	Waste Management	Chickasaw County, MS	Landfill gas	1.6
BioEnergy Sand Valley	BioEnergy (Alabama) LLC	DeKalb County, AL	Landfill gas	4.8
Columbus Cellulose Fibers Cogeneration Facility	International Paper	Columbus, MS	Biomass	20
Bristol Landfill Gas	Ingenco Renewable Development, LLC	Bristol, VA	Landfill gas	2.3
Mulberry Solar Farm	Mulberry Farm LLC (Dominion)	McNairy County, TN	Solar PV	20
Selmer Solar Farm	Selmer Farm LLC (Dominion)	McNairy County, TN	Solar PV	20
Bi-County Landfill Gas	Bi-County Landfill Gas Producers LLC	Montgomery County, TN	Landfill Gas	2
Selmer North I Solar Farm	Selmer North I LLC (Silicon Ranch Corp.)	McNairy County, TN	Solar PV	10
Providence Solar Center	Providence Solar Center LLC (Silicon Ranch Corp.)	Madison County, TN	Solar PV	20
Wildberry Solar Center	Wildberry Solar Center LLC	Fayette County, TN	Solar PV	20
Selmer North II Solar Farm	Selmer North II LLC (Silicon Ranch Corp.)	McNairy County, TN	Solar PV	10

1 Capacities for the solar PV facilities are direct current; all other capacities are alternating current.

Facility	Owner/Marketer	Location	Fuel	Capacity[1]
Hampton Solar	Cumberland Land Holdings LLC (Silicon Ranch Corp.)	Limestone County, AL	Solar PV	20
Haywood County Solar Farm	Haywood Solar LLC (Silicon Ranch Corp.)	Haywood County, TN	Solar PV	3.9
Latitude Solar Center	Latitude Solar Center LLC (Coronal Energy)	Hardeman County, TN	Solar PV	20
Chickasaw County Solar Farm	SR Houston Holdings LLC (Silicon Ranch Corp.)	Chickasaw County, MS	Solar PV	3.9
Jonesborogh Solar	SR Jonesborough LLC (Silicon Ranch Corp.)	Washington County, TN	Solar PV	5

2.5 Demand-Side Management Programs

TVA has had a portfolio of demand-side management programs focusing on energy efficiency and demand response for many years. Energy efficiency (EE) programs are designed to reduce the use of energy while still providing reliable electric service. Smart electric technology programs improve consumer energy performance, safety, and comfort. Demand response (DR) programs are designed to temporarily reduce a customer's use of electricity, typically during peak periods and for system reliability or economic reasons. Because the energy use is typically shifted to off-peak times, demand response typically has little effect on total energy use. It does, however, provide system reliability and reduce the need for peaking generation capacity. DR program participants receive credits on their electric bills. The TVA demand-side management (DSM) portfolio is a combination of fully deployed mature programs, recently initiated programs and programs under development.

The 2015 Integrated Resource Plan (IRP) identified goals of additional energy efficiency savings, through programs administered by TVA and the LPCs, of 900 to 1,300 MW by 2023 and 2,000 to 2,800 MW by 2033. It also identified the demand response goal of 450 to 750 MW of additional demand reduction by 2023 and similar additional amounts by 2033. Through its EnergyRight Solutions program (described in more detail below), TVA realized 379 gigawatt hours (GWh), 378 GWh, and 170 GWh of energy efficiency savings in 2016, 2017, and 2018, respectively. Based on the rate at which additional energy efficiency savings are being realized, TVA is unlikely to meet the 2023 goal. TVA also provided 1,547 MW, 1,614, and 1,635 MW of potential demand reduction through DR in 2016, 2017, and 2018, respectively. Following are descriptions of DSM programs that have operated since 2015.

2.5.1 Energy Efficiency Programs and Smart Energy Technologies

TVA implements its DSM efforts through its EnergyRight® Solutions (ERS) portfolio. EnergyRight® Solutions targets three sectors: EnergyRight® Solutions for the Home, EnergyRight® Solutions for Business, and EnergyRight® Solutions for Industry. The ERS programs include a variety of energy-saving tools and incentives that help save energy and reduce power costs while providing peak reduction benefits for the power system. They change over time to adapt to new technologies, TVA system needs, and other factors. Unlike integrated power systems where the utility generates and distributes electricity to end users, most of the electricity TVA generates is distributed to end users by the 154 LPCs. This complicates the development and implementation of many types of DSM programs are delivered through partnerships with participating LPCs, which requires coordination.. The TVA DSM portfolio is described in more detail below; information about programs is also available at http://www.energyright.com/.

EnergyRight® Solutions for the Home

eScore Program – eScore is a home energy upgrade program designed to provide homeowners with smart energy advice, access to a network of specially trained and approved contractors through the TVA Quality Contractor Network, a free inspection of any work performed, and the assurance that the job will be done correctly. The eScore Program is delivered by LPCs and TVA. Homeowners can reengage with the program as many times as needed to achieve their home's best possible energy performance. Financing is available in most areas to help homeowners make upgrades. Rebates are available for qualifying smart energy technology upgrades. Through the end of 2018, over 150,000 customers registered for the program and nearly 70,000 have completed eScores. The eScore program was created as part of the CAA Environmental Agreement described in Section 2.3.

eScore Self Audit Program – Homeowners complete an online home energy survey. The homeowners then receive a personalized report that breaks down their annual and monthly energy usage by category and makes recommendations for increasing energy efficiency. Participants also receive a free energy efficiency kit that may include items such as light emitting diode (LED) light bulbs and gaskets for wall outlet and light switches. Over 37,000 self-audits were conducted by the end of 2018.

Heat Pump Program – Under this program, TVA promoted the installation of high-efficiency heat pumps by providing low-interest, fixed-rate financing for up to 10 years through a third-party lender, with repayment through the consumer's electric bill. Installations were performed by a member of the QCN and TVA reimbursed LPCs for inspection and loan processing/collection. During 2017, 939 heat pumps were installed through the program with an estimated annual energy saving of 1.78 GWh. In late 2017, the Heat Pump Program was merged into the eScore Program.

Volume Heat Pump Program for Manufactured Homes –The Volume Heat Pump Program was an upstream program that promoted the installation of electric heat pumps in qualified manufactured homes. Its features included a network of heating, ventilation, and air conditioning (HVAC) wholesalers, incentives and an on-site validation of 10 percent of randomly-selected installations. The program had 128 installations in 2017 with annual energy savings of 504,220 kWh. This program has since been terminated.

ENERGY STAR© Pilot Program for Manufactured Homes – This program was an upstream program administered by Systems Building Research Alliance. A rebate was paid to manufactured homes producers to encourage them to build ENERGY STAR homes to be sited in the Tennessee Valley. The program yielded 1,731 manufactured homes in 2014. It was terminated in 2016.

New Homes Program – The New Homes Program offers a suite of HVAC and water heating equipment incentives to encourage builders to use electric equipment instead of non-electric alternatives. Incentives are offered for single family homes, duplexes, and multi-family homes. The program incentives help builders purchase technologies that are highly desired for efficiency, effectiveness, and longevity, making these new homes more marketable. Over 500 homebuilders have applied for membership in the Homebuilder Network. In FY18, nearly 4,500 homes received incentives through the redesigned program.

Smart Communities Program – Smart Communities is a mitigation program developed as part of TVA's CAA Environmental Agreements described above in Section 2.3. The program is made up of two components: Smart Energy Technologies and Extreme Energy Makeovers. The Smart Energy Technologies component tested the integration of ultra-efficient homes with smart grid technologies, and the human interaction with such technologies, in the Glasgow (Kentucky) Electric Plant Board service area. The ultimate goal of the program was to reduce emissions of air pollutants. The Smart Communities Program ended in 2017.

As part of the Extreme Energy Makeovers component, whole-home, deep energy retrofits for 20-year-old or older homes in lower income communities were provided in the service areas of 4-County Electric

Power Association and Columbus Light & Water in Mississippi, Cleveland Utilities, Knoxville Utilities Board, and Oak Ridge Electric Department in Tennessee, Huntsville Utilities in Alabama, and North Georgia Electric Membership Corporation. The program goal was to achieve a 25 percent energy reduction in each home's energy use for an estimated energy savings of 1,000 MWh/year at a cost of approximately $10/square foot. Typical retrofits included insulation, new or repaired heating, ventilation, and air conditioning (HVAC) systems, air sealing, new windows/doors, and energy-saving appliances. Through 2017, the program had 3,400 participants and resulted in an average energy bill reduction of 35 percent.

Home Energy Improvement Program – This pilot program, begun in 2017, was modeled after the Department of Energy (DOE) Weatherization Assistance Program (WAP). It provided approximately $8,000 per home for improvements to about 125 homes in the Memphis area at no cost to the low-income homeowners. Typical improvements included insulation, air sealing, HVAC repair or replacement, and water heater upgrades.

Home Uplift – Launched in 2018 in collaboration with state and local community groups, Home Uplift provides energy upgrades for low-to-moderate households. Modeled after the DOE WAP, this program provides approximately $8,000 per home at no cost to qualified homeowners for improvements such as HVAC repair or replacement, insulation, air sealing, replacement windows, and water heater upgrades. As of September 2018, 531 homes participated in this pilot.

Weatherization Assistance Program – This program is a partnership with the Tennessee Housing and Development Agency to provide support for the DOE-funded WAP program in Tennessee. Since 2010, TVA has provided direct install kits for all pre-audits and in 2018 created an innovative platform, WAPez, to streamline the WAP administrative process to help serve more consumers and leverage all sources of funding. As of September 2018, TVA has provided support for 22,834 homes.

Home Energy Workshops – Launched as a Middle Tennessee pilot in 2015, the Home Energy Workshops expanded in 2018 to provide energy education workshops throughout the Valley. Through September 2018, 1,236 participants attended workshops.

Water Heating Program – The Water Heater Program promotes the installation of electric water heaters in homes and small businesses. A principal program feature is a Market Value Payment from TVA to the LPC for each electric water heater installed. In FY18, over 8,099 water heaters came through the program.

EnergyRight® Solutions for Business

ERS for Business program transitioned during 2018 from providing incentives for energy efficiency upgrades through measures such as lighting upgrades to providing incentives for smart energy technologies such as dual fuel heat pumps, variable refrigerant flow HVAC units, outdoor lighting for safety, and food service equipment.

During the transition year, the ERS for Business program saved 61 GWh, while providing incentives of $4.9 million through 116 LPCs. Approximately 86 percent of the energy savings were through lighting upgrades, and about 5 percent through HVAC upgrades. The remaining 9 percent of energy savings were through other comparatively small measures. Incentives for energy efficiency measures through this program were discontinued in 2018. TVA continues to support energy efficiency through engagement initiatives such as Strategic Energy Management.

While transitioning away from incentives for energy efficiency, efforts to incentivize smart energy technologies continue to grow. In 2018 ERS for Business program added 21.3 GWh of load while providing incentives of $2.8 million through 39 LPCs. Approximately 31 percent of load added was from HVAC measures, 23 percent from non-road electric vehicles, and 32 percent from custom projects where TVA personnel found tailored solutions for consumers. The remaining 14 percent of load was added from other comparatively small measures.

EnergyRight® Solutions for Industry
EnergyRight® Solutions (ERS) for Industry program transitioned during 2018 from providing incentives for energy efficiency upgrades through measures like lighting upgrades to providing incentives for smart energy technologies such as dual fuel heat pumps, variable refrigerant flow HVAC units, outdoor lighting for safety, and process heating equipment.

During the transition year, the ERS for Industry program saved 74.8 GWh, while providing incentives of $5.9 million through 82 LPCs. Approximately 58 percent of the energy savings were through lighting upgrades, 19 percent through compressed air upgrades, and about 15 percent through HVAC upgrades. The remaining 8 percent of energy savings were through other comparatively small measures. Incentives for energy efficiency measures through this program were discontinued in 2018. TVA continues to support energy efficiency through engagement initiatives like Strategic Energy Management.

While transitioning away from energy efficiency, efforts to incent smart energy technologies continue to grow. In 2018 ERS for Industry program added 38.3 GWh of load while providing incentives of $3.2 million through 27 LPCs. Approximately 19 percent of load added was from process heating solutions, motors and HVAC contributed approximately 7 percent of the projects, and 63 percent was contributed from custom projects where TVA personnel found tailored solutions for consumers. The remaining 4 percent of load was added from other comparatively small measures.

Education and Outreach
The EnergyRight® Solutions for Youth energy education program that was in place in 2015 is now run by the Tennessee Valley Public Power Association.

2.5.2 TVA Facilities

The Internal Energy Management Program, created by TVA in 1978, is responsible for the planning, coordination of regulatory reviews, performance analysis and reporting, oversight of energy related audits, and sustainable design for TVA facilities. The program coordinates TVA compliance with energy efficiency goals and objectives for Federal agencies established by the National Energy Conservation Policy Act, the subsequent Energy Policy Acts of 1992 and 2005, Energy Independence and Security Act of 2007, and several Executive Orders (E.O.) including E.O. 13834, Efficient Federal Operations (2018). This program has resulted in significant reductions in energy use; for example, between 2003 and 2017 energy intensity in TVA facilities was reduced by 36.9 percent. Over the past 10 years the program, through the implementation of energy efficient projects in TVA buildings, helped TVA save 540 GWh cumulatively, which is enough to power 36,800 Valley homes for one year. See https://www.tva.gov/About-TVA/Guidelines-and-Reports/Sustainability-Plans-and-Performance for more information and annual reports of accomplishments.

2.5.3 Demand Response Programs

Interruptible Power – These programs enable TVA to suspend a portion of the electric load of participants during times of power system need. The three Interruptible Power programs had a total capacity of 1,716 MW at the end of 2018. The programs are differentiated by the time period between when participants are notified to reduce their load and when the load reductions must be in place. These programs are Interruptible Power – 5 minutes (650 MW in 2018), Interruptible Power – 30 minutes (769 MW), and Instantaneous Response (297 MW). In early 2017, TVA changed its policies to allow participants in the Interruptible Power programs to generate power using diesel-fueled generators during DR events.

Aggregated Demand Response – This program provides peak load reduction to TVA during periods of power system need, at TVA's request. This program had a total capacity of 188 MW at the end of 2018; most of this capacity is implemented by Enel X (formerly known as EnerNOC).

Voltage Optimization – This is a mitigation program developed as part of TVA's CAA Environmental Agreements described above in Section 2.3. In this program, TVA works with LPCs to operate their distribution lines in the lower half of the acceptable voltage range, thereby lowering demand and reducing energy consumption.

2.5.4 Renewable Energy Certificate (REC) Programs

Under the Green Power Switch program, TVA customers can support renewable energy by purchasing 150-kWh blocks of renewable energy for $4/block/month. TVA generates or acquires the renewable energy from specific sources, including the Buffalo Mountain Windfarm described above and the Green Power Providers program participants. In fiscal year 2018, 10,568 residential and 425 business participants in the Green Power Switch program supported the generation of 62,641 MWh of renewable energy. For 2018, 70 percent of this energy marketed through the Green Power Switch program was from solar, 20 percent from wind, and 10 percent from biomass.

Green Power Switch Southeastern RECs is a pilot program initiated in 2012 that provides a bulk purchase option for businesses in the Valley. It gives an organization the ability to make renewable energy claims, using Green-e certified RECs, and allows them to demonstrate to their customers and stakeholders that they support green initiatives. The RECs purchased through the program are delivered to the Valley along with the renewable energy, and the cost of the RECs are added to the customer's regular electricity bill. In fiscal year 2018, 14 customers supported green initiatives through this program accounting for 629,176 MWh sold.

2.6 Transmission System

TVA operates one of the largest transmission systems in the U.S. It serves an area of 80,000 square miles through a network of approximately 16,200 miles of transmission line; 508 substations, switchyards and switching stations; and 1,321 individual customer connection points. The system connects to switchyards at generating facilities and transmits power from them at either 161 kV or 500 kV to LPCs and directly served customers. Substations at delivery points reduce the voltage for delivery through LPC distribution lines serving end users.

The TVA transmission system operates at a range of voltages:

- 500-kV lines – 2,471 miles
- 345- and 230-kV lines – 150 miles
- 161-kV lines – 11,625 miles
- 138- and 115-kV lines – 202 miles
- 69-kV lines – 1,120 miles
- 46-kV lines – 608 miles
- 26- and 13-kV lines – 15 miles

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 power 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 transmission services to others to transmit power at wholesale in a manner that is comparable to TVA's own use of the transmission system. TVA has also adopted and operates in accordance with the Standards of Conduct for Transmission Providers (FERC 2008) and appropriately separates its transmission functions from its marketing functions.

In recent years, TVA has built an average of about 150 miles of new transmission lines and several new substations and switching stations per year to serve new customer connection points and/or to increase the capacity and reliability of the transmission system. The majority of these new lines are 161-kV. In 2008, TVA completed a 39-mile 500-kV transmission line in Tennessee which was the first major TVA 500-kV line built since the 1980s. TVA also completed a 27-mile 500-kV transmission line in Tennessee in 2010. TVA has also upgraded many existing transmission lines in recent years to increase their capacity and reliability by re-tensioning or replacing conductors, installing lightning arrestors and other measures.

A major focus of recent transmission system upgrades has been to maintain reliability when coal units are retired. Between 2011 and 2018, TVA spent $419 million on these upgrades and anticipates spending $10 million on coal-retirement related transmission system upgrades in 2019 and 2020. The upgrades include modifications of existing lines and substations and new installations as necessary to provide adequate power transmission capacity, maintain voltage support and ensure generating plant and transmission system stability. In May 2017, TVA began a $300 million, multi-year effort to upgrade and expand its fiber-optic network to help meet the power system's growing need for bandwidth as well as accommodate the integration of new distributed energy resources.

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3 Alternatives

Tennessee Valley Authority (TVA) uses a scenario planning approach in integrated resource planning, a common approach in the utility industry. Scenario planning is useful for determining how various business decisions will perform in an uncertain future. The goal of the Integrated Resource Plan (IRP) is to develop a least-cost plan that is consistent with TVA's legislatively mandated mission described in Section 1.1.1 of Volume I and the IRP objectives described in Section 1.2.1 of Volume I. The final, optimal plan will be low-cost, risk-informed, environmentally responsible, reliable, diverse, and flexible.

Multiple strategies, which represent business decisions that TVA can control, are modeled against multiple scenarios, which represent uncertain futures outside of TVA's control. The intersection of a single strategy and a single scenario results in a resource portfolio. A portfolio is a 20-year capacity plan that is unique to each combination of strategy and scenario. A detailed description of the development of the portfolios is in Chapter 6 of Volume I (Draft IRP).

3.1 Development of Scenarios

Based on the scoping comments, IRP Working Group input, and further analysis, TVA identified six scenarios:

1. The Current Outlook – Continuation of TVA's current forecasts, including a regional gross domestic product growth rate of 2 percent, slow customer growth, and declining customer energy use.
2. Economic Downturn – Prolonged, stagnant economy resulting in weak growth and delayed need for new generation.
3. Valley Load Growth – Rapid regional economic growth resulting in higher energy sales.
4. Decarbonization – Federal push to curb greenhouse gas (GHG) emissions with CO_2 emission penalties and incentives for non-emitting technologies.
5. Rapid Distributed Energy Resources (DER) Adoption – High penetration of distributed generation, energy storage, and energy management resulting in decreased demand from utilities.
6. No Nuclear Extensions – Regulatory challenges to relicensing existing and constructing new large-scale nuclear plants.

Each of the scenarios has a unique set of uncertainties, attributes that are likely to change in the future. These include the demand for electricity, the market price of power, fuel prices, regulations affecting electric utilities, regulations on CO_2 emissions, availablility of power for purchase from other producers, national energy efficiency adoption, and regional and national economic conditions. These and other aspects of the scenarios are described in detail in Section 6.1 of Volume I (Draft IRP).

3.2 Alternative Strategies and Associated Capacity Expansion Plans

3.2.1 Development of Alternative Strategies

After review of the scoping comments, five alternative planning strategies were developed by TVA in coordination with the IRP Working Group. The five alternative strategies include the Base Case, which represents the continued implementation of the 2015 IRP in accordance with least-cost optimization and reliability constraints. For purposes of the Environmental Impact Statement (EIS), Strategy A – Base Case represents the No Action alternative and the four other strategies represent action alternatives.

- Strategy A: Base Case
- Strategy B: Promote Distributed Energy Resources (DER)
- Strategy C: Promote Resiliency
- Strategy D: Promote Efficient Load Shape
- Strategy E: Promote Renewables

The five alternative strategies differ in, among other things, whether or not they include incentives for particular resources. In this context, an incentive is the mechanism to promote additional penetration of a resource and is equal to the difference between the cost of a resource in the Base Case and the cost to achieve the targeted level of penetration in the other four strategies.

Strategy attributes were used in the modeling in several different ways. Resources that were promoted generally received a modeled incentive that improved economics for their adoption or selection. In some cases, a resource category may be limited, such as new coal being excluded in the Promote Distributed Energy Resources (DER) and Promote Renewables strategies. Others have temporal restrictions, such as allowing retirements to take effect in a certain year when transmission work to allow plant separation could be completed. The Base Case represents the continuation of TVA's current power supply plan based on least cost planning with no specific resources promoted and reflects decisions made to date by the TVA Board of Directors. The remaining strategies provide incentives to promote adoption of certain resources, with consideration of market potential, pace of adoption, and reserve margin.

After defining each strategy's key characteristics, three incentive levels – Base (no incentive), Moderate, and High – were determined to achieve the objectives of the strategy as shown in Figure 3-1. These incentive levels influenced the selection of the affected energy resources during the development of the resource portfolios. The Strategy Design Matrix provided the roadmap for how resource promotions were applied in capacity planning. The key characteristics of each alternative strategy are summarized in Table 3-1. Further information on the strategies can be found in Section 6.1.2 and Appendix E of Volume I (Draft IRP).

Strategy	Distributed Resources & Electrification						Utility Scale Resources					
	Distributed Solar	Distributed Storage	Combined Heat & Power	Energy Efficiency	Demand Response	Beneficial Electrification	Solar	Wind	Biomass & Biogas	Storage	Aero CTs & Recip Engines	Small Modular Reactors
Base Case	Base	Base	Base	Base	Base	Base	Base	Base	Base	Base	Base	Base
Promote DER	High	Moderate	High	Moderate	Moderate	Base	Base	Base	Base	Base	Base	Base
Promote Resiliency	Moderate	High	Moderate	Base	Moderate	Base	Base	Base	Base	Moderate	Moderate	Moderate
Promote Efficient Load Shape	Base	Moderate	Base	High	High	Moderate	Base	Base	Base	High	Base	Base
Promote Renewables	Moderate	Moderate	Base	Base	Base	Base	Moderate	Moderate	Moderate	Moderate	Base	Base

Figure 3-1: Incentive levels for selected energy resources associated with each strategy.

Table 3-1. Key characteristics of the five alternative strategies.

Strategies	Description and Attributes
A- Base Case	• Planning Reserve margins for summer and winter peak seasons are applied, targeting an industry best-practice level of reliability (applies in all strategies) • No specific resource types are promoted beyond business as usual
B- Promote DER	• DER is incented to achieve higher end of long-term penetration levels • New coal is excluded, and all other technologies are available while Energy Efficiency, demand response, distributed generation and storage are promoted • Programs targeting low income customers will be part of Energy Efficiency promotion
C- Promote Resiliency	• Small, agile capacity is incented to maximize flexibility and promote ability to respond to short-term disruptions on the power system • All technologies are available while small modular reactors (SMRs) and small gas additions (aeroderivative turbines, reciprocating engines), demand response, storage and distributed generation are promoted • Combinations of storage and distributed generation could be installed as microgrids • Flexible loads and DERs are aggregated to provide synthetic reserves to the grid to promote resiliency
D- Promote Efficient Load Shape	• Targeted electrification and demand and energy management are incented to minimize peaks and troughs and promote an efficient load shape • All technologies are available but those that minimize load swings, including energy efficiency, demand response and storage, are promoted • Programs targeting low-income customers will be a part of EE promotion
E- Promote Renewables	• Renewables at all scales are incented to meet growing prospective or existing customer demands for renewable energy • New coal is excluded, and all other technologies are available while renewables are promoted

3.2.2 Capacity Expansion Plans

The following section provides a summary of the capacity expansion plans, also known as resource portfolios, developed for each of the alternative strategies. Capacity additions and reductions are quantified in megawatts (MW) and energy additions and reductions are quantified in gigawatt hours (GWh).

The capacity expansion plans are based on the assumption that all pending coal unit or plant retirements described in Section 3.2.3 will occur as scheduled, with all retired by 2038. Several current Power Purchase Agreements (PPAs) are assumed to expire during the planning period, including wind energy PPAs from 2024 through 2032, PPAs for diesel-generated power totaling 115 MW, and the Red Hills lignite coal plant PPA in 2032.

All portfolios considered in the 2019 IRP have the following common features:

- In all strategies, except for Strategy A - Base Case, promotions are applied first, and then the balance of the system is optimized in a least-cost manner.

- No new hydroelectric or coal plants were selected in any portfolio.
- Hydroelectric capacity and generation are the same across all portfolios.
- Coal capacity is the same or less than currently planned, as no coal was added. Coal generation reflects potential facility retirements described in Section 3.2.3.
- No new wind was selected in the portfolios, while solar expansion was significant.

In the following descriptions of the alternative strategies, the stated capacities are summer net dependable (SND) capacities except for wind and solar generation, which are nameplate capacities. For wind and solar generation, SND capacities are significantly less than nameplate capacities due to their intermittent nature. For the other energy resources, the difference between SND capacities and nameplate capacities is relatively small. These differences, as well as the methodology used to determine SND, are described in Appendix A of Volume I. The portfolios associated with the alternative strategies are described in greater detail in Chapter 7 of Volume I.

3.2.3 Potential Retirement of TVA Generating Facilities

Several TVA facilities have units that are being considered for retirement during the planning period. The following sections describe in general the activities that would occur upon potential retirement of these facilities.

Combustion Turbine Facilities

All of the alternatives and portfolios include the potential retirement of Allen CT Plant, Colbert CT Plant, Johnsonville CT Units 1 – 16, and Gallatin CT Units 1 – 8 as early as 2020. Because these facilities are considered for potential retirement within the next five years, Chapter 4 and Chapter 5 of Volume II provide site specific information about the affected environment and impacts of retirement and decommissioning activities for each CT facility.

Decommissioning is the performance of activities required to ready a facility for deactivation. Key decommissioning activities at CTs include:

- Tag out all unit or plant equipment except service water, lighting, etc.
- Remove and properly dispose of hazardous and other wastes, including polychlorinated biphenyl (PCB)-containing equipment
- Empty all storage tanks and reuse or dispose of contents (fuel oil, glycol, demin water, raw water, condensable fluids from gas supply)
- Open all equipment electrical breakers not in use
- Drain oil, fuel and fluids
- Salvage and store all useable equipment, components, materials, spare parts, office products, etc. Relocate as practical.
- Salvage and store all key plant records

Deactivation is the shutting down of power and energized systems as appropriate as well as severing and/or isolating power, water, fuel supply and piping to the plant to provide a cold, dark and dry structure. Activities may also include rerouting of power and services as required for any facilities that will remain operational.

Limited decontamination involves removing select regulated materials in a safe and practical manner in such a way that the plant is left in a status that does not present a hazard or risk to the environment or personnel. Work may include abatement and disposal of regulated materials. Regulated materials include but are not limited to PCB equipment, asbestos, hazardous waste, solid waste, products, etc. Key decontamination activities at CTs include:

- Removal and proper disposal of regulated materials, as practical.
- Periodic materials condition monitoring.
- Periodic waste removal as materials deteriorate over time.

Coal Plants

All of the alternatives and portfolios include the potential retirement of the coal-fired Shawnee, Cumberland, Gallatin, and Kingston Fossil Plants by 2038.

Depending on the plan selected for implementation, these facilities could be retired in whole or in part during the planning period. The strategies and portfolios also include the potential retirement of the Paradise and Bull Run Fossil Plants, which is currently under evaluation. Actions associated with the retirement of these two plants, and the associated environmental impacts, are described in TVA 2019a and TVA 2019b.

For coal plants or units selected for retirement, TVA would cease most plant operations and reduce plant staff at the time of retirement. In order to minimize environmental and safety risks and comply with applicable laws and regulations, TVA would implement the actions described below.

Decommissioning is the performance of activities required to ready a facility for deactivation. Work performed includes removal of equipment, components, and parts that can be used at other sites, draining of oil/fluids from equipment, removal of coal and ash from boilers and other equipment, removal of hazardous materials and potential waste like materials, removal of PCB equipment, removal of furniture/furnishings, removal of installation technology assets, removal of plant records. Key decommissioning activities at coal plants include:

- Tagging out all unit or plant equipment except service water, lighting, etc.
- Emptying and cleaning hoppers, bins, bunkers, etc.
- Opening all equipment electrical breakers not in use.
- Draining oil and fluids
- Salvaging and storing all useable equipment, components, materials, spare parts, office products, etc. and relocating them, as practical
- Salvaging and storing all key plant records.

Deactivation is the shutting down of power and energized systems as appropriate as well as isolating and/or severing power, water and piping to the plant to provide a cold, dark and dry structure. Work includes removing power and services, installing bulkheads, and sealing tunnels. Activities may also include rerouting of power and services as required for any facilities that would remain operational. Key deactivation activities at coal plants include:

- Performing electrical and mechanical isolation of systems, components and areas.
- Installing bulkheads and/or fill tunnels.
- Providing alternate power and services (sump pumps, Federal Aviation Administration stack lighting, etc.).

Limited decontamination involves removing select regulated materials in a safe and practical manner in such a way that the plant is left in a status that does not present a hazard or risk to the environment or personnel. Limited contamination work may include abatement and disposal of regulated materials, which include but are not limited to PCB equipment, asbestos, hazardous waste, solid waste, products, etc. Key decontamination activities at coal plants include:

- Removal and proper disposal of regulated materials, as practical.
- Periodic materials condition monitoring.
- Periodic waste removal as materials deteriorate over time.

3.3 Strategy A: Base Case - No Action Alternative

The No-Action Alternative is Strategy A: Base Case, which is TVA’s least-cost optimization plan that applies no special constraints or targets beyond the reserve margin constraint for reliability. In the Base Case, planning reserve margins for summer and winter peak seasons are applied, targeting an industry best-practice level of reliability (applies in all strategies). No specific resource types are promoted beyond business as usual.

Figure 3-2 summarizes the incremental capacity changes in the portfolios associated with each alternative strategy that would occur by 2038. Figure 3-3 presents the capacities, in SND MWs, of the various energy resources comprising each portfolio. The resulting generation by each energy resource is shown in Figure 3-4. Figure 3-5 provides additional detail on the solar additions in each portfolio.

The nuclear portfolio is the same in all Strategy A portfolios, except for Scenario 6 where the Browns Ferry units are retired between 2033 and 2036 at the expiration of their current operating licenses. Hydro capacity is the same in all cases. Coal assets decrease in most scenarios, especially in the lower load scenarios. Solar capacity is added beginning in the mid-2020 time frame, and continues to be added throughout most of the planning period. Including hydro, renewables account for 18 percent of the capacity portfolio on average. Natural gas assets increase over time, beginning with CC additions that could be achieved through renewal of existing contracts, acquisitions or builds. These are augmented by Combustion Turbine (CT) plant additions in Scenario 1, 3 and 6. With current cost projections and no promotion in Strategy A, no new storage appears in any portfolios. Energy efficiency increases modestly in all scenarios, with impacts lessened as efficiencies from codes and standards increase. Demand response increases similarly across scenarios, with some differentiation due to load shape and strategic focus.

Nuclear generation remains the same over time across the cases, with the exception of the Scenario 6 where energy from the retired Browns Ferry units is replaced primarily with solar and gas generation. Hydro energy remains the same across portfolios. Coal generation decreases over the planning horizon as units are retired and declines further in lower load cases, especially in Scenarios 4 and 5. Solar generation increases substantially in all cases, with the highest increases seen in the Scenario 3 and 4 portfolios. Including hydro, renewables account for 20 percent of total generation on average. Natural gas generation varies with load and strategic focus, with the highest gas generation seen in Scenario 3 and 6. The combination of incremental energy efficiency and demand response contributes a small amount to the portfolios. Strategy A results in 61 percent carbon-free generation in 2038 on average.

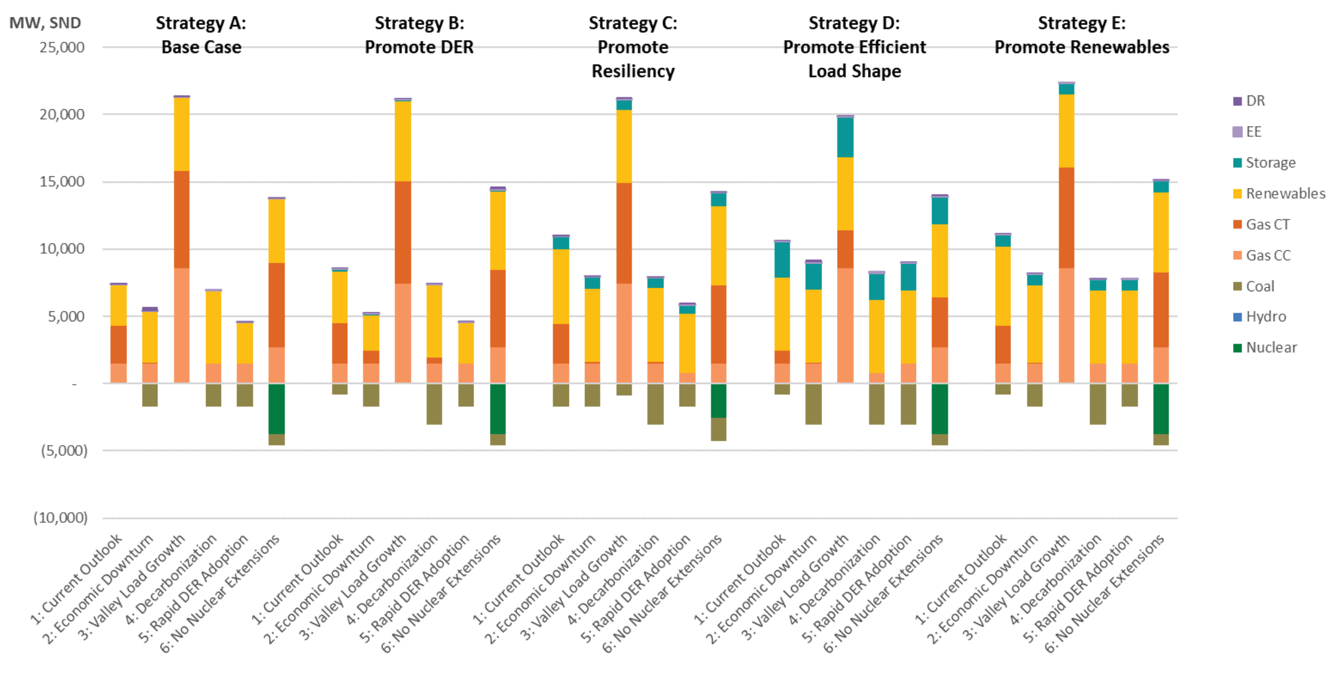

Figure 3-2: Incremental capacity by 2038, consisting of additions of new energy resources and retirement of existing energy resources, for the portfolios associated with each alternative strategy.

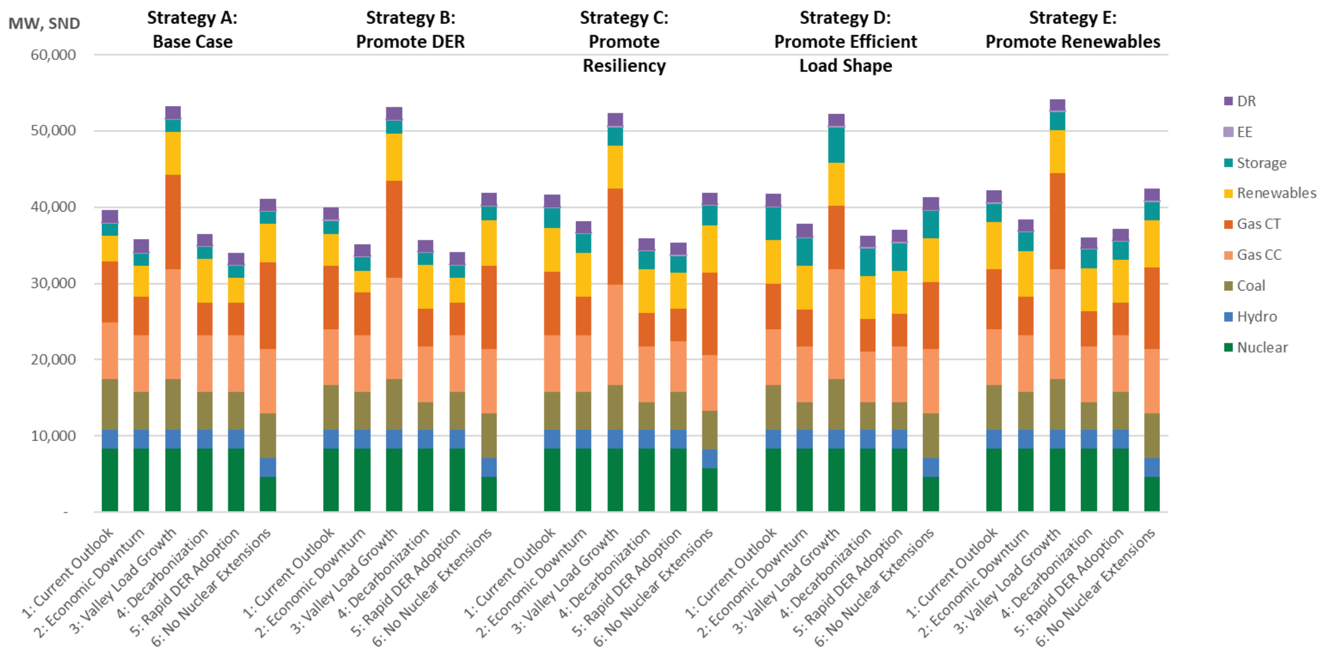

Figure 3-3: Total Capacity in 2038 by resource type in the portfolios associated with each alternative strategy.

Figure 3-4: Energy in 2038 by resource type in the portfolios associated with each alternative strategy.

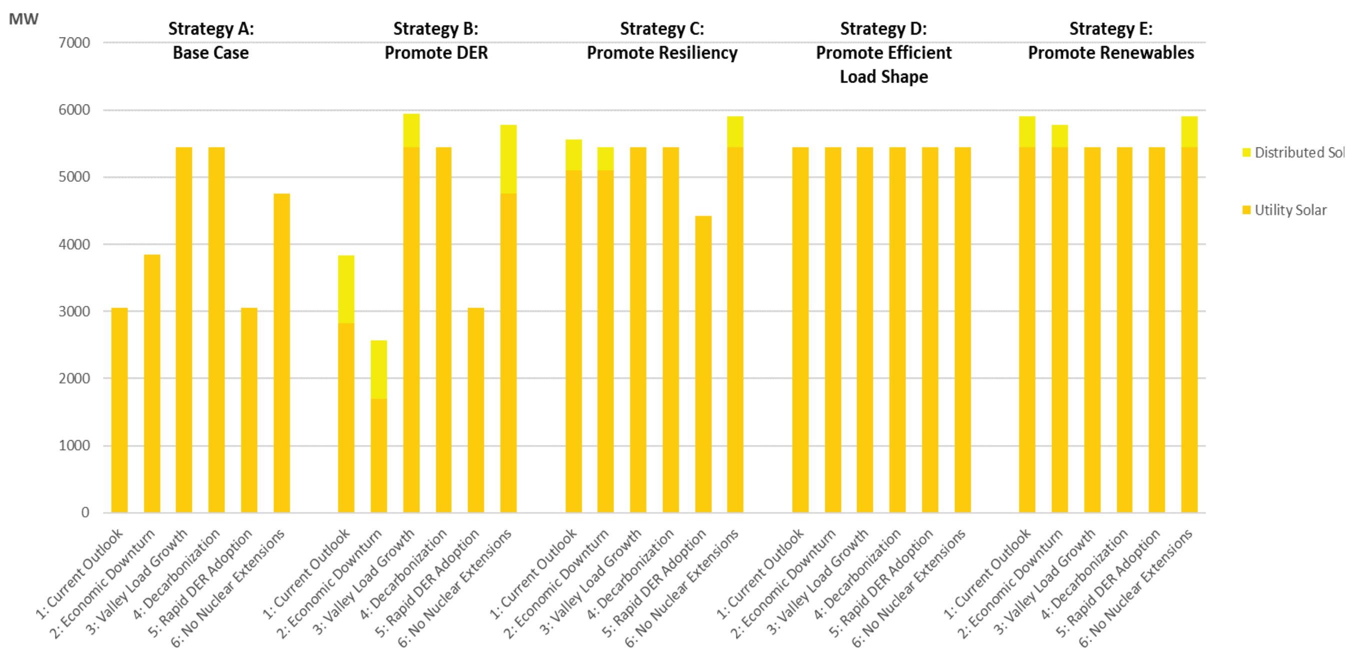

Figure 3-5: Solar capacity additions, in nameplate capacity, through 2038 in the portfolios associated with each alternative strategy.

3.4 Strategy B: Promote DER

Strategy B focuses on increasing the pace of DER adoption by incentivizing distributed solar and storage, combined heat and power, energy efficiency and demand response. Programs targeting low income customers is included in the EE promotion. Under Strategy B, the retirement of TVA generating facilities described in Section 3.2.3 can also occur. Figure 3-2 shows the capacity resources added by 2038 in Strategy B across the six scenarios. The results from this strategy are very similar to Strategy A with a few notable differences. Distributed solar is promoted in this strategy and generally replaces a portion of lower cost utility solar. Distributed storage is also promoted, replacing a portion of demand response but at a higher cost. Finally, combined heating and power is promoted, contributing to additional coal retirements in some cases.

Figure 3-4 shows how the energy portfolios for Strategy B play out driven by the capacity changes and other factors in the scenarios. Including hydro, renewables account for 21 percent of total generation on average. Strategy B results in 61 percent carbon-free generation in 2038 on average, similar to Strategy A.

3.5 Strategy C: Promote Resiliency

Strategy C promotes higher adoption of small, agile capacity to increase the operational flexibility of TVA's power system, while also improving the ability to respond locally to short-term disruptions. Under Strategy C, the retirement of TVA generating facilities described in Section 3.2.3 can also occur.

Figure 3-3 presents the total capacity portfolios in 2038 for Strategy C. The nuclear and hydro portfolios are the same as in Strategy A. Additional coal is retired in this strategy with the promotion of more flexible or locally resilient resources. In cases where more coal is retired, solar capacity increases at both utility and distributed scales. Storage additions are promoted, resulting in somewhat lower gas capacity additions on average.

Energy efficiency and demand response volumes remain similar across the scenarios in this strategy.

Figure 3-4 shows the resulting energy portfolios for Strategy C driven by the capacity changes and other factors in the scenarios. Including hydro, renewables account for 22 percent of total generation on average. Strategy C results in 63 percent carbon-free generation in 2038 on average compared to 61 percent in Strategy A.

3.6 Strategy D: Promote Efficient Load Shape

Strategy D promotes targeted electrification, demand response, and energy management to optimize load shape, including programs targeting low-income energy efficiency. Under Strategy D, the retirement of TVA generating facilities described in Section 3.2.3 can also occur. Figure 3-2 shows the capacity resources added by 2038 in Strategy D across the six scenarios. The nuclear and hydro portfolios are the same as in Strategy A. This strategy results in the highest amount of coal retirements on average. That capacity is replaced with a combination of solar, storage and gas additions, with a high penetration solar achieved in all cases. Storage is promoted to the greatest degree in this strategy, resulting in the highest storage capacity overall. The storage additions drive the lowest need for gas capacity, especially CT peaking units. The highest energy efficiency volumes are seen in this strategy, and demand response volumes are similar to Strategy A, as the promotion of storage meets peaking needs.

Figure 3-4 shows the corresponding energy portfolios for Strategy D driven by the capacity changes and other factors in the scenarios. Including hydro, renewables account for 22 percent of total generation on average. Strategy D results in 62 percent carbon-free generation in 2038 on average compared to 61 percent in the Base Case.

3.7 Strategy E: Promote Renewables

Strategy E promotes renewables at all scales to meet growing prospective or existing customer demands for renewable energy. Under Strategy E, the retirement of TVA generating facilities described in Section 3.2.3 can also occur.

Figure 3-3 presents the total capacity portfolios in 2038 for Strategy E. The nuclear and hydro portfolios are the same as in Strategy A. Strategy E cases have similar levels of additional coal retirements as in Strategy B. The highest levels of solar additions are seen in this strategy across all scenarios, averaging almost 6,000 MW SND capacity and 8,800 MW nameplate. Including hydro, renewables account for 20 percent of the capacity portfolio on average. Storage is also promoted, resulting in comparable levels of storage additions to Strategy C, and similarly reducing the need for gas capacity additions. Energy efficiency and demand response volumes remain similar across the scenarios in this strategy, also resembling Strategy C.

Figure 3-4 shows the corresponding energy portfolios for Strategy E driven by the capacity changes and other factors in the scenarios. Including hydro, renewables account for 23 percent of total generation on average. Strategy E results in 63 percent carbon-free generation in 2038 on average compared to 61 percent in the Base Case.

3.8 Comparison of Environmental Impacts of the Alternatives

The following section provides a summary of the environmental impacts of the alternatives. Detailed analysis of the anticipated environmental impacts is provided in Chapter 5. Emissions of air pollutants, the intensity of greenhouse gas emissions and generation of coal waste decrease under all strategies. Strategies focused on resiliency, load shape and renewables have the largest amounts of solar and storage expansion and coal retirements, resulting in lower environmental impact overall but higher land use. For most environmental resources, the impacts are greatest for Strategy A (the No Action alternative) except for the land area required for new generating facilities, which is greater for the action alternatives, particularly Strategies C, D, and E.

All alternative strategies will result in significant long-term reductions in emissions of sulfur dioxide (SO_2), nitrogen oxides (NO_x), and mercury. A large portion of these reductions, especially for SO_2 and mercury, result from the full or partial retirement of coal plants. The overall reductions in emissions under each strategy, averaged across the associated scenarios, show relatively little variation. Total and annual direct emissions of CO_2, as well as CO_2 emission rates, also referred to as CO_2 intensity, decrease under all alternative strategies. The variation among the strategies for both CO_2 emissions and emission rates is relatively small and much less than the variation among the scenarios associated with each strategy. All alternative strategies will result in the continued, significant, long-term reductions in CO_2 emissions from the generation of power marketed by TVA. The reduction in CO_2 emissions will have small but beneficial impacts on the potential for associated climate change.

The volume of water used by thermal generating facilities, (i.e., nuclear, coal, and CC facilities) decreases between 2019 and 2038 under all alternative strategies. The reductions in water consumption would have beneficial impacts; these impacts would generally be small and vary with the characteristics of the source area of the water withdrawal. The potential retirement of generating facilities, as described in Section 3.2.3, would result in minor, beneficial impacts to nearby rivers and waterways. The reductions in water use would result in localized beneficial impacts to aquatic ecosystems.

All alternative strategies will result in long-term reductions in the production of CCRs due to the retirement of coal plants/units. The quantity of CCR produced during the 2019-2038 planning period shows little variation between alternative strategies. It varies much more between the scenarios associated with each strategy and is greatest with Scenario 3 and lowest with Scenario 5. Potential retirement of coal and CT plants (Section 3.2.3) would primarily result in a decrease in solid and hazardous waste produced.

For all combinations of strategies and scenarios, at least 97 percent of the land required for new generating and storage facilities is for utility-scale, single-axis tracking solar facilities. Relative to other types of generation, solar PV facilities have a high land requirement in relation to their generating capacity. Smaller land areas would be occupied by new natural gas-fired and storage facilities.

Socioeconomic impacts, as quantified by the change to per capita income of TVA service area residents that is attributable to the cost of operating of the TVA power system, are minimal. The differences in annual per capita income and employment of residents of the TVA service area were compared to Strategy A for each scenario. The differences in per capita income are small; averaged across scenarios, there would be no change under Strategies B and E and small decreases under Strategies C and D. The potential retirement of generating facilities, as described in Section 3.2.3, would result in minor, adverse, direct and indirect socioeconomic impacts.

4 Affected Environment

4.1 Introduction

This chapter describes the natural and socioeconomic resources that could be affected by the alternative strategies and portfolios developed in the integrated resource planning process. These resources are generally described at a regional scale rather than a site-specific scale. Site-specific conditions are, however, described for some generating facilities that, depending on the plan selected for implementation, could be retired in whole or in part during the planning period.

The primary study area, hereinafter call the Tennessee Valley Authority (TVA) region, is the combined TVA PSA and the Tennessee River watershed (Figure 1-1), including all counties in Tennessee and portions of Alabama, Georgia, Kentucky, Mississippi, North Carolina, and Virginia. The TVA PSA is comprised of 202 counties and approximately 59 million acres. All but one of TVA's hydroelectric plants, as well as all of its nuclear plants, are located in the Tennessee River watershed. Its coal-fired plants are located in the Tennessee River watershed as well as along the Cumberland, Green, and Ohio rivers (Figure 1-1). Seven of the eight windfarms from which TVA purchases power (see Section 2.4) are outside the TVA region. TVA also purchases power from several U.S. Army Corps of Engineers' (USACE) hydroelectric plants in the Cumberland River drainage basin. Some of these plants are located in the TVA region, and the others are in southern Kentucky north of the TVA region.

For some resources such as air quality, climate change, and renewable energy resources, the assessment area extends beyond the TVA region. For most socioeconomic resources, the primary study area consists of the 180 counties where TVA is a major provider of electric power and Muhlenberg County, Kentucky, where the TVA Paradise coal and Combined Cycle (CC) plants are located. The economic model used to compare the effects of the alternative strategies on general economic conditions in the TVA region includes surrounding areas to address some of TVA's major fuel sourcing areas and inter-regional trade patterns.

4.2 Air Quality

4.2.1 Regulatory Framework for Air Quality

The Clean Air Act (CAA), as amended, is the comprehensive law that affects air quality by regulating emissions of air pollutants from stationary sources (such as power plants and factories) and mobile sources (such as automobiles). It requires U.S. Environmental Protection Agency (EPA) to establish National Ambient Air Quality Standards (NAAQS) for specific air pollutants and directs the states to develop State Implementation Plans to achieve these standards. This is primarily accomplished through permitting programs that establish limits for emissions of air pollutants from various sources. The CAA also requires EPA to set standards for emissions of hazardous air pollutants.

4.2.2 Criteria Air Pollutants

EPA has established NAAQS for the six criteria air pollutants: carbon monoxide (CO), /l, nitrogen dioxide (NO_2), ozone, particulate matter (PM), and sulfur dioxide (SO_2). TVA's entire PSA, with the exception of a small SO_2 nonattainment area in part of Sullivan County, Tennessee, is currently designated as attainment, attainment/unclassifiable, or unclassifiable with respect to all NAAQS. There are currently no other NAAQS nonattainment areas within the TVA PSA.

An unclassifiable status or attainment/unclassifiable status means that an area has insufficient air quality monitoring data to make a firm determination of attainment. However, the unclassifiable or attainment/unclassifiable status areas are treated as in attainment with NAAQS, for the purposes of CAA planning and permitting requirements.

In general, for all of the six criteria pollutants regulated under the NAAQS, air quality nationwide has been improving for several decades. This has been due in large part to compliance with CAA-related regulations developed by the EPA and state/local agencies that have dramatically reduced pollutant emissions from stationary and mobile sources. The reductions in emissions of air pollutants have come about as a result of the development and use of emission control technologies that prevent pollutants from forming during combustion or other processes, technologies that remove the pollutants from the exhaust streams after the pollutants have formed, and the switch to cleaner fuels. A summary of improvements in air quality nationally is provided in Table 4-1, which shows the percent improvement for each NAAQS-regulated pollutant from the start of each decade since 1980 through 2017. For some of the listed pollutants, there are multiple standards based on different sampling time intervals. The standards for PM also address two different sizes of particles, one for particles less than 10 microns in size (PM_{10}), and one for particles less than 2.5 microns in size ($PM_{2.5}$). The major criteria pollutants emitted by power plants are nitrogen oxides (NO_x including NO_2) and SO_2. Ozone is not directly emitted by any source; it is formed by a chemical reaction between NO_x and volatile organic compounds (VOCs) in the presence of sunlight. VOCs are produced by both man-made and natural sources; in the Southeast, most VOCs are from natural sources and power plants are not significant emitters of VOCs.

Improvement in air quality has been realized in TVA's service region as well, as many counties in this region were previously designated as nonattainment for one or more NAAQS, and in recent decades have come into attainment.

The improvement in air quality and attainment of NAAQS in the region is even more remarkable considering that several of the NAAQS have been made substantially more stringent in the past two decades. The improvements in air quality in TVA's service region is representative of what has happened nationally.

Regional emissions trends for the TVA PSA are approximated for this assessment by using statewide Tennessee emissions. TVA serves nearly all of Tennessee, and portions of several adjacent states, so the emissions trends for Tennessee are used here as a surrogate for regional emissions trends in the TVA service region. Figure 4-1 shows the trend lines of Tennessee pollutant emissions from 1990 through 2017, based on data obtained from EPA's National Emissions Inventory web site at https://www.epa.gov/air-emissions-inventories/air-pollutant-emissions-trends-data (USEPA 2018b).

Table 4-1: Percent change in ambient concentrations of air pollutants in the United States, 1980-2017.

Air Pollutant	1980 to 2017	1990 to 2017	2000 to 2017	2010 to 2017
Carbon Monoxide	-84	-77	-61	-13
Lead	-99	-98	-94	-80
Nitrogen Dioxide (annual)	-63	-56	-49	-21
Nitrogen Dioxide (1-hour)	-60	-50	-35	-14
Ozone (8-hour)	-32	-22	-17	-5
PM_{10} (24-hour)	---	-34	-30	0
$PM_{2.5}$ (annual)	---	---	-41	-18
$PM_{2.5}$ (24-hour)	---	---	-40	-10
Sulfur Dioxide (1-hour)	-90	-88	-79	-66

Source: USEPA 2018a (https://www.epa.gov/air-trends/air-quality-national-summary)

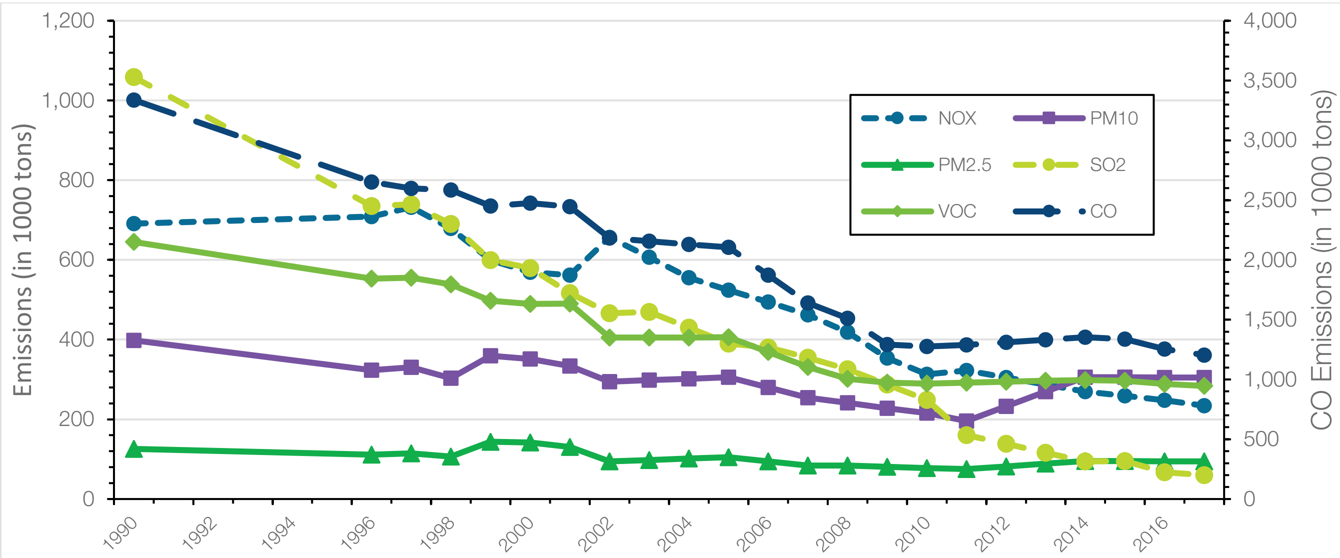

Figure 4-1: Trends in emissions of air pollutants in Tennessee, 1990-2017. Source: USEPA 2018c.

The data in Figure 4-1 represent, for each pollutant, the sum of emissions from all stationary and mobile source sectors, including wildfires and prescribed fires for those years where fires were inventoried. As shown in this chart, there is a significant downward trend for all pollutants in the region, especially for pollutants of concern emitted from stationary combustion sources such as SO_2 and NO_x.

TVA's emissions reductions are responsible for the majority of the statewide Tennessee stationary source SO_2 and NO_x emission reductions since 1990. The utility sector SO_2 emissions in Tennessee, the vast majority of which were from TVA, decreased from 817,612 tons in 1990 to 24,293 tons in 2017, a decrease of over 97 percent.

Utility sector NO_x emissions in Tennessee (most also due to TVA) increased from 240,359 tons in 1990 to 283,464 tons in 1997, before decreasing for the next two decades to 15,517 tons in 2017, a decrease of nearly 95 percent from the 1997 peak.

4.2.3 TVA Emissions

4.2.3.1 TVA System-Wide Emissions

The trends in TVA's reported SO_2, NO_x, and mercury emissions from 1990 through 2017 (TVA 2018a, TVA 2018b) are shown in Figure 4-2. These data represent emissions from TVA's facilities across its entire PSA.

4.2.3.2 Emissions from Facilities Considered for Retirement

Several TVA facilities have units that are being considered for retirement in the next decade. Table 4-2 lists those units and the emissions by plant for the potential retirement units over the past three years (2015-2017). Two scenarios are shown for the Shawnee Fossil Plant, one for retirement of just Units 1 and 4, and one for retirement of all units except for Units 1 and 4. Table 4-2 shows the annual emissions by plant in tons, and emission rates in units of pounds per megawatt-hour (lb/MWh).

The coal-fired units/plants have significantly higher emission rates than the Combustion Turbine (CT) units due to the higher concentrations of pollutant-forming compounds in coal. The relatively higher mercury emissions from the Allen CTs are because that plant burned mostly oil during the 3-year period from 2015 to 2017, whereas the other CT plants burned mostly natural gas.

Table 4-2: Three-Year (2015-2017) average emissions of units considered for future retirement.

Facility and Units	Generation (MWh)	SO_2 (3-yr average)		NOx (3-yr average)		Mercury (3-yr average)	
	3-year avg.	Tons/yr	lbs/MW-hr	Tons/yr	lbs/MW-hr	lbs/yr	lbs/GW-hr
Coal Units							
Shawnee 1, 4	1,461,122	4,841	6.63	2,213	3.03	14.73	1.01E-02
Shawnee 2, 3, 5-9	5,556,417	18,027	6.49	7,865	2.83	46.73	8.41E-03
Kingston 1-9	5,126,243	1,974	0.77	1,759	0.69	33.03	6.44E-03
Gallatin 1-4	5,308,503	4,942	1.86	5,837	2.20	66.16	1.25E-02
Cumberland 1-2	13,380,397	8,541	1.28	4,472	0.67	49.44	3.69E-03
Combustion Turbine Units							
Allen 1-16	3,388	0.018	0.01	12	6.81	0.03	9.54E-03
Allen 17-20	1,774	0.008	0.01	6	6.70	0.01	7.08E-03
Gallatin 1-4	35,406	0.155	0.01	122	6.91	0.01	2.35E-04
Colbert 1-8	9,449	0.040	0.01	29	6.09	0.01	6.20E-04
Johnsonville 1-16	42,237	0.156	0.01	117	5.53	0.04	9.74E-04
Total w/ Shawnee 1, 4 Retired	25,368,520	20,299	1.60	14,566	1.15	163	6.44E-03
Total w/all except Shawnee 1, 4	**29,463,815**	**33,484**	**2.27**	**20,218**	**1.37**	**195**	**6.63E-03**

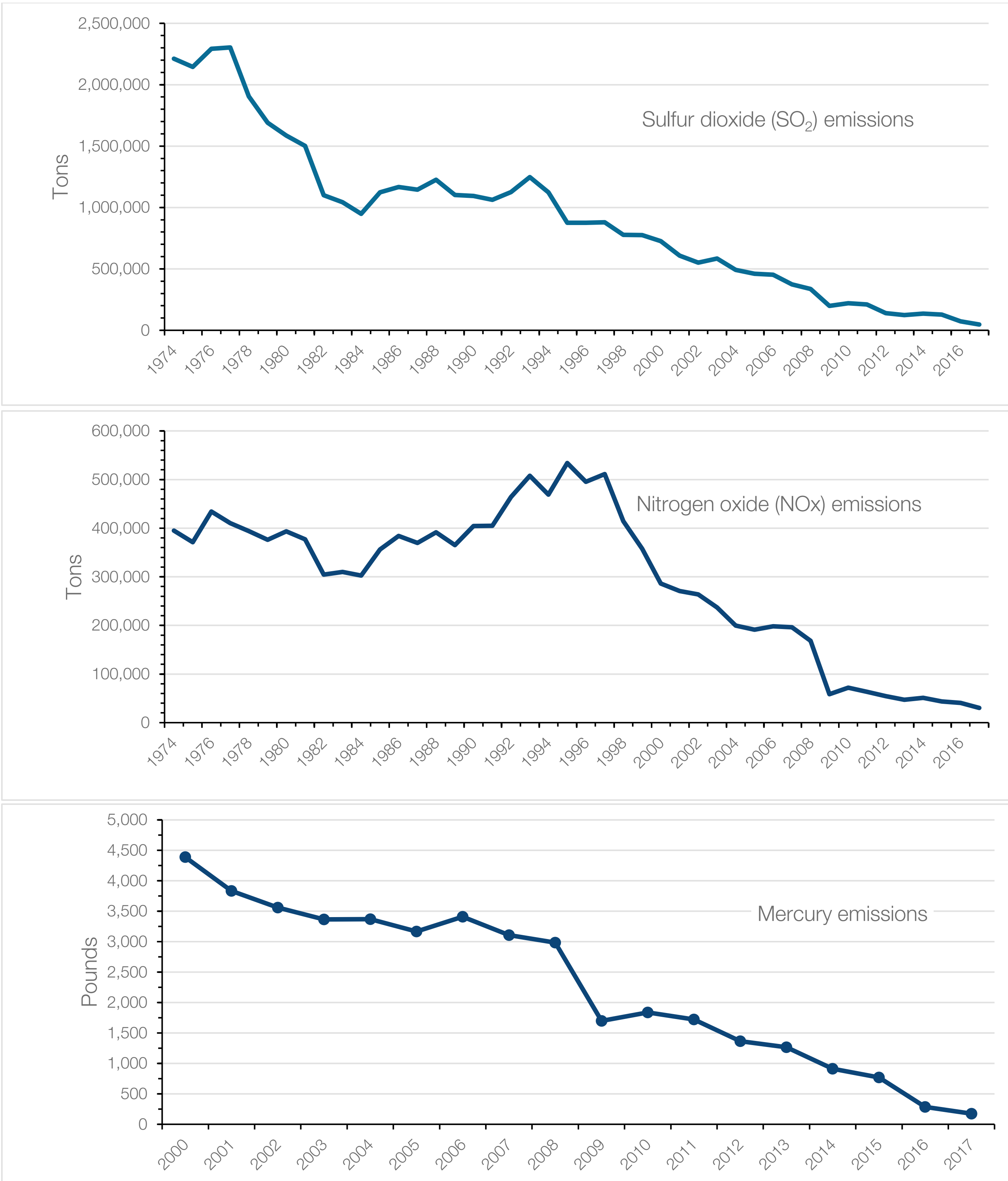

Figure 4-2: TVA emission trends for sulfur dioxide (SO2), 1974-2017 (top), nitrogen oxides (NO_x), 1974-2017 (middle), and mercury, 2000-2017 (bottom). Sources: TVA 2015b, 2018a, 2018b

4.2.4 Hazardous Air Pollutants

Hazardous Air Pollutants (HAPs) are toxic air pollutants, which are known or suspected to cause cancer or other serious health effects or adverse environmental effects. The CAA identifies 187 pollutants as HAPs. Most HAPs are emitted by human activity, including motor vehicles, factories, refineries and power plants. There are also indoor sources of HAPs such as building materials and cleaning solvents. Some HAPs are emitted by natural sources, such as volcanic eruptions and forest fires. Exposure to HAPs can result from breathing air toxics, drinking water in which HAPs have deposited, or eating food exposed to HAPs deposition on soil or water. Exposure to high levels of HAPs can cause various chronic and acute harmful health effects, including cancer. The level of exposure which may result in adverse health impacts varies for each pollutant.

Emissions of HAPs including organic compounds, acid gases, and heavy metals have also been generally decreasing in recent decades along with the SO_2 and NO_x emissions, as coal use has decreased, and as coal and gas-fired electric generating units are fitted with better emissions controls.

4.2.5 Mercury

One HAP that has been singled out for a focused effort at emission reduction with respect to fossil-fueled facilities is mercury. Mercury is emitted to the air by human activities, such as burning coal or manufacturing, and from natural sources, such as volcanoes. Once it is in the environment, mercury cycles between air, water and soils, being re-emitted and re-deposited.

Once mercury is deposited in streams and lakes, it can be converted to methyl-mercury, the most toxic form of mercury, through microbial activity. Methyl-mercury accumulates in fish at levels that may cause harm to the fish and the animals that eat them. Some wildlife species with high exposures to methyl-mercury have shown increased mortality, reduced fertility, slower growth and development, and abnormal behavior that affects survival (USEPA 1997). Studies have also shown impaired neurological development in fetuses, infants and children with high exposures to methyl-mercury. In June 2014, EPA and the Food and Drug Administration issued an updated draft fish consumption advisory recommending that pregnant and breastfeeding women, those who may become pregnant, and young children avoid some marine fish and limit consumption of others. TVA region states have also issued advisories on fish consumption due to mercury for several rivers and reservoirs across the TVA region (see Section 4.4.2).

Global emissions of mercury were estimated at approximately 6,500 tons/year in 2010 (UNEP 2013). As of 2011, EPA estimated US mercury emissions at 52 tons/year (EPA 2011), or 0.8 percent of the 2010 global total estimate.

In 2011, EPA finalized the Mercury and Air Toxics Standards (MATS) rule to reduce mercury and other toxic air pollution from coal and oil-fired power plants. EPA estimated this rule would prevent about 90 percent of the mercury in coal burned in power plants from being emitted to the air. EPA also estimated the rule would result in a 5 percent reduction in U.S. nationwide mercury deposition from 2005 levels. This small overall reduction is largely due to the fact that mercury emissions tend to be deposited globally, rather than locally, with most of the deposition occurring in precipitation. In the technical support document for the 2011 MATS rule, EPA estimated that with partial MATS and other emission control rule implementation, the contribution by US electric generating units (EGUs) to total US mercury deposition would drop from 5 percent in 2011 to 2 percent in 2016 (EPA 2011).

Deposition occurs in two forms: wet (dissolved in rain, snow or fog) and dry (solid and gaseous particles deposited on surfaces during periods without precipitation). Wet mercury deposition is measured at Mercury Deposition Network monitors operated by the National Atmospheric Deposition Program. The highest wet deposition of mercury in the U.S. occurs in Florida and along the Gulf Coast, as shown in Figure 4-3. Mercury deposition in the TVA region ranges from nine to 15 micrograms per square meter, in the medium-high range for North America.

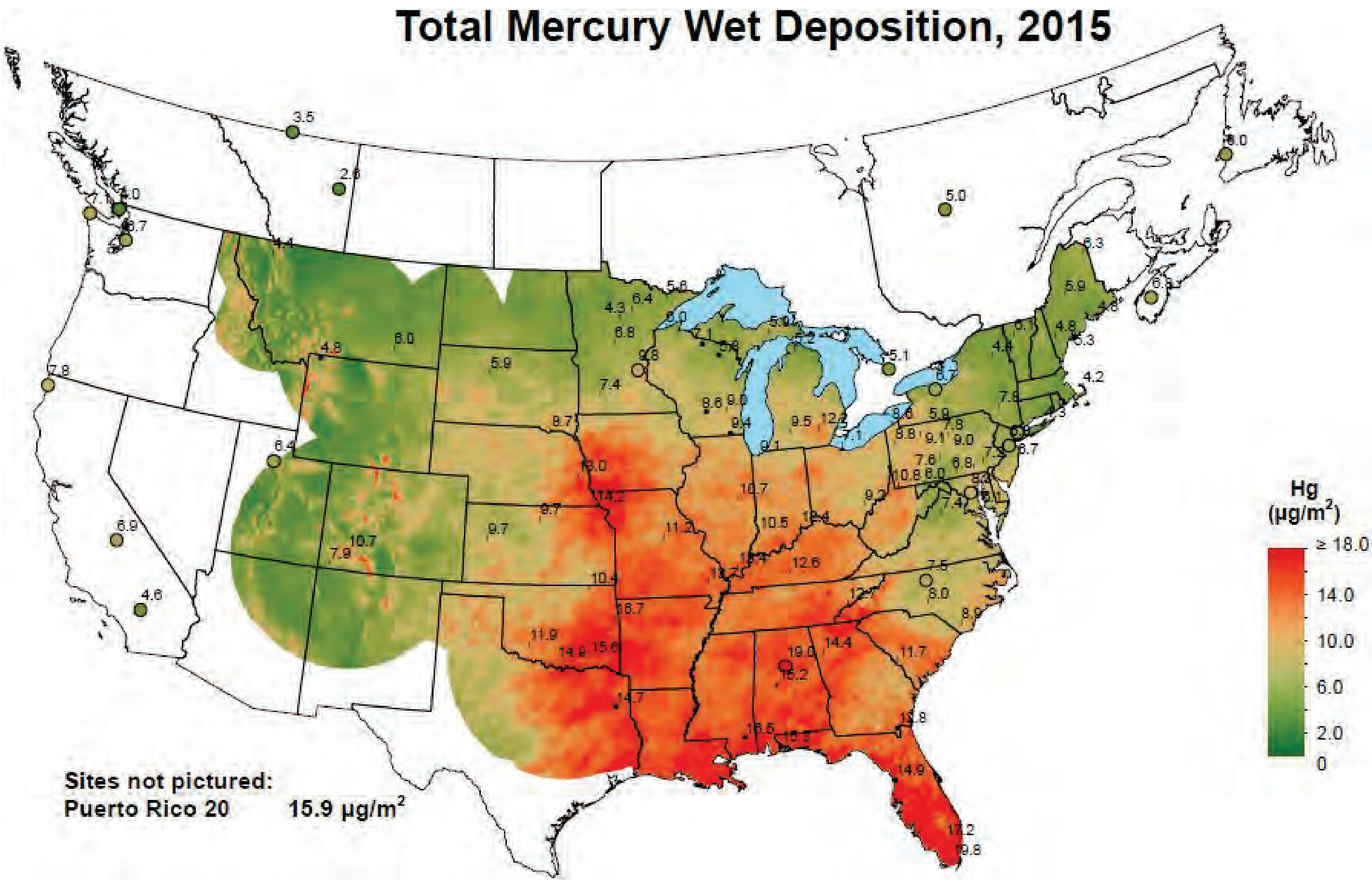

Figure 4-3: Total wet mercury deposition in the United States in 2015. Source: NADP 2018.

TVA mercury emissions have decreased 96 percent from 4,388 pounds in 2000 to 175 pounds in 2017 (Figure 4-2). Much of this reduction has resulted from the retirement of coal-fired units and the installation and operation of flue gas desulphurization (FGD) and selective catalytic reduction (SCR) systems on most of the remaining coal units. TVA has also taken specific measures to reduce mercury emissions in response to MATS, including the installation of activated carbon injection systems on some units and the retirement and replacement of Paradise Fossil Plant Units 1 and 2 with natural-gas fueled generation.

4.2.6 Visibility

Air pollution can impact visibility, which is a particularly important issue in national parks and wilderness areas where millions of visitors expect to be able to enjoy scenic views. Historically, "visibility" has been defined as the greatest distance at which an observer can see a black object viewed against the horizon sky. However, visibility is more than just a measurement of how far an object can be seen; it is a measurement of the conditions that allow appreciation of the inherent beauty of landscape features.

Visibility in the eastern United States is estimated to have declined by as much as 60 percent in the second half of the 20th Century (USEPA 2001). Visibility impairment is caused when sunlight is scattered or absorbed by fine particles of air pollution obscuring the view. Some haze-causing particles are emitted directly to the air, while others are formed when gases are transformed into particles. In the TVA region, the largest contributor to visibility impairment is ammonium sulfate particles formed from SO_2 emissions (primarily from coal-fired power plants). Other particles impacting visibility include nitrates (from motor vehicles, utilities, and industry), organic carbon (predominantly from motor vehicles), elemental carbon (from diesel exhaust and wood burning) and dust (from roads, construction, and agricultural activities). Visibility extinction is a measure of the ability of particles to scatter and absorb light and is expressed in units of inverse mega-meters (Mm^{-1}). Another metric used to measure visibility impairment is the deciview (dV), which is calculated from the atmospheric light extinction coefficient (b_{ext}) expressed in inverse megameters (Mm−1):

$$\text{Deciview index (dV)} = 10 \ln (b_{ext}/10\ Mm^{-1}).$$

The deciview unit is used to establish thresholds under visibility rules in 40 CFR 51, Appendix Y, as a basis for determining whether modeled visibility impacts from a source are great enough to warrant Best Available Retrofit Technology (BART) retrofits. Substantial progress toward attaining natural visibility conditions nationwide has been made since the issuance of the BART requirements in 2005. Some of the improvement has been due to BART implementation, and much improvement has also resulted from other regulatory programs to reduce stationary source and mobile source emissions.

The CAA designated national parks greater than 6,000 acres and wilderness areas greater than 5,000 acres as Class I areas in order to protect their air quality under more stringent regulations. There are eight Class I areas in the vicinity of the TVA region: Great Smoky Mountains National Park, Mammoth Cave National Park and the Joyce Kilmer, Shining Rock, Linville Gorge, Cohutta, Sipsey, and Upper Buffalo Wilderness Areas (Figure 4-4). The Great Smoky Mountains National Park is the largest Class I area in the TVA region.

Chapter 4: Affected Environment

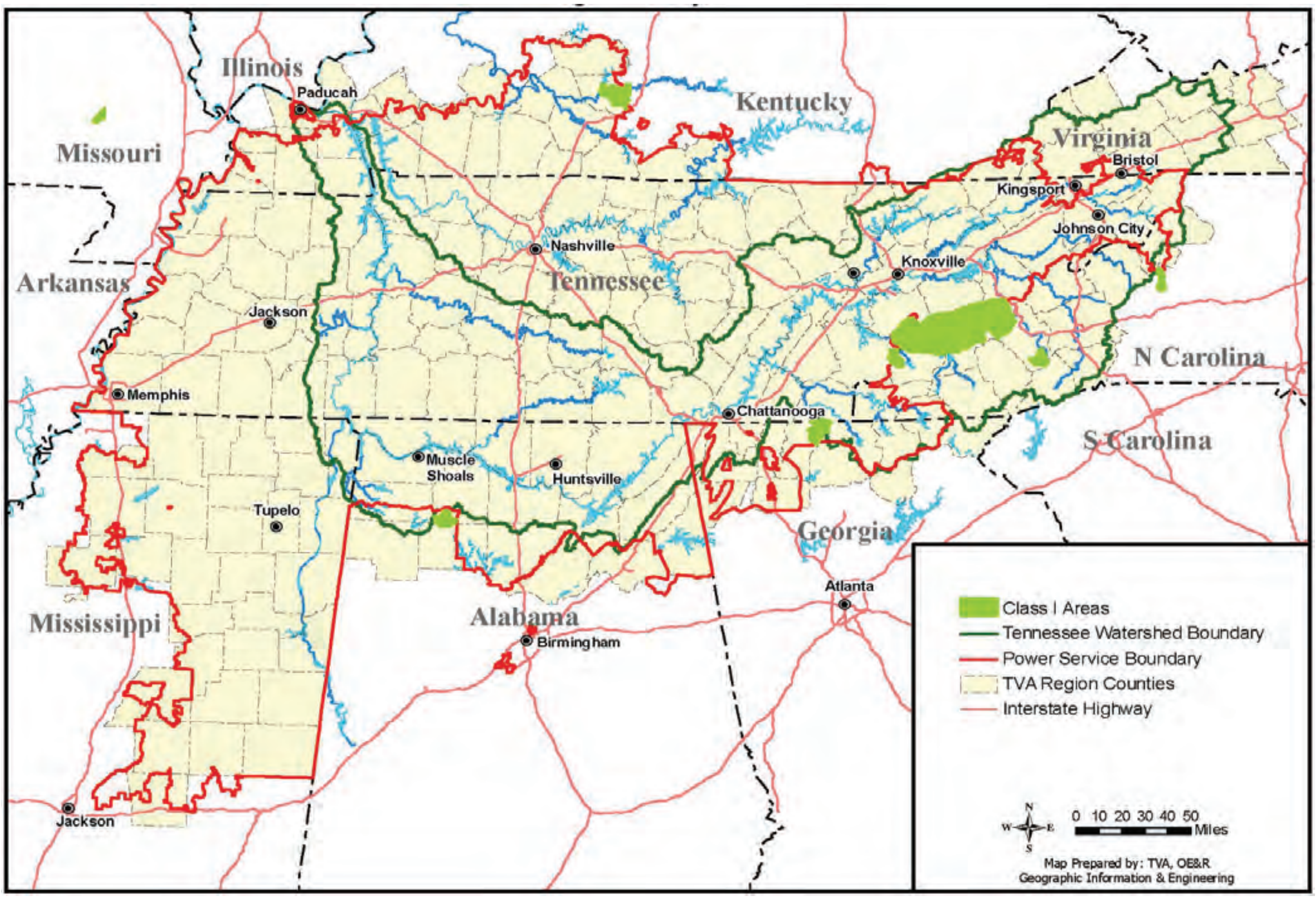

Figure 4-4: The TVA service area and Class I Areas.

In 1999, EPA promulgated the Regional Haze Rule to improve visibility in Class I areas. This regulation requires states to develop long-term strategies to improve visibility with the ultimate goal of restoring natural background visibility conditions by 2064. Visibility trends are evaluated using the average of the 20 percent worst days and the 20 percent best days with the goal of improving conditions on the 20 percent worst days, while preserving visibility on the 20 percent best days.

The trend in visibility improvement measured at Great Smoky Mountains National Park is shown in Figure 4-5, which shows the visibility improvement in deciviews on average for the worst 20 percent of days and the best 20 percent of days. From 1990 to 2016, there was a 47 percent improvement in the visibility on the worst days and a 44 percent improvement on the best days. For a comparison with natural conditions (no human emissions impacts), the Federal Land Manager Environmental Database lists the natural conditions at the Great Smoky Mountains as 11.2 dV on the haziest days and 4.6 dV on the clearest days.

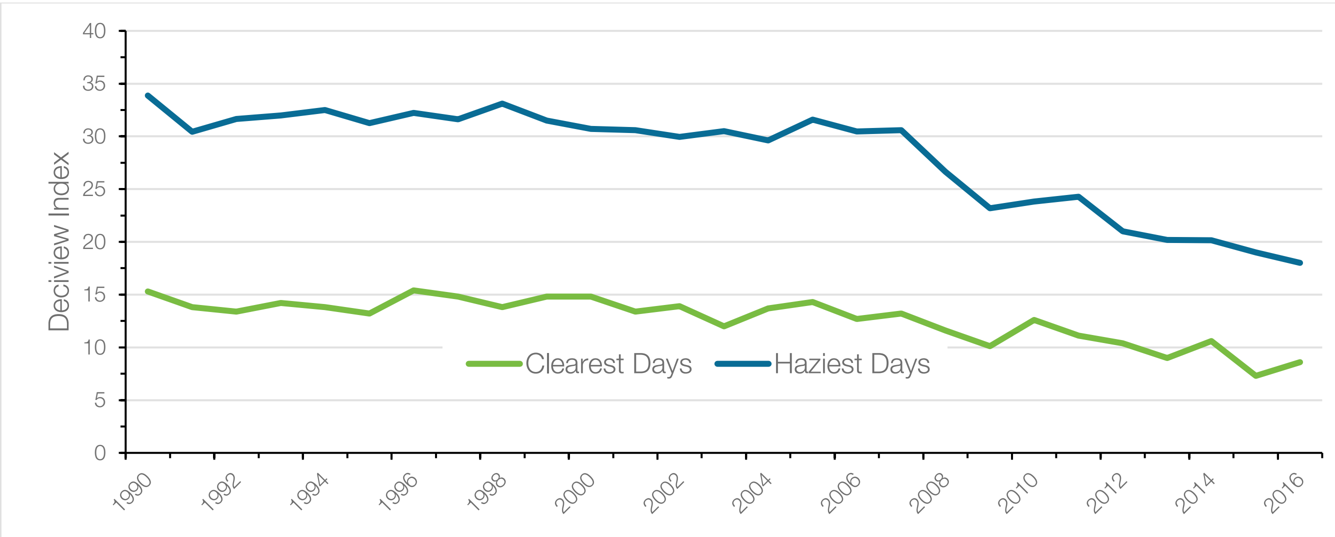

Figure 4-5: Change in visibility in the Great Smoky Mountains National Park on the worst 20 percent of days and the best 20 percent of days, 1990-2016. Smaller deciview values indicate better visibility. Source: FLMED 2018.

4.2.7 Acid Deposition

Acid deposition, also called acid rain, is primarily caused by SO_2 and NO_x emissions which are transformed into sulfate (SO_4) and nitrate (NO_3) aerosols, then deposited in precipitation (rain, snow, or fog). Acid deposition causes acidification of lakes and streams in sensitive ecosystems, which can adversely impact aquatic life. Acid deposition can also reduce agricultural and forest productivity. Some ecosystems, such as high elevation spruce-fir forests in the southern Appalachians, are quite sensitive to acidification, while other ecosystems with more buffering capacity are less sensitive to the effects of acid deposition. The acidity of precipitation is typically expressed on a logarithm scale called pH which ranges from zero to 14 with seven being neutral. pH values less than seven are considered acidic and values greater than seven are considered basic or alkaline. It is thought that the average pH of pre-industrial rainfall in the eastern United States was approximately 5.0 (Charlson and Rodhe 1982).

Based on the data reflected in Figure 4-1, together with TVA emissions data for Tennessee, as of 2017, the TVA SO2 and NOx emission represented 40 percent and less than 7 percent, respectively, of statewide total emissions of these pollutants. As stated above, TVA's SO_2 emissions in Tennessee have decreased by 97 percent since 1990 and its NO_x emissions in the state have decreased by 95 percent from their peak level in 1997. Emissions from utilities across the eastern US have also decrease significantly, and emissions from mobile sources have started a substantial downward trend as well in the past decade or more.

The 1990 CAA Amendments established the Acid Rain Program to reduce SO_2 and NO_x emissions and the resulting acid deposition. Since this program was implemented in 1995, reductions in SO_2 and NO_x emissions have contributed to significant reductions in acid deposition, concentrations of $PM_{2.5}$ and ground-level ozone, and regional haze. Other regulatory programs aimed at industrial emitters and vehicle engines (onroad and nonroad) are also driving down emissions.

Figure 4-6 and Figure 4-7 illustrate the dramatic decreases in total sulfate deposition between 2000 and 2016 (most recent data available) across the US (NADP 2018). Similar reductions in nitrate deposition have also occurred over the 2006 to 2016 period. Even by the year 2000, deposition of sulfate and nitrate was decreasing across the US, as pollution control retrofits were already in place for many large utility sources.

However, the decreases since that time have been even more dramatic. The values in Figure 4-6 and Figure 4-7 are based on a hybrid approach of combining monitoring and modeling to develop the plots.

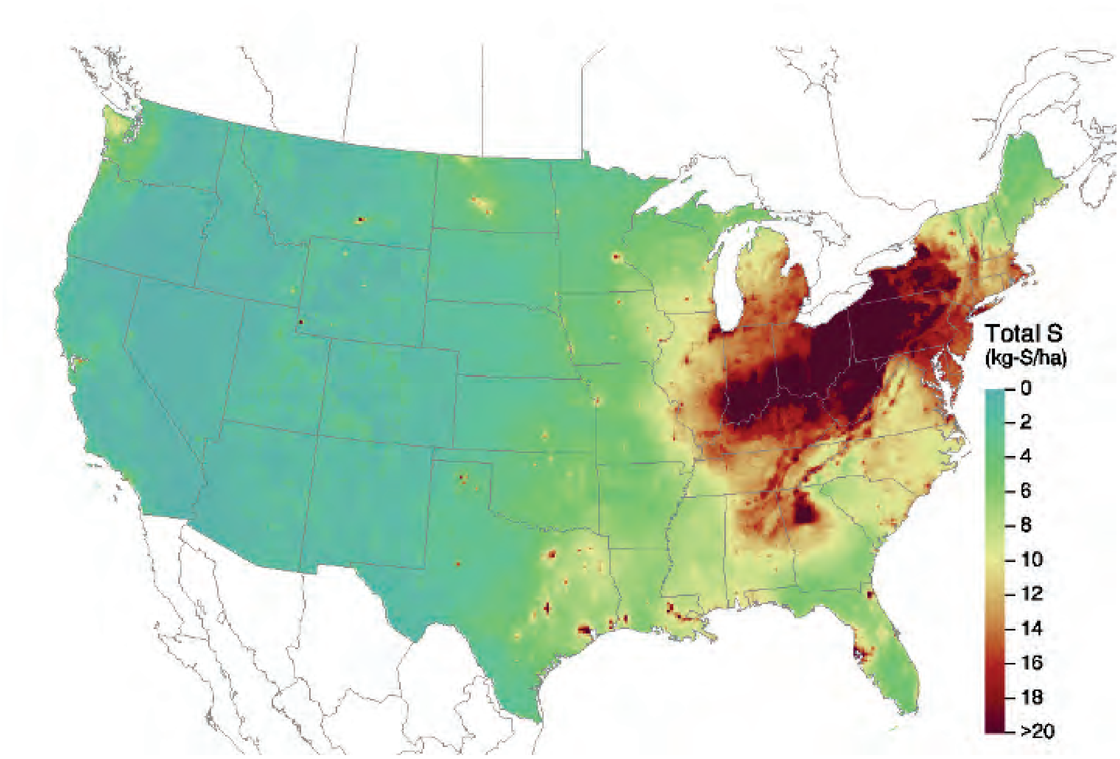

Figure 4-6: Year 2000 total sulfate deposition. USEPA 08/28/18. Source: CASTNET/CMAQ/NADP.

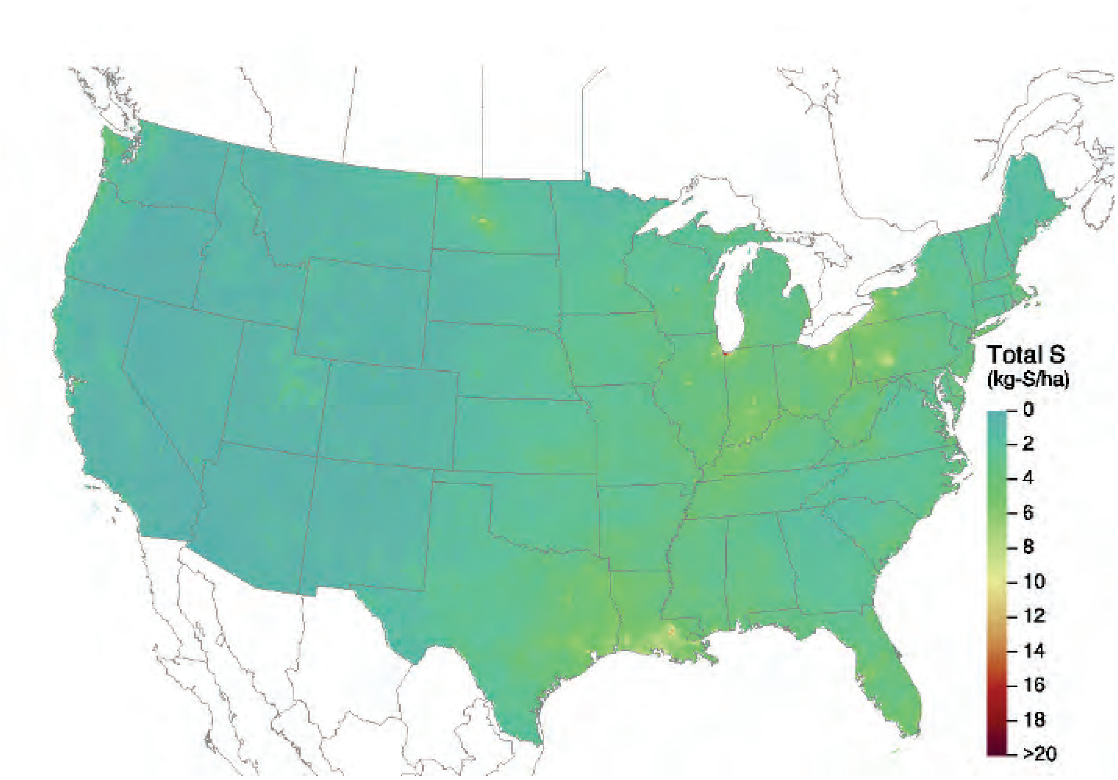

Figure 4-7: Year 2016 total sulfate deposition. USEPA 03/06/18. Source: CASTNET/CMAQ/NADP.

4.3 Climate and Greenhouse Gases

The TVA region spans the transition between a humid continental climate to the north and a humid subtropical climate to the south. This provides the region with generally mild temperatures (i.e., a limited number of days with temperature extremes), ample rainfall for agricultural and water resources, vegetation-killing freezes from mid-autumn through early spring, occasional severe thunderstorms, infrequent snow and infrequent impacts—primarily in the form of heavy rainfall—from tropical storms. The seasonal climate variation induces a dual-peak in annual power demand, one for winter heating and a second for summer cooling. Rainfall does not fall evenly throughout the year, but tends to peak in late winter/early spring and again in mid-summer. Winds over the region are generally strongest during winter and early spring and lightest in late summer and early autumn. Solar radiation (insolation) varies seasonally with the maximum sun elevation above the horizon and longest length in summer. However, insolation is moderated by frequent periods of cloud cover typical of a humid climate.

The remainder of this section describes the current climate and recent climate trends of the TVA region in more detail. It describes emissions of greenhouse gases (GHGs), widely considered to be a major source of climate change (NAS and RS 2014). It also describes projected changes in climate during this century, based on the Fourth National Climate Assessment (4th NCA, USGCRP 2017) and related sources. Identifying recent trends in regional climate parameters such as temperature and precipitation is a complex problem because year-to-year variation may be larger than the multi-decadal change in a climate variable. Climate is frequently described in terms of the climate "normal," the 30-year average for a climate parameter (NCEI 2011). The climate normals described below are for the most recent period of record, 1981–2010. Earlier and more recent data are also presented where available. The primary sources of these data are National Weather Service (NWS) records and records from the rain gauge network maintained by TVA in support of its reservoir operations. NWS records, unless stated otherwise, are from Memphis, Nashville, Chattanooga, Knoxville, and the Tri-Cities area in Tennessee and Huntsville, Alabama.

4.3.1 1981–2010 Climate Normals and Trends

Temperature – Observed average monthly temperatures for the TVA region during 1981–2010 ranged from 39.1°F in January to 79.3°F in July (Table 4-3). These data show considerable year-to-year variability with an overall warming trend of 0.4–0.5°F (0.2–0.3°C) per decade for 1981–2010. This is greater than the global average trend reported by the U.S. Climate Change Science Program (Lanzante et al. 2006), which shows an increase in global surface temperature of about 0.16°C per decade between 1979 and 2004. Longer term temperature data for Tennessee (assumed to be representative of the TVA region) are illustrated in Figures 4-8, 4-9, and 4-10. Both annual average temperature and annual average winter temperature showed very small increases (0.24°F/100 years and 0.67°F/100 years, respectively) since the 1890s. The annual average summer temperature showed a small, long-term decrease of 0.09°F/100 years.

Table 4-3: Monthly, seasonal and annual temperature averages for six NWS stations in the TVA region for 1981–2010. Source: NCEI 2011.

	Jan	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ºF	39.1	59.7	68.1	76.0	79.3	78.6	71.9	60.8	50.5	41.5
ºC	3.9	15.4	20.1	24.4	26.3	25.9	22.1	16.0	10.3	5.3

	Winter	Spring	Summer	Fall	Annual
ºF	41.2	59.7	78.0	61.1	60.0
ºC	5.1	15.4	25.5	16.1	15.5

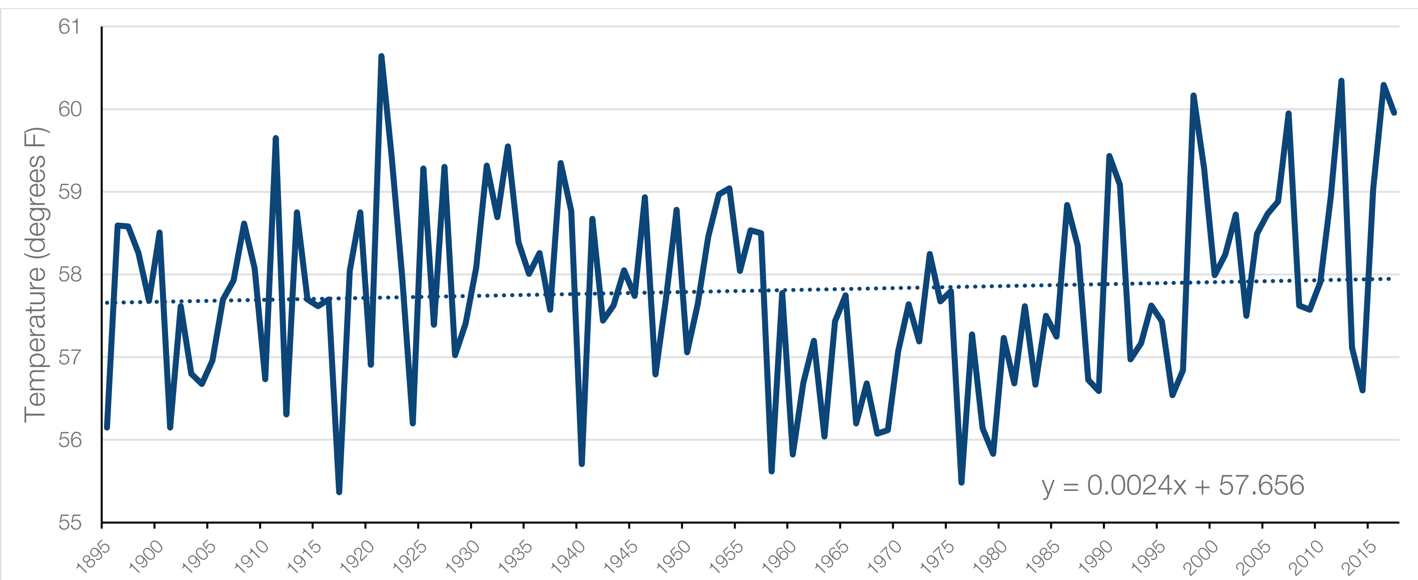

Figure 4-8: Annual average temperature (ºF) in Tennessee, 1895–2017. The dashed line is the trend based on least squares regression analysis. Source: WRCC 2018.

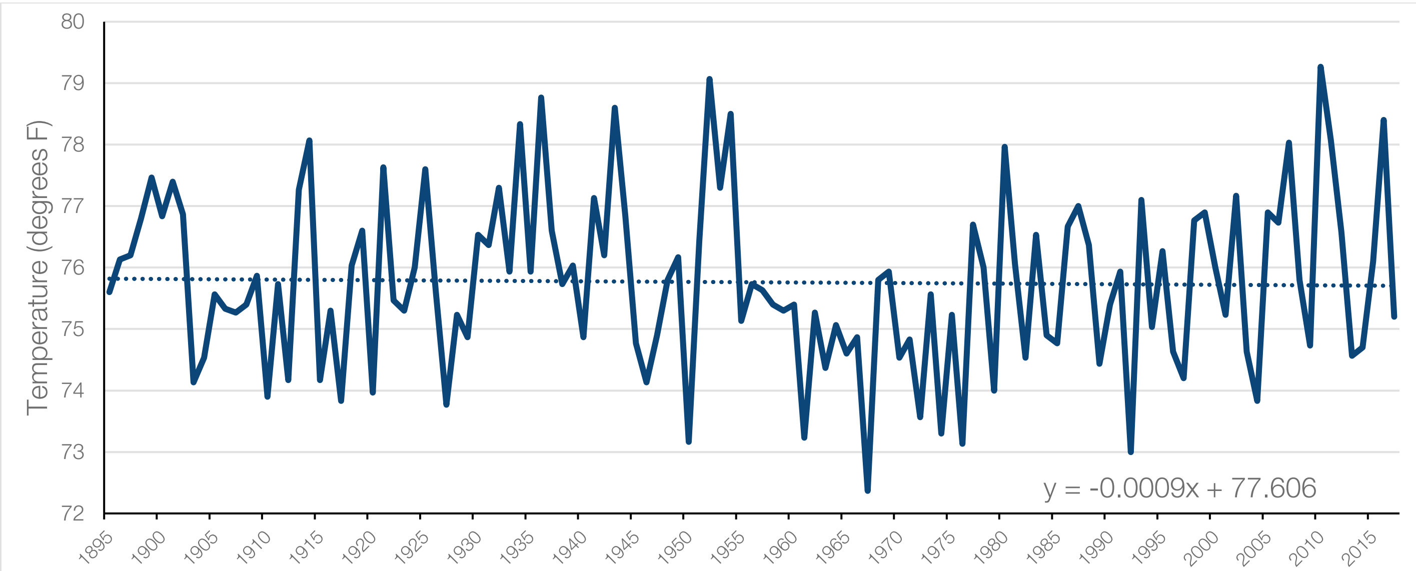

Figure 4-9: Annual average summer temperature (°F) in Tennessee, 1895–2017. The dashed line is the trend based on least squares regression analysis. Source: WRCC 2018.

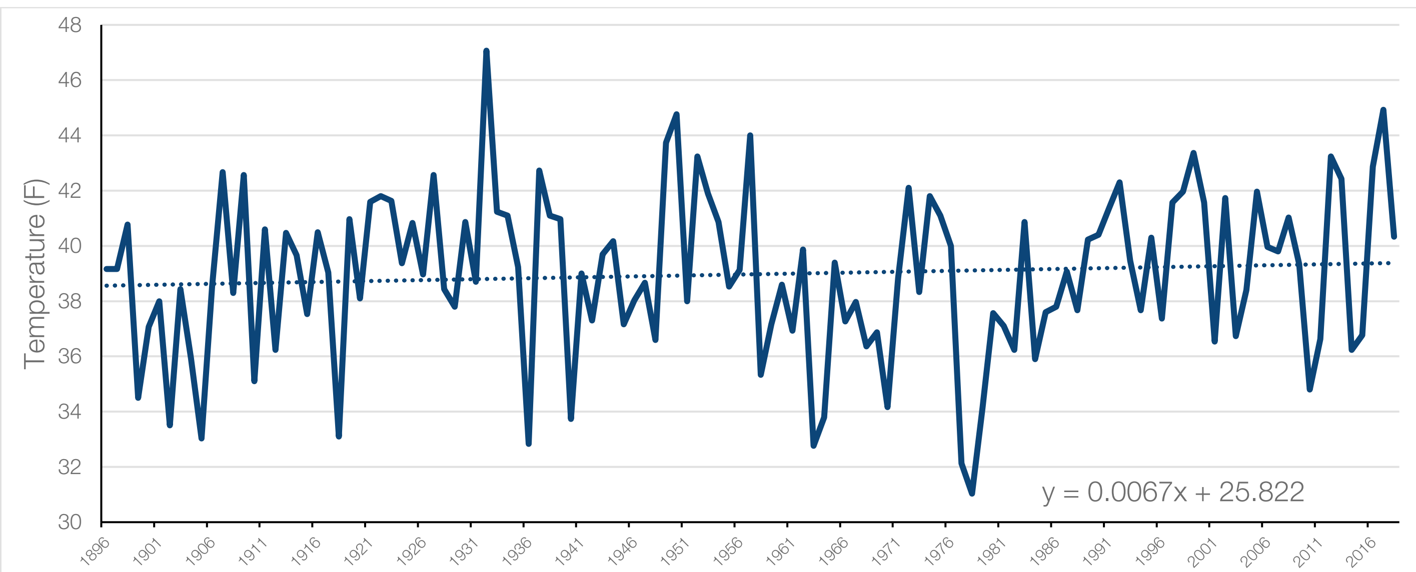

Figure 4-10: Annual average winter temperature (°F) in Tennessee, 1896–2018. The dashed line is the trend based on least squares regression analysis. Source: WRCC 2018.

Precipitation – The observed average annual precipitation in the Tennessee River watershed during 1981–2010 was 49.92 inches; monthly averages range from 2.86 inches in October to 4.73 inches in December (Table 4-4). There is significant year-to-year variability in precipitation with no discernable trend during the 30-year period. The wettest locations in the TVA region occur in southwestern North Carolina and the driest locations are in northeast Tennessee (SERCC 2018). The annual average of snowfall across most of the TVA region ranges from five to 25 inches, except in the higher elevations of the southern Appalachians in North Carolina and Tennessee. These locations can receive up to 100 inches of snowfall (Walsh et al. 2014a).

Table 4-4: Monthly, seasonal, and annual precipitation averages in the Tennessee River watershed for 1981-2010. Source: TVA rain gage network data.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Inches	4.22	4.23	4.26	3.79	4.23	3.64	3.89	3.23	3.42	2.86	4.01	4.73
Centimeters	10.7	10.8	10.8	9.6	10.8	9.2	9.9	8.2	8.7	7.3	10.2	12.0

	Winter	Spring	Summer	Fall	Annual
Inches	13.18	12.28	10.76	10.29	46.51
Centimeters	33.5	31.2	27.3	26.1	118.1

Figure 4-11 shows Tennessee annual total precipitation for the period 1895 through 2017. These data show that over this period of record, the average annual precipitation has increased at an average rate of around 8 percent per 100 years, as is apparent from the linear regression equation provided on this chart. The increase in average annual precipitation occurred prior to 1970 and there has been no significant trend for the last 50 years.

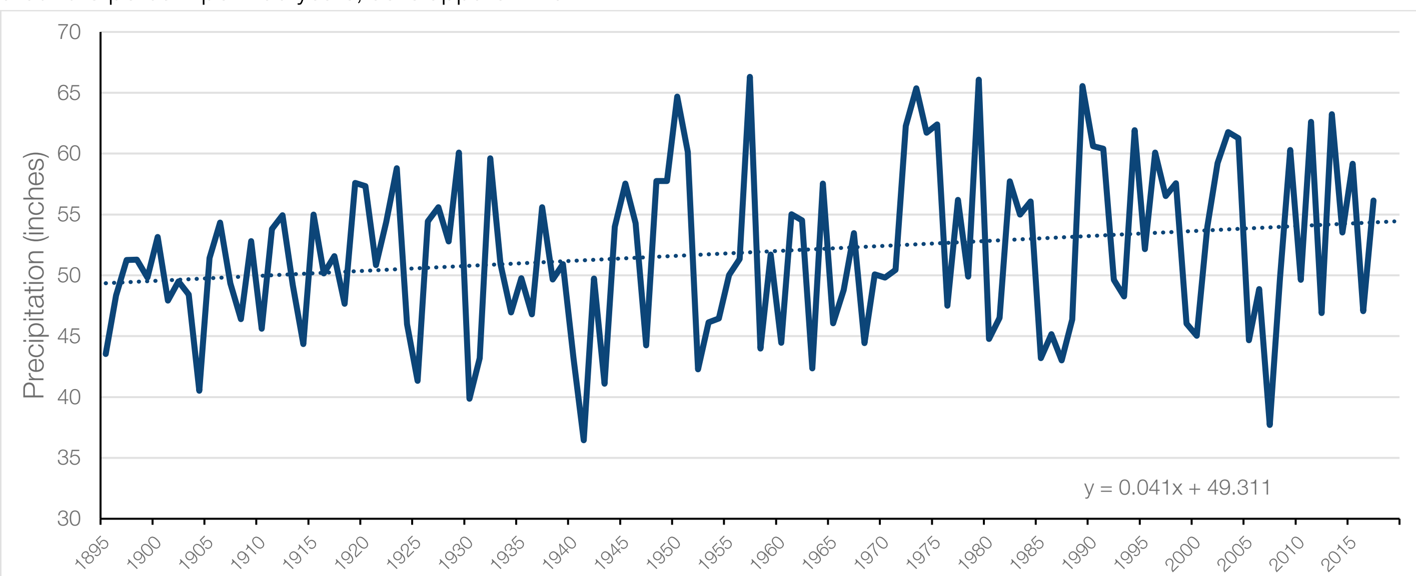

Figure 4-11: Annual average precipitation in Tennessee, 1895-2017. The dashed line is the trend based on least squares regression analysis.

4.3.2 Greenhouse Gas Emissions

The sun is the primary source of energy for the Earth's climate. About 30 percent of the sun's energy that reaches Earth is reflected back to space by clouds, gases and small particles in the atmosphere. The remainder is absorbed by the atmosphere and the surface. Earth's temperature depends on the balance between the energy entering and leaving the planet's system. When energy is absorbed by the Earth's system, global temperatures increase. Conversely, when the sun's energy is reflected back into space, global temperatures decrease (Walsh et al. 2014b).

In nature, carbon dioxide (CO_2) is exchanged continually between the atmosphere, plants and animals through processes of photosynthesis, respiration and decomposition, and between the atmosphere and oceans through gas exchange. Billions of tons of carbon in the form of CO_2 are annually absorbed by oceans and living biomass (i.e., sinks) and are annually emitted to the atmosphere through natural and man-made processes (i.e., sources). When in equilibrium, carbon fluxes among these various global reservoirs are roughly balanced (Galloway et al. 2014).

Similar to the glass in a greenhouse, certain gases, primarily CO_2, nitrous oxide (N_2O), methane (CH_4), hydroflurocarbons (HFCs), perflourocarbons (PFCs) and sulfur hexafluoride (SF_6), absorb heat that is radiated from the surface of the Earth. Increases in the atmospheric concentrations of these gases cause the Earth to warm by trapping more heat. The common term for this phenomenon is the "greenhouse effect," and these gases are typically referred to as GHGs. Atmospheric levels of CO_2 are currently increasing at a rate of 0.5 percent per year and between 1900 and 2017 increased from less than 300 parts per million (ppm) to 405 ppm (NOAA 2018), higher than the Earth has experienced in over a million years (Walsh et al. 2014b).

While water vapor is the most abundant GHG in the atmosphere, it is not included in the above list of GHGs because changes in the atmospheric concentration of water vapor are generally considered to be the result of climate feedbacks related to the warming of the atmosphere, rather than a direct result of human activity. That said, the impact of water vapor is critically important to projecting future climate change. Quantifying the effect of feedback loops on global and regional climate is the subject of ongoing data collection and active research (Walsh et al. 2014b).

The magnitude of the warming induced by the greenhouse effect depends largely on the amount of GHG accumulating in the atmosphere (Walsh et al. 2014a). GHGs can remain in the atmosphere for different amounts of time, ranging from a few years to thousands of years (NAS and RS 2014). GHGs are assigned global warming potentials, a measure of the relative amount of infrared radiation they absorb, their absorbing wavelengths and their persistence in the atmosphere. All of these gases remain in the atmosphere long enough to become well mixed, meaning the amount that is measured in the atmosphere is roughly the same all over the world, regardless of the source of the emissions.

The primary GHG emitted by electric utilities is CO_2 produced by the combustion of fossil fuels. CO_2 is also produced by the combustion of biomass fuels, although these fuels when derived from plant (i.e., vegetation) sources are often considered to be carbon-neutral since the subsequent plant regrowth sequesters carbon. Small amounts of SF_6, which has a very high global warming potential relative to other GHGs (Global Warming Potential for SF_6 = 22,800 times CO_2 on a pound-for-pound basis, per 40 CFR 98), are released due to its use in high-voltage circuit breakers, switchgears, and other electrical equipment. CH_4, which has a global warming potential of 25 times that of CO_2 (per 40 CFR 98), is emitted during coal mining and from natural gas wells and delivery systems.

Nationwide anthropogenic emissions of GHGs are estimated by EPA annually, for each of several sectors of the economy. The 2016 estimates by sector are shown in the chart in Figure 4-12 and represent the most recent data available. Transportation and electricity generation each represented approximately 28 percent of nationwide GHG emissions in 2016, with industrial sources, commercial and residential buildings, and agriculture each representing successively smaller portions of the total.

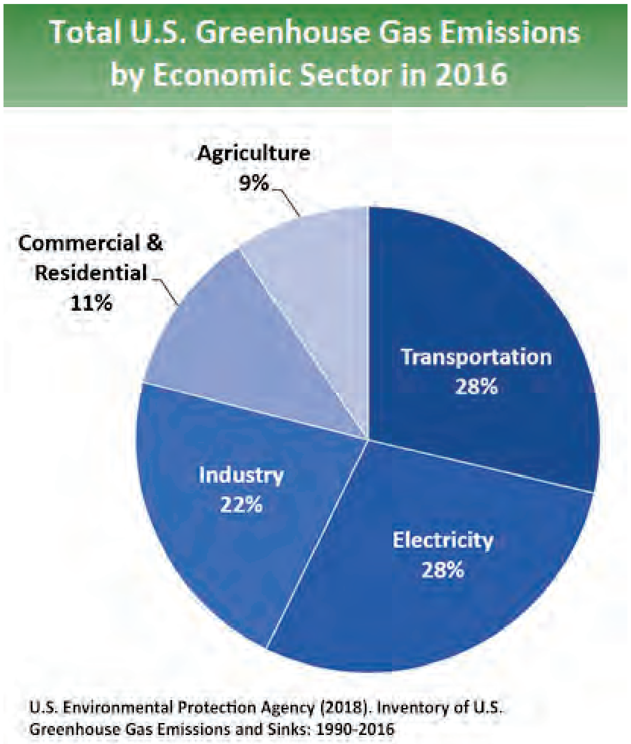

Figure 4-12: US 2016 GHG emissions by sector.

4.3.2.1 TVA System-Wide Emissions

CO_2 emissions from the TVA power system have decreased by 51 percent since 1995 (Figure 4-13). This decrease is mainly due to the retirement of coal plants, which emit large quantities of CO_2 relative to other types of electrical generation, and the replacement of coal generation with nuclear and natural gas-fueled generation. Nuclear generation does not emit CO_2 and CO_2 emissions from natural gas-fueled generation are about half that of coal.

Figure 4-13 also shows the trend in TVA system-wide emission rate on a pounds per megawatt-hour (lb/MWh) basis. This value has decreased as more coal units have shut down, replaced by lower-emitting natural gas-fired units and by renewables. The lb/MWh rates included purchased and owned generation. TVA's system rate is not appropriate for individual customer carbon disclosure as TVA allocates actual CO_2 emissions to customers in the same manner as it allocates costs. As a service, TVA provides as-delivered CO_2 emission rates to its customers and stakeholders in a manner consistent with generally accepted carbon accounting standards, such as the Climate Registry's Electric Power Sector Protocol for the Voluntary Reporting Program and the new World Resources Institute and World Business Council for Sustainable Development's Greenhouse Gas Protocol's Scope 2 Guidance. For formal disclosure of customer CO_2 rates appropriate for carbon accounting purposes, one should contact TVA or your local power company directly.

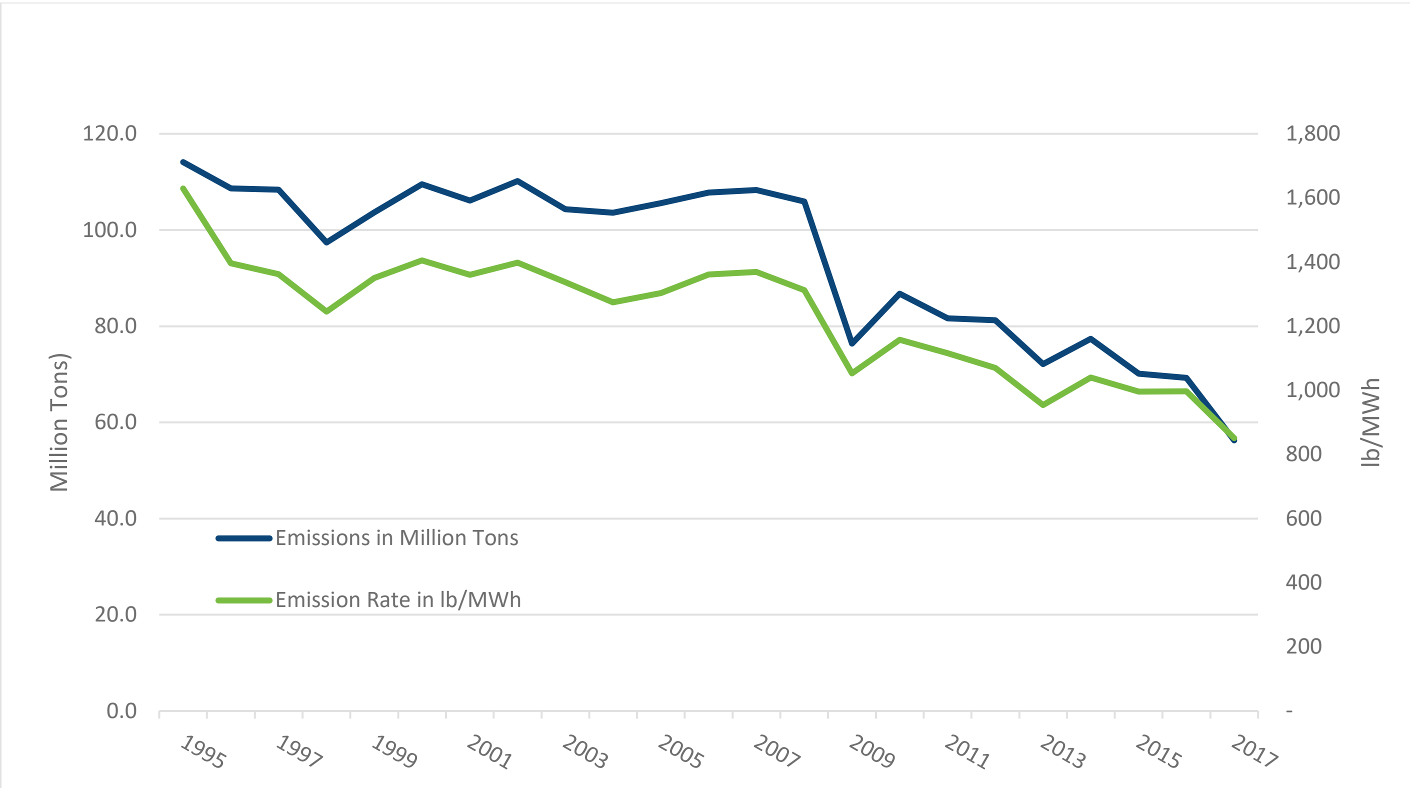

Figure 4-13: 1995-2017 CO_2 emissions (million tons) and emission rate (lb/MWh) from generation of power marketed by TVA. Source: TVA 2018c.

4.3.2.2 Emissions from Facilities Considered for Retirement

Table 4-5 shows the 2015-2017 three-year average CO_2-equivalent emissions (CO_2-eq) reported (from TVA's annual emissions reports) for the facilities being considered for potential retirement. These are the same facilities listed in Table 4-2 for SO_2, NO_x, and mercury.

Table 4-5: Three-Year (2015-2017) average CO_2-eq emissions of units considered for future retirement.

Facility and Units	Gen. (MWh)	CO2-eq (3-yr average)	CO2-eq (3-yr average)
	3-year avg.	Tons/yr	lbs/MW-hr
Coal Units			
Shawnee 1, 4	1,461,122	1,693,176	2318
Shawnee 2, 3, 5-9	5,556,417	6,298,424	2267
Kingston 1-9	5,126,243	5,636,184	2199
Gallatin 1-4	5,308,503	5,819,979	2193
Cumberland 1-2	13,380,397	12,943,973	1935
Combustion Turbine Units			
Allen 1-16	3,388	3,304	1950
Allen 17-20	1,774	1,566	1766
Gallatin 1-4	35,406	29,547	1669
Colbert 1-8	9,449	8,375	1773
Johnsonville 1-16	42,237	33,917	1606
Total w/ Shawnee 1, 4 Retired	25,368,520	26,170,021	2063
Total w/all except Shawnee 1, 4	29,463,815	30,775,270	2089

4.3.3 Forecast Climate Trends

The modeled projections of temperature and precipitation cited here are from the Fourth National Climate Assessment (4th NCA) published by the U.S. Global Change Research Program (USGCRP 2017). This publication cites climate change projections for various emissions scenarios, which result in "representative concentration pathways" (RCPs) that each relate to a given amount of radiative forcing in the year 2100. For example, an RCP2.6 scenario means that emissions would increase at a rate sufficient to create 2.6 watts/m^2 of radiative forcing in 2100.

For the southeast U.S., the 4th NCA projects that temperatures will rise under all emissions scenarios presented, including a "very low" scenario where emissions peak soon and begin to decrease globally (RCP2.6). Under a low emissions increase scenario (RCP4.5) that includes a modest rise in global GHG emissions that peaks in about 20 years and then declines steeply, the 4th NCA projects that average annual temperatures in the Southeast U.S. will be 3.4°F higher than recent climate normals by mid-century with temperatures 4.4°F higher by late century. The report, however, notes that Southeast temperatures have not increased in the last century, contrary to climate model projections of what should have happened with the increase in atmospheric GHG concentrations that has already occurred.

For extreme high temperatures, under a high emissions scenario (RCP8.5, with GHG emissions continuing to increase at near their present rate of increase) the 4th NCA states that climate model predictions show large changes from the near present climate normals. For the coldest and warmest day of the year, the climate modeling predicts that the coldest day of the year will be on average nearly 5°F warmer and the warmest day of the year will be nearly 6°F warmer by mid-century in the Southeast. The 4th NCA concludes that extreme temperatures will increase by even more than average temperatures. This prediction also deviates from observed trends for hot days, which have decreased in the Southeast over the past century.

Climate models are generally not good at predicting precipitation variability and amounts across different geographic areas, or variability over time. One reason for this is their inability to simulate convective precipitation processes, given that these processes occur at scales smaller than the grid scales used to run global circulation climate models. However, the 4th NCA (see Figure 7.5 of that report) provides projections for changes in seasonal precipitation across North America for late this century, assuming the RCP8.5 high emissions scenario. For the Southeast, the modeled changes from current (1976-2005 average) precipitation conditions are generally within the range of natural variability, with the exception of a slightly greater amount of winter precipitation predicted for much of the TVA region.

4.3.4 Climate Adaptation

TVA has adopted a climate adaptation plan that establishes adaptation planning goals and describes the challenges and opportunities a challenging climate may present to its mission and operations (TVA 2016g). The goal of TVA's adaptation planning process is to ensure that the Agency continues to achieve its mission and program goals and to operate in a secure, effective and efficient manner in a changing climate.

TVA manages the effects of climate change on its mission, programs and operations within its environmental management processes. TVA's Environmental Policy (TVA 2008a) provides objectives for an integrated approach related to providing cleaner, reliable and affordable energy, supporting sustainable economic growth and engaging in proactive environmental stewardship. The policy includes the specific objective of stopping the growth in volume of emissions and reducing the rate of carbon emissions by 2020 by supporting a full slate of reliable, affordable, lower-CO_2 energy-supply opportunities and energy efficiency. TVA's Adaptation Plan (TVA 2016g) specifies that each TVA major planning process shall identify any significant climate change risks. Significant climate change risks are those with the potential to substantially impair, obstruct or prevent the success of agency mission activities, both in the near term and particularly in the long term, using the best available science and information.

4.4 Water Resources

This section describes water resources in the TVA region that could be affected by the alternative strategies. Potentially affected water resources include groundwater, surface water, water supply, and aquatic life.

4.4.1 Groundwater

4.4.1.1 Regulatory Framework for Groundwater

The Safe Drinking Water Act of 1974 established the sole source aquifer protection program which regulates certain activities in areas where the aquifer (water-bearing geologic formations) provides at least half of the drinking water consumed in the overlying area. This act also established both the Wellhead Protection Program, a pollution prevention and management program used to protect underground sources of drinking water, and the Underground Injection Control Program to protect underground sources of drinking water from contamination by fluids injected into wells. Several other environmental laws contain provisions aimed at protecting groundwater, including the Resource Conservation and Recovery Act (RCRA), the Comprehensive Environmental Response, Compensation, and Liability Act and the Federal Insecticide, Fungicide, and Rodenticide Act. On April 17, 2015, the USEPA published the Disposal of Coal Combustion Residuals from Electric Utilities final rule (CCR Rule) in the *Federal Register* to provide a comprehensive set of requirements for the safe disposal of CCRs from coal-fired power plants. The CCR Rule addresses the risks of coal ash contaminants migrating into groundwater.

4.4.1.2 TVA Region Aquifers

Three basic types of aquifers occur in the TVA region: unconsolidated sedimentary sand, carbonate rocks, and fractured non-carbonate rocks. Unconsolidated sedimentary sand formations, composed primarily of sand with lesser amounts of gravel, clay and silt, constitute some of the most productive aquifers. Groundwater movement in sand aquifers occurs through the pore spaces between sediment particles. Carbonate rocks are another important class of aquifers. Carbonate rocks, such as limestone and dolomite, contain a high percentage of carbonate minerals (e.g., calcite) in the rock matrix. Carbonate rocks in some parts of the region readily transmit groundwater through enlarged fractures and cavities created by dissolution of carbonate minerals by acidic groundwater. Fractured non-carbonate rocks represent the third type of aquifer found in the region. These aquifers include sedimentary and metamorphic rocks (e.g., sandstone, conglomerate, and granite gneiss) which transmit groundwater through fractures, joints, and beddings planes. Eight major aquifers occur in the TVA region (Table 4-6). These aquifers generally align with the major physiographic divisions of the region (Figure 4-18).

The aquifers include (in order of increasing geologic age): Quaternary age alluvium occupying the floodplains of major rivers, notably the Mississippi River; Tertiary and Cretaceous age sand aquifers of the Coastal Plain Province; Pennsylvanian sandstone units found mainly in the Cumberland Plateau section; carbonate rocks of Mississippian, Silurian and Devonian age of the Highland Rim section; Ordovician age carbonate rocks of the Nashville Basin section; Cambrian-Ordovician age carbonate rocks within the Valley and Ridge Province; and Cambrian-Precambrian metamorphic and igneous crystalline rocks of the Blue Ridge Province.

The largest withdrawals of groundwater for public water supply are from the Tertiary and Cretaceous sand aquifers in the Mississippi Alluvial Plain and Coastal Plain physiographic areas. These withdrawals account for about two-thirds of all groundwater withdrawals for public water supply in the TVA region. The Pennsylvanian sandstone and Orodovician carbonate aquifers have the lowest groundwater use (less than 1 percent of withdrawals) and lowest potential for groundwater use. Groundwater use is described in more detail in Section 4.4.3.

The quality of groundwater in the TVA region largely depends on the chemical composition of the aquifer in which the water occurs (Table 4-6). Precipitation entering the aquifer is generally low in dissolved solids and slightly acidic. As it seeps through the aquifer it reacts with the aquifer matrix and the concentration of dissolved solids increases.

Table 4-6: Aquifer, well, and water quality characteristics in the TVA region. Source: Webbers (2003).

Aquifer Description	Well Characteristics (common range, maximum)		Water Quality Characteristics
	Depth (feet)	Yield (gpm*)	
Quaternary alluvium: Sand, gravel, and clay. Unconfined.	10–75, 100	20–50, 1,500	High iron concentrations in some areas.
Tertiary sand: Multi-aquifer unit of sand, clay, silt and some gravel and lignite. Confined; unconfined in the outcrop area.	100–1,300, 1,500	200–1,000, 2,000	Problems with high iron concentrations in some places
Cretaceous sand: Multi-aquifer unit of interbedded sand, marl and gravel. Confined; unconfined in the outcrop area.	100–1,500, 2,500	50–500, 1,000	High iron concentrations in some areas

Aquifer Description	Well Characteristics (common range, maximum)		Water Quality Characteristics
Pennsylvanian sandstone: Multi-aquifer unit, primarily sandstone and conglomerate, interbedded shale and some coal. Unconfined near land surface; confined at depth.	100–200, 250	5–50, 200	High iron concentrations are a problem; high dissolved solids, sulfide or sulfate are problems in some areas
Mississippian carbonate rock: Multi-aquifer unit of limestone, dolomite, and some shale. Water occurs in solution and bedding-plane openings. Unconfined or partly confined near land surface; may be confined at depth.	50–200, 250	5–50, 400	Generally hard; high iron, sulfide, or sulfate concentrations are a problem in some areas
Ordovician carbonate rock: Multi-aquifer unit of limestone, dolomite, and shale. Partly confined to unconfined near land surface; confined at depth.	50–150, 200	5–20, 300	Generally hard; some high sulfide or sulfate concentrations in places
Cambrian-Ordovician carbonate rock: Highly faulted multi-aquifer unit of limestone, dolomite, sandstone, and shale; structurally complex. Unconfined; confined at depth.	100–300, 400	5–200, 2,000	Generally hard, brine below 3,000 feet
Cambrian-Precambrian crystalline rock: Multi-aquifer unit of dolomite, granite gneiss, phyllite, and metasedimentary rocks overlain by thick regolith. High yields occur in dolomite or deep colluvium and alluvium. Generally unconfined.	50–150, 200	5–50, 1,000	Low pH and high iron concentrations may be problems in some areas

*gpm = gallons per minute
Source: TVA 2015b

4.4.1.3 Causes of Degraded Groundwater Quality

Causes of degraded groundwater quality include:

- Spills - Electrical generating plants and other industrial facilities often utilize chemicals, including fuels, in their processes or to operate machinery. If accidental spills of these chemicals occur during usage, storage, or transport, vertical migration of the chemicals into the underlying groundwater aquifer may occur.
- Waste Storage – Over time, many electrical generating stations stored waste byproducts (e.g., CCRs) either in landfills or in surface impoundments. Rainfall infiltration into and through dry stacked waste can migrate vertically downward over time, carrying contaminants into groundwater, particularly in unlined landfills or surface impoundments. Storage of waste in unlined landfills and surface impondments may result in direct contact between the waste material and groundwater, whereby contaminants can leach from the waste material into groundwater over time.
- Air pollution – Airborne pollutants (e.g., mercury, sulfates) can affect groundwater through rainfall and infiltration.

4.4.1.4 Groundwater Quality at Facilities Considered for Future Retirement

Several TVA facilities have units that are being considered for retirement in the next decade. The following sections provide an overview of the groundwater conditions at each of these facilities.

Cumberland Fossil Plant

Cumberland Fossil Plant (herein, Cumberland) is located on the southern side of the Cumberland River and is bordered by Wells Creek to the south and west. It is located within the Wells Creek Impact Structure of the Highland Rim Physiographic Province, which is underlain by a sequence of sedimentary bedrock that extends from Mississippi and Northern Alabama through Tennessee, northward into Kentucky, Indiana, and Illinois. The formations that underlie this province consist of dolostone, limestone, shale, and sandstone. Aquifers near Cumberland are described as the bedrock carbonate aquifer and the alluvial aquifer associated with the Wells Creek Embayment and the Cumberland River. It is thought that groundwater recharge occurs primarily along the elevated perimeter of the basin where a portion of rainfall percolates into the near-surface rock outcrops and overburden soils. Groundwater flows downgradient by forces of gravity through the pore spaces of soils and along any fractures, faults, or joints in the bedrock (Law Engineering 1992). The results of groundwater monitoring at Cumberland indicate that groundwater occurs in the unconsolidated alluvial aquifer and the bedrock aquifer beneath the site.

In accordance with Rule 0400-11-.04(7) and the current Groundwater Quality Assessment Plan approved by TDEC on November 9, 2018, TVA conducted the most recent groundwater sampling event at Cumberland between October 3 and 10, 2018. The October 2018 groundwater assessment monitoring results indicated an exceedance of the arsenic maximum contaminant level (MCL) in one monitoring well at the site; this concentration was consistent with historical levels. A newly established federally listed alternate regulatory limit was also exceeded for lithium in one monitoring well; however, this limit has not yet been adopted by TDEC. Over 13 consecutive sampling events from July 2013 to July 2016, no MCL exceedances were observed for target analytes. Since October 2016, only arsenic has been detected at concentrations that exceed the MCL. Note that trends for several groundwater constituents demonstrated stable or decreasing concentrations. In addition to the exceedances of regulatory criteria, statistical exceedances of upper prediction limits (UPLs) established from background sampling were observed for barium, cobalt, fluoride, nickel, vanadium, and zinc. TVA currently conducts quarterly monitoring, but will monitor in accordance with TDEC and EPA CCR Rule requirements, which may change that frequency.

In accordance with the CCR Rule, TVA established groundwater monitoring well networks to evaluate potential impacts to groundwater from four CCR units: Dry Ash Stack, Gypsum Storage Area, Bottom Ash Pond, and Stilling Pond (including Retention Pond). The results of detection monitoring and comparison to background concentrations indicated that statistically significant increases (SSIs) of Appendix III constituents (boron, calcium, chloride, pH, sulfate, and TDS) above background were detected at the Bottom Ash Pond, Gypsum Storage Area, and Dry Ash Stack multi-unit CCR unit. As allowed under 40 CFR 257.94(e)(2), TVA performed an Alternate Source Demonstration (ASD) for the multi-unit CCR unit to evaluate if an alternate source was responsible for the SSIs. The ASD did not conclusively demonstrate an alternate source. Thus, TVA has established an Assessment Monitoring Program at the multi-unit CCR unit in accordance with 40 CFR 257.94(e)(2) and will continue to investigate groundwater quality under the requirements of the CCR Rule, potentially including an Assessment of Corrective Measures, and any required Corrective Action..

Gallatin Fossil Plant

Gallatin Fossil Plant (herein, Gallatin) is located on the northern side of Odoms Bend in the Cumberland River. It is located within the Interior Low Plateaus Physiographic Province, which is characterized by carbonate rock (karst) aquifers composed of limestone and minor dolostone, interlayered with shale and shaley limestone confining layers (TVA 2017e). Groundwater is present in fractures within the limestone bedrock. Locally, these fractures may be enlarged due to dissolution of the limestone. Features characteristic of karst development, such as sinkholes, have been observed in specific areas at Gallatin, but there does not appear to be significant groundwater flow conduit. Beneath portions of the plant site, the limestone bedrock is overlain by variable thicknesses of overburden consisting primarily of residuum derived from weathering of the underlying bedrock. Closer to the river, significant thicknesses of a clay alluvium are present. Groundwater at the project site is encountered within the residuum and rocks of the Carters and Lebanon Limestones. Groundwater is expected to flow vertically downward from the clay-rich residuum to the underlying bedrock, and then through bedrock fractures towards the Cumberland River.

The groundwater in the carbonate formations in the Central Basin aquifer system is typically of the calcium or calcium-magnesium bicarbonate water type. Groundwater chemistry is controlled primary by dissolution of limestones, dolomites, and gypsum (Hileman and Lee 1993). Water quality conditions can be highly variable, with total dissolved solids varying from under 500 mg/l to over 10,000 mg/l, due to the presence of localized flow systems. Groundwater in the Central Basin is commonly hard and contains hydrogen sulfide gas (Brahana and Bradley 1986).

TVA has been working with TDEC to monitor the closed ash impoundment (Non-Registered Site (NRS); IDL 83-1324)) and the North Rail Loop Landfill (NRL; IDL #83-0219) in accordance with Rule 0400-11-01-.04(7) and the facility Groundwater Monitoring Program Plan that was approved by TDEC on October 14, 2009. At the NRS, Groundwater Protection Standards (GWPSs) historically are exceeded for beryllium, cadmium and nickel at one of the four compliance wells (GAF-19R). Similar results were observed during recent sampling conducted in October 2018. Elevated levels of beryllium, cadmium and nickel at GAF-19R are associated with unusually low pH (i.e., median pH is 3.8 standard units (SU) at this location). By comparison, median pH values for compliance and background wells range from 5.7 and 7.1 SU. The unusually low pH is currently under investigation by TVA. Groundwater sampling results for GAF-19R may be localized to this portion of the NRS because the other three compliance wells, along with the background well, did not exhibit sampling results exceeding GWPs; therefore, the results from those compliance wells may be more representative of a greater portion of the site (TVA 2016h). At the NRL, no MCL exceedances were reported during the recent sampling event conducted in October 2018. Statistical analysis of the October 2018 data did indicate exceedances of the UPLs for barium, calcium, chloride, fluoride, nickel, and sulfate. However, based on evaluation of concentrations over time (time series plots), the October 2018 results were within the baseline range of concentrations and deemed to not be the result of the landfill. Exceedances of alternative regulatory limits recently promulgated by EPA under the CCR Rule were observed for lithium; however, these limits have not yet been adopted by TDEC. The results for lithium are consistent with historical results, including results obtained prior to placement of waste in the landfill. TVA continues to work with TDEC at the site under a Groundwater Assessment Program.

In accordance with the CCR Rule, TVA established groundwater monitoring well networks to evaluate potential impacts to groundwater from five CCR units: North Rail Loop Landfill, Ash Pond A, Ash Pond E, Middle Pond A, and Bottom Ash Pond. As allowed under the CCR Rule, Ash Pond A, Ash Pond E, Middle Pond A, and Bottom Ash Pond were grouped in to a multi-unit CCR unit for monitoring purposes. The results of detection monitoring and comparison to background concentrations indicated that SSIs of Appendix III constituents (boron, calcium, pH, and sulfate) above background were detected at the multi-unit CCR unit. TVA performed an ASD for the multi-unit CCR unit to evaluate if an alternate source was responsible for the SSIs. The ASD did not conclusively demonstrate an alternate source. Thus, TVA has established an Assessment Monitoring Program at the multi-unit CCR unit and will continue to investigate groundwater in accordance with the requirements of the CCR Rule. SSIs for boron and chloride were identified at the North Rail Loop Landfill CCR unit. An ASD was performed by TVA in 2018 and the source of SSIs for boron and chloride was determined to be the multi-unit CCR unit. Thus, the North Rail Loop Landfill remains in detection monitoring, in accordance with the CCR Rule.

In addition, TVA is conducting a site-wide environmental investigation, including groundwater monitoring, as a part of ongoing litigation related to the Gallatin. The groundwater monitoring results from that environmental investigation are consistent with the discussion above.

Kingston Fossil Plant

Kingston Fossil Plant (herein, Kingston) is situated on a peninsula formed by the confluence of the Clinch and Emory Rivers. It is located in the Valley and Ridge Physiographic Province and is underlain by folded and faulted carbonate, sandstone, and shale bedrock. Groundwater is derived from infiltration of precipitation and from lateral inflow along the western boundary of the reservation. Groundwater movement generally follows topography with flow in an easterly direction from Pine Ridge toward the Emory River and Watts Bar Reservoir. An exception to this trend occurs on the northern margin of the ash disposal area where groundwater movement is northerly toward Swan Pond Creek. Groundwater originating on, or flowing beneath, the site ultimately discharges to the reservoir without traversing off-site property.

In accordance with TDEC Rule 0400-11-01.04(7) and the facility Groundwater Monitoring Plan, TVA conducts periodic groundwater monitoring at the Kingston Class II Gypsum Disposal Facility, Ash Processing Area, and the Ash Disposal Area (ADA; IDL #73-0094). Results of recent sampling activities conducted in September 2018 at the Gypsum Disposal Facility indicated that concentrations for all Appendix I constituents (of Rule 0400-11-01.04) were below the site-specific Groundwater Protection Standards (GWPs). Statistical analysis of the September 2018 data identified exceedances of background for fluoride and arsenic. These constituents have historically exhibited statistical exceedances at this site. Observed metals concentrations continue to decline from peak levels following the conversion of the Gypsum Disposal Facility from wet to dry disposal in 2011. Although the concentrations have been around the GWPs, they do not display a discernable trend. It is possible these fluctuations are related to seasonality variations and/or associated with solids remaining in the aquifer. As demonstrated by historic arsenic results from the facility compliance wells, TVA believes that elevated turbidity and TSS values reflects the potential to impact / elevate metal concentrations detected in the groundwater samples collected from this site. Declining TDS levels appear to correspond to the decreasing detections noted for sample constituents since 2010. This indicates the detections are not associated with a new release from the lined landfill. Constituents will continue to be closely examined and efforts to reduce turbidity in samples collected from the facility wells and the collection of filtered metals samples will continue.

Results of recent sampling activities conducted in September 2018 at the Ash Processing Area indicate that constituent concentrations reported for all samples were below USEPA primary MCLs and TDEC MCLs, except for zinc in two of the three wells sampled. This constituent had been at or near the laboratory detection limit during previous sampling events, therefore, these detections appear anomalous. Data from subsequent sampling events at the site will be closely examined to see if a trend is developing. Results from sampling conducted at the ADA in September 2018 indicate that arsenic and zinc were detected above the MCLs in select wells. Concentrations of all other Appendix I inorganic constituents were below applicable MCLs. Statistical analysis of the September 2018 data indicated exceedances of UPLs for arsenic, cobalt, nickel, and zinc. Confirmation resampling was not conducted for these constituents since the results are consistent with historical values. TVA continues to work with TDEC to evaluate the MCL exceedance for arsenic.

Also in accordance with the CCR Rule, TVA established groundwater monitoring well networks to evaluate potential impacts to groundwater from three CCR units: Peninsula Disposal Area, Stilling Pond, and Sluice Trench and Area East of Sluice Trench. The results of detection monitoring and comparison to background concentrations indicated that SSIs of Appendix III constituents (boron, calcium, chloride, fluoride, pH, sulfate, and TDS) above background were detected at the Peninsula Disposal Area CCR unit. TVA is currently working to identify and assess, if necessary, the source of SSIs at this CCR unit. The Stilling Pond, and Sluice Trench and Area East of Sluice Trench were not originally identified as CCR units subject to regulation under the CCR Rule. TVA has since determined that they are subject to the CCR Rule and is currently evaluating groundwater quality data associated with these CCR units to determine whether SSIs exist. If SSIs are identified, TVA will continue to investigate groundwater quality in accordance with the CCR Rule and TDEC requirements.

Shawnee Fossil Plant

The Shawnee Fossil Plant (herein, Shawnee) is bounded by the Ohio River to the northeast and Little Bayou Creek to the southwest. It is located within the northwestern limit of the Mississippi Embayment and within the Gulf Coastal Plain Physiographic Province. The plant site is underlain by more than 300 ft of unconsolidated deposits of clay, silt, sand, and gravel, ranging from Cretaceous to Holocene in age. The principal aquifer beneath Shawnee is referred to as the Regional Gravel Aquifer, which represents the lower part of alluvial terrace deposits of the Ohio River and averages approximately 47 feet thick in the vicinity of the Dry Stack Area.

Groundwater sampling at the Shawnee Special Waste Landfill is conducted semi-annually and has been permitted by the Kentucky Division of Waste Management (KDWM) since 1993. During sampling conducted in June 2017, statistical exceedances were identified for total alpha, aluminum, boron, calcium, cobalt, fluoride, iron, magnesium, manganese, molybdenum, nickel, pH, potassium, specific conductance, strontium, sulfate, total organic carbon, and total dissolved solids. Flood waters in May 2017 resulted in submerged wells within the sampling network. Although wells were redeveloped prior to the June sampling event, it is possible that the statistical exceedances were, in part, attributable to the flooding and not necessarily related to the Special Waste Landfill (SWL) itself. Statistical findings indicate the likelihood of coal-combustion by-product effects on groundwater beneath and downgradient of the SWL. However, current groundwater quality in the landfill locality does not exceed KDEP or EPA MCLs for drinking water. In addition, the entire Shawnee reservation is within the Department of Energy (DOE) Water Policy Boundary, restricting use of groundwater and surface water (Little Bayou Creek) due to adjacent DOE activities over the past 50 years. Studies have not been conducted to fully evaluate and distinguish between the constituents in groundwater on the Shawnee reservation that originate from off-site, as compared to on-site contribution. TVA continues to monitor groundwater in accordance with the requirements of KDWM.

In accordance with the CCR Rule, TVA established groundwater monitoring well networks to evaluate potential impacts to groundwater from a CCR multiunit which combines the Special Waste Landfill with Ash Pond 2 (Main Ash Pond and Stilling Pond). The results of detection monitoring and comparison to background concentrations indicated that SSIs of Appendix III constituents (boron, calcium, pH, sulfate, and TDS) above background were detected at the multi-unit CCR unit. TVA performed an ASD for the multi-unit CCR unit to evaluate if an alternate source was responsible for the SSIs. The ASD did not conclusively demonstrate an alternate source. Thus, TVA has established an Assessment Monitoring Program at the multi-unit CCR unit and will continue to investigate groundwater quality in accordance with the requirements of the CCR Rule.

4.4.2 Surface Water

The quality of the region's surface waters – its streams, rivers, lakes, and reservoirs – is critical to protection of human health and aquatic life. Water resources provide habitat for aquatic life, recreation opportunities, domestic and industrial water supplies and other benefits. Major watersheds in the TVA region include the entire Tennessee River basin, most of the Cumberland River basin, and portions of the lower Ohio, lower Mississippi, Green, Pearl, Tombigbee, and Coosa River basins. Fresh water abounds in much of this area and generally supports most beneficial uses, including fish and aquatic life, public and industrial water supply, waste assimilation, agriculture, and water-contact recreation, such as swimming. Water quality in the TVA region is generally good.

4.4.2.1 Regulatory Framework for Surface Water Quality

The Federal Water Pollution Control Act, commonly known as the Clean Water Act (CWA), is the primary law that affects water quality. It establishes standards for the quality of surface waters and prohibits the discharge of pollutants from point sources unless a National Pollutant Discharge Elimination System (NPDES) permit is obtained. NPDES permits also address CWA Section 316(b) requirements for the design, location, construction and capacity of cooling water intakes to reflect the best technology available for minimizing environmental impact as well as Section 316(a) requirements for effluent limitations on thermal discharges to assure maintenance of a balanced indigenous population of fish and wildlife. Section 404 of the CWA further prohibits the discharge of dredge and fill material to waters of the United States, which include many wetlands, unless authorized by a permit issued by the USACE.

The seven states in the TVA PSA have enacted laws regulating water quality and implementing the CWA. As part of this implementation, the states classify water bodies according to their uses and establish water quality criteria specific to these uses. Each state has also issued an antidegradation statement containing specific conditions for regulated actions and designed to maintain and protect current uses and water quality conditions.

4.4.2.2 Surface Water Quality of TVA Region River Systems

Tennessee River Basin

The Tennessee River basin contains all except one of TVA's dams and covers about half of the TVA PSA (Figure 4-14). A series of nine locks and dams built mostly in the 1930s and 1940s regulates the entire length of the Tennessee River and allows navigation from the Ohio River upstream to Knoxville (TVA 2004). Almost all the major tributaries have at least one dam, creating 14 multi-purpose storage reservoirs and seven single-purpose power reservoirs. The construction of the TVA dam and reservoir system fundamentally altered both the water quality and physical environment of the Tennessee River and its tributaries. While dams promote navigation, flood damage reduction, power generation, water supply, water quality, and river-based recreation by moderating the flow effects of floods and droughts throughout the year, they also disrupt the daily, seasonal and annual flow patterns characteristic of a river. Damming of most of the rivers was done at a time when there was little regard for aquatic resources (Voigtlander and Poppe 1989). Beyond changes in water quality, flood control activities and hydropower generation have altered the flow regime (the main variable in aquatic systems) to suit human demands (Cushman 1985). This system of dams and their operation is the most significant factor affecting water quality and aquatic habitats in the Tennessee River and its major tributaries. Portions of several rivers downstream of dams are included on state CWA Section 303(d) lists of impaired waters (e.g., Tennessee Department of Environment and Conservation (TDEC) 2018) due to low dissolved oxygen (DO) levels, flow modifications and thermal modifications resulting from impoundment. TVA has undertaken several major efforts (e.g., TVA's Lake Improvement Plan, Reservoir Release Improvement Plans, and Reservoir Operations Study (ROS, TVA 2004)) to mitigate some of these impacts on aquatic habitats and organisms. While these actions have resulted in improvements to water quality and habitat conditions in the Tennessee River basin, the Tennessee River and its tributaries remain substantially altered by human activity.

Major water quality concerns within the Tennessee River drainage basin include point and nonpoint sources of pollution that degrade water quality at several locations on mainstream reservoirs and tributary rivers and reservoirs.

<u>Mainstem Reservoirs</u> - The nine mainstem reservoirs on the Tennessee River differ from TVA's tributary reservoirs primarily in that they are shallower, have greater flows and retain the water in the reservoir for a shorter period of time. Although DO in the lower lake levels is often reduced, it is seldom depleted. Winter drawdowns on mainstem reservoirs are much less severe than tributaries, so bottom habitats generally remain wetted all year. This benefits benthic (bottom-dwelling) organisms, but promotes the growth of aquatic plants in the extensive shallow overbank areas of some reservoirs. Tennessee River mainstem reservoirs generally support healthy fish communities, ranging from about 50 to 90 species per reservoir. Good to excellent sport fisheries exist, primarily for black bass, crappie, sauger, white and striped bass,

sunfish and catfish. The primary commercial species are channel and blue catfish and buffalo.

Tributary Reservoirs and Tailwaters - Tributary reservoirs are typically deep and retain water for long periods of time. This results in thermal stratification, the formation of an upper layer that is warmer and well oxygenated (high DO), an intermediate layer of variable thickness and a lower layer that is colder and poorly oxygenated (low DO). These aquatic habitats are simplified compared to undammed streams and fewer species are found. Aquatic habitats in the tailwater can also be impaired due to intermittent flows and low DO levels which restrict the movement, migration, reproduction and available food supply of fish and other organisms. Dams on tributary rivers affect the habitat of benthic invertebrates, which are a vital part of the food chain of aquatic ecosystems. Benthic invertebrates include worms, snails and crayfish (which spend all of their lives in or on the stream beds), and mussels, clams and aquatic insects (which live on the stream beds during all or part of their life cycles). Many benthic organisms have narrow habitat requirements that are not always met in reservoirs or tailwaters below dams. Farther downstream from dams, the number of benthic species increases as natural re-aeration occurs and DO levels and water temperatures rise.

TVA regularly evaluates several water quality indicators as well as the overall ecological health of reservoirs through its Ecological Health Monitoring Program. This program evaluates five metrics: chlorophyll concentration, fish community health, bottom life, sediment contamination and DO (TVA 2004: 4.4-3, -4). Scores for each metric from monitoring sites in the deep area near the dam (forebay), mid-reservoir, and at the upstream end of the reservoir (inflow) are combined for a summary score and rating. Vital Signs ratings, major areas of concern, and fish consumption advisories are listed in Table 4-7.

Two of TVA's six operating coal-fired power plants, one CC natural gas plant and all of TVA's nuclear plants are in the Tennessee River watershed. All of these facilities depend on the river system for cooling water. Two of TVA's CT plants are along or close to the Tennessee River; they are not dependent for cooling water.

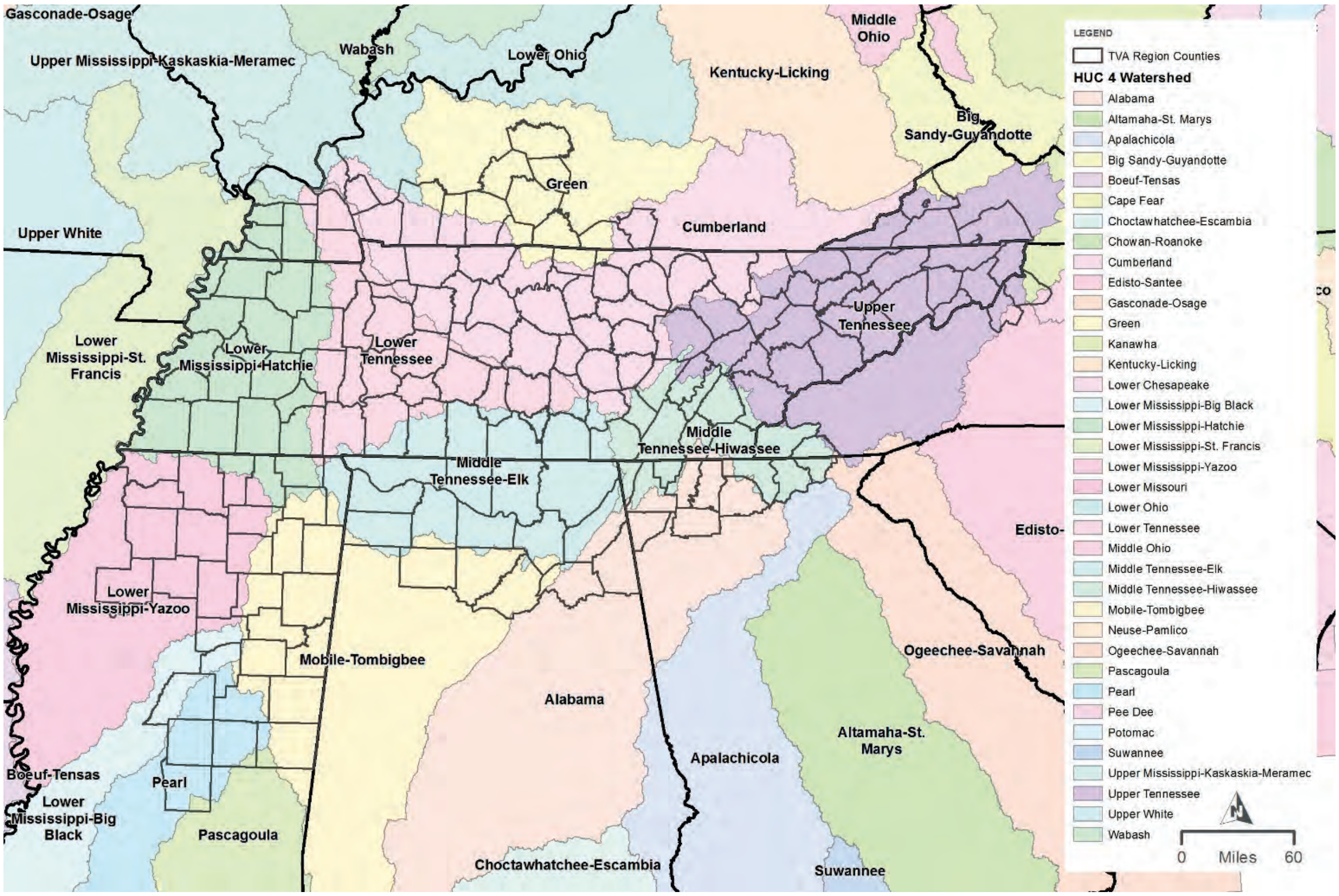

Figure 4-14: Major watersheds within TVA region.

Other Major River Systems

The other major river drainages within the TVA region (the Cumberland, Mobile, and Mississippi River drainages) share a diversity of aquatic life equal to or greater than the Tennessee River drainage. As with the Tennessee River, these river systems have seen extensive human alteration including construction of reservoirs, navigation channels and locks. Despite these changes (as with the Tennessee River drainage), diverse aquatic communities are present in each of these river systems.

Major TVA generating facilities located in these watersheds include Cumberland and Gallatin Fossil Plants (Cumberland River), Paradise Fossil and CC Plants (Green River/Ohio River) and Shawnee Fossil Plant (Ohio River). CT and CC plants are also located on the Mississippi River, in the Hatchie, Obion and Tallahatchie River (tributaries to the Mississippi River) drainage basins, and the Tombigbee and Pearl River drainage basins.

TVA operates two coal-fired plants on the main stem of the Cumberland River and Great Falls, a small hydroelectric plant on the Caney Fork River, a Cumberland River tributary. In 2007, because of low summer flows in the Cumberland River due to repairs on Wolf Creek Dam by the USACE and drought conditions, thermal discharges from the Cumberland Fossil Plant led the State of Tennessee to place the Barkley Reservoir segment of the Cumberland River on the state 303(d) list of impaired waters (TDEC 2008). The segment was listed as impaired due to low levels of DO and temperature alterations. Repairs to Wolf Creek Dam were completed in late 2013 and river flows greatly improved in the summer of 2014 leading to the delisting of DO as an impairment for the stream (TDEC

2016). Due to a continued lowering of ambient temperatures the Barkley Reservoir segment was completely delisted in the latest state 303(d) list (TDEC 2018). Fish consumption advisories are in effect for waters in the vicinity of the Shawnee Fossil and Allen CC plants. Otherwise, water resources conditions and characteristics in these river systems are generally similar to those in the Tennessee system.

Table 4-7: Ecological health ratings, major water quality concerns, and fish consumption.

Reservoir	Ecological Health Rating – Score	Latest Survey Date	Concerns	Fish Consumption Advisories
Apalachia	Good – 75	2015	--	Mercury (NC statewide)
Bear Creek	Poor – 54	2017	DO[1], chlorophyll, bottom life	Mercury (dam forebay area)
Beech	Fair – 66	2015	DO, chlorophyll	Mercury
Blue Ridge	Good – 84	2017	--	Mercury
Boone	Fair – 63	2016	DO, chlorophyll, bottom life, sediments	PCBs[2], chlordane
Cedar Creek	Fair – 69	2017	DO	Mercury (dam forebay to 1 mile upstream of dam
Chatuge	Fair – 62	2015	DO, chlorophyll	Mercury
Cherokee	Poor – 56	2015	DO, chlorophyll, bottom life	None
Chickamauga	Good – 83	2017	--	Mercury (Hiwassee River from Hwy 58 (river mile 7.4) upstream to river mile 18.9.
Douglas	Poor – 63	2016	DO, chlorophyll	None
Fontana	Fair – 67	2016	DO, bottom life	Mercury
Fort Loudoun	Fair – 60	2017	DO, chlorophyll, bottom life	PCBs, mercury (upstream US 129)
Fort Patrick Henry	Fair – 69	2016	Chlorophyll	None
Guntersville	Fair – 72	2016	Chlorophyll	Mercury (Vicinity of Tennessee River mile 408, just downstream of Widows Creek; Sequatchie River)
Hiwassee	Fair – 67	2015	DO	Mercury (Statewide advisory)
Kentucky	Good – 75	2017	Chlorophyll (Big Sandy only - DO, bottom life)	Mercury (State of Kentucky statewide advisory; State of Tennessee, Big Sandy River and embayment)
Little Bear Creek	Fair – 69	2017	DO	Mercury
Melton Hill	Good – 80	2016	Sediments	PCBs, mercury (Poplar Creek embayment)
Nickajack	Good – 84	2016	--	PCBs, chlordane (Chattanooga Creek)
Normandy	Poor – 40	2016	DO, chlorophyll, bottom life	None

Reservoir	Ecological Health Rating – Score	Latest Survey Date	Concerns	Fish Consumption Advisories
Norris	Fair – 69	2014	DO	Mercury (Clinch River portion)
Nottely	Poor – 47	2014	DO, chlorophyll, bottom life	Mercury
Parksville	Fair – 66	2017	Sediments	None
Pickwick	Fair – 59	2016	DO, chlorophyll, bottom life	None
South Holston	Fair - 67	2015	DO	Mercury (Tennessee portion)
Tellico	Fair – 63	2015	DO, bottom life	PCBs
Tims Ford	Poor – 52	2016	DO, chlorophyll, bottom life	None
Watauga	Good - 77	2015	DO	Mercury
Watts Bar	Fair - 62	2016	DO, chlorophyll, bottom life	PCBs
Wheeler	Fair - 68	2015	DO, chlorophyll, bottom life	Mercury (Limestone Creek, Round Island Creek embayments); PFOS[3] (Baker Creek embayment, river miles 296-303)
Wilson	Poor - 57	2016	DO, chlorophyll, bottom life	Mercury (Big Nance Creek embayment)

Source: TVA 2018d
Notes:
1. DO = Dissolved Oxygen
2. PCB = Polychlorinated biphenyls
3. PFOS = Perfluorooctane sulfonate

4.4.2.3 Causes of Degraded Water Quality

Causes of degraded water quality include:

- Wastewater discharges – Municipal sewage treatment systems, industrial facilities, concentrated animal feeding operations and other sources discharge waste into streams and reservoirs. These discharges are controlled through state-issued NPDES permits issued under the authority of the CWA. NPDES permits regulate the amounts of various pollutants in the discharges (including heat) and establish monitoring and reporting requirements.
- Runoff discharges – Runoff from agriculture, forest management (silvicultural) activities, urban uses and mined land can transport sediment and other pollutants into streams and reservoirs. Runoff from some commercial and industrial facilities and some construction sites is regulated through state NPDES stormwater permitting programs. Runoff from agriculture, silvicultural and other sources not regulated under the NPDES program is referred to as "nonpoint source" runoff.
- Cooling Systems – Electrical generating plants and other industrial facilities withdraw water from streams or reservoirs, use it to cool facility operations, and discharge heated water into streams or reservoirs. The aquatic community may be impacted due to temperature changes in the receiving waters and from fish and other organisms being trapped against the intake screens or sucked into the facility cooling system. These water intakes and discharges are controlled through state-issued NPDES permits.
- Air pollution – Airborne pollutants (e.g., mercury, sulfates) can affect surface waters through rainout and deposition.

Following is an overview of how power generation can affect water quality.

Coal and Natural Gas Plant Wastewater – Coal-fired power plants have several liquid waste streams that are released to surface waters following any required treatment. These include condenser cooling water, cooling tower blowdown, ash sluice water, metal-cleaning wastewaters and various low volume wastes including sumps and drains. Combined cycle natural gas plant wastewaters include cooling tower blowdown and various low volume wastewaters. Coal and gas plant sites use best management practices to control stormwater runoff such as retention ponds to capture sediment and oil/water separators to remove oil and grease. Discharges are regulated by each state under the NPDES program. Many of the waste streams receive treatment before they are discharged. Analytical monitoring and periodic toxicity testing ensure there are no acute or chronic toxic effects to aquatic life. Discharges from coal plants include those from Coal Combustion Residuals (CCR) storage areas; these discharges can occur through permitted discharges and from seepage into groundwater which then enters surface waters. See Section 4.7 for further discussion of CCR management at TVA coal plants.

Nuclear Plant Wastewater – Liquid waste streams at nuclear plant sites include condenser cooling water, cooling tower blowdown, water treatment wastewaters, steam generator blowdown, liquid rad-waste including tritiated wastewater and various low volume wastes including sumps and drains.

Periodic analytical monitoring and toxicity testing is performed on these discharges as required by the NPDES permit to ensure that plant wastes do not contain chemicals at deleterious levels that could affect aquatic life. Best management practices are used to control stormwater runoff and may include retention ponds to capture sediment and oil/water separators. The radiological component of discharges from nuclear plants is regulated by the Nuclear Regulatory Commission (NRC) and by states under the CWA.

Thermal Plant Cooling Systems – All of TVA's coal-fired and nuclear plants and two CC gas plants withdraw water from reservoirs or rivers for cooling and discharge the heated water back into the water body (see Section 4.4.3). In some cases, the cooling water is chemically treated to prevent corrosion or biofouling of the cooling system. TVA conducts extensive monitoring programs to help ensure permit compliance and to provide information about potential adverse effects from the heated and/or chemically treated discharges. Plant-specific monitoring includes concentrations of various chemicals, toxicity, discharge flow rates, discharge and receiving stream temperatures, DO, fish communities, and benthic organisms.

Recent programs have also focused on spawning and development of cool-water fish species such as sauger, the attraction of fish to the heated discharges and changes in undesirable aquatic micro-organisms such as blue-green algae. In general, these monitoring programs have not detected significant negative effects resulting from release of heated water from TVA facilities in the Tennessee River drainage basin.

Runoff and Air Pollution – Many nonpoint sources of water pollution are not subject to government regulations or control. Principal causes of non-point source pollution are agriculture, including runoff from fertilizer, pesticide applications, erosion and animal wastes; silvicultural activities; mining, including erosion and acid drainage; and urban runoff. Pollutants reach the ground from the atmosphere as dust fall or are carried to the ground by precipitation.

Low DO Levels and Low Flow Downstream of Dams – A major water quality concern is low DO levels in reservoirs and in the tailwaters downstream of dams. Long stretches of river can be affected, especially in areas where pollution further depletes DO. In addition, flow in these tailwaters is heavily influenced by the amount of water released from the upstream dams; in the past, some of the tailwaters were subject to periods of little or no flow. Since the early 1990s, TVA has addressed these issues in the Tennessee River system by installing equipment and making operational changes to increase DO concentrations below 16 dams and to maintain minimum flows in tailwaters (TVA 2004: 4.4-3).

NPDES Permit Requirements – All of TVA's coal, CC natural gas, and nuclear generating facilities have state-issued NPDES permits for discharging to surface waters or pretreatment permits issued under state-approved programs for discharging into public sewer systems. At a minimum, these permits restrict the discharge of pollutants to levels established by EPA Effluent Limitation Guidelines. Additional, and sometimes more restrictive, limits may also be included based on state water quality standards.

EPA published an update of the Effluent Limitation Guidelines rule on November 3, 2015, that revised and strengthened the technology-based effluent limitations guidelines and standards for discharges from steam electric power plants. The final rule sets limits on the amount of metals and other pollutants that are allowed to be discharged from several of the largest sources of wastewater at steam electric power plants, based on technology improvements in the industry over the last three decades. Generally, the final rule established new requirements for wastewater streams from the following processes and byproducts associated with steam electric power generation: flue gas desulfurization, fly ash, bottom ash, flue gas mercury control, and gasification of fuels such as coal and petroleum coke. The final rule phases in more stringent requirements in the form of effluent limits for arsenic, mercury, selenium, and nitrate/nitrite as nitrogen for wastewater discharged from wet scrubber systems (flue gas desulfurization waste stream) and zero discharge of pollutants in ash transport water that must be incorporated into the plants' NPDES permits. The rule has currently been stayed and certain points are being reevaluated; however, it still requires that each plant must comply between 2018 and 2023 depending on when its NPDES permit is due for renewal.

After publication of the rule, the EPA postponed the earliest compliance dates for the new, more stringent, best available technology effluent limitations and pretreatment standards for bottom ash transport water and FGD wastewater for a period of two years. The outermost compliance date of 2023 remains in effect.

Finalized 316(b) regulations for existing facilities (USEPA 2014) require TVA and other utilities to perform additional evaluations of the impacts of their facilities and cooling water intakes and may require modifications to plant cooling systems and/or plant operations to reduce impacts to fish and other aquatic organisms.

Fuel Cycle Impacts – The extraction, processing, and transportation of fuel can affect water quality. Runoff and other discharges from coal and uranium mines, natural gas well sites, and from fuel processing facilities can discharge sediment and other pollutants into surface waters. These discharges are typically subject to NPDES permit requirements, as well as permit requirements specific to coal and uranium mining. Mining operations can also result in the alteration and elimination of streams. Mining and natural gas extraction can also affect groundwater quality and quantity. Impacts to water quality from the extraction of natural gas by hydraulic fracturing are described in more detail in Section 5.5.4.

4.4.2.4 Surface Water Quality at Facilities Considered for Future Retirement

Several TVA facilities have units that are being considered for retirement in the next decade. The following sections provide an overview of the surface water conditions at each of these facilities. Stormwater discharges from each of TVA's coal-fired power plants are regulated under NPDES individual permits that are administered at the state level. For those plants located in Tennessee, some stormwater discharge associated with industrial activity is also regulated under Tennessee Storm Water Multi-Sector General Permit for Industrial Activities permits. In general, storm water is either comingled with process water or discharged through permitted outfalls; only the major outfalls at each plant are discussed herein.

Cumberland Fossil Plant

Cumberland Fossil Plant (herein, Cumberland) is located on the southern side of the Cumberland River and is bordered by Wells Creek to the south and west. Cumberland withdraws an average of 2,096 million gallons per day (MGD) from the Cumberland River for use as condenser cooling water (CCW) and plant process water (e.g., sluice water, fire protection, boiler feed water, safety, and miscellaneous water uses). Approximately 98 percent of the water withdrawal is used for cooling, while approximately 2 percent is used for other uses including process water. The withdrawn water is returned to the river after appropriate treatment and complies with Cumberland's NPDES permit requirements.

Existing wastewater streams at Cumberland are permitted under TDEC NPDES Permit No. TN0005789, effective through 2023. The Internal Monitoring Point (IMP) 001 discharges process and stormwater from the Main Ash Impoundment to the CCW channel at an average flow of 21.73 MGD. TVA is required under NPDES Permit No. TN0005789 to meet pH, total suspended solids (TSS), and oil and grease effluent limitations at IMP 001. TVA is required to report flow, nitrogen, ammonia, fluoride, calcium, sulfate, total dissolved solids (TDS), radium 226 and 228, and 20 additional metals on a monthly to quarterly basis under the current NPDES permit.

Outfall 002 discharges approximately 2,097 MGD of once-through condenser cooling water, in addition to flows from IMP 001 to the Cumberland River. Per the 2018 NPDES permit, TVA is required to meet effluent limitations for temperature, toxicity, and total residual oxidants on a daily to annual basis.

Gallatin Fossil Plant

Gallatin Fossil Plant (herein, Gallatin) is located on the northern side of Odoms Bend in the Cumberland River. Gallatin withdraws approximately 916 MGD for use as CCW and plant process water (i.e., sluice water, fire protection, boiler feed water, miscellaneous water uses). Approximately 97 percent of the water withdrawal is used for cooling, while approximately 3 percent is used for process water. The withdrawn water is returned to the river after appropriate treatment and complies with Gallatin's NPDES permit.

There are several existing wastewater streams at Gallatin permitted under NPDES No. TN0005428, effective through May 2023. The main plant area is drained by permitted stormwater outfalls, wet weather conveyances, intermittent streams, the condenser cooling water discharge (Outfall 002), and the intake screen backwash (Outfall 004) along with process and storm water discharges from the ash impoundment system (Outfall 001).

From 2015 to 2018, an average of 20.86 MGD of water was discharged from the ash pond through NPDES Outfall 001. Under the current NPDES permit, TVA is required to meet effluent limitations for pH, TSS, oil and grease, and toxicity, in addition to periodic reporting of flow, sulfate, fluoride, calcium, TDS, radium 226 and 228, and 19 metals.

Approximately 855 MGD is discharged from the CCW discharge channel through NPDES Outfall 002. The plant's permitted discharges from Outfall 002 are once-through cooling water, auxiliary cooling water, and storm water runoff. The current NPDES permit contains limitations on the CCW discharge for temperature, and total residual oxidants and toxicity (when chlorine, bromine, or other oxidants are added to the cooling water). This permit also requires reporting of flow and intake temperature.

Kingston Fossil Plant

Kingston Fossil Plant (herein, Kingston) is situated on a peninsula formed by the confluence of the Clinch and Emory Rivers. Kingston withdraws approximately 1,107 MGD from the Clinch and Emory rivers for use as CCW and plant process water (e.g., sluice water, fire protection, boiler feed water, and other miscellaneous uses). Approximately 99 percent of the water withdrawal is used for cooling, while approximately 1 percent is used for other uses including process water. The withdrawn water is returned to the river after appropriate treatment and complies with Kingston's NPDES permit.

There are several existing wastewater streams at Kingston permitted to be discharged under the Kingston NPDES permit (Number TN0005452), effective through February 2023. The main plant area is drained by permitted stormwater outfalls, wet weather conveyances, intermittent streams, the condenser cooling water discharge (Outfall 002), and the intake screen backwash (Outfall 004) along with process and storm water discharges from the ash impoundment system (Outfall 001). The majority of discharge from Kingston leaves the site via Outfall 001, which conveys an average of 13.67 MGD of treated ash pond effluent and other wastewater, based on flow data recorded by TVA between November 2016 and November 2018.

TVA is required to meet effluent limitations at Outfall 001 for pH, TSS, and oil and grease, while reporting flow and 16 metals on a weekly to monthly basis.

Over the same 2016-2018 time period, an average of approximately 7.42 MGD of wastewater was discharged through Outfall 002. Under the current NPDES permit, TVA is required to meet effluent limitations for pH, temperature, mercury, toxicity, duration of chlorination, and total residual oxidants, while reporting flow and intake temperature.

Shawnee Fossil Plant

The Shawnee Fossil Plant (herein, Shawnee) is bounded by the Ohio River to the northeast and Little Bayou Creek to the southwest. Shawnee withdraws an average of 1,487.72 MGD of water for use as CCW and plant process water. Approximately 98 percent of the water withdrawal is used for cooling, while approximately 2 percent is used for process water. Essentially all of the water withdrawn is returned to the Ohio River.

There are several existing wastewater streams at Shawnee permitted under Kentucky Pollutant Discharge Elimination System (KPDES) Permit Number KY0004219, effective through June 2023. The main plant area is drained by permitted storm water outfalls, wet weather conveyances, the CCW discharge (Outfall 002), the chemical treatment pond (Outfall 004), and process and storm water discharges from the ash pond system (Outfall 001). Potentially impacted onsite wastewater streams include the dry stack storm water discharge, CCW discharge channel, and ash pond discharge.

The majority of wastewater from the Shawnee site is discharged to the Ohio River through Outfalls 001 and 002. From August to November 2018 (under the new KPDES Permit), an average of 19.74 MGD were discharged from the ash pond through Outfall 001. Outfall 001 discharges into the CCW discharge channel. During the same time period, the pH (a measure of acidity) of the ash pond discharge ranged from 7.31 to 8.22. The ash pond is being dewatered, closed, and capped. From the effective date of the permit until commencement of mechanical dewatering, TVA is required to meet the ash pond effluent limits for pH, oil and grease, total suspended solids, and acute toxicity. During dewatering, TVA is required to meet limitations for pH, oil and grease, total suspended solids, and acute toxicity, in addition to the following metals: antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc, while reporting hardness. Subsequent to completion of dewatering, the KPDES permit reverts back to monitoring consistent with the pre-dewatering requirements previously noted. Based on data from weekly monitoring conducted between August and October 2018, all permit-required constituents were within regulatory limits at Outfall 001.

From 2016 to 2018, an average of 872 MGD of once-through cooling water was discharged from the CCW discharge channel through KPDES Outfall 002. The current KPDES permit contains limitations on the CCW discharge for temperature, free available chlorine, total residual chlorine, total residual oxidants, and time of oxidant addition, as well as reporting of flow, discharge temperature, and pH.

Combustion Turbine Facilities

TVA currently operates CTs at their Allen (20 turbines), Colbert (8 turbines), Gallatin (8 turbines), and Johnsonville (20 turbines) plants. CTs require no cooling, and therefore, operation and/or retirement of CTs does not affect surface water at these facilities.

4.4.3 Water Supply

The TVA PSA contains most of the Tennessee River Basin, which is considered one of the most water rich basins in the United States (Figure 4-14). The Tennessee River Basin, which is about half of the TVA PSA, has been defined as the most intensively used basin in the contiguous United States as measured by intensity of freshwater withdrawals in gallons per day per square mile (gal/d/mi2) (Hutson et al. 2004). While the withdrawal rate is highest, the basin has the lowest consumptive use in the nation by returning about 96 percent of the withdrawals back for downstream use (Bowen and Springston 2018).

In 2015, estimated average daily water withdrawals in the TVA PSA totaled 12,966 MGD (Dieter et al. 2018, Bowen and Springston 2018). About 6.6 percent of these water withdrawals were groundwater and the remainder was surface water. The largest water use (77.7 percent of all withdrawals) was for thermoelectric generation as shown in Figure 4-15. Even though thermoelectric generation has the greatest withdrawal, about 99.2 percent is recycled and returned for downstream use in the TVA system (Bowen and Springston 2018).

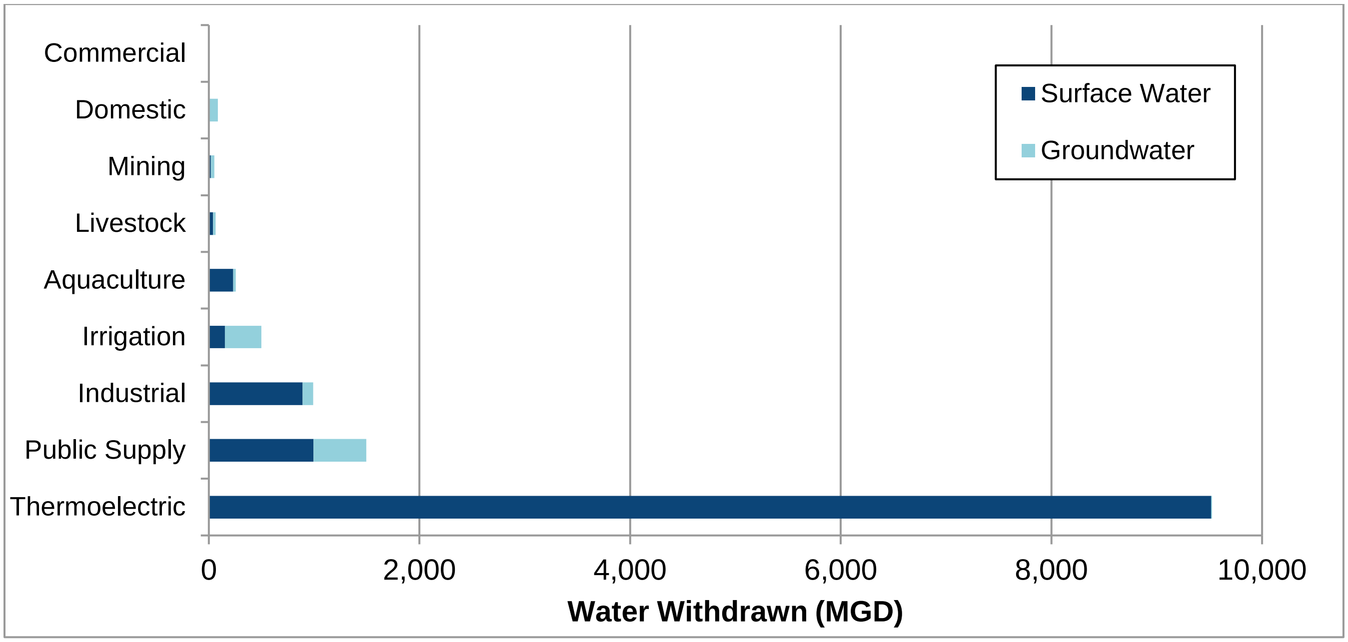

Figure 4-15: 2015 water withdrawals in the TVA power service area by source and type of use Source: Dieter et al. (2018), Bowen and Springston (2018).

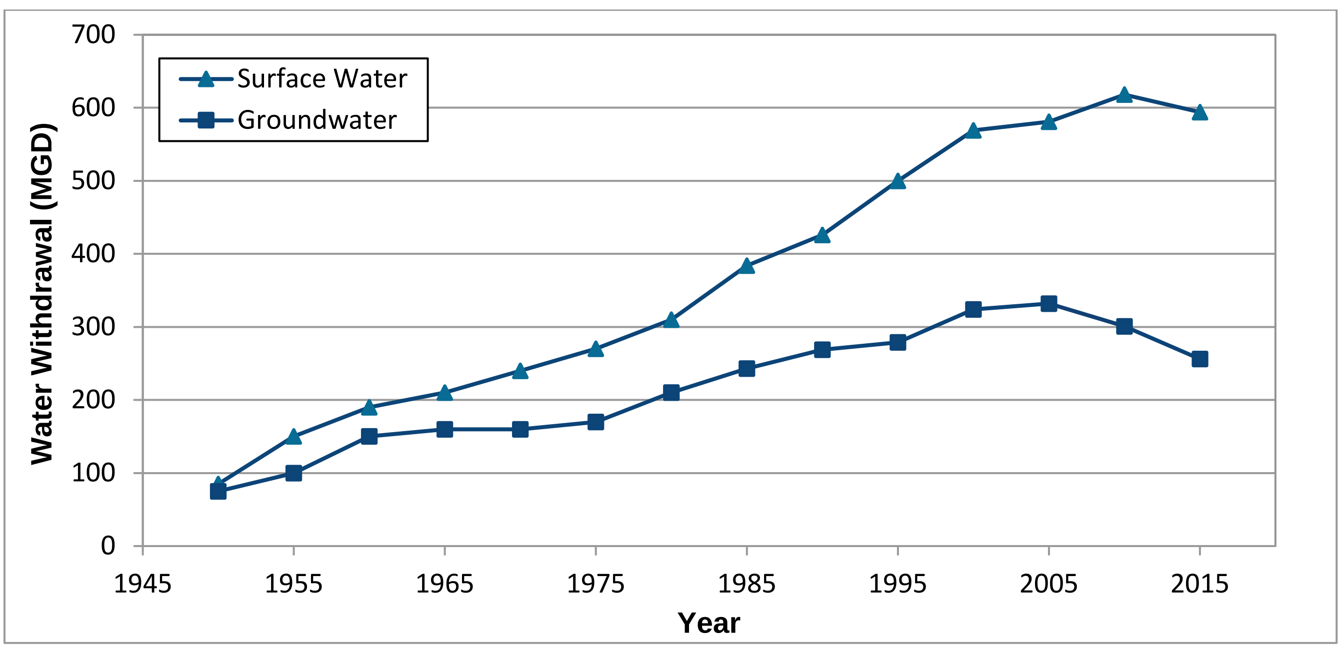

Figure 4-16: Groundwater and surface water withdrawals by water public systems in Tennessee, 1950 to 2015. Adapted from Webbers (2003). Additional Data: Kenny et al. (2009), Bohac and Bowen (2012), Bowen and Springston (2018).

Since 1950, the annual increase in groundwater withdrawals for public supply in Tennessee has averaged about 2.2 percent and the increase in surface water withdrawals has averaged about 3.5 percent (Figure 4-16). For the first time since 1950, there was a decrease in surface water withdrawal for public supply systems in Tennessee between 2010 and 2015. Although these data are for Tennessee public water supplies, they are representative of the overall trends in water use for the TVA PSA.

4.4.3.1 Groundwater Use

Groundwater data are compiled by the U.S. Geological Survey (USGS) and cooperating state agencies in connection with the national public water use inventory conducted every five years (Dieter et al. 2018, Bowen and Springston 2018). The largest use of groundwater is for public water supply, illustrated in Figure 4-16. Almost all of the water used for domestic supply and 55 percent of water used for irrigation in the TVA PSA is groundwater. Groundwater is also used for industrial, mining, livestock, and aquaculture purposes.

The use of groundwater to meet public water supply needs varies across the TVA PSA and is the greatest in West Tennessee and Northern Mississippi. This variation is the result of several factors, including groundwater availability, surface water availability, where both surface and groundwater are present in adequate quantity and quality, which water source can be developed most economically, and public water demand, which is largely a function of population. There are numerous sparsely populated, rural counties in the region with no public water systems. Residents in these areas are self-served by individual wells or springs.

Total groundwater use for public water supply in 2015 was 500 MGD in the TVA PSA. Approximately 60 percent of all groundwater withdrawals were supplied by Tertiary sand aquifers in West Tennessee and North Mississippi. Shelby County, Tennessee (Memphis) accounted for about 38 percent of the total 2015 public supply regional pumpage. The dominance of groundwater use over surface water use in the western portion of the TVA PSA is due to the availability of prolific aquifers and the absence of adequate surface water resources in some areas. Additionally, several TVA facilities, primarily combined cycle plants, which use groundwater for industrial purposes are in this area. Generally those purposes are for fire protection and cooling, and are discharged through an NPDES outfall.

4.4.3.2 Surface Water Use

The majority of water used for thermoelectric, public supply, aquaculture, and industrial uses is surface water (Figure 4-15). Large public supply withdrawals correspond to the population centers throughout the valley. The top five counties for surface water public supply are Davidson, Knox, Hamilton, and Rutherford counties, Tennessee, and Madison County, Alabama. These counties contain the large cities of Nashville, Knoxville, Chattanooga, and Murfreesboro, Tennessee and Huntsville, Alabama, respectively. These five counties account for 40 percent of all surface water public supply for the entire TVA PSA.

Thermoelectric withdrawal decreased about 2,400 MGD in 2015 compared to 2010. This was due to the retirement of TVA coal-fired power plants that used water withdrawals for cooling water. Public supply, industrial, and livestock uses decreased in 2015. Decrease in public supply use can be attributed to technology upgrades at two of the most populous counties in the PSA and general public decrease of per-capita use. Industrial use decreased because of the closure of a few larger demand plants. Mining, aquaculture, and irrigation uses increased in 2015, but these uses are more variable because they are sensitive to weather and economic conditions.

4.4.3.3 Water Use for Thermoelectric Power Generation

Thermoelectric power generation uses steam produced from the combustion of fossil fuels or from a nuclear reaction. A substantial volume of cooling water is required to condense steam into water. All TVA coal-fired plants and nuclear plants are cooled by water withdrawn from adjacent rivers or reservoirs. Surface water withdrawls may be supplemented by groundwater withdrawn via production wells at some plants, though the quantity of groundwater withdrawn is significantly less than the quantity of surface water withdrawn. The amount of water required is highly dependent on the type of cooling system employed. While the volume of water used to cool the plants is large, most of this water is returned to the adjacent rivers or reservoirs.

In 2015, TVA's three nuclear plants and the 10 coal-fired plants then in operation withdrew an average of 12,699 MGD (Table 4-8). The total plant water withdrawal divided by the net generation is the water use factor. All TVA coal-fired plants except Paradise employ open-cycle (once-through) cooling all the time. In open cycle systems, water is withdrawn from a water body, circulated through the plant cooling condensers, and then discharged back to the water body. Plant water use factors for the coal plants, except for Colbert, Johnsonville and Paradise, ranged from about 54,000 to 83,000 gal/MWh of net generation. Differences in river temperature, plant design, atmospheric conditions, and plant operation account for the variability in water use factors.

Plant water use factors for Colbert were not within this range because the plant was offline for a portion of 2016, so for several months the pumps were still operational even though the units were not generating electricity. Johnsonville was excluded from the plant water use factor range because the plant was converted to a CT plant, and four units were operating at a decreased production, without commensurate withdrawal reductions.

Table 4-8: 2015 water use for TVA coal-fired and nuclear generating plants (TVA unpublished data).

Plant	Units	Withdrawal (MGD)	Return (MGD)	Consumption (Withdrawal - Return, MGD)	Net Generation (MWh/year)	Water Use Factor (gallons/MWh)
Coal-Fired						
Allen	3	490.2	490.1	0.1	3,129,703	57,173
Bull Run	1	528.6	528.2	0.4	2,487,210	64,611
Colbert	5	963.9	963.1	0.8	2,685,375	131,015
Cumberland	2	2319.2	2311.6	7.6	14,438,617	58,627
Gallatin	4	678.6	678.3	0.3	3,826,403	64,730
Johnsonville	4	491.3	490.9	0.4	1,964,467	91,276
Kingston	9	956.6	955.7	0.8	3,857,821	83,006
Paradise	3	333.8	273.1	60.7	12,008,149	10,145
Shawnee	9	902.8	902.4	0.4	6,141,807	53,654
Widows Creek	2	470.7	470.0	0.7	1,627,447	78,957
Nuclear						
Browns Ferry	3	2850.6	2840.2	10.4	27,669,694	37,603
Sequoyah	2	1526.6	1524.3	2.3	16,511,322	33,747
Watts Bar	1	185.9	170.7	15.2	8,449,150	8,030

Paradise employs substantial use of cooling towers (closed-cycle cooling) resulting in a relatively low plant water use factor and less water returned to the river (Table 4-8). In closed-cycle systems, water from the steam turbine condensers is circulated through cooling tower where the condenser water is cooled by transfer of heat to the air by evaporation, conduction, and convection. The proportion of cooling water discharged to the river or reservoir is lower than for open-cycle systems, as are the overall volume of water required and the plant water use factor.

Browns Ferry and Sequoyah nuclear plants operate primarily in the open-cycle mode, with infrequent use of cooling towers. Watts Bar nuclear plant uses a combination of open-cycle and closed-cycle cooling.

Natural gas-fueled CC plants (gas turbine followed by a steam turbine) require water for steam generation and condensation. Water use in 2015 for TVA's CC plants are shown in Table 4-9. The Caledonia plant uses reclaimed wastewater. Ackerman, Lagoon Creek, Magnolia, and Southaven use groundwater. John Sevier uses surface water and closed-cycle cooling. With the exception of the Ackerman plant, all of these facilities return their process water to surface waters. Ackerman does not discharge process water.

Although TVA generates the majority of electrical energy in the TVA PSA and Tennessee River basin, there are non-TVA power plants in these areas that used substantial volumes of water in 2015 (Table 4-10). Two of the non-TVA plants (Decatur and Morgan) sell all or a large amount of their electricity to TVA. The Clinch River (closed during 2015) and Asheville coal-fired plants withdraw surface water from Tennessee River tributaries, but are located outside of TVA's PSA. The coal-fired Asheville plant is scheduled to be retired in 2020, following the completion of an adjacent 2-unit combined cycle natural gas plant that is currently under construction. Batesville, Morgan and Decatur withdraw surface water and are in the TVA PSA. The Choctaw Gas Plant is also in the TVA PSA, but utilizes saline groundwater instead of fresh water.

Table 4-9: 2015 water use for TVA combined cycle generating plants (TVA unpublished data).

Plant	Units	Withdrawal (MGD)	Return (MGD)	Consumption (Withdrawal - Return, MGD)	Net Generation (MWh/year)	Water Use Factor (gallons/MWh)
Ackerman	1	1.3	0.0	1.3	1,991,097	935
Caledonia	3	2.3	0.6	1.7	3,390,679	244
John Sevier	3	3.6	0.9	2.7	4,766,759	279
Lagoon Creek	3	2.2	0.6	1.6	3,171,381	258
Magnolia	3	3.7	0.7	3.0	4,972,280	269
Southaven	3	2.2	0.4	1.8	3,798,356	208

Note: The TVA CC generating plants at Paradise and Allen are not included because these plants began commercial operation in 2017 and 2018, respectively.

Table 4-10: 2015 water use by non-TVA thermal generating plants in the TVA power service area and Tennessee River basin. Source: U.S. Department of Energy EIA-923 Database (2015)

Plant	Units	Withdrawal (MGD)	Return (MGD)	Consumption (Withdrawal - Return, MGD)	Net Generation (MWh/year)	Water Use Factor (gallons/MWh)
Coal						
Asheville, NC	4	116.8	2.3	114.5	1,590,539	26,803
Clinch River, VA	3	9.2	3.5	5.7	461,977	7,269
Combined Cycle						
Batesville, MS	3	3.2	0.2	0.2	3,761,639	311
Decatur Energy Center, AL		0.7	0.1	0.6	1,486,854	172
Morgan Energy Center, AL		3.2	0.4	2.8	4,955,877	236
Choctaw Gas, MS[1]		4.1			3,033,410	493

[1]Saline Groundwater

4.4.3.4 Trends in Thermoelectric Water Withdrawal

Nationally, water use factors have been declining since the 1960s. The national power plant water use factors have declined from a high of about 60,000 gal/MWh to a low of about 23,000 gal/MWh (Electric Power Research Institute (EPRI) 2002). The reduction was primarily due to increasing use of closed-cycle cooling, particularly in the western United States where water is relatively scarce. TVA's water use factor is higher than the national average because the TVA system was designed and located to specifically take advantage of open-cycle cooling, and therefore has a lower percentage of closed-cycle cooling systems than the national average. While closed-cycle cooling systems withdraw less water, they actually consume more water in their cooling tower systems due to evaporation. TVA's systems are designed for less overall water consumption, even though they do require more water withdrawal upfront.

Figure 4-17 shows the total withdrawal from 2000 to 2015 and the combined water use factor for TVA's coal-fired, nuclear, and CC plants. The combined water use factors for 2000 and 2005 were about 39,300 gal/MWh. A slight increase was observed in 2010 to 42,300 gal/MWh, largely as the result of abnormal operation at Kingston Fossil Plant and reduced generation without commensurate withdrawal reductions at other plants such as Cumberland and Bull Run. The combined water use factor remained failry steady in 2015 at 40,743 gal/MWh because while Colbert and Widows Creek were being prepared to be retired, the pumps for the open cycle cooling systems were still operating even though the units were not generating electricity. Further, while a heat recovery steam generator was being added to a CT unit at Johnsonville, a few coal units were still operating at a decreased production rate.

In addition to recent historic combined water use factors, Figure 4-17 also shows the anticipated combined water use factor for changes that have occurred since 2015. Those changes include the startup of Watts Bar Unit 2, the retirement of the coal units and construction of a CC plant at Allen, the retirement of two coal units and construction of a CC plant at Paradise, the closure of Colbert and Widows Creek Fossil plants, and the retirement of the coal units and startup of a heat recovery steam generator at Johnsonville. The startup of Watts Bar Unit 2 results in approximately 33 percent reduction in water use factor because Watts Bar Unit 2 primarily operates in closed-cycle mode. Therefore, the plant water use factor with both units operating will decrease but water consumption will increase from that of Unit 1 operation. The Johnsonville heat recovery steam generator does not use water so it is not included in the water use projections.

Table 4-11 shows the changes in the combined water use factor after the changes described in the previous paragraph for Allen, Paradise and Watts Bar went into effect. The additions, conversions, and closures would reduce the combined water use factor for TVA-owned facilities to about 24,100 gal/MWh in 2025. The data point in Figure 4-17 in year 2025 is based on the assumption that the plant modifications that are currently under way are completed.

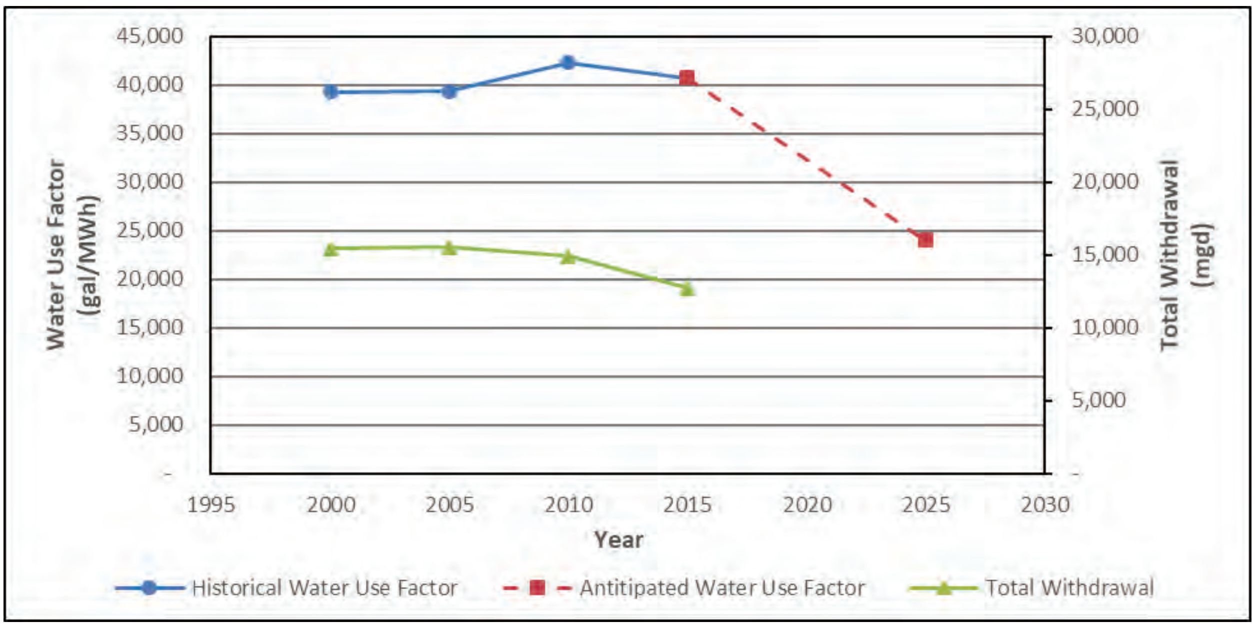

Figure 4-17: Total withdrawal and combined water use factor for TVA-owned thermal generating plants.

Table 4-11: Changes in water use factors for 2016-2018 plant conversions and unit additions .

Plant	Year Completed	Average Water Use Factor 2000 – 2010 gal/MWh	Water Use Factor after Modification – gal/MWh
Allen	2018	33,801	364
Paradise	2017	8,990	3,108
Watts Bar	2016	7,525	4,927

4.4.3.5 Water Use at Facilities Considered for Future Retirement

Several TVA facilities have units that are identified for potential retirement in the 20-year study period of this IRP . Recent water use at the coal plants identified for potential retirement (Shawnee, Cumberland, Gallatin, and Kingston), as well as their water use factors, are shown in Table 4-8. The CT units identified for potential retirement (Allen, Gallatin, Colbert, and Johnsonville) do not makewater withdrawals and are not included in water use factor calculations.

4.4.4 Aquatic Life

4.4.4.1 Regulatory Framework for Aquatic Life

Aside from the Endangered Species Act (ESA) and related state laws described in Section 4.5.3, and harvest regulations established by states, the CWA is the major law affecting aquatic life. Water quality standards and NPDES discharge limits are established, in part, to protect aquatic life. CWA Section 316 regulates (a) the design and operation of cooling water intake structures to minimize adverse effects to aquatic life from entrainment and impingement, and (b) wastewater discharges in order to minimize adverse effects of heat on aquatic life.

4.4.4.2 Aquatic Life within the TVA Region

The TVA region encompasses portions of several major river systems including all of the Tennessee River drainage and portions of the Cumberland River drainage, Mobile River drainage (primarily the Coosa and Tombigbee Rivers), and larger eastern tributaries to the Mississippi River in Tennessee and Mississippi (Figure 4-14). These river systems support a large variety of freshwater fishes and invertebrates (including freshwater mussels, snails, crayfish, and insects). Due to the presence of several major river systems, the region's high geologic diversity (see Section 4.5.1), and the lack of glaciation, the region is recognized as a globally important area for freshwater biodiversity (Stein et al. 2000).

4.4.4.3 Aquatic Life at Facilities Considered for Future Retirement

Aquatic life in the vicinity of the eight TVA plants that are candidates for partial or full retirement is described in this subsection.

Shawnee Fossil Plant

Shawnee Fossil Plant is located approximately 10 miles west of Paducah, Kentucky along the Ohio River and within the Ohio River–Bayou Creek Hydrologic Unit (Code 051402060701). Natural streams in this region generally are low-gradient, meandering channels with silt and sand bottoms, often filled with woody debris, and inhabited by fish fauna typical of the Ohio River basin. The Shawnee facility is bordered by the Ohio River and Little Bayou Creek, which are all classified as warm-water aquatic habitat (TVA 2018e).

The Ohio River Valley Water Sanitation Commission (ORSANCO) operates programs to improve water quality in the Ohio River and its tributaries, including setting waste water discharge standards, performing biological assessments, and monitoring the physical and chemical properties of the waterway. Fish population data was collected in 2009 at 17 randomly selected locations throughout the reach of the Ohio River near Shawnee (ORSANCO 2009). Forty-eight fish species and one hybrid taxon were collected, representing 13 different families. Overall, the most abundant species collected was gizzard shad, with large numbers of freshwater drum, river carpsucker, channel catfish, sauger, longear sunfish, yellow bass, and bluegill also collected. Benthic substrate samples collected in the river revealed that it is dominated by sand followed by fines then gravel. Woody cover was present at all of the 17 sample sites and riparian land cover was primarily natural forest with some agriculture and residential uses present. The section of the Ohio River adjacent to Shawnee is designated critical habitat for the threatened rabbitsfoot mussel. A generally balanced, indigenous, aquatic community exists in the Ohio River adjacent to Shawnee, although fish consumption advisories are in effect for Little Bayou Creek due to pollutants that include metals and radiation (KDEP 2016).

Kingston Fossil Plant

Kingston Fossil Plant is located on a peninsula at the confluence of the Emory and Clinch rivers on Watts Bar Reservoir. The Kingston discharge point is located across the peninsula at Clinch River Mile (CRM) 2.6, while the intake is located at Emory River Mile (ERM) 1.9. The Watts Bar Dam impounds the 39,090-ac Watts Bar Lake (TVA 2016a).

Shoreline and substrate sections were evaluated for aquatic habitat upstream and downstream of Kingston in 2013. The shoreline sections had average scores of "fair," while limited aquatic macrophytes were noted along approximately 25 percent of the banks during the shoreline evaluation. The substrate was dominated by clay (56.8 percent), silt (14.9 percent) and bedrock (9.3 percent) downstream of Kingston and by clay (36.7 percent), detritus (19.4 percent) and sand (14.7 percent) upstream of Kingston (TVA 2014a).

TVA has evaluated the health of the fish community near CRM 1.5 downstream of Kingston and at CRM 4.4 upstream of Kingston. The fish community rated "good" at both of these locations in 2013. Historically, the fish community has rated "good" at these locations. During the 2013 study, 31 indigenous species were collected at the downstream site and 31 at the upstream site; this includes 16 commercially valuable and 23 recreationally valuable species as follows:

- Common centrarchid species present at Kingston included bluegill, longear sunfish, redear sunfish, warmouth and green sunfish.
- Benthic invertivore species present included black redhorse, freshwater drum, logperch, northern hogsucker, spotted sucker, golden redhorse and silver redhorse.
- Top carnivore species present included largemouth bass, skipjack herring, smallmouth bass, spotted gar, yellow bass, striped bass, spotted bass, hybrid bass, sauger, walleye, rock bass and flathead catfish.
- Intolerant species present included skipjack herring, northern hogsucker, spotted sucker, black redhorse, longear sunfish, smallmouth bass, brook silverside and rock bass. In addition, two thermally sensitive species, spotted sucker and logperch, were present.
- Aquatic nuisance species included common carp, redbreast sunfish, striped bass and Mississippi silverside that were collected at the downstream and upstream of Kingston and yellow perch that was collected upstream of Kingston (TVA 2014a).

Benthic community data was collected from three sites upstream and downstream of Kingston in 2013. Monitoring results for 2013 support the conclusion that a balanced indigenous population of benthic macroinvertebrates is maintained downstream of Kingston. Sites had taxa averages of 17.0, 14.1 and 17.5 at CRM 1.5, 2.2 and 3.75, respectively. The Ephemeroptera, Plecoptera and Trichoptera taxa present were 1.2, 1.7 and 1.5 at CRM 1.5, 2.2 and 3.75, respectively, mid- to high-range numbers. In addition, the proportion of oligochaetes were 15 percent, 7.2 percent and 10 percent, also mid- to high-range numbers (TVA 2014a).

The mussel fauna in the Emory River near Kingston has been greatly altered by the impoundment of Watts Bar Reservoir while upstream impacts include mining and urbanization. Six mussel species (the giant floater, fragile papershell, pistolgrip, pimpleback, wartyback and three-horn wartyback) and a common aquatic snail (hornsnail) were found in a survey of this area (Yokley 2005; Parmalee and Bogan 1998). All of these species, except pistolgrip, are considered tolerant of reservoir conditions.

Cumberland Fossil Plant

Cumberland Fossil Plant is located on Barkley Reservoir (Cumberland River, a tributary to the Ohio River). The Cumberland River is impounded prior to its confluence with the Ohio River to create Lake Barkley (TVA 2018f). Near Cumberland, Lake Barkley-Cumberland River is more riverine, approximately 72 miles upstream of Lake Barkley Dam. Cumberland is located along the left descending bank near River Mile (RM) 103. Lake Barkley-Cumberland River adjacent to Cumberland is characterized as having poor to fair shoreline aquatic habitat with no aquatic macrophytes. The fish community consists of more warmwater species with a mix of species typical of both rivers and reservoirs due to the Cumberland proximity to the main stem of Lake Barkley and more riverine conditions near the Cumberland (TVA 2016b).

Wells Creek is a small tributary of the Cumberland River that flows south-north through the central portion of the Cumberland property. Scott Branch is a tributary of Wells Creek that flows west-east through the property. Due to their proximity and connection to the Cumberland River, species composition and abundances are expected to be similar to that described above for the Cumberland River.

TVA has used a Reservoir Ecological Health monitoring program since 1990 to evaluate ecological conditions in major reservoirs in the region. A component of this monitoring program is a multi-metric approach to data evaluation for fish communities known as the Reservoir Fish Assemblage Index (RFAI). Fish communities are used to evaluate ecological conditions because of their importance in the aquatic food web and because fish life cycles are long enough to integrate conditions over time. Benthic macroinvertebrate populations are assessed using the Reservoir Benthic Index (RBI) methodology. Because benthic macroinvertebrates are relatively immobile, negative impacts to aquatic ecosystems can be detected earlier in benthic macroinvertebrate communities than in fish communities. A component of this monitoring program includes sampling the benthic macroinvertebrate community (TVA 2016b).

TVA sampled fish upstream and downstream of Cumberland between RM 102 and 107 in the spring, summer, and autumn of 2015. Upstream of Cumberland, 1,576 fish (34 species) were collected in the spring 2015, 753 fish (32 species) were collected in the summer 2015, and 597 fish (37 species) were collected in the autumn 2015. Typical species upstream of Cumberland included gizzard shad, spotfin shiner, emerald shiner, yellow bass, bluegill, longear sunfish, and largemouth bass. Downstream of Cumberland, 1,643 fish (32 species) were collected in the spring 2015, 604 fish (27 species) were collected in the summer 2015, and 705 fish (31 species) were collected in the autumn 2015. Typical species downstream of Cumberland included threadfin shad, longear sunfish, emerald shiner, largemouth bass, bluegill, gizzard shad, and yellow bass. Ecological health ratings were similar for both the upstream and downstream sites for all three seasons, ranging from fair to good (TVA 2016b).

As part of the same TVA 2015 study, benthic (or bottom-dwelling) invertebrates were also collected. Oligochaetes, chironomids, and Asiatic clams were the dominant taxa both upstream and downstream of Cumberland. Ecological health ratings were similar between the upstream and downstream sites for all three seasons, ranging from fair to good (TVA 2016b).

A 2011 mussel survey conducted to characterize the freshwater mollusk community on the Cumberland River (spot dives) and Wells Creek (along sampling transects) near Cumberland found low abundances of a small number of relatively common mussel species. The three most numerous freshwater mussel species included mapleleaf, wartyback, and pink heelsplitter. On the Cumberland River, 24 mussels were collected from 23 locations (catch per unit effort = 9 mussels/hour). On Wells Creek, 11 mussels were collected along four transect locations (density = 0.05 mussels/square meter) (Third Rock Consultants 2011).

Gallatin Fossil Plant

The Gallatin Fossil Plant is located within a large peninsula on Old Hickory Lake at Cumberland River mile (CRM) 241.5 to 246.0. The Cumberland River was altered from a free-flowing river to a reservoir due to impoundment by Old Hickory Dam, located 27 river miles downstream. Upstream of Gallatin, Old Hickory Lake extends 70 river miles to Cordell Hull Dam (TVA 2017e).

The cooling water discharge channel is commonly visited by local fishermen on the reservoir, particularly in winter when the warm water of the discharge attracts fish. Beginning in 2001, TVA began a fish community monitoring program in the Cumberland River downstream (CRM 239 to CRM 240.6) and upstream (CRM 248.4 to CRM249.9) of the Gallatin discharge in order to verify that a Balanced Indigenous Population of aquatic life was being maintained. Fish community monitoring was conducted during 2001, 2002, 2003, 2005, 2007, 2008, 2010, 2011, 2012, 2013, and 2014. (TVA 2016c). Over the 11 sampling years, the average RFAI scores at the location just downstream of the Gallatin discharge and at the reference location upstream of Gallatin were identical, and differences between the scores for each location was six points or less each sample year, with the downstream location scoring higher than or within two points of the upstream location in eight of 11 years. The condition of the fish community downstream of Gallatin has been rated as fair to good in each of the years it was evaluated, with an average rating of fair based on an average score of 40. The condition of the fish community upstream of Gallatin also has been rated as fair to good in each of the years it was evaluated, with an average rating of good based on an average score of 41. Thus, the difference in fish community ratings upstream and downstream of Gallatin is minimal and does not indicate that the fish community has been adversely affected by the long-term operation of Gallatin.

Similar to the fish community monitoring program, the benthic macroinvertebrate community is monitored at two upstream and two downstream locations in the Cumberland River. Benthic macroinvertebrate monitoring was conducted during 2010, 2011, 2012, 2013, and 2014 (TVA 2016c). Recent benthic macroinvertebrate data indicated healthy benthic communities downstream and upstream of Gallatin, with the downstream locations consistently scoring higher than the upstream locations and rated as excellent the last two years. Thus, the benthic community ratings upstream and downstream of Gallatin do not indicate that the benthic macroinvertebrate community has been adversely affected by the operation of Gallatin. Neither fish nor benthic macroinvertebrate data indicate adverse impacts from Gallatin to the aquatic community downstream of the Gallatin discharge (TVA 2013a and 2016c).

Allen Combustion Turbine Plant

Allen CT Plant is co-located on the Allen Fossil Plant and CC plant reservation. Allen CT Plant and Fossil Plant lies approximately 1.8 miles east of the Mississippi River at Mississippi River Mile 725, and is located approximately 7.7 miles from downtown Memphis along the southern shore of McKellar Lake. McKellar Lake is an oxbow lake (a lake formed in the bend of a river) that has a watershed area of 2,176 ac (TVA 2014b). It connects to the Mississippi and much of the lake shoreline is developed for industrial and commercial purposes. The water quality in the lake is considered impaired (TDEC 2014). Fish consumption advisories have been in effect for the entirety of McKellar Lake since 2010 due to elevated levels of mercury, chlordane and other organics.

Gallatin Combustion Turbine Plant

The Gallatin CT Plant is located adjacent to the Gallatin Fossil Plant (see above).

Colbert Combustion Turbine Plant

The Colbert CT Plant is on the same reservation as the recently retired Colbert Fossil plant. Colbert Fossil plant is located within the Tennessee River-Pickwick Lake watershed, on the eastern shore of the Pickwick Reservoir at Tennessee River Mile (TRM) 245. The reach of the Tennessee River adjacent to Colbert Fossil plant has been altered from its former free-flowing character by the presence of Pickwick Dam, located approximately 38 river miles downstream of COF, and Wilson Dam, located approximately 14 miles upstream of Colbert Fossil plant (TVA 2016d).

TVA initiated a study in 2000 to evaluate fish communities in areas immediately upstream and downstream of Colbert Fossil plant in Pickwick Reservoir using RFAI multimetric evaluation techniques. Overall results indicate that the fish assemblage in Pickwick Reservoir has been consistently “good” to “fair” from 2000 to 2014.

Johnsonville Combustion Turbine Plant

The Johnsonville CT Plant is located adjacent to the retired Johnsonville Fossil Plant. Johnsonville Fossil Plant is located in Humphreys County, Tennessee, in the Western Highland Rim subregion of the greater Interior Plateau ecoregion (Griffith et al. 1998). Johnsonville Fossil Plant lies within the Tennessee River 10-digit Hydrologic Unit Code (HUC) watershed 0604000504. The Western Highland Rim of the Interior Plateau is characterized by dissected, rolling terrain of open hills, with elevations of 400-1000 feet. Soils in this region tend to be acidic, cherty, and moderate in fertility (Griffith et al. 1998). Streams in this region are relatively clear with moderate gradients, with substrates consisting primarily of course chert gravel and sand with some bedrock. Much of the region is heavily forested, with some agriculture in the stream and river valleys.

Johnsonville Fossil Plant and CT Plantare located on the eastern shore of Kentucky Reservoir at TRM 100. The reach of the Tennessee River adjacent to

Johnsonville Fossil Plant has been altered from its former free-flowing character by the presence of Kentucky Dam, located approximately 76 river miles downstream of Johnsonville Fossil Plant, and Pickwick Dam, located approximately 107 river miles upstream (TVA 2018g).

Reservoir Benthic Index data was collected upstream and downstream of Johnsonville Fossil Plant from 2001 to 2017. Compared to stations at other TVA run-of-the-river reservoirs, monitoring sites on Kentucky Reservoir have consistently rated "Fair" to "Excellent" since 2001.

TVA initiated a study in 2001 to evaluate fish communities in areas immediately upstream and downstream of Johnsonville Fossil Plant using RFAI multi-metric evaluation techniques. Electrofishing and gill netting sampling stations correspond to those described for benthic macroinvertebrate sampling (TVA 2011a). Overall Reservoir Ecological Health fish community monitoring results indicate that the Kentucky fish assemblage has been consistently "good" from 2001 to 2017, with the exception of the "excellent" score at the inflow in 2011 (TVA 2011a).

4.5 Land Resources

This section describes the land resources in the TVA region that could be affected by the alternative strategies. The potentially affected land resources include geology, vegetation and wildlife, endangered and threatened species, wetlands, parks, managed areas and ecologically significant sites, land use, and cultural resources.

4.5.1 Geology

The TVA region encompasses portions of the following major physiographic provinces and physiographic sections (Figure 4-18) (Fenneman 1938, Miller 1974).

- Blue Ridge
- Valley and Ridge
- Interior Low Plateaus Province
    - Highland Rim
    - Nashville Basin
- Appalachian Plateaus Province
    - Cumberland Plateau
    - Cumberland Mountains
- Coastal Plain Province
    - East Gulf Coastal Plain

Physiographic provinces and sections are areas of characteristic geomorphology and geology resulting from similar geologic events.

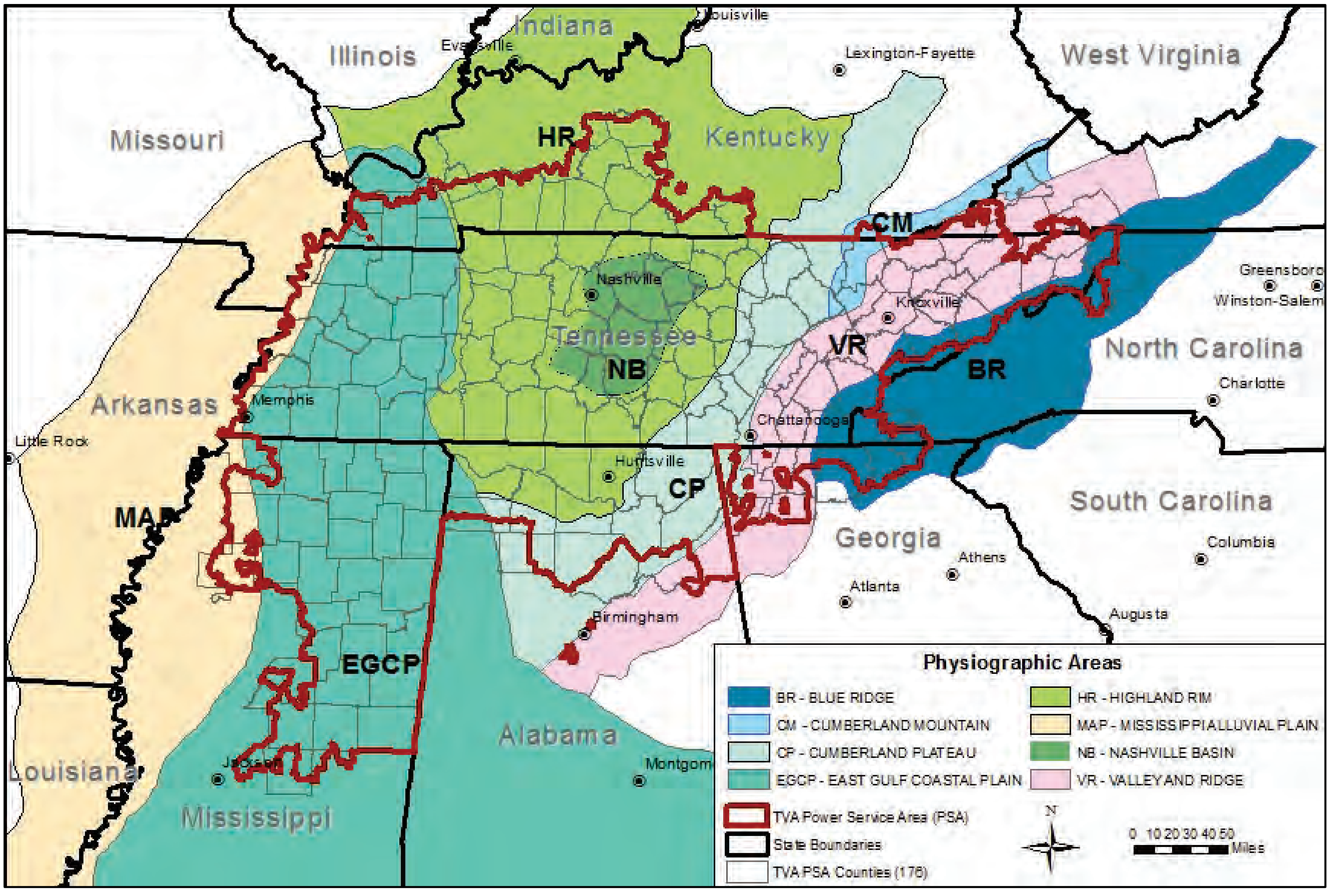

Figure 4-18: Physiographic areas of TVA region. Adapted from Fenneman (1938).

The easternmost part of the region is the Blue Ridge physiographic province, an area composed of the remnants of an ancient mountain chain. This province has the greatest variation in terrain within the TVA region. Terrain ranges from nearly level along floodplains at elevations of about 1,000 feet to rugged mountains that reach elevations greater than 6,000 feet above sea level. The rocks of the Blue Ridge have been subjected to significant folding and faulting and are primarily sedimentary (shales, sandstones, conglomerates, quartzite) and metamorphic (slate, phyllite, gneiss) rocks of Precambrian and Cambrian age.

Located west of the Blue Ridge and east of the Appalachian Plateau, the Valley and Ridge Province is characterized by alternating valleys and ridges that trend northeast to southwest. Ridges have elevations up to 3,000 feet and are generally capped by dolomites and resistant sandstones, while valleys have been formed in less resistant dolomites and limestones. Dominant soils in this province are residual clays and silts derived from in-place weathering of rock. Karst features such as sinkholes and springs are common in the Valley and Ridge province.

The Appalachian Plateaus Province is an elevated area between the Valley and Ridge and Interior Low Plateaus provinces. It is comprised of two sections in the TVA region: the extensive Cumberland Plateau and the smaller Cumberland Mountains (Figure 4-18). The Cumberland Plateau rises about 1,000 – 1,500 feet above the adjacent provinces and is formed by layers of near horizontal Pennsylvanian sandstones, shales, conglomerates and coals, underlain by Mississippian and older shale and limestones. The sandstones are resistant to erosion and have produced a relatively flat landscape cut by deep stream valleys. Toward the northeast, the Cumberland Mountains section is more rugged due to extensive faulting and several peaks exceeding 3,000 feet elevation. The province has a long history of coal mining and encompasses the Appalachian coal field (USGS 1996). Coal mining has historically occurred in much of the province. The most recent Appalachian coal mining within the TVA region has been from the southern end of the province in Alabama, the northern portion of the Cumberland Plateau section in Tennessee and the Cumberland Mountains section.

Two sections of the Interior Low Plateaus Province occur in the TVA region. The Highland Rim section is a plateau that occupies much of central Tennessee and parts of Kentucky and northern Alabama. The bedrock of the Highland Rim is Mississippian limestones, chert, shale, and sandstone. The terrain varies from hilly to rolling to extensive relatively flat areas in the northwest and southeast. The southern end of the Illinois Basin coal region (USGS 1996) overlaps the Highland Rim in northwest Kentucky and includes part of the TVA region. The Nashville Basin (also known as the Central Basin) section is an oval area in middle Tennessee with an elevation about 200 feet below the surrounding Highland Rim. The bedrock is composed of generally flat-lying limestones. Soil cover is usually thin and streams cut into bedrock. Karst is well-developed in parts of both the Highland Rim and the Nashville Basin.

The Coastal Plain Province encompasses much of the western and southwestern TVA region (Figure 4-18). Most of the Coastal Plain portion of the TVA region is in the extensive East Gulf Coastal Plain section. The underlying geology is a mix of poorly consolidated gravels, sands, silts and clays. Soils are primarily of windblown and alluvial (deposited by water) origin, low to moderate fertility and easily eroded. The terrain varies from hilly to flat in broad river bottoms. The Mississippi Alluvial Plain section occupies the western edge of the TVA region and much of the historic floodplain of the Mississippi River. Soils are deep and often poorly drained. The New Madrid Seismic Zone, an area of large prehistoric and historic earthquakes, is in the northern portion of the section.

4.5.1.1 Geologic Carbon Dioxide Sequestration Potential

The sequestration (i.e., capture and permanent storage) of CO_2 from large stationary point sources, such as coal-fired power plants, is potentially an important component of efforts to significantly reduce anthropogenic CO_2 emissions. Successful large-scale, economical CO_2 sequestration (also referred to as carbon capture and storage (CCS)) would enable coal to continue to be used as an energy source with greatly reduced CO_2 emissions. Few power plant CCS projects are currently operating and the technology is in a relatively early stage of development.

Geologic CO_2 storage involves capturing and separating the CO_2 from the power plant exhaust; drying, purifying, and compressing the CO_2; and transporting it by pipeline to the storage site where it is pumped through wells into deep geological formations. When the CO_2 capacity of the formation has been reached or when the pressure of the formation or injection well has reached a pre-determined level, CO_2 injection is stopped and the wells are permanently sealed. The storage site would then be monitored for a period of time.

The suitability of a particular underground formation for CO_2 storage depends on its geology, as well as the geology of adjacent and overlying formations. In the central and southeastern U.S., deep saline formations, unmineable coal seams, and oil and gas fields are considered to have the best potential to store CO_2 from large point sources (NETL 2012). A brief description of each of these formations, as well as its storage potential in and near the TVA PSA, is given below.

In 2002, the Department of Energy's National Energy Technology Laboratory launched the Regional Carbon Sequestration Program to identify and evaluate carbon sequestration in different regions of the country. Areas studied include parts of the Southeast and the Illinois Basin area of Illinois, Indiana and Kentucky. Experimental CO_2 injection tests for enhanced coalbed methane recovery have been conducted in southwest Virginia and for enhanced oil recovery in southwest Kentucky (NETL 2012a).

Saline Formations – Saline formations are layers of porous rock that are saturated with brine. They are more extensive than unmineable coal seams and oil and gas fields and have a high CO_2 storage potential. However, because they are less studied than the other two formations, less is known about their suitability and storage capacity. Potentially suitable saline formations are capped by one or more layers of non-porous rock, which would prevent the upward migration of injected CO_2. Saline formations also contain minerals that could react with injected CO_2 to form solid carbonates, further sequestering the CO_2. Saline formations provide the greatest potential for CO_2 storage in the TVA region. Middle Tennessee and much of west-central Kentucky are underlain by the Mt. Simon and associated basal sandstone formations. These deep formations have a potential CO_2 storage capacity of up to about 9 billion metric tons. Recent research conducted by the Tennessee Geological Survey has shown that the shallower Knox-Stones River Groups underlying the Cumberland Plateau may be a viable storage reservoir. The extensive Tuscaloosa Group in Alabama and Mississippi south of the TVA region also has a high potential for CO_2 storage (NETL 2012).

Unmineable Coal Seams – Unmineable coal seams are typically too deep or too thin to be economically mined. When CO_2 is injected into them, it is adsorbed onto the surface of the coal. Although their storage potential is much lower than saline formations, they are attractive because they are relatively shallow and because the injected CO_2 can be used to displace coalbed methane, which can be recovered in adjacent wells and used as a natural gas substitute. Coal seams within the TVA region in Tennessee and Alabama have little potential for CO_2 storage. Coal seams with greater potential near the TVA PSA occur in southwest Virginia, in Alabama and Mississippi south of the TVA PSA, and in the Illinois Basin of western Kentucky mostly north of the TVA PSA (NETL 2012).

Natural gas-producing shales in the Illinois Basin also offer the potential for storing CO_2, including its use for enhanced gas recovery (NETL 2012). The occurrence of suitable unmineable coal seams and organic-rich shales in the TVA region is limited, but more extensive elsewhere in the Illinois Basin, as well as in southeast Kentucky/southwest Virginia, west-central Alabama, and southwest Mississippi.

Oil and Gas Fields – Mature oil and gas fields/reservoirs are considered good storage formations because they held crude oil and natural gas for millions of years. Their storage characteristics are also well known and some are currently used for storing natural gas. Like saline formations, they consist of layers of permeable rock with one or more layers of cap rock. Injected CO_2 can also enhance the recovery of oil or gas from mature fields. The potential for CO_2 storage in the oil and gas fields of Tennessee, southwest Virginia, and east-central Mississippi is limited (NETL 2012). Greater potential exists in oil and gas fields in central southern Mississippi. The potential for CO_2 storage is also high in the gas-rich New Albany Shale in northwest Kentucky and adjacent Illinois and Indiana (NETL 2012).

The Kemper County integrated gasification combined cycle (IGCC) plant was constructed near the southern edge of the TVA PSA in Mississippi; as originally designed, CO_2 from the plant would have been captured and used for enhanced oil recovery in oil fields south of the TVA PSA (USDOE 2010, NETL 2012). Due to problems unrelated to the area's CO_2 sequestration potential, the plant is being operated as a CC plant fueled by natural gas (Wagman 2017).

4.5.2 Vegetation and Wildlife

The TVA region encompasses nine ecoregions (Omernik 1987) which generally correspond with physiographic provinces and sections (see Section 4.5.1 and Figure 4-18).

1. Blue Ridge
2. Ridge and Valley
3. Central Appalachian
4. Southwestern Appalachian
5. Interior Plateau
6. River Valley and Hills
7. Southeastern Plains
8. Mississippi Valley Loess Plain
9. Mississippi Alluvial Plain

The terrain, plant communities, and associated wildlife habitats in these ecoregions vary from bottomland hardwood and cypress swamps in the floodplains of the Mississippi Alluvial Plain to high elevation balds and spruce-fir and northern hardwood forests in the Blue Ridge. About 3,500 species of herbs, shrubs and trees, 55 species of reptiles, 72 species of amphibians, 182 species of breeding birds and 76 species of mammals occur in the TVA region (Ricketts et al. 1999, Stein 2000, TWRA 2005, TOS 2014). Although many plants and animals are widespread across the region, others are restricted to one or a few ecoregions. For example, high elevation communities in the Blue Ridge support several plants and animals found nowhere else in the world (Ricketts et al. 1999), as well as isolated populations of species typically found in more northern latitudes.

4.5.2.1 Regulatory Framework for Vegetation and Wildlife

Aside from the ESA and related state laws described in Section 4.5.3, there are few laws specifically focused on protecting plant species and plant communities. The Plant Protection Act of 2000 consolidated previous legislation and authorized the U.S. Department of Agriculture (USDA) to issue regulations to prevent the introduction and movement of identified plant pests and noxious weeds. E.O. 13112 – Invasive Species directs Federal agencies to prevent the introduction of invasive species (both plants and animals), control their populations, restore invaded ecosystems and take other related actions. E.O. 13751 – Safeguarding the Nation from the Impacts of Invasive Species amends E.O. 13112 and directs actions to continue coordinated Federal prevention and control efforts related to invasive species. Agencies are also directed to incorporate consideration of human and environmental health, climate change, technological innovation, and other emerging priorities into their efforts to address invasive species (USDA 2018a).

A number of species of wildlife are protected under the ESA and related state laws. In addition to these laws, the regulatory framework for protecting birds includes the Migratory Bird Treaty Act (MBTA) of 1918, the Bald and Golden Eagle Protection Act of 1940 and E.O. 13186 – Responsibilities of Federal Agencies to Protect Migratory Birds. The MBTA and E.O. 13186 address most native birds occurring in the U.S. The MBTA makes the purposeful taking, killing, or possession of migratory birds, their eggs, or nests unlawful, except as authorized under a valid permit. Federal agency actions are not subject to the MBTA. E.O. 13186, however, focuses on Federal agencies taking actions with the potential to have negative impacts on populations of migratory birds. It provides broad guidelines on avian conservation responsibilities and requires agencies whose actions affect or could affect migratory bird populations to develop a memorandum of understanding (MOU) on migratory bird conservation with the U.S. Fish and Wildlife Service (USFWS). TVA is currently coordinating with USFWS the development of an MOU under the E.O. 13186.

Aside from federal and state laws regulating the hunting, trapping or other capture, and possession of some species, most wildlife other than birds generally receives no legal protection.

4.5.2.2 Regional Vegetation

The southern Blue Ridge Ecoregion, which corresponds to the Blue Ridge physiographic province, is one of the richest centers of biodiversity in the eastern United States and one of the most floristically diverse (Griffith et al. 1998). The most prevalent land cover (80 percent) is forest, dominated by the diverse, hardwood-rich mesophytic forest and its Appalachian oak subtype (Dyer 2006; USGS 2016). About 14 percent of the land cover is agricultural and most of the remaining area is developed. Relative to the other eight ecoregions, the Blue Ridge Ecoregion had the least change in land cover from 1973 through 2000 (USGS 2016).

Over half (56 percent) of the Ridge and Valley Ecoregion, which corresponds to the Valley and Ridge physiographic province, is forested. Dominant forest types are the mesophytic forest and Appalachian oak sub-type. In the southern portion of the region, the southern mixed forest and oak-pine sub-type (Dyer 2006, USGS 2016) dominate. About 30 percent of the area is agricultural and 9 percent is developed (USGS 2016).

The Cumberland Mountains physiographic section comprises the southern portion of the Central Appalachian Ecoregion. This ecoregion is heavily forested (83 percent), primarily with mesophytic forests including large areas of Appalachian oak (Dyer 2006, USGS 2016). The remaining land cover is mostly agriculture (7 percent), developed areas (3 percent) and mined areas (3 percent). The dominant source of land cover change from 1973 through 2000 was mining (USGS 2016), and this ecoregion, together with the Southwestern Appalachian Ecoregion, comprises much of the Appalachian coalfield.

The Southwestern Appalachian Ecoregion corresponds to the Cumberland Plateau physiographic section. About 75 percent of the land cover is forest, predominantly mesophytic forest; about 16 percent is agricultural and 3 percent is developed (USGS 2016). The rate of land cover change from 1973 through 2000 is relatively high, mostly due to forest management activities.

The Interior Plateau Ecoregion consists of the Highland Rim and Nashville Basin physiographic sections. The limestone cedar glades and barrens communities associated with thin soils and limestone outcrops in the Nashville Basin support rare, diverse plant communities with a high proportion of endemic (i.e., restricted to a particular area) species (Baskin and Baskin 2003). About 38 percent of the ecoregion is forested, 50 percent in agriculture and 9 percent developed (USGS 2016). Forests are predominantly mesophytic, with a higher proportion of American beech, American basswood and sugar maple than in the Appalachian oak subtype (Dyer 2006). Eastern red cedar is also common. For the ecoregion as a whole, the rate of land cover change has been relatively low, with the predominant changes from forest and agriculture to developed land. The rate of these changes from the 1970s to the present has been very high in the greater Nashville and Huntsville areas.

A small area in the northwest of the TVA region is in the Interior River Valley and Hills Ecoregion, which overlaps part of the Highland Rim physiographic section. This ecoregion is relatively flat lowland dominated by agriculture (almost two-thirds), with about 20 percent forested hills, 7 percent developed, and 5 percent wetlands (USGS 2016). It contains much of the Illinois Basin coalfield. Drainage conditions and terrain strongly affect land use. Bottomland deciduous forests and swamp forests were common on wet lowland sites, with mixed oak and oak-hickory forests on uplands. A large portion of the lowlands has been cleared for agriculture. The rate of land cover change from 1973 through 2000 is moderate and primarily from forest to agriculture and from agriculture and forest to developed.

The Southeastern Plains and Mississippi Valley Loess Plain Ecoregions correspond, respectively, to eastern and western portions of the East Gulf Coastal Plain physiographic section. These ecoregions are characterized by a mosaic of forests (52 percent of the land area), agriculture (22 percent), wetlands (10 percent) and developed areas (10 percent). Forest cover decreases and agricultural land increases from east to west. Natural forests of pine, hickory, and oak once covered most of the ecoregions, but much of the natural forest cover has been replaced by heavily managed timberlands, particularly in the Southeastern Plains (USGS 2016). The Southeastern Plains in Alabama and Mississippi include the Black Belt, an area of rich dark soils and prairies. Much of this area has been cleared for agricultural purposes and only remnant prairies remain. The rate of land cover change in the Southeastern Plains Ecoregion is the highest of the nine ecoregions in the TVA region, with intensive forest management practices the leading cause of the change. The rate of land cover change in the Mississippi Valley Loess Plain Ecoregion is moderate to high relative to the other ecoregions.

The Mississippi Alluvial Plain is a flat floodplain area originally covered by bottomland deciduous forests. A large portion has been cleared for agriculture and subjected to drainage activities including stream channelization and extensive levee construction. Most of the land cover is agricultural and the remaining forests are southern floodplain forests dominated by oak, tupelo and bald cypress. The rate of land cover change since the 1970s has been moderate (USGS 2016), with the major land cover change from agriculture to developed.

The major forest regions in the TVA region include mesophytic forest, southern-mixed forest, and

Mississippi alluvial plain (Dyer 2006). The mesophytic forest is the most diverse with 162 tree species. While canopy dominance is shared by several species, red maple and white oak have the highest average importance values. A distinct section of the mesophytic forest, the Appalachian oak section, is dominated by several species of oak including black, chestnut, northern red, scarlet and white oaks. The Nashville Basin mesophytic forest has close affinities with the beech-maple-basswood forest that dominates much of the Midwest. The oak-pine section of the southern mixed forest region occurs in portions of Alabama, Georgia and Mississippi, where the dominant species are loblolly pine, sweetgum, red maple and southern red oak (Dyer 2006). The Mississippi alluvial plain forest region is restricted to its namesake physiographic region. The bottomland forests in this region are dominated by American elm, bald cypress, green ash, sugarberry and sweetgum.

Numerous plant communities (recognizable assemblages of plant species) occur in the TVA region. Several of these communities are rare, restricted to very small geographic areas and/or threatened by human activities. A disproportionate number of these imperiled communities occur in the Blue Ridge region; smaller numbers are found in the other ecoregions (NatureServe 2018). Many of the imperiled communities occur in the Southern Appalachian spruce-fir forest; cedar glades; grasslands, prairies and barrens; Appalachian bogs, fens and seeps; and bottomland hardwood forest ecosystems. Major threats to the Southern Appalachian spruce-fir forest ecosystem include invasive species such as the balsam wooly adelgid, acid deposition, ozone exposure and climate change (TWRA 2009). The greatest concentration of cedar glades is in the Nashville Basin; a few also occur in the Highland Rim and the Valley and Ridge. Cedar glades contain many endemic plant species, including a few listed as endangered (Baskin and Baskin 2003); threats include urban development, highway construction, agricultural activities, reservoir impoundment and incompatible recreational use. The category of grasslands, prairies and barrens includes remnant native prairies; they are scattered across the TVA region but most common on the Highland Rim. This category also includes the high elevation grassy balds in the Blue Ridge and the Black Belt prairie in the East Gulf Coastal Plain. Threats to these areas include agricultural and other development, invasive plants and altered fire regimes. Appalachian bogs, fens and seeps are often small, isolated, and support several rare plants and animals. Threats include drainage for development and altered fire regimes. Bottomland hardwood forests are most common in the Mississippi Alluvial Plain and East Gulf Coastal Plain; they also occur in other physiographic regions. About 60 percent of their original area is estimated to have been lost, largely by conversion to croplands (USEPA 2018d).

4.5.2.3 Wildlife Population Trends

Many animals are wide-ranging throughout the TVA region; most species tolerant of humans have stable or increasing populations. The populations of many animals have been greatly altered by changes in habitats from agriculture, mining, forestry, urban and suburban development and the construction of reservoirs. While some species flourish under these changes, others have shown marked declines. For example, populations of several birds dependent on grassland and forest have shown dramatic decreases in their numbers (SAMAB 1996). Across North America, 27 percent of grassland-breeding birds are of high conservation concern because of declining populations, as are 22 percent of temperate forest-breeding birds (NABCI 2016). A large number of the declining birds are Neotropical migrants, species that nest in the United States and Canada and winter south of the United States. Over 30 species of birds breeding in the TVA region are considered to be of conservation concern (USFWS 2008). A few additional bird species are considered to be of management concern because of overly abundant populations, leading to damage to natural ecosystems and human interests (USFWS 2011); the resident population of the Canada Goose in the TVA region is an example of such species. Global amphibian declines have been well documented, but declines in amphibian populations in the TVA region also have been reported (Caruso and Lips 2012). The primary causes for these declines are the loss and fragmentation of habitats from urban and suburban development and agricultural and forest management practices. Introduced pathogens have also contributed to wildlife population declines. Populations of bats have been observed dying off in the TVA region after the introduction of a novel pathogen causing white nose-syndrome. In general gulls, wading birds, waterfowl, raptors, upland game birds (with the exception of the northern bobwhite) and game mammals are stable or increasing in the TVA region.

The construction of the TVA and USACE reservoir systems created large areas of habitat for waterfowl, herons and egrets, ospreys, gulls and shorebirds, especially in the central and eastern portions of the TVA region where this habitat was limited. Ash and gypsum settling and storage ponds at TVA fossil plants also provide regionally important habitat for these birds and other wetland species although many of these are being closed (see Section 4.7). These overall increases in aquatic habitats, as well as the ban on the use of the pesticide dichlorodiphenyltrichloroethane (DDT), have resulted in large increases in resident and migratory populations of several birds in the TVA region. Both short-term and long-term changes in the operation of the reservoir system affect the quality of habitat for these species (TVA 2004), as do pond management practices at fossil plants.

4.5.2.4 Invasive Species

Invasive species are species that are not native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health (NISC 2016). Invasive species include terrestrial and aquatic plants and animals as well as other organisms such as microbes. Human actions, both intentional and unintentional, are the primary means of their introductions.

Four plants designated by the USDA as noxious weeds under the Plant Protection Act occur in the TVA region: hydrilla, cogongrass and tropical soda apple (USDA 2010). Hydrilla is a submersed aquatic plant present in several TVA reservoirs. Giant salvinia, also an aquatic plant, occurs in ponds, reservoirs and slow-moving streams. It primarily occurs south of the TVA region and has not yet been reported from the Tennessee River drainage. Cogongrass is an upland plant present in several TVA region counties in Alabama and Mississippi. It occurs on and near several TVA transmission line right-of-ways and can be spread by line construction and maintenance activities. Tropical soda apple has been reported from a few counties in the TVA region and primarily occurs in agricultural areas.

Several additional invasive plants considered to be an established or emerging threat (TN-IPC 2018) occur on or near TVA generating facilities and transmission line right-of-ways. These include tree-of-heaven, Asian bittersweet, autumn olive, Chinese privet, kudzu, phragmites, Eurasian water-milfoil, multiflora rose, and tall fescue. Phragmites occurs in ash ponds at several TVA coal-fired plants and is otherwise uncommon in the TVA region.

Invasive aquatic animals in the TVA region that harm or potentially harm aquatic communities include the common, grass, bighead and silver carp; alewife; blueback herring; rusty crayfish; Asiatic clam and zebra mussel. Because of their potential to affect water intake systems, TVA uses chemical and warm-water treatments to control Asiatic clams and zebra mussels at its generating facilities.

Invasive terrestrial animals at TVA generating facilities which occasionally require management include the rock pigeon, European starling, house sparrow, and fire ant. These species have little effect on the operation of TVA's power system.

4.5.3 Endangered and Threatened Species

The TVA region provides habitat for numerous species of plants and animals that have declining populations or are otherwise rare and considered to be endangered, threatened, or of special concern at the national and state levels.

4.5.3.1 Regulatory Framework for Endangered and Threatened Species

The Endangered Species Act of 1973 (ESA; 16 U.S.C. §§ 1531-1543) was passed to conserve the ecosystems upon which endangered and threatened species depend and to conserve and recover those species. An endangered species is defined by the ESA as any species in danger of extinction throughout all or a significant portion of its range. A threatened species is likely to become endangered within the foreseeable future throughout all or a significant part of its range. Areas known as critical habitats, essential to the conservation of listed species, also can be designated under the ESA. The ESA establishes programs to conserve and recover endangered and threatened species and makes their conservation a priority for Federal agencies. Under Section 7 of the ESA, Federal agencies are required to consider the potential effects of their proposed action on endangered and threatened species and critical habitats. If the proposed action has the potential to affect these resources, the federal agency is required to consult with the USFWS and take measures to avoid or mitigate adverse effects.

All seven states in the TVA region have enacted laws protecting endangered and threatened species. In other states, the legal protections also apply to additional species designated by the state as endangered, threatened, or otherwise classified such as "in need of management."

4.5.3.2 Endangered and Threatened Species in the TVA Region

Thirty-eight species of plants, one lichen and 127 species of animals in the TVA region area are listed under the ESA as endangered or threatened or formally proposed for such listing by the USFWS. One additional species in the TVA region has been identified by the USFWS as a candidate for listing under the ESA. Candidate species receives no statutory protection under the ESA but by definition may warrant future protection. Several areas across the TVA region are also designated as critical habitat essential to the conservation of listed species. In addition to the species listed under the ESA, about 1,350 plant and animal species are formally listed as protected species by one or more of the states or otherwise identified as species of conservation concern.

The highest concentrations of terrestrial and aquatic species listed under the ESA occur in the Blue Ridge, Appalachian Plateaus and Interior Low Plateau regions. Relatively few listed species occur in the Coastal Plain and Mississippi Alluvial Plain regions. The taxonomic groups with \the highest proportion of species listed under the ESA are fish and mollusks. Factors contributing to the high proportions of vulnerable species in these groups include the high number of endemic species in the TVA region and the alteration of their habitats by reservoir construction and water pollution. River systems with the highest numbers of listed aquatic species include the Tennessee, Cumberland and Coosa rivers.

Populations of a few listed species have increased, primarily because of conservation efforts, to the point where they are no longer listed under the ESA (e.g., bald eagle, peregrine falcon, Tennessee coneflower) or their listing status has been downgraded from endangered to threatened (e.g., snail darter, large flowered skullcap, small whorled pogonia). Among the listed species with populations that continue to decline are the American hart's tongue fern and the Indiana bat. The formerly common northern long-eared bat was listed in 2015 under the ESA as threatened due to recent dramatic population declines caused by white-nose syndrome. In the TVA region, this pathogen was first reported in 2009. Population trends of many other listed species in the TVA region are poorly understood.

4.5.3.3 Endangered and Threatened Species in Vicinity of TVA Generating Facilities

In addition to ESA-listed species, several species listed by TVA-region states occur on or very near TVA generating facilities and transmission lines. Appendix A lists the endangered and threatened species reported in the vicinity of TVA generating facilities. Species considered to be locally extirpated are not listed in Appendix A.

4.5.4 Wetlands

Wetlands are areas that are inundated or saturated by water at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions (EPA regulations at 40 C.F.R § 230.3(t)). Wetlands generally include swamps, marshes, bogs and similar areas. Wetlands are highly productive and biologically diverse ecosystems that provide multiple public benefits such as flood control, reservoir shoreline stabilization, improved water quality and habitat for fish and wildlife resources.

4.5.4.1 Regulatory Framework for Wetlands

Section 404 of the CWA prohibits the discharge of dredge and fill material to waters of the United States, which include most wetlands, unless authorized by a permit issued by the USACE. The scope of this regulation includes most construction activities in wetlands. E.O. 11990 – Protection of Wetlands requires federal agencies to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance their natural and beneficial values. Wetlands are also protected by state regulations (e.g. Tennessee's Aquatic Resources Alteration Permit program).

4.5.4.2 Wetlands in the TVA Region

Wetlands occur across the TVA region and are most extensive in the south and west where they comprise 5 percent or more of the landscape (USGS 2016). Wetlands in the TVA region consist of two main systems: palustrine wetlands such as marshes, swamps and bottomland forests dominated by trees, shrubs, and persistent emergent vegetation, and lacustrine wetlands associated with lakes such as aquatic bed wetlands (Cowardin et al. 1979). Riverine wetlands associated with moving water within a stream channel are also present but relatively uncommon. Almost 200,000 acres of wetlands are associated with the TVA reservoir system, where they are more prevalent on mainstem reservoirs and tailwaters than tributary reservoirs and tailwaters (TVA 2004). Almost half of this area is forested wetlands; other types include aquatic beds and flats, ponds, scrub/shrub wetlands and emergent wetlands.

Manmade emergent wetlands occur on many TVA generating facility sites, often in association with CCR disposal ponds and water treatment ponds. However, CCR and water treatment ponds are excluded from regulation under CWA Section 404. Some of these wetlands provide important wildlife habitat; due to their location and composition, they do not provide the surrounding watershed with any significant flood abatement, or nutrient or sediment retention wetland functions. Many of these wetlands are being eliminated as TVA converts wet CCR storage ponds to dry storage facilities. Approximately 6,750 acres of wetlands have been mapped within TVA transmission line right-of-ways (TVA 2018h). Due to periodic clearing, the right-of-ways are dominated by scrub-shrub and emergent wetlands; forest wetlands make up less than 1 percent of the wetlands. A large proportion of these wetlands were forested until cleared during transmission line construction.

National and regional trends studies have shown a large, long-term decline in wetland area both nationally and in the southeast (Dahl 2000, Dahl 2006, Dahl 2011, Hefner et al. 1994). Wetland losses have been greatest for forested and emergent wetlands and have resulted from drainage for agriculture, forest management activities, urban and suburban development and other factors. The rate of loss has significantly slowed over the past 20 years due to regulatory mechanisms for wetland protection. While the rate of wetland loss has slowed, urbanization continues to impact the ecological function of wetlands across the southeast. Threats to wetlands associated with urbanization include habitat fragmentation, invasive species, hydrologic alteration and changes in species composition due to global climate change (Wright et al. 2006).

4.5.5 Floodplains

Floodplains are the relatively level land areas along a stream or river that are subjected 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. It is necessary to evaluate development in the 100-year floodplain to ensure that the project is consistent with the requirements of E.O. 11988 – Floodplain Management.

4.5.5.1 Regulatory Framework for Floodplains

TVA adheres to the requirements of E.O. 11988, Floodplain Management. The objective of E.O. 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" (E.O. 11988, Floodplain Management). The E.O. 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 E.O. requires that agencies avoid the 100 year floodplain unless there is no practicable alternative.

For "Critical Actions", the minimum floodplain of concern is the 500-year floodplain. The U.S. Water Resources Council defines "critical actions" as "any activity for which even a slight chance of flooding would be too great" (U.S. Water Resources Council, 1978). Critical actions can include facilities producing hazardous materials (such as liquefied natural gas terminals), facilities whose occupants may be unable to evacuate quickly (such as schools and nursing homes), and facilities containing or providing essential and irreplaceable records, utilities, and/or emergency services (such as large power-generating facilities, data centers, museums, hospitals, or emergency operations centers).

4.5.5.2 Floodplains in the TVA Region

In the TVA region, floodplains are associated with reservoirs, streams, ponds, and sinkholes. Power generation facilities of any type, as well as electric transmission lines, could be proposed by TVA or outside entities anywhere in the TVA region.

Floodplains are mapped under the Federal Emergency Management Agency National Flood Insurance Program (NFIP). Through their floodplain ordinances, counties and municipalities ensure that development within the floodplain complies with the NFIP.

In addition, development across, along, or in the Tennessee River and its tributaries is also subject to the requirements of Section 26a of the TVA Act. Activities proposed within Section 26a jurisdiction and/or in places where TVA owns property or property rights would be subject to review under E.O. 11988 in connection with TVA's Section 26a or land use approvals, or both.

4.5.6 Parks, Managed Areas and Ecologically Significant Sites

4.5.6.1 Parks and Managed Areas in the TVA Region

Numerous areas across the TVA region are recognized and, in many cases, managed for their recreational, biological, historic and scenic resources. These areas are owned by 1) federal and state agencies 2) local governments 3) non-governmental organizations such as the Nature Conservancy 4) regional land trusts and private corporations and 5) private individuals.

Parks, managed areas and ecologically significant sites are typically managed for one or more of the following objectives:

- Recreation areas- managed for outdoor recreation or open space. Examples include national, state and local parks and recreation areas, reservoirs (TVA and other), picnic and camping areas; trails and greenways, and TVA small wild areas.
- Species/Habitat Protection- places with endangered or threatened plants or animals, unique natural habitats, or habitats for valued fish or wildlife populations. Examples include national and state wildlife refuges, mussel sanctuaries, TVA habitat protection areas and nature preserves.
- Resource Production/Harvest- lands managed for production of forest products, hunting and fishing. Examples include national and state forests, state game lands and wildlife management areas and national and state fish hatcheries.
- Scientific/Educational Resources- lands protected for scientific research and education. Examples include biosphere reserves, research natural areas, environmental education areas, TVA ecological study areas and federal research parks.
- Historic Resources- lands with significant historic resources. Examples include national

battlefields and military parks, state historic sites and state archeological areas.

- Scenic Resources- areas with exceptional scenic qualities or views. Examples include national and state scenic trails, scenic areas, wild and scenic rivers and wilderness areas.
- Agricultural Resources- lands with significant local agricultural production and open space value, often in areas where suburban development is increasing. Examples include working family farms protected by conservation easements.

Numerous parks, managed areas and ecologically significant sites occur throughout the TVA service area in all physiographic regions, but are mostly concentrated in the Blue Ridge and Mississippi Alluvial Plain physiographic regions. Individual ecologically significant areas vary in size from a few acres to thousands of acres. Many areas cross state boundaries or are managed cooperatively by multiple agencies.

Parks, managed areas, and ecologically significant sites occur on or very near many TVA generating plant reservations, including the Allen, Colbert, Gallatin, Kingston, and Shawnee plants. This is especially the case at hydroelectric plants, where portions of the original dam reservations and reservoir lands have been developed into state and local parks. TVA transmission line rights-of-way cross eleven National Park Service (NPS) units, nine National Forests, six National Wildlife Refuges, and numerous state wildlife management areas, state parks, and local parks (TVA 2018h).

4.5.6.2 Parks and Managed Areas at Facilities Identified for Potential Future Retirements

Parks, managed areas, and ecologically significant sites on and in the vicinity of the eight generating plants considered for full or partial retirement are described in this subsection.

Cumberland Fossil Plant

A boat ramp with a capacity of approximately 15 vehicles/trailers is located on plant property. The ramp is located at CRM 102.8L. The cooling water discharge attracts boat fishing and some bank fishing may also occur in this area.

Gallatin Fossil Plant and Combustion Turbine Plant

There are several managed areas on Gallatin Fossil Plant property. Most of the Gallatin reservation is designated as the Gallatin Steam Plant WMA. This WMA is managed by Tennessee Wildlife Resources Agency (TWRA) for hunting within specified hunting zones. Only deer and turkey can be hunted, and only with archery equipment. A special permit issued by TWRA is required to hunt on the WMA. About 229 acres of the Gallatin reservation and WMA are open to hunting. The ash impoundments, and to a lesser extent the stilling ponds, are used by shorebirds during migration and by waterfowl throughout much of the year, but especially during the winter.

The Old Hickory State WMA is managed by TWRA for small and large game, including waterfowl. It is located along the shoreline of the reservoir. The Old Hickory State WMA is to the east, adjacent to an approved onsite landfill. Portions of the Old Hickory WMA are located within the Gallatin property boundary, primarily along the shoreline. A boat ramp providing lake access is located on the eastern side of the Gallatin property off Steam Plant Road. In addition to hunting and fishing, these areas also provide limited public opportunities for watching wildlife, especially shorebirds, waterfowl, and wading birds.

There is a small boat ramp on the eastern edge of the plant property (CRM 244.7R). Ramp parking capacity is limited to about 3 vehicles with boat trailers. Boat fishing occurs in the vicinity of the plant's water discharge area.

There are no parks, managed areas, or ecologically significant sites on the Gallatin CT Plant property.

Kingston Fossil Plant

There is a boat ramp near the cooling water discharge channel on the plant site that is accessible to the public. This ramp has a capacity of 15 vehicles/trailers and is located at CRM 2.5R. Bank fishing may also occur in the open space area adjacent to the ramp.

Shawnee Fossil Plant

There is one managed area on the Shawnee property. The Bayou Creek Ridge TVA Habitat Protection Area is one of the finest examples of a high-quality old-growth, mesic bottomland forest remaining in Kentucky. The largest eastern cottonwood tree in Kentucky is on the tract, which is dominated by white oak, northern red oak, tupelo, and swamp hickory.

Portions of the Western Kentucky Wildlife Management Area (WKWMA) are on the southwest side of Shawnee property. The WKWMA extends south from Shawnee and surrounds the Paducah Gaseous Diffusion Plant . The WKWMA consists of lands leased to the Kentucky Department of Fish and Wildlife Resources (KDFWR). Public activities in this area include hunting, horseback riding, hiking, and biking (KDFWR 2018a). This WMA also has a fishing pier and a boat ramp (KDFWR 2018b). The WKWMA allows hunting during the appropriate seasons and has a public skeet-shooting range (KDFWR 2018c).

Allen Combustion Turbine Plant

There are no parks, managed areas, or ecologically significant sites on the Allen CT Plant property. Such areas in the surrounding area are described in TVA (2014b).

Colbert Combustion Turbine Plant

Cane Creek Recreation Area is located near the mouth of Cane Creek at TN River mile 244L on the Colbert reservation, close to the Colbert CT site. Facilities include a boat ramp and picnic tables. The ramp has a capacity of 20 vehicles/trailers.

Johnsonville Combustion Turbine Plant

There are no parks, managed areas, or ecologically significant sites on the Johnsonville CT Plant property. Such areas elsewhere on or in the vicinity of the larger Johnsonville reservation are described in TVA (2018g).

4.5.7 Land Use

This section describes the range of land uses in the TVA region.

4.5.7.1 Regulatory Framework for Land Use

Use of federal lands is generally regulated by the acts establishing the various agencies as well as other laws. For example, the TVA Act gives TVA the authority to regulate the use of lands it manages as well as development across, along, or in the Tennessee River or any of its tributaries. The Farmland Protection Policy Act of 1981 (7 U.S.C. 4201 *et seq.*) recognizes the importance of prime farmland. Various state laws and local ordinances regulate land use, although a large portion of land in the TVA region is not subject to local zoning ordinances.

4.5.7.2 Major Land Uses in the TVA Region

Major land uses in the TVA region include forestry, agriculture and urban/suburban/industrial (USDA 2013). About 3 percent of the TVA region is water, primarily lakes and rivers. This proportion has increased slightly since 1982, primarily due to the construction of small lakes and ponds. About 5.5 percent of the land area is in federal ownership; this proportion has also increased slightly since 1982. The major components of federal land are national parks, national forests, national wildlife refuges, and TVA reservoir lands. Of the remaining non-federal land area, about 12 percent is classified as developed and 88 percent as rural. Rural undeveloped lands include farmlands (28 percent of the rural area) and forestland (about 60 percent of the rural area). The greatest change since 1982 has been in developed land, which almost doubled in area due to high rates of urban and suburban growth in much of the TVA region. The rate of land development was high during the 1990s and early 2000s and slowed in the late 2000s. Both cropland and pastureland have decreased in area since 1982 (USDA 2013).

Approximately 51 percent of the TVA region is forested (Homer et al. 2015). Forestland increased in area through much of the 20th century; this rate of increase has slowed and/or reversed in parts of the TVA region in recent years (Conner and Hartsell 2002, USDA 2015). Forestland is predicted to decrease between 1997 and 2060 in the majority of counties in the TVA region, with several counties in the vicinity of Memphis, Nashville, Huntsville, Chattanooga, Knoxville and the Tri-Cities area of Tennessee predicted to lose more than 25 percent of forest area (Wear and Greis 2013).

Loss of forest area within the TVA region is primarily a result of increasing urbanization and development. Most of the TVA region in Mississippi, as well as some rural parts of western Tennessee and Kentucky are predicted to show little change, or in some scenarios, small increases in forestland by 2060 (Wear and Greis 2013).

Agriculture – Agriculture is a major land use and industry in the TVA region. In 2012, 41 percent of the land area in the TVA region was farmland that comprised 151,000 individual farms (USDA 2014). Average farm size was 160 acres, a 6.3 percent increase since 1982. The proportion of land in farms has decreased by 4.2 percent since 1982; since 2007, the decrease was 0.3 percent. Over the 1982–2012 period, the number of farms decreased by 14.7 percent while the average size of farms increased by 6.3 percent. Farm size in the TVA region varies considerably with numerous small farms and a smaller number of large farms. The median farm size in most counties is generally less than 100 acres, and increases from east to west (USDA 2014). Almost half of the farmland (47.0 percent) was classified in 2012 as cropland, which includes hay and short-rotation woody crops (USDA 2014). A quarter (24.6 percent) of the farmland was pasture and the remainder was woodland or devoted to other uses such as buildings and other farm infrastructure.

Farms in the TVA region produce a large variety of products that vary across the region. While the proportion of land in farms is greatest in Mississippi, southern Kentucky and central and western Tennessee, the highest farm income occurs in northern Alabama and Georgia (EPRI and TVA 2009). Compared to farms in the southern and western portions of the TVA region, farms in the eastern and northern portions tend to be smaller and receive a higher proportion of their income from livestock sales than from crop sales. Region-wide, the major crop items by land area are forage crops (hay and crops grown for silage), soy, corn and cotton. The major farm commodities by sales are cattle and calves, poultry and eggs, grains and beans, cotton and nursery products (USDA 2014).

Although the area of irrigated farmland is small (5.7 percent of farmland), it quadrupled between 1982 and 2012 to 1,271,043 acres (USDA 2014). Much of this increase was due to individual farmers increasing the acreage they irrigated, as the number of irrigated farms slightly more than doubled during this period. The area of irrigated farmland is likely to increase in the future as temperature and precipitation patterns become less predictable or if drought conditions become more prevalent (EPRI and TVA 2009).

Crops grown specifically to produce biomass for use as fuels (dedicated energy crops) are a potentially important commodity in the TVA region. In 2002, the Census of Agriculture began recording information on short rotation woody crops, which grow from seed to harvestable tree in 10 years or less. These crops have traditionally been used by the forest products industry for producing pulp or engineered wood products and are also a potential source of biomass for power generation. In 2012, there were 117 farms in the TVA region growing at least 2,704 acres of short rotation woody crops, a large decrease from the 286 farms in 2007.

The Census of Agriculture has also recently begun recording information on the cultivation of switchgrass, a bioenergy crop that can be directly used as fuel and for producing ethanol. In 2012, it was grown by 18 farms in the TVA region that harvested at least 1,800 acres (USDA 2014). Most of these farms were located in eastern Tennessee and grew switchgrass as part of research studies at the University of Tennessee. Three facilities in the TVA region produce ethanol from corn, primarily for use as biofuels with a total production capacity of 263 million gallons per year (Renewable Fuels Association 2018). A large proportion of their corn feedstock is likely grown within the TVA region. Corn grown in the TVA region is also likely used by ethanol producers elsewhere.

Prime Farmland - Prime farmland is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber and oilseed crops, and is available for these uses (USDA 2015). Prime farmland has the combination of soil properties, growing season, and moisture supply needed to produce sustained high yields of crops in an economic manner if it is treated and managed according to acceptable farming methods. Prime farmland is designated independently of current land use, but it cannot be areas of water, urban, or built-up land.

Approximately 22 percent[2] of the TVA region is classified as prime farmland (NRCS 2018). An additional 4 percent of the TVA region would be classified as prime farmland if drained or protected from flooding.

Forest Management - About 97 percent of the forestland in the TVA region is classified as timberland (USFS 2014), forestland that is producing or capable of producing more than 20 cubic feet of merchantable wood per acre per year and is not withdrawn from timber harvesting by law. About 14 percent of timberland is in public ownership, primarily in national forests. About 20 percent is owned by corporations and the remainder is in non-corporate private ownership. While the majority of corporate timberlands have historically been owned by forest industries, this proportion has decreased in recent years as many forest product companies have sold timberlands due to changing market conditions.

4.5.8 Cultural Resources

Cultural resources include prehistoric and historic archaeological sites, districts, buildings, structures, and objects, as well as locations of important historic events that lack material evidence of those events. Cultural resources are considered historic properties if included in, or considered eligible for inclusion in, the National Register of Historic Places (NRHP) maintained by the NPS. The eligibility of a resource for inclusion in the NRHP is based on the Secretary of the Interior's criteria for evaluation (36 CFR 60.4), which state that significant cultural resources possess integrity of location, design, setting, materials, workmanship, feeling and association, and:

1. are associated with important historical events; or
2. are associated with the lives of significant historic persons; or
3. embody distinctive characteristics of a type, period, or method of construction or represent the work of a master, or have high artistic value; or
4. have yielded or may yield information (data) important in history or prehistory.

4.5.8.1 Regulatory Framework for Cultural Resources

Because of their importance to the Nation's heritage, historic properties are protected by several laws. Federal agencies, including TVA, have a statutory obligation to facilitate the preservation of historic properties, stemming primarily from the National Historic Preservation Act (NHPA; 16 U.S.C. §§ 470 *et seq*.). Other relevant laws include the Archaeological and Historic Preservation Act (16 U.S.C. §§ 469-469c), Archaeological Resources Protection Act (16 U.S.C. §§ 470aa-470mm) and the Native American Graves Protection and Repatriation Act (25 U.S.C. §§ 3001-3013).

Section 106 of the NHPA requires federal agencies to consider the potential effects of their actions on historic properties and to allow the Advisory Council on Historic Preservation an opportunity to comment on the action. Section 106 involves four steps: 1) initiate the process; 2) identify historic properties; 3) assess adverse effects; and 4) resolve adverse effects. This process is carried out in consultation with the State Historic Preservation Officer (SHPO) of the state in which the action would occur and with any other interested consulting parties, including federally recognized Indian tribes.

Section 110 of the NHPA sets out the broad historic preservation responsibilities of federal agencies and is intended to ensure that historic preservation is fully integrated into their ongoing programs. Federal agencies are responsible for identifying and protecting historic properties and avoiding unnecessary damage

[2] This estimate does not include about 20 counties for which soil survey information is incomplete or not available.

to them. Section 110 also charges each Federal agency with the affirmative responsibility for considering projects and programs that further the purposes of the NHPA, and it declares that the costs of preservation activities are eligible project costs in all undertakings conducted or assisted by a federal agency.

4.5.8.2 Archaeological Resources

Human occupation in the TVA region began at the end of the Ice Age with the Paleo-Indian Period (13,500 – 11,000 years before present, or "B.P."). In the Tennessee Valley, prehistoric archaeological chronology is generally broken into four broad time periods: following the Paleo-Indian Period are the Archaic (11,000 – 3,000 B.P.), Woodland (3,000 – 1,100 B.P.), and Mississippian (1,100 – 500 B.P.) periods. Archaeological sites from all these periods, as well as from the more recent historic period, are very numerous throughout the TVA region. They occur on a variety of landforms and in a variety of environmental contexts. Sites are rarely found on steep slopes, with the exception of rockshelters, which have been used throughout the prehistoric and historic periods and often contain artifacts and features with value to archaeology and history. Areas affected by construction, mining, civil works projects and highways, for example, tend to lack significant archaeological resources due to modern ground disturbing activities.

The most reliable information about the locations of archaeological sites is produced during Phase I archaeological surveys conducted for compliance with Section 106. Numerous surveys have been conducted along reservoir shorelines, within reservoirs, and on power plant reservations. However, large areas remain that have not been surveyed. Some TVA transmission line and many highway corridors have also been surveyed. But outside of TVA reservoirs and power plant reservations, the density of surveys is low and relatively little is known about archaeological site distributions.

The earliest documentation of archaeological research in the region dates back to the 19th century when entities such as the Smithsonian Institute and individuals such as Cyrus Thomas undertook some of the first archaeological excavations in America to document the history of Native Americans (Guthe 1952). TVA was a pioneer in conducting archaeological investigations during the construction of its dams and reservoirs in the 1930s and early 1940s (Olinger and Howard 2009). Since then, TVA has conducted numerous archaeological surveys associated with permitting actions, power plants, and transmission system construction and maintenance. These surveys, as well as other off-reservoir projects, have identified more than 2,000 sites, including over 250 within or in the immediate vicinity of TVA transmission line rights-of-way. A large proportion of these sites have not been evaluated for NRHP eligibility. The number of eligible or potentially eligible for listing on the NRHP is unknown.

Archaeological survey coverage and documentation in the region varies by state. Each state keeps records of archaeological resources in different formats. While digitization of this data is underway, no consistent database is available for determining the number of archaeological sites within the TVA region. Survey coverage on private land has been inconsistent and is largely project-based rather than focusing on high-probability areas, so data is unlikely to be representative of the total population of archaeological sites. Based on a search through TVA's data and reports of archaeological surveys on reservoirs, TVA estimates that over 11,000 archaeological sites have been recorded on TVA reservoir lands, including submerged lands. Significant archaeological excavations have occurred as a result of TVA and other Federal projects and have yielded impressive information regarding the prehistoric and historic occupation of the Southeastern U.S. Notable recent excavations and related projects in the region include those associated with the Townsend, Tennessee highway expansion; Shiloh Mound on the Tennessee River in Hardin County, Tennessee; the Ravensford site in Swain County, North Carolina; and documentation of prehistoric cave art in Alabama and Tennessee.

4.5.8.3 Historic Structures

Historic architectural resources are found throughout the TVA region and can include houses, barns and public buildings. Many historic structures in the region have been either determined eligible for listing or have been listed in the NRHP. However, historic architectural surveys have been conducted in only a fraction of the land area within the region.

Over 5,000 historic structures have been inventoried in the vicinity of TVA reservoirs and power system facilities. Of those evaluated for NRHP eligibility, at least 85 are included in the NRHP and about 250 are considered eligible or potentially eligible for listing.

TVA power system facilities listed in the NRHP prior to 2016 include the Ocoee 1, Ocoee 2, Great Falls, and Wilson dams and hydroelectric plants. Wilson Dam is also listed as a National Historic Landmark.

Shawnee Fossil Plant was listed in the NRHP in 2016.It generates electricity through coal-fired, steam-generating furnaces that powered a series of ten turbo-generator units. The first unit at the plant began operation in 1953 and the final unit came online in 1956. The NRHP boundary contains 684 acres with a total of 33 resources. Nineteen resources are considered contributing resources, including the powerhouse, which anchors the historic district. The remaining contributing resources are original support buildings and structures that facilitate the transfer of coal, water, and the resultant electricity through the facility. Smaller storage buildings and maintenance facilities which date to the original construction of the plant are also considered contributing. Fourteen resources were erected after the close of the Period of Significance (1965) and are considered noncontributing (National Park Service 2016).

In 2017 as part of a multiple property submission evaluating the TVA hydroelectric system, 22 additional hydroelectric projects were listed in the NRHP (National Park Service 2017). These projects are Chickamauga, Douglas, Fort Loudoun, Nottely, Kentucky, Cherokee, Hiwassee, Chatuge, Apalachia, Fontana, Watauga, Melton Hill, Tellico, Nickajack, Ocoee No. 3, Watts Bar, Boone, Fort Patrick Henry, Tims Ford, Normandy, Pickwick Landing, and South Holston. The Blue Ridge, Norris, and Guntersville dams have been determined in consultation with SHPOs to be eligible or potentially eligible for the NRHP.

Based on a TVA-wide inventory of facilities, it is TVA's opinion that Browns Ferry Nuclear Plant is eligible for listing in the NRHP, but TVA has not consulted with the SHPO on its eligibility. The various SHPOs have agreed with TVA that the Paradise, Allen (now retired), Cumberland, Kingston and Gallatin Fossil Plants in Tennessee are not eligible.

Allen CT Plant, located southwest of Memphis, Tennessee, was completed in 1972. Colbert Combustion Turbine Plant, located in Tuscumbia, Alabama, was completed in 1972. Construction of the Gallatin Combustion Turbine Plant, located adjacent to the Gallatin Fossil Plant was begun in 1975 and completed in 2000. Johnsonville Combustion Turbine Plant, was initially completed in 1975, and four more CT units were added in 2000. These three plants have not yet reached the 50-year mark to be eligible for survey and assessment, and they likely would not be eligible for the NRHP under Criteria Consideration G (properties that have achieved significance within the last 50 years).

The switch houses at several TVA substations are also likely eligible for listing, and some of the oldest transmission lines are potentially eligible for listing.

4.5.8.4 Traditional Cultural Properties

The TVA region is a diverse cultural landscape that held special meaning to its past inhabitants and to their descendants. Some of these places can be considered Traditional Cultural Properties (TCP). A TCP is defined as a property that is eligible for inclusion on the NRHP because of its association with cultural practices or beliefs of a living community that (a) are rooted in that community's history, and (b) are important in maintaining the continuing cultural identity of the community (Parker and King 1998). Similarly, a cultural landscape is defined as "a geographic area, including both cultural and natural resources and the wildlife or domestic animals therein, associated with a historic event, activity, or person or exhibiting other cultural or aesthetic values" (Birnbaum 1994). TVA does not make public sensitive information regarding the location or other information regarding sacred sites or TCPs identified by consulting tribes. Some examples of TCPs within the study area include mound sites, segments of the Trail of Tears, and stacked stone features. The Trail of Tears consisted of many routes and sub-routes that were traveled by Native Americans during their removal from their ancestral homelands. Segments of the Trail of Tears cross TVA transmission lines at approximately 278 locations (TVA 2018h). Stacked stone features often appear as single or a group of cylindrically stacked limestone. The origin and purpose of these stone features is uncertain, but a resolution passed by the United South and Eastern Tribes, Inc. (USET), in 2007, recommended that all federal agencies involved in the Section 106 process consider stacked stone features that cannot be conclusively linked to a historic origin to be a TCP under NRHP Criterion A (USET 2007).

4.6 Availability of Renewable Energy Resources

The alternative strategies being evaluated include the potential for increased reliance on renewable generating resources. TVA includes all renewable resources in its definition of renewable energy, including hydroelectric generation. This assessment of the availability of renewable resources does not include TVA's existing hydroelectric facilities and considers renewable resources in the context of many state renewable portfolio standards to include solar, wind, small hydroelectric (see Volume I Section 5.2.2) and upgrades to existing large hydroelectric plants, biomass (including biogas), and geothermal energy. Geothermal generation using currently available and near-term emerging technologies is not considered further because of the lack of a developable resource in the TVA region (Augustine 2011).

Following is an assessment of the availability of potential renewable resources for generating electricity in and near the TVA region.

4.6.1 Wind Energy Potential

The suitability of the wind resource in an area for generating electricity is typically described in terms of wind power classes ranging from Class 1, the lowest, to Class 7, the highest (Elliott et al. 1986). The seven classes are defined by their average wind power density (in units of watts/m^2) or equivalent average wind speed for a specified height above ground. Areas designated Class 3, corresponding to a windspeed of at least 6.4 meters/second (m/s; 14.3 mph) or greater at a height of 50 meter (m) above ground usually have adequate wind for most commercial wind energy developments.

Early regional assessments of wind energy potential were based on wind turbines with a 50-m hub height (i.e., the height of the rotor hub above ground) and focused on ridgetop sites in the eastern part of the TVA region. Raichle and Carson (2008) presented the results of a detailed wind resource assessment at the 50-m height in the southern Appalachian Mountains. Measured annual wind speeds at nine representative privately owned sites ranged from 4.4 m/s on the Cumberland Plateau in northwest Georgia to 7.3-7.4 m/s on sites in the Blue Ridge Mountains near the Tennessee/North Carolina/Virginia border. Two sites in the Cumberland Mountains and one site in the Blue Ridge Mountains were categorized as Class 3 and two sites in the Blue Ridge Mountains were categorized as Class 4. The Class 3 and Class 4 sites had capacity factors of 28 to 36 percent and an estimated energy output of 2.8 to 3.5 GWh per year for each MW of installed capacity. All sites had significantly less wind during the summer than during the winter and significantly less wind during the day than at night during all seasons. Due to the configuration of ridge tops within this area in relation to prevailing wind directions, potential wind projects would likely be linear in extent and relatively small. These conditions describe the only operating windfarm in the TVA region; this facility (see Section 2.4) is located in the Cumberland Mountains.

More recent wind assessments have shifted from a power class rating to increased focus on wind speed and potential capacity factor, and to higher elevations of 80 m (262 feet) and 100 m (328 feet) above ground, tower heights more representative of recently installed wind turbines (Wiser and Bolinger 2018). This re-evaluation showed an increased potential for wind generation in the western portion of the TVA region (Figure 4-19, Figure 4-20). Based on windspeed and windfarm performance data available at that time, the 2010 Eastern Wind Integration and Transmission Study conducted by the National Renewable Energy Laboratory (NREL 2011) estimated a wind potential of 1,247 MW in the TVA region, with an expected annual energy generation value between 3,500 and 4,000 GWh. The DOE Wind Energy Technologies Office currently lists Tennessee's potential wind capacity at 116,000 MWs at 80 meters (USDOE 2018).

Current 80-meter and 100-meter wind speed maps also show the greater potential for wind energy development in the upper Midwest and the Great Plains, where TVA currently acquires most of its wind energy (see Section 2.4). The acquisition of additional wind energy from these areas, as well as from within the TVA PSA, is among the energy resource options considered in this IRP (see Volume I Section 5.2.2).

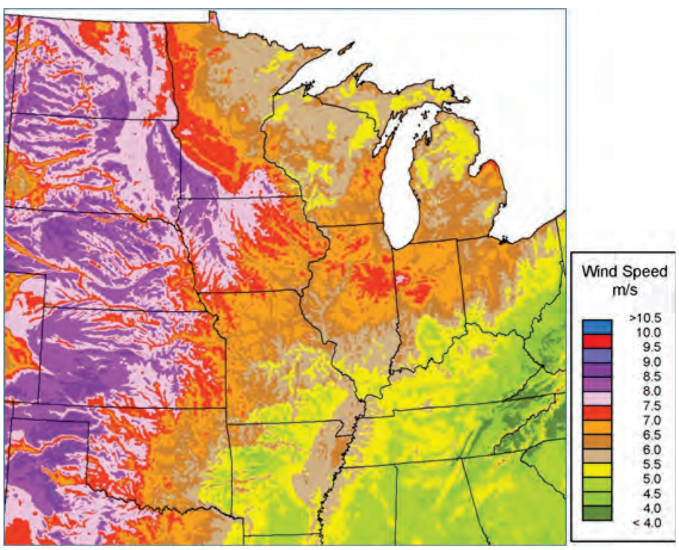

Figure 4-19: Wind resource potential of the eastern and central U.S. at 80 m above ground. Source: Adapted from NREL (2011).

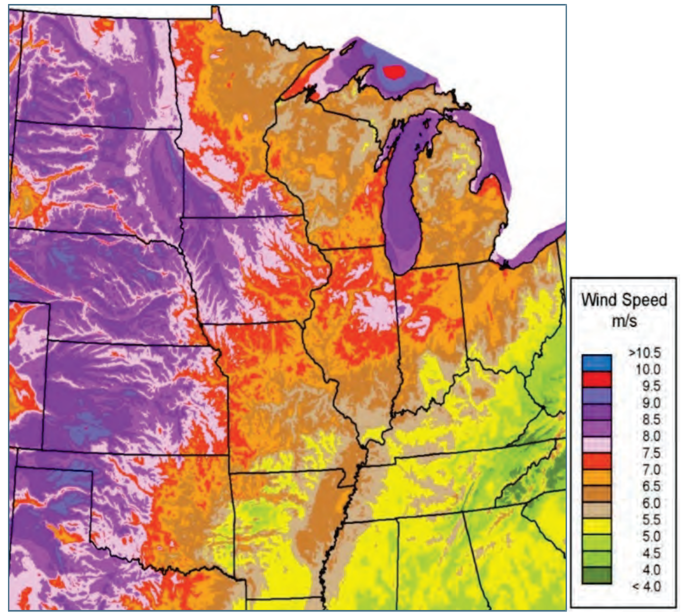

Figure 4-20: Wind resource potential of the eastern and central U.S. at 100 m above ground. Source: Adapted from NREL (2013).

4.6.2 Solar Energy Potential

Solar energy resource potential is a function of average daily solar insolation (see Section 4.3) and is expressed as kWh/m^2/day (available energy (kWh) per unit area (square meters, m^2) per day). Solar resource measurements are reported as either direct normal radiation (no diffuse light) or total radiation (a combination of direct and diffuse light). Diffuse or scattered light, which is common in eastern North America, is caused by cloud cover, humidity, or particulates in the air. Solar PV panels are capable of generating with both direct and diffuse light sources. These measurements do not incorporate losses from converting PV-generated energy (direct current) to alternating current or the reduced efficiency of some PV panels at high temperatures. Figure 4-21 shows the regional solar generation potential for flat plate PV panels; all current and foreseeable solar generation in the TVA region is PV as concentrated solar technologies are not economically feasible due to high amounts of diffuse light. The PV potential assumes flat-plate panels are oriented to the south and installed at an angle from horizontal equal to the latitude of the location. More detailed, state-specific maps are available at NREL (2017). The TVA region has between

4.1 and 4.8 kWh/m^2/day of available solar insolation for flat-plate PV panels, with the potential greatest in the southwestern portion of the region and decreasing towards the northeast. Most of the larger (i.e., >1 MW capacity) utility-scale solar facilities operating, under construction, or proposed in the TVA region are in areas with between 4.5 and 4.8 kWh/m^2/day of insolation.

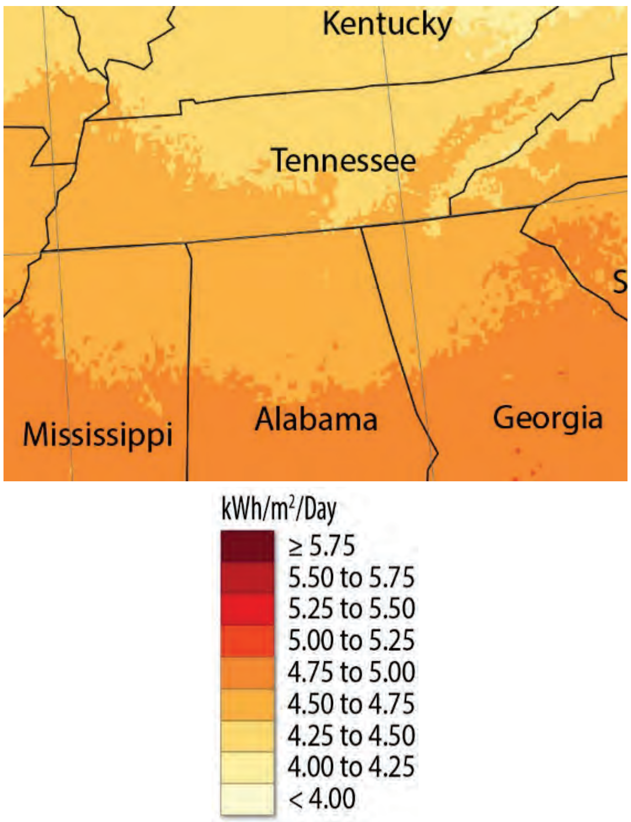

Figure 4-21: Solar photovoltaic generation potential in the TVA region. Source: Adapted from NREL (2018).

Because PV is the most abundant and easily deployable renewable resource, it is difficult to accurately assess a feasible potential total value for the TVA region. Denholm and Margolis (2007) studied the land area of each state necessary to meet the state's entire electrical load by PV generation. To determine the annual PV generation per unit of module power, hourly insolation values were used for 2003–2005 from 216 sites in the lower 48 states. Net PV energy density (the annual energy produced per unit of land area) for each state was calculated using the weighted average of three distinctive PV technologies (polycrystalline silicon, monocrystalline silicon and thin film) which vary in their generating efficiency. Various panel orientations including fixed positions and 1- and 2-axis tracking were included. Tracking panels (i.e., on mounts that pivot to follow the sun) produce more energy per unit area than fixed panels although their initial installation costs are higher.

The resulting state-level solar electric footprint shows that achieving all of the electrical load is theoretically possible (Figure 4-22). Because PV generation is variable depending on time of day and cloud cover, a scaling factor of 1.23 was applied to compensate for losses associated with back-up battery storage. Generating all of the region's electricity by PV is not a practical goal unless very inexpensive energy storage devices become widely available. Therefore, the conclusion of this analysis is not to assign a specific theoretical solar potential but to point out that the solar resource in the TVA region is plentiful. Relative to other states, the seven TVA region states ranked between 14th (Alabama) and 29th (Kentucky) in PV energy density (Denholm and Margolis 2007). Mississippi ranked 18th and Tennessee ranked 27th.

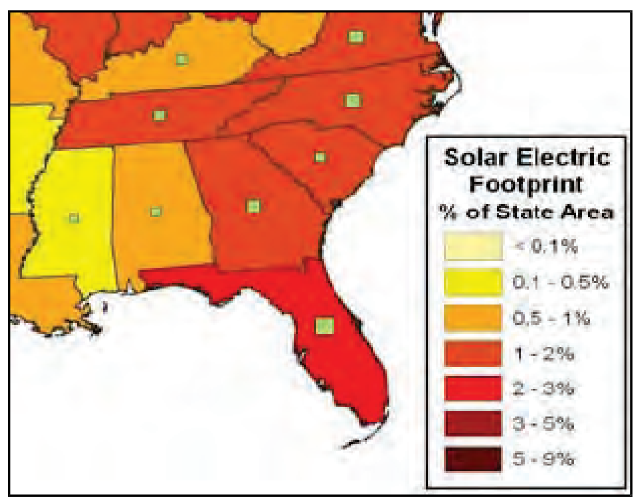

Figure 4-22: Solar electric footprint of southeastern states (2003-2005). Source: Adapted from Denholm and Margolis (2007).

Gagnon et al. (2016) examined the technical potential of PV systems installed on rooftops. Technical potential includes the number and area of rooftops (dependent in large part on population density), geographic location, system, topographic, and land-use constraints, and system performance, but not projected costs. Across most of the TVA region, between 80 and 90 percent of small buildings (e.g., single family homes) were technically suitable for PV systems. For the TVA region states, the proportion of 2013 electricity sales that could be provided by small building, rooftop PV ranged from a low of 16.0 percent for Kentucky to 23.5 percent for North Carolina. With the inclusion of rooftop PV on medium and large buildings, the proportion of 2013 electricity sales that could be provided by rooftop solar ranged from 25.2 percent for Kentucky to 33.8 percent in Georgia.

4.6.3 Hydroelectric Energy Potential

Hydroelectric generation (excluding the Raccoon Mountain pumped storage facility) presently accounts for about 10 percent of TVA's generating capacity (see Section 2.3.5). TVA has gradually increased this capacity by upgrading the hydro turbines and associated equipment. To date, this program has increased TVA's hydro generating capacity by about 15 percent. This capacity increase would qualify as renewable energy under most renewable portfolio standards.

Hall et al. (2006) surveyed the potential for development of low power (<2 MW) and small hydro (between 2 and 60 MW) projects in ways that would not require the stream to be obstructed by a dam, such as partial stream diversion through a penstock to a conventional turbine and unconventional ultra-low head and in-stream kinetic energy turbines (see Volume I Section 5.2.2.5). Feasibility criteria, in addition to the water energy resource, included site accessibility, load or transmission proximity, and land use or environmental constraints that would inhibit development. The study identified numerous small hydro and low power sites with an estimated total feasible capacity of 1,770 MW. The study did not evaluate the hydrokinetic potential of sites with little or no elevation difference and thus likely underestimates this potential resource.

Hadjerioua et al. (2012) surveyed the nation-wide potential for hydroelectric generation of at least 1 MW capacity at existing dams lacking hydroelectric generators. The potential of each dam was determined from regional precipitation and runoff, stream flow data and characteristics of the individual dams. Within the Tennessee River watershed, the survey identified a potential capacity of 38.5 MW and potential generation of 144 GWh/year. This total includes six TVA dams with a total potential capacity of 27.5 MW and potential generation of 103 GWh/year. Non-power dams elsewhere in the TVA PSA have a potential capacity of about 135 MW; most of these dams are in the Tennessee-Tombigbee, Green River (Kentucky), Tallahatchie River and Green River (Mississippi) drainages and are operated by the USACE.

A second recent study by Kao et al. (2014) surveyed the nationwide potential for hydroelectric generation on undeveloped (i.e., without dams) stream reaches. The total potential capacity in the Tennessee River watershed, assuming the new hydroelectric projects are operated with run- of-river flows, was 1,363 MW and the potential generation was about 8,000 GWh/year. The potential capacity of other watersheds within the TVA PSA is less than that of the Tennessee River watershed. The incorporation of environmental attributes such as protected land designation (e.g., National Parks, Wild and Scenic Rivers, wilderness areas), presence of species listed under the ESA, and recreational uses substantially reduces this potential.

4.6.4 Biomass Fuels Potential

NREL (Milbrandt 2005, NREL 2014) analyzed geographic patterns in the availability of biomass suitable for power generation. These analyses included the solid biomass resources of crop residues, forest residues, primary and secondary mill residues, urban wood waste and dedicated energy crops, and biogas. Biogas is methane produced by the biological breakdown of organic matter in the absence of oxygen. Feedstocks for biogas can come from a variety of sources, including landfills, livestock and poultry manure management, wastewater treatment, and various other industrial and commercial organic wastes and byproducts. If not used for generating power, much biogas would otherwise be burned in open flares. Its use for generating power can replace fossil fuels, therefore resulting in a net reduction in GHG emissions.

TVA currently purchases power generated from methane at several landfills across the region (see Section 2.4).

Many TVA region counties had a total biomass resource potential of over 100,000 tons/year; these counties are concentrated in Kentucky, western Tennessee, Mississippi and Alabama (Figure 4-23, Figure 4-24). The total potential biomass resource for the TVA region was estimated in 2010 to be approximately 36 million tons/year. This equates to a potential of up to 47,000 GWh[3] of annual biomass energy generation. ‘

The TVA region biomass resource potential for each resource type is shown in Figure 4-25.

[3] Based on assumed heating values for agricultural crops and wood residues of 7,200–8,570 Btu/lb and for methane of 6,400–11,000 Btu/lb, depending on feedstock type. Assumed generating unit heat rates are 13,500 Btu/kWh for crop and wood residues and 12,500 Btu/kWh for methane.

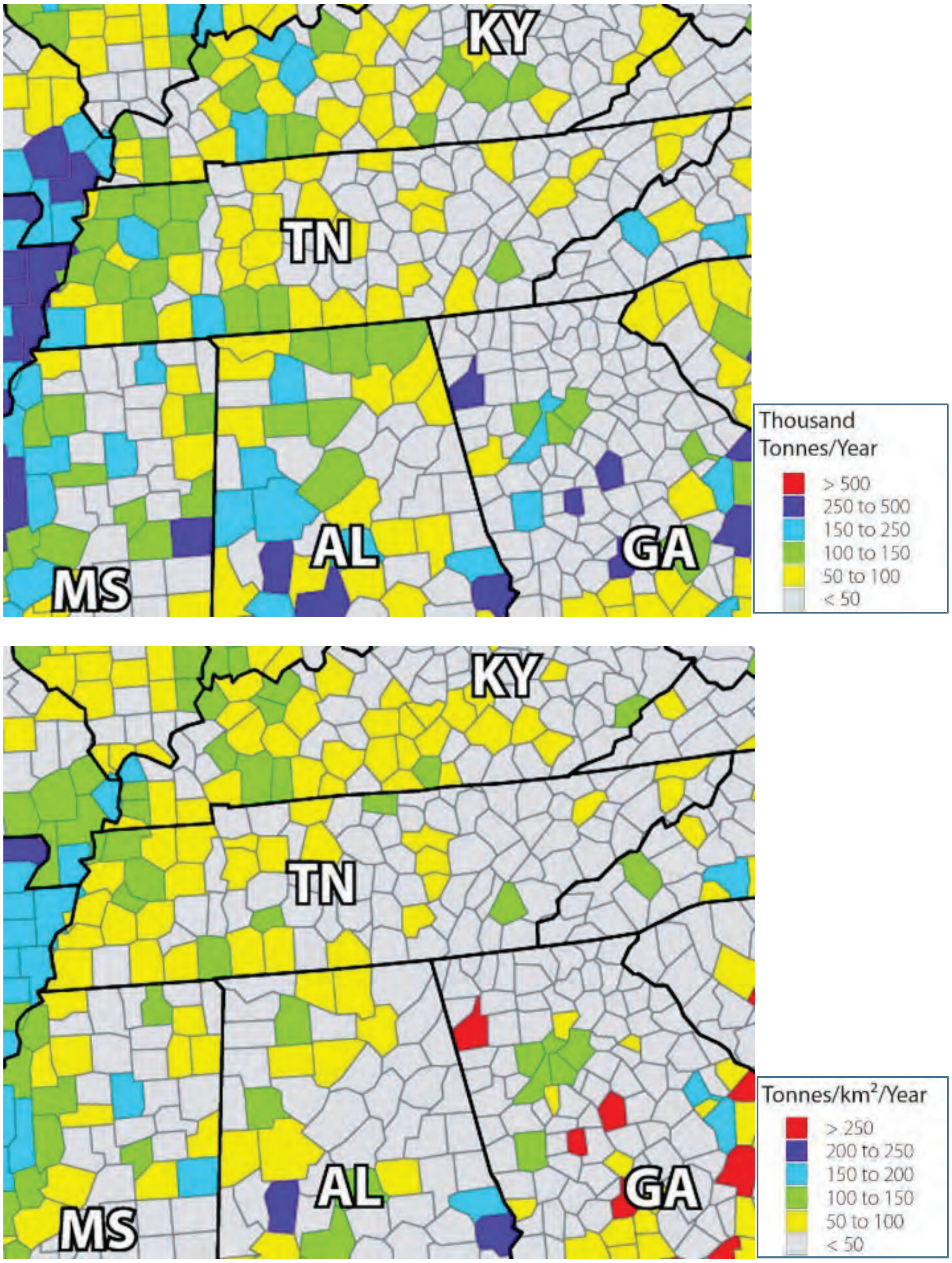

Figure 4-23: Total solid biomass resources in metric tons potentially available in the TVA region by county (top) and per square kilometer by county (bottom). Source: Adapted from NREL (2014).

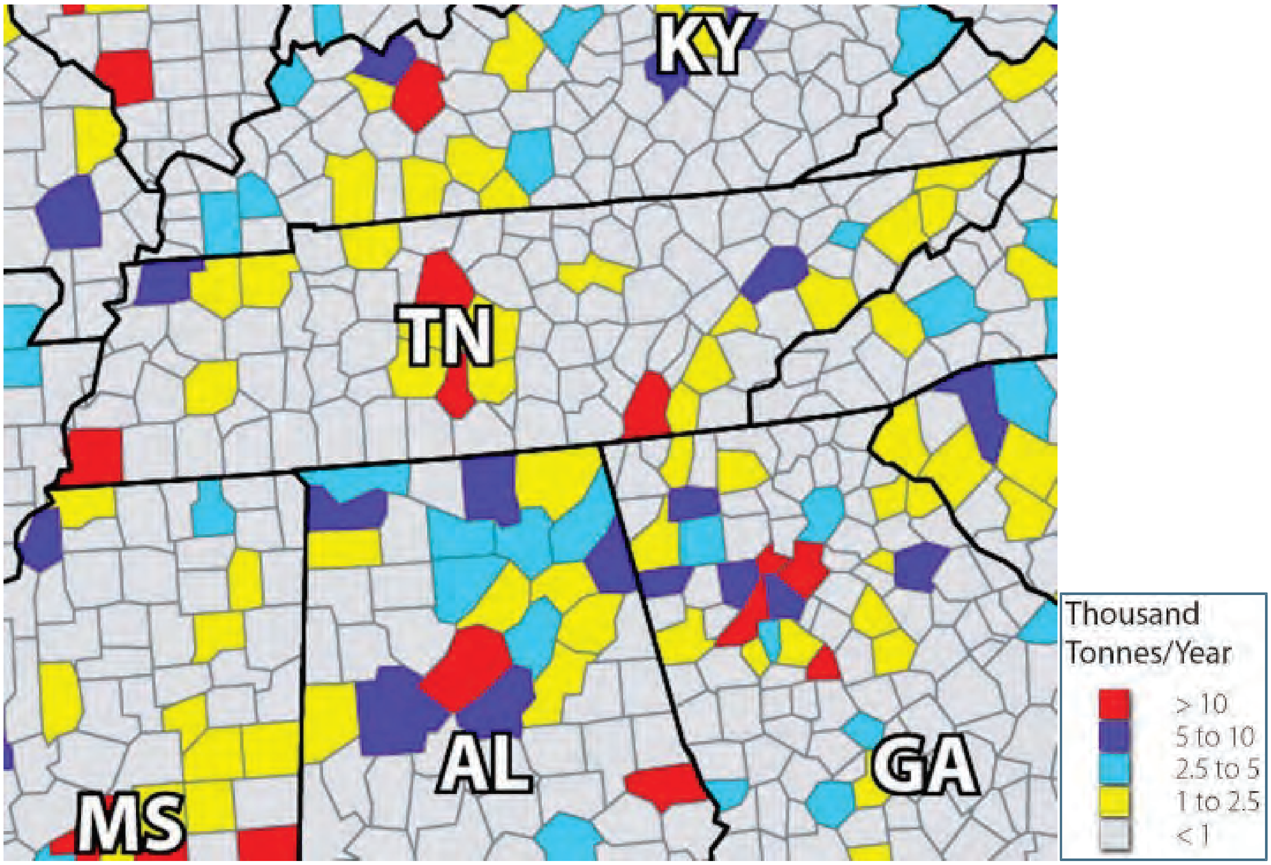

Figure 4-24: Total biogas (methane) resources in metric tons potentially available in the TVA region by county. Source: Adapted from NREL (2014).

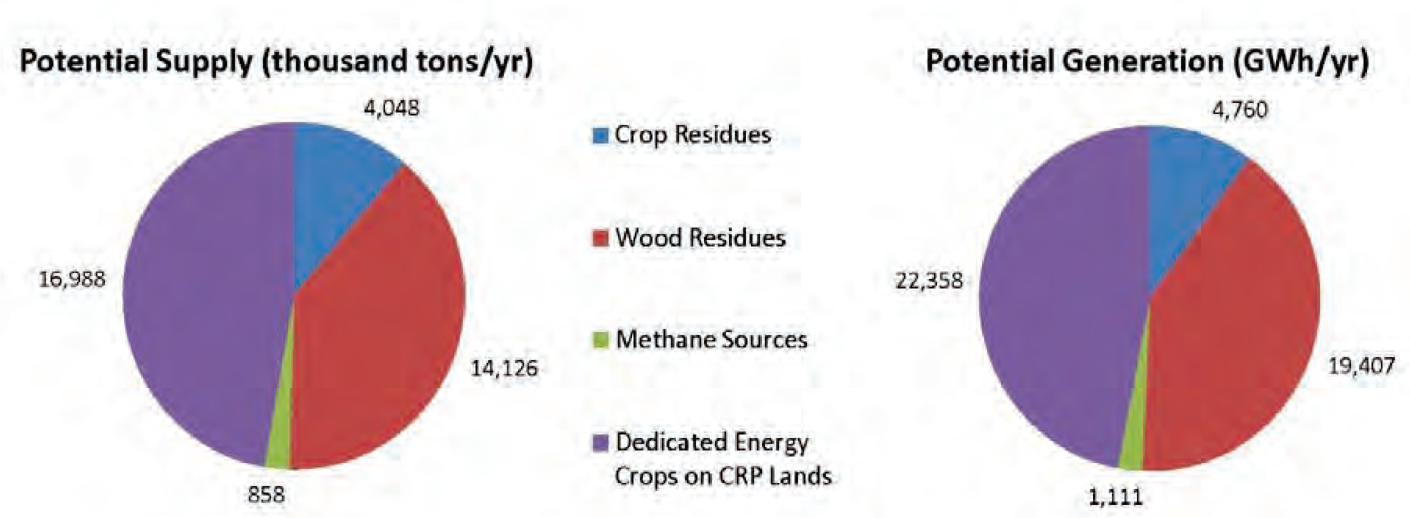

Figure 4-25: TVA region potential biomass resource supply (left) and generation (right). Source: Adapted from Milbrandt (2005) and NREL (2014).

Forest residues consist of logging residues and other removable material left after forest management operations and site conversions, including unused portions of trees cut or killed by logging and left in the woods. Mill residues consist of the coarse and fine wood materials produced by mills processing round wood into primary wood products (primary mill residues) and residues produced by woodworking shops, furniture factories, wood container and pallet mills and wholesale lumberyards (secondary mill residues) (Milbrandt 2005). Crop residues are plant parts that remain after harvest of traditional agricultural crops; the amount available was adjusted to account for the amount left in fields for erosion control and other purposes. Methane sources include landfills, domestic wastewater treatment plants, and emissions from farm animal manure management systems.

Dedicated energy crops are crops grown specifically for use as fuels, either by burning them or converting them to a liquid fuel, such as ethanol, or a solid fuel, such as wood pellets or charcoal. They can include traditional agricultural crops, non-traditional perennial grasses and short rotation woody crops. Traditional agricultural crops grown for fuels include corn, whose kernels are fermented to produce ethanol and soybeans, whose extracted oil can be converted to biodiesel. Sorghum is also a potential fuel feedstock. Non-traditional perennial grasses suitable for use as fuel feedstocks include switchgrass (*Panicum virgatum*) and miscanthus, also known as E-grass (*Miscanthus x giganteum*, a sterile hybrid of *M. sinensis* and *M. sacchariflorus*) (Dale et al. 2010). Short rotation woody crops are woody crops that are harvested at an age of 10 years or less. Trees grown or potentially grown for short rotation woody crops in the TVA region include eastern cottonwood, hybrid poplars, willows, American sycamore, sweetgum and loblolly pine (UT 2008; Dale et al. 2010). Plantations of these trees are typically established from stem cuttings or seedlings. With the exception of loblolly pine, these trees readily re-sprout from the stump after harvesting. As described in Section 4.5.7, the area of short rotation woody crops in the TVA region is small. Milbrandt (2005) analyzed the potential production of dedicated energy crops on Conservation Reserve Program lands, a voluntary program that encourages farmers to address natural resource concerns by removing land from traditional crop production. Growing dedicated energy crops on conservation reserve lands reduces their impact on food production.

The estimate of 36 million potential tons/year does not consider several important factors and may be optimistic. The analysis assumes that all of the biomass is available for use without regard to current ownership and competing markets. Growth in use of biomass will likely result in increased competition for biomass feedstock and reduce the feasibility of some biomass.

TVA has commissioned studies of the biomass potentially available for fueling its coal-fired generating plants. A 1996 study (ORNL 1996) addressed the potential supply of short rotation woody crop and switchgrass biomass grown on crop and pasture lands. The potential supply is greatly influenced by the price paid for biomass, which influences its profitability relative to the profitability of conventional crops. With higher prices, larger amounts of more productive farmland would likely be converted from food production to biomass production, and the western portion of the TVA region has the greatest potential for producing large energy crop supplies.

In a more recent study, Tillman (2004) surveyed the availability of woody biomass for cofiring at eight TVA coal-fired plants (all except Bull Run, Cumberland, and Gallatin) then in operation. Potential sources included producers of primary and secondary mill residues as described above. These sources produced about 433,000 dry tons/year (approximately 7,153,000 Million British Thermal Units (MBtu)/yr) of potential biomass fuels within economical haul distances of TVA coal-fired plants. The most abundant material type was sawdust (about 57 percent of the total) and only about 2 percent of the biomass was not already marketed. At a 2004 price of $1.25–1.50/MBtu, sufficient biomass would be available to support 75–80 MW of generating capacity and the annual generation of 300,000–450,000 MWh of electricity. The availability of woody biomass has likely changed since 2004 because of the closure of some major wood product mills in the region and other forest industry developments.

4.7 Solid and Hazardous Wastes

This section focuses on the solid and hazardous wastes produced by the construction and operation of generating plants and transmission facilities. Wastes typically produced by construction activities include vegetation, demolition debris, oily debris, packing materials, scrap lumber and domestic wastes (garbage). Non-hazardous wastes typically produced by common facility operations include sludge and demineralizers from water treatment plant operations, personal protective equipment, oils and lubricants, spent resins, desiccants, batteries and domestic wastes. In 2016, TVA facilities produced approximately 23,000 tons of non-hazardous solid waste. This quantity decreased to approximately 18,750 tons in 2017. The amount of waste produced at any one facility, however, can vary significantly from year to year due to maintenance, decommissioning, and asset improvement activities. In an effort to reduce waste generation, especially hazardous waste, TVA has incorporated into its procedures waste minimization efforts including reuse and recycling, substitution of less hazardous products and chemical traffic control.

Hazardous, non-radiological wastes typically produced by common facility operations include paint and paint solids, paint thinners, discarded out-of-date chemicals, parts washer liquids, sand blast grit, chemical waste from cleaning operations and broken fluorescent bulbs. The amount of these wastes generated varies with the size and type of facility (Table 4-12). Special projects such as large scale renovations, demolitions, decommissioning and boiler cleaning are considered non-routine and are not reflected in this table. Hazardous wastes, wastes requiring special handling under the Toxic Substances Control Act (TSCA) and universal waste (see explanations below) generated from routine facility operations are generally shipped to Waste Management's Emelle, Alabama facility for disposal.

Table 4-12: Annual quantities (in tons) of hazardous wastes generated by routine operations at TVA facilities, 2015-2017.

	Type of Facility					
Year	Coal Plant	Nuclear Plant	Hydroelectric Plant	Natural Gas Plant	Other	Total
2015	1.65	3.76	1.42	0.03	0.28	7.14
2016	1.21	1.40	0.14	0.02	0.22	2.99
2017	16.06	1.63	0.57	0.04	0.05	18.35
Annual Average	6.31	2.26	0.71	0.03	0.18	9.49

Hazardous wastes are defined by RCRA to include those that meet the regulatory criteria of ignitability, corrosively, reactivity, or toxicity. They can include such materials as paints, solvents, corrosive liquids and discarded chemicals. Wastes regulated under the TSCA that are typically encountered at TVA sites include polychlorinated biphenyls (PCBs), historically used in insulating fluids in electrical equipment. PCB items are typically shipped to Trans Cycle Industries in Pell City, Alabama or handled through Clean Harbor's Tucker, Georgia facility.

Used oil, if not recycled is considered a waste. Used oils include gear oils, greases, mineral oils and an assortment of other petroleum- and synthetic-based oils. The majority of TVA's used oil, approximately 35,000 kilograms, is recycled annually by TVA. Used oil containing 50 or greater parts per million (ppm) PCB is regulated by TSCA and must be disposed of as PCB-contaminated oil.

Universal wastes are a subset of hazardous wastes that are widely available, easily recyclable, and generally pose a relatively low threat. However, these wastes can contain materials that cannot be released into the environment. This classification includes batteries, pesticides, fluorescent bulbs and equipment containing mercury. In 2017, approximately 27.4 tons of universal waste were generated and recycled by TVA.

Coal-fueled generating plants produce large quantities of ash and other coal combustion solid wastes and nuclear plants produce radioactive wastes. These wastes are described in more detail below.

4.7.1 Coal Combustion Solid Wastes

The primary solid wastes produced by coal combustion are fly ash, bottom ash, boiler slag, char, spent bed material and FGD residue. The properties of these wastes (also known as CCRs or coal combustion products) vary with the type of coal plant, the chemical composition of the coal, and other factors. Ash and slag are formed from the noncombustible matter in coal and small amounts of unburned carbon. Fly ash is composed of small, silt- and clay-sized, mostly spherical particles carried out of the boiler by the exhaust gas. Bottom ash is heavier and coarser with a grain size of fine sand to fine gravel and falls to the bottom of the boiler where it is typically collected by a water-filled hopper. Boiler slag, a coarse, black, granular material, is produced in cyclone furnaces when molten ash is cooled in water. Ash and slag are primarily composed of silica (SiO_2), aluminum oxide (Al_2O_3), and iron oxide (Fe_2O_3). Spent bed material is produced in fluidized bed combustion boilers (e.g., the now retired Shawnee Fossil Plant Unit 10).

FGD residue is formed in FGD systems (scrubbers) by the interaction of sulfur in the flue gas with finely ground limestone or slaked lime. TVA's currently operating FGD systems use limestone as the reagent to bond with the sulfur, producing hydrated calcium sulfate ($CaSO_4 2H_2O$), also known as synthetic gypsum. The recently installed FGD systems at the Gallatin Fossil Plant and on Shawnee Fossil Plant Units 1 and 4 use slaked lime as the reagent and produce calcium sulfite ($CaSO_3$). Unlike the other plants with FGD systems that segregate the ash and FGD residue waste streams, the CCRs at Gallatin and Shawnee are combined in a single dry waste stream.

During 2017, TVA produced approximately 2.5 million tons of CCRs, with approximately 46 percent being gypsum, 29 percent being fly ash, and the remaining 25 percent bottom ash, boiler slag, and dry scrubber product (Table 4-13). Of the 2.5 million tons, 1.0 million tons, or 40 percent, were utilized or marketed. From 2013 to 2016, on average, TVA utilized or marketed approximately 1.2 million tons of CCRs per year, 30 percent of the total CCRs produced during this time. Thus the total quantity of CCRs utilized or marketed decreased in 2017, but the proportion utilized or marketed increased (29 to 40 percent). The decreased quantity utilized or marketed is largely due to reduced total production of CCRs resulting from coal plant retirements. TVA fly ash is utilized as a replacement for Portland cement in ready mix concrete and also as structural fill. TVA gypsum is used to produce wallboard and also in cement. The uses for TVA boiler slag include abrasives and blasting agents. It should be noted that opportunities for reuse of the combined fly ash and FGD residue CCR produced at Gallatin and Shawnee are currently very limited.

CCRs are regulated by 40 CFR Parts 257 and 261, also known as the CCR Rule. This rule regulates the disposal of CCR as solid waste under the subtitle D of RCRA.

Table 4-13: TVA coal combustion residual production and utilization, 2014-2017.

Material	CCR in Tons							
	2014		2015		2016		2017	
	Production	Utilization	Production	Utilization	Production	Utilization	Production	Utilization
Fly Ash	1,454,706	416,922	1,124,402	291,806	911,078	280,071	740,912	286,609
Bottom Ash	294,199	-	247,553	23	218,760	6,660	239,044	4,810
Boiler Slag	485,275	347,265	389,616	285,411	353,850	257,927	143,610	69,338
Gypsum	2,446,508	608,156	2,122,196	729,181	1,882,784	707,837	1,181,731	667,921
Dry Scrubber Product	-	-	-	-	211,840	-	235,801	-

The CCRs that are not sold for reuse are stored in landfills and impoundments at or near coal plant sites. As of early 2019, TVA operates six coal-fired plants. Two of the six facilities (Bull Run and Kingston) have been converted to dry storage and disposal, while three more facilities (Cumberland, Gallatin, and Shawnee) are projected to complete the conversion by October 2020. Proposed CCR management activities, as well as activities that are currently underway, are described in more detail below in Section 4.7.3.

4.7.2 Nuclear Waste

The nuclear fuel used for power generation produces liquid, gaseous, and solid radioactive wastes ("radwaste") that require storage and disposal. These wastes are categorized as high-level waste and low-level waste based on the type of radioactive material, the intensity of its radiation, and the time required for decay of the radiation intensity to natural levels.

High-Level Waste – About 99 percent of high-level waste generated by nuclear plants is spent fuel, including the fuel rod assemblies. Nuclear fuel is made up of small uranium pellets placed inside long tubular metal fuel rods which are grouped into fuel assemblies and placed in the reactor core. In the fission process, uranium atoms split in a chain reaction yielding heat. Radioactive fission products, the nuclei left over after the atom has split, are trapped and gradually reduce the efficiency of the chain reaction. Consequently, the oldest fuel assemblies are removed and replaced with fresh fuel at about 18-month intervals. Because nuclear plants normally operate continuously at full load, spent fuel production varies little from year to year. The seven operating nuclear units produce about 700 tons of high-level waste per year.

After it is removed from the reactor, spent fuel is stored at the nuclear plants in pools (steel lined, concrete vaults filled with water) inside the plant. The spent fuel pools were originally intended to store spent fuel onsite until a monitored retrievable storage facility and a permanent repository were built by the Department of Energy as directed by the Nuclear Waste Policy Act of 1982. Because these facilities have not yet been built, the storage capacity of the spent fuel pools at Watts Bar, Sequoyah and Browns Ferry nuclear plants has been exceeded. TVA, like other utilities, now stores spent fuel at all three nuclear plants in above-ground dry storage casks constructed of concrete and metal and placed on concrete pads inside of the plant security perimeter.

Low-Level Waste – Low-level waste consists of items that have come into contact with radioactive materials. At nuclear plants, these wastes consist of solids such as filters, spent resins (primarily from water filtration systems), sludge from tanks and sumps, cloth and paper wipes, plastic shoe covers, tools and materials; liquids such as tritiated waste (i.e., containing tritium), chemical waste, and detergent waste; and gases such as radioactive isotopes created as fission products and released to the reactor coolant. Nuclear plants have systems for collecting these radioactive wastes, reducing their volume, and packaging them for interim onsite storage and eventual shipment to approved processing and storage facilities.

Dry active wastes, which typically have low radioactivity, are presently shipped to a processor in Oak Ridge, Tennessee, for compaction and then to a processor in Clive, Utah, for disposal. Wet active wastes with low radioactivity are shipped to the Clive processor. Other radioactive wastes are currently shipped to and stored at the Sequoyah plant. Table 4-14 lists the amounts of low level waste produced at TVA nuclear plants between 2010 and 2017.

Table 4-14: Low-level radioactive waste generated at TVA nuclear plants (cubic feet).

	2010	2011	2012	2013	2014	2015	2016	2017
Browns Ferry	50,656	49,898	69,480	85,599	57,123	67,609	62946	81251
Sequoyah	7,995	13,148	8,063	15,284	33415	31590	36695	16094
Watts Bar	9,781	14,543	8,212	9,450	14,906	24,112	8,140	4,065
Total	68,432	77,589	85,755	110,333	105,444	123,311	107,781	101,410

Definition: Low-level radioactive waste includes class A, B and C radioactive waste as reported to the NRC.

Mixed Waste – Mixed Waste is a classification of waste that is dually regulated as radioactive and contains some other components regulated by additional environmental regulations (i.e., RCRA or TSCA). Examples of mixed waste, usually generated during maintenance activities, include lead paint chips, cleanup debris, resin, transformers, and unpunctured aerosol cans. Because of the dual regulation, it is extremely difficult to find a properly permitted outlet for disposal of this material. Table 4-15 shows the mixed waste sent for disposal from TVA sites during 2010–2017.

Table 4-15: Mixed waste generated at TVA nuclear plants and other facilities (kg).

	2010	2011	2012	2013	2014	2015	2016	2017
Browns Ferry	0	0	101	0	0	0	0	4645
Sequoyah	0	0	86	731	0	0	0	2.3
Watts Bar	0	0	0	0	0	0	0	0
Power Service Shops	0	0	1,066	0	0	0	0	0
Total	0	0	1,253	731	0	0	0	4,647

4.7.3 Solid and Hazardous Wastes at Facilities Considered for Potential Retirement

Potential retirement of coal and CT plants would primarily result in a decrease in solid and hazardous waste produced. Currently, CCRs constitute the majority of waste produced at these facilities. Appendix B shows actual and average CCR production at each coal-fired plant between 2012 and 2018. Appendix B also shows projected CCR production at these facilities from 2019 to 2030, should the facilities not be retired. CT plants produce very small quantities of solid waste during normal operation and therefore these wastes are not further described here.

4.7.3.1 Cumberland Fossil Plant

Cumberland disposes of a wide range of solid wastes including refuse, sanitary wastes, contaminated environmental media, scrap metals, non-hazardous wastewater treatment plant sludge, non-hazardous air pollution control wastes, various nonhazardous industrial wastes (e.g., CCRs), and other materials. The primary solid wastes that result from the operation of Cumberland are collectively known as CCR. The primary CCR waste streams at Cumberland are fly ash, bottom ash and gypsum. From 2012 to 2018, Cumberland produced between 412,200 and 606,500 tons of ash per year. During that same time, Cumberland generated between 695,600 and 987,600 tons of gypsum per year. TVA has historically managed storage of CCR materials generated at Cumberland in four CCR units: the Dry Ash Stack, Gypsum Storage Area, Bottom Ash Pond, and Main Ash Pond (including Stilling Pond).

In response to the CCR Rule, TVA published closure plans for each Cumberland CCR unit. The Dry Ash Stack and Gypsum Storage Area have a landfill permit approved under the Tennessee state regulations, which also includes a closure plan. The CCR Rule closure plans for the Dry Ash Stack and Gypsum Storage Area align with the state permitted closure plan, and reflect closure of these units in-place. Similarly, the closure plans reflect closure of the Bottom Ash Pond and Main Ash Pond (including Stilling Pond) in-place. Under these plans, each impoundment would undergo dewatering, waste stabilization, and capping with a geosynthetics-soil matrix.

In May 2018, TVA issued a final EIS (TVA 2018f) for the actions described in the preceding paragraph as well as for the construction and operation of a bottom ash dewatering facility, an onsite CCR landfill, and process water basins at Cumberland. Construction of the on-site CCR landfill is ongoing. In order to accommodate construction of process water basins within the footprint of the Main Ash Pond/Stilling Pond, the preferred alternative for closure of these units in the EIS is a combination of closure-in-place and closure-by-removal.

The CCR units at Cumberland are subject to Order No. OGC15-0177 entered by the Tennessee Department of Environment and Conservation (TDEC) in 2015 (TDEC Order). The TDEC Order outlines a process for the investigation, assessment, and remediation of any unacceptable risks associated with CCR units at all TVA coal-fired power plant sites in Tennessee, except Gallatin. The process will result in a determination of the final closure methodology for the CCR units at Cumberland and any other necessary corrective actions.

4.7.3.2 Gallatin Fossil Plant

Solid waste generated at Gallatin is similar to that described above for Cumberland. From 2015 to 2018, Gallatin produced between 226,400 and 286,700 tons of ash per year. Calcium sulfite production began in 2015 with the startup of the FGD system; since then this FGD byproduct is combined with ash into a single CCR waste stream. CCRs are managed in five CCR units (landfills and surface impoundments): North Rail Loop Landfill, Ash Pond A, Ash Pond E, Bottom Ash Pond, and Middle Pond A.

In response to the CCR Rule, TVA published closure plans for each Gallatin CCR unit. The North Rail Loop Landfill has a landfill permit approved under the Tennessee state regulations, which also includes a closure plan. The North Rail Loop Landfill is currently under development with Cell 1 operational. Closure of the North Rail Loop Landfill is expected to be accomplished by leaving CCR in place and applying a final cover system that meets the CCR Rule closure in-place performance standards, as well as applicable state standards. Potential closure methodologies for the ponds are the subject of an EIS that TVA began preparing in late 2018. TVA is considering various closure methodologies for Ash Pond A, Middle Pond A, Bottom Ash Pond, and Ash Pond E in accordance with CCR Rule performance standards and applicable state standards. If closed in place, the CCR pond closure would require decanting, subgrade preparation, final cover system installation, and the establishment of vegetative cover. Other options being considered in the EIS include removal of the CCR to a new on-site landfill expansion or beneficial reuse of the CCR. The final closure methodology for these CCR ponds may also be impacted by ongoing litigation.

4.7.3.3 Kingston Fossil Plant

Kingston disposes of a wide range of solid wastes similar to that described above for Cumberland. From

2012 to 2018, Kingston generated between 114,100 and 195,800 tons of coal ash per year. During that same time, Kingston generated between 127,800 and 225,000 tons of gypsum per year. CCRs are managed in three CCR units (landfills and surface impoundments): the Peninsula Disposal Area, the Sluice Trench and Area East of the Sluice Trench, and the Stilling Pond.

In response to the CCR Rule, TVA published closure plans for each Kingston CCR unit. The Peninsula Disposal Area has a landfill permit approved under the Tennessee state regulations, which also includes a closure plan.The closure plans reflect closure of the Peninsula Disposal Area in place via engineered cover systems consisting of a 40-mil thick textured high-density polyethylene (HDPE) geomembrane and double-sided geocomposite drainage layer, protective cover soil layer, and vegetative soil cover. Under its closure plan, the Stilling Pond would be dewatered, stabilized, filled and graded, and capped with a low-permeability final cover. In-place closure of the Sluice Trench was completed in September 2017. The area encompassing the Sluice Trench consisted of two separate cap systems that will require minimal maintenance. In-place closure of the Area East of the Sluice Trench is scheduled to be completed in 2019. The CCR units at Kingston are subject to the TDEC Order, and the process under that order will result in a determination of the final closure methodology for the CCR units at Kingston and any other necessary corrective actions.

4.7.3.4 Shawnee Fossil Plant

Solid waste generated at Shawnee is similar to that described above for Cumberland. From 2012 to 2018, Shawnee generated between 215,800 and 266,500 tons of coal ash per year. Calcium sulfite production began in 2017 with the completion of the FGD systems on Units 1 and 4; this scrubber byproduct is combined with ash into a single CCR waste stream. CCRs are managed in two CCR units (landfills and surface impoundments): the Consolidated Waste Dry Stack, and the Ash Pond 2 (Main Ash Pond and Stilling Pond).

In 2015, in response to the CCR Rule, TVA began an evaluation of converting ash handling processes at Shawnee from wet sluicing to dry handling. In December 2017, TVA issued a final EIS on CCR management at (TVA 2018e). The EIS analyzed closing both the SWL and Ash Pond 2, as well as building and operating a new lined landfill to store dry CCR waste produced by SHF in the future. The preferred Alternative B included construction of an onsite CCR landfill, closure-in-place of Ash Pond 2 with a reduced footprint, and closure-in-place of the SWL. On January 16, 2018, TVA issued a record of decision (ROD) to implement construction of the new dry CCR landfill, and elected to further consider the alternatives regarding the closure of the SWL and Ash Pond 2 before making a decision.

In April 2018, TVA issued a draft supplemental EIS (SEIS) to further analyze the alternatives for closure of the SWL and Ash Pond 2. The new preferred alternative in the SEIS is generally consistent with the preferred alternative proposed in the 2017 EIS; however the SEIS proposed that ash in the northwest corner of Ash Impoundment 2 would not be removed and consolidated. Instead, both the SWL and Ash Impoundment 2 would be closed-in-place and regraded with materials redistributed within the existing facilities or using borrow material from the Shawnee East Site (as needed) to establish appropriate drainage and stability. New storm water outfalls would be installed along the perimeter of the facilities to outlet at elevations at or above the 100-year flood elevation.

4.8 Socioeconomics

This section describes social and economic conditions in the TVA PSA and near vicinity. It presents and compares qualitative and quantitative data from varying geographies in order to characterize the regional human population and associated demographics, sociocultural factors, and economics. Depending on availability and comparability, the census data derive from the U.S. Census Bureau (USCB) 2010 decennial census (2010 Census), 5-year estimates of the 2012 – 2016 American Community Survey (2016 ACS), and the 2000 – 2010 and the 2010 – 2017 estimates of the USCB Population Estimates Program (2010 PEP and 2017 PEP). These data were obtained utilizing USCB

American FactFinder, TIGER Products, and Population and Housing Unit Estimates (USCB 2018a, 2018b, 2018c). Spatial data for figures were obtained through USCB TIGER Products. Other quantitative and qualitative data were gathered from TVA staff, US Bureau of Economic Analysis (USBEA), regional commissions, counties and communities, and other relevant sources, as cited within each subsection.

Generally, when census data are presented, information on the TVA PSA as a whole is given as a baseline for comparison to smaller parts of the PSA. The TVA PSA considered for socioeconomics consists of 180 counties and two independent cities in seven states, including all counties in Tennessee and portions of Alabama, Georgia, Kentucky, Mississippi, North Carolina, and Virginia (see Appendix C for a complete list of counties considered). Smaller areas are defined as relevant to the topic and may consist of metropolitan statistical areas (MSAs), urban or rural areas, counties, or census tracts.

Where relevant, information from USCB Division 6, East South Central, is employed for comparative purposes. Division 6 includes the majority of the TVA PSA, consisting of Alabama, Kentucky, Mississippi, and Tennessee (USCB 2018d). USCB Division 6 data may be more comparable to the TVA PSA than that of USCB Region 3, the South, because of similarities in population densities, demographics, sociocultural characteristics, and economics. For many topics, U.S.-wide data are also employed due to their usefulness in understanding how the TVA PSA compares with the rest of the nation.

4.8.1 Population and Demographics

Population and various demographic data are presented in this subsection. First, population change for the TVA PSA between 2010 and 2017 are compared with that for Division 6 and the U.S. Then, population variation across the TVA PSA and among its most populous MSAs is discussed. The most current population estimates, the 2017 PEP, informed this analysis. Finally, demographic variables for the TVA service are compared with those of Division 6 and the nation.

4.8.1.1 Population

As shown in Table 4-16, the estimated population of the TVA PSA was 9.8 million in July 2010 and almost 10.3 million by July 2017, a 4.4 percent increase (2017 PEP). Between 2002 and 2010, the rate of increase was about 9.2 percent, greater than the 7.2 percent increase of Division 6 or the 7.6 percent increase of the U.S. as a whole (2010 PEP). In more recent years, the rate of increase has been declining. The 2010 to 2017 rate of increase for the TVA PSA (4.4 percent) was greater than the Division 6 rate of 3.1 percent and less than the national rate of 5.3 percent (2017 PEP). Based on TVA estimates, the annual rate of population growth in the TVA PSA is expected to decline to about 0.5 percent by 2043.

Population varies greatly among the counties in the TVA PSA (Figure 4-26). The larger population concentrations tend to be located along major river corridors: the Tennessee River and its tributaries from northeast Tennessee through Knoxville and Chattanooga into north Alabama; the Nashville area along the Cumberland River; and the Memphis area on the Mississippi River. Low population counties are scattered around the region, but most are in Mississippi, the Cumberland Plateau in Tennessee, and the Highland Rim in Tennessee and Kentucky.

An increasing proportion of the total population of the TVA PSA, 66.5 percent in 2010 and an estimated 67.6 percent in 2017, lives in USCB-defined metropolitan statistical areas[4] (MSAs; Table 4-16). Two of these areas were estimated to have populations greater than one million in 2017: Nashville, 1.9 million, and Memphis, almost 1.4 million. The Knoxville and Chattanooga MSAs were estimated to have populations of approximately 877,000 and 557,000, respectively. These four MSAs accounted for nearly 46 percent of the TVA PSA's population based on the 2017 PEP.

Table 4-16: Population data for the TVA PSA, TVA MSAs, Division 6, and U.S.

Area	2010 Population [a]	2017 Population [b]	% Increase 2010 – 2017	% of TVA PSA Pop., 2017
United States	309,338,421	325,719,178	5.3	--
Division 6	18,459,846	19,719,178	3.1	--
TVA PSA	9,810,629	10,246,104	4.4	--
MSAs in TVA PSA				
Bowling Green, KY	159,309	174,835	9.7	1.7
Chattanooga, TN-GA	529,196	556,548	5.2	5.4
Clarksville, TN-KY	261,619	285,042	9.0	2.8
Cleveland, TN	115,913	122,317	5.5	1.2
Dalton, GA	142,315	144,440	1.5	1.4
Decatur, AL	153,949	151,867	-1.4	1.5
Florence-Muscle Shoals, AL	147,260	147,038	-0.2	1.4
Huntsville, AL	419,279	455,448	8.6	4.5
Jackson, TN	130,031	129,235	-0.6	1.3
Johnson City, TN	199,010	202,053	1.5	2.0
Kingsport-Bristol-Bristol, TN-VA	309,494	306,659	-0.9	3.0
Knoxville, TN	838,748	877,104	4.6	8.6
Memphis, TN-AR	1,326,280	1,348,260	1.7	13.2
Morristown, TN	114,219	118,081	3.4	1.2
Nashville- Davidson-Murfreesboro-Franklin, TN	1,675,757	1,903,045	13.6	18.6
TVA MSA TOTALS	6,522,379	6,921,972	6.1	67.6

Sources:
a 2010 PEP
b 2017 PEP

[4] The Memphis MSA has two counties outside the TVA PSA, Crittenden County, Arkansas and Tunica County, Mississippi.

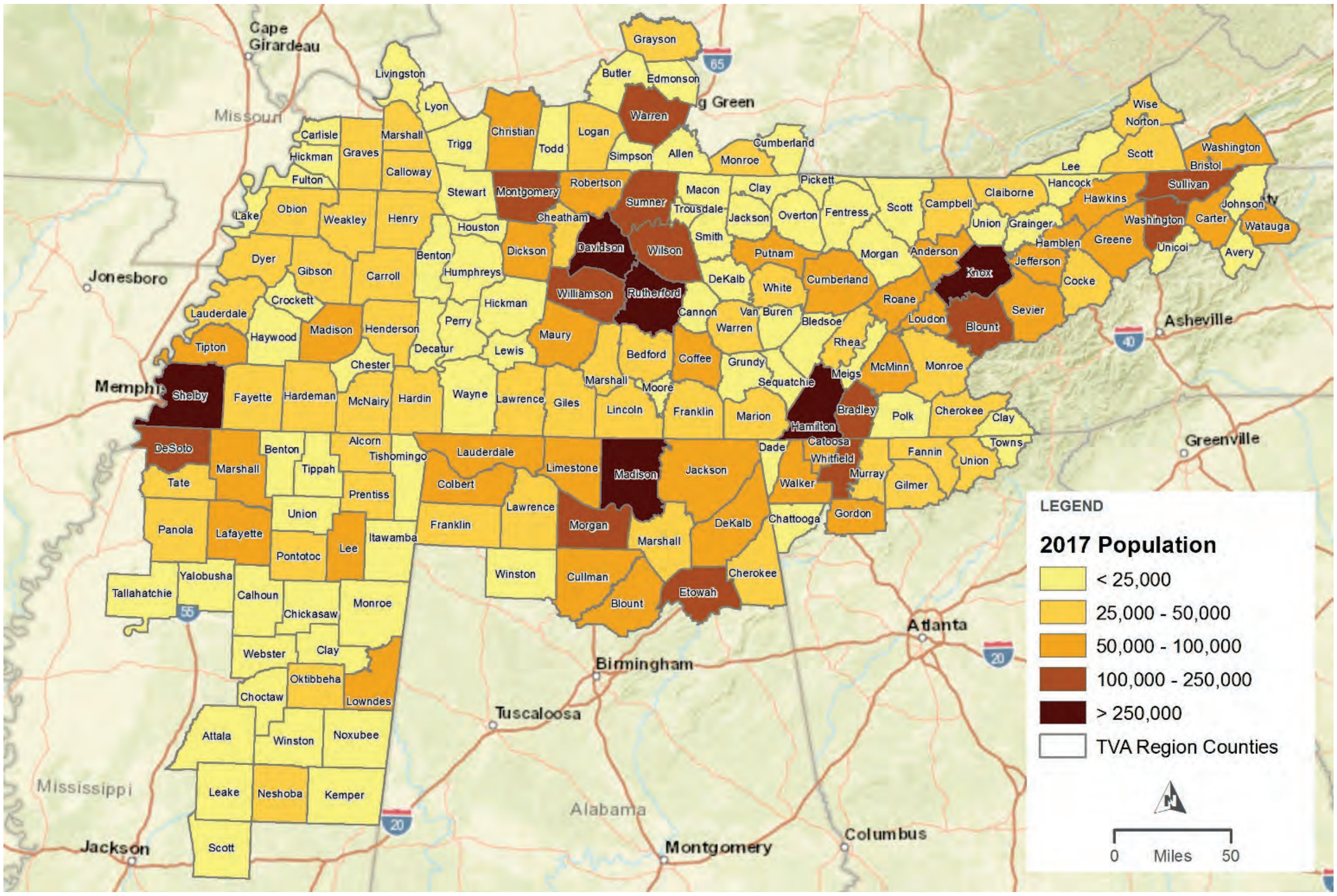

Figure 4-26: Variation in population of counties in the TVA PSA.

While the proportion of the region's population living in metropolitan areas was estimated by the 2017 PEP to be lower than the national average of about 85 percent, the proportion has been increasing, and this trend appears likely to continue in the future. A substantial part of this increase is likely to follow the pattern of increases in the physical size of metropolitan areas as growth expands from the central core of these areas. Conversely, several lifestyle and economic concerns, including commuting time and costs and proximity to social amenities, have led to increased residential populations in the urban core areas of several cities in the TVA PSA, including the largest cities.

4.8.1.2 Demographics

As shown in Table 4-17, the 2016 ACS estimated the median age in the TVA PSA to be 40.8 years, an increase from the median age of 37.9 years when compared to the 2010 Census. The TVA PSA also has a higher percentage of people over 65 years of age than in Division 6 or the nation as a whole. The percentage of people identifying themselves as White alone was 78.7 percent, with the remaining 21.3 percent of people identifying themselves as another race or more than one race (including White). The White alone percentage is greater than that of Division 6 and the U.S., where the percentages were estimated to be 71.3 percent and 73.4 percent, respectively, in the 2016 ACS.

Table 4-17: Demographics of the TVA PSA, Division 6, and U.S.

Geography	Median Age	% White Alone	% Age 65 or More	% High School or Higher
United States	37.7	73.4	14.5	87.0
Division 6	37.5	71.3	14.9	85.6
TVA PSA	40.8	78.7	15.3	84.7

Sources: 2016 ACS Data Profile (DP) 05 and High Sampling (S) 1501

Of the TVA PSA population 25 years old or older, the 2016 ACS estimated that approximately 85 percent hold a high school diploma, equivalency diploma, or higher degree, as shown in Table 4-17. This percentage is lower than in Division 6 and the U.S. as a whole, where 86 and 87 percent of the populations 25 years old or older, respectively, were estimated to hold high school diplomas, the equivalent, or higher degrees, as shown in Table 4-17.

4.8.2 Sociocultural Characteristics

This subsection describes historical and cultural characteristics of USCB Division 6, which encompasses the majority of TVA's PSA (USCB 2018c). The USCB regions and divisions were developed based on "practice and tradition" rather than under any statute or legislation (USCB 1994). Division 6 overlaps the central portion of the culture region known as the South or Southeast. Culture region is a social science concept based on the idea that human culture is formed through the relationships created by people in close proximity and such associations are often related to the geography, climate, resources, population density, and history of an area (Beck et al. 2009).

Distinctions between urban and rural areas across the TVA PSA are also described in this subsection. USCB-defined urban areas are densely developed areas that encompass residential, commercial, and other non-residential land uses (USCB 2016). USCB differentiates two types of urban areas: urbanized areas and urban clusters. Urbanized areas are those consisting of 50,000 or more people, while urban clusters are areas having between 2,500 and 49,999 people. Due to availability, completeness, and comparability, data used for this discussion derive from the 2010 Census.

4.8.2.1 Historical and Cultural Characteristics

Rural lifestyles dominated the Southeast until the mid- to late twentieth century. Earlier in the century, the predominant rural lifestyle, along with high unemployment and poverty rates, extensive flooding, and lagging electrification influenced the passage of the Tennessee Valley Authority Act of 1933 (TVA Act) that created TVA. The TVA Act was part of President Roosevelt's program to assist the nation during the Great Depression (TVA 2018i). The act directed TVA to "provide for the agricultural and industrial development of [the Tennessee Valley]," among other purposes. Flood control and the development of fertilizers were TVA programs designed to assist farmers of the region. Electrification by TVA was intended to help modernize rural communities and encourage economic development. While the Tennessee Valley region has substantially modernized since passage of the TVA Act, rural traditions continue to influence Southeastern culture, including its values, attitudes, music, language, class and race distinctions, and political and religious views (Beck et al. 2009).

Much of the TVA PSA is included in the Appalachian region, which generally straddles the ridgeline of the Appalachian Mountains (ARC 2018a). The Appalachian Regional Commission (ARC) was created in 1965 "to address the persistent poverty and growing economic despair of the Appalachian Region" (ARC 2018b). The ARC service territory extends beyond the Appalachian Mountains to include northern Alabama and a large portion of the TVA PSA in Mississippi. When ARC was formed, Appalachia, to which the region is often referred, was heavily dependent on farming, natural resource extraction, and heavy industries, and the region had a 31-percent poverty rate. More recently, the region has incorporated manufacturing and professional service industries into its economy, and poverty rates have declined to around 17 percent, approximately 4 percent higher than the nation as estimated in the 2016 ACS. Forty-two percent of the population of the Appalachian region is considered rural, as compared with 20 percent of the overall U.S. population.

Portions of the TVA PSA in Mississippi are included in the Mid-South Delta subregion of the South, which generally surrounds the Mississippi River in Arkansas, Louisiana, and Mississippi (Beaulieu and Littles 2009). The subregion is characterized by dependence on natural resources that are integrally linked to cultural heritage and local economies. Similar to many other areas of the South, the Mid-South Delta subregion is distinguished by its sociocultural divisions based on class and race.

Similar to the Mid-South Delta subregion is the Mid-South subregion of the South, which encompasses portions of western and central Tennessee and Kentucky. Inhabitants of western portions of this subregion have strong cultural connections to the Mississippi River. Rural areas of the Mid-South are generally characterized by the predominance of farming traditions. According to the USDA Census of Agriculture, approximately 68,050 farms on nearly 11 million acres were active across Tennessee in 2012 (USDA 2018b). Since 2002, the age of active farmers has increased, while the numbers of new farmers has declined. However, active farmers enjoy an increasing market value for their products.

Resource extraction, especially in relation to coal, remains an important aspect of the economies in portions of the Appalachian region and the Mid-South subregion (USEIA 2018b). Many people in these areas have been employed in coal extraction for decades and often have generational connections to coal mining whether or not they are currently involved in the industry (Carley et al. 2018). These facts have influenced personal identities as well as the broader culture in these areas. In interviews conducted among Appalachian coal mining communities, Carley et al. 2018 found that "[c]oal was frequently framed as the common bond—or identity—that held the entire community together." Interview participants conveyed that these cultural connections are associated with "location, landscape, and personal networks" and that the potential loss of such connections can lead to intense feelings of grief that make choosing different occupations or home locations difficult.

Coal mining areas in the TVA PSA are in northern Alabama, eastern Tennessee, and extreme eastern Kentucky, and the southern portion of the Illinois Basin coalfield in western Kentucky (USEIA 2018c). TVA has not recently purchased coal from Alabama or Tennessee; recent purchases have been from the Illinois Basin coalfield in western Kentucky, southwestern Indiana, and southern Illinois, the Powder River Basin in Wyoming and Montana, and the Uinta Basin in Colorado and Utah (see Section 2.3.1). The Red Hills plant in east-central Mississippi, from which TVA purchases power, is supplied by a nearby lignite mine.

4.8.2.2 Urban-Rural Distinctions

In 2010, the TVA PSA included 160 separate USCB-designated urban areas, 141 of these being smaller urban clusters and 19 being larger urbanized areas. Urban areas composed approximately 1.5 percent of the TVA PSA and contained nearly 59 percent of the population (Figure 4-27; USCB 2010). This is compared with the U.S. as a whole, where approximately 80.7 percent of the population resided within approximately 3.1 percent of the total land area in 2010 (Ratcliffe et al. 2016). Across Division 6, approximately 60 percent of the population lived in urban areas.

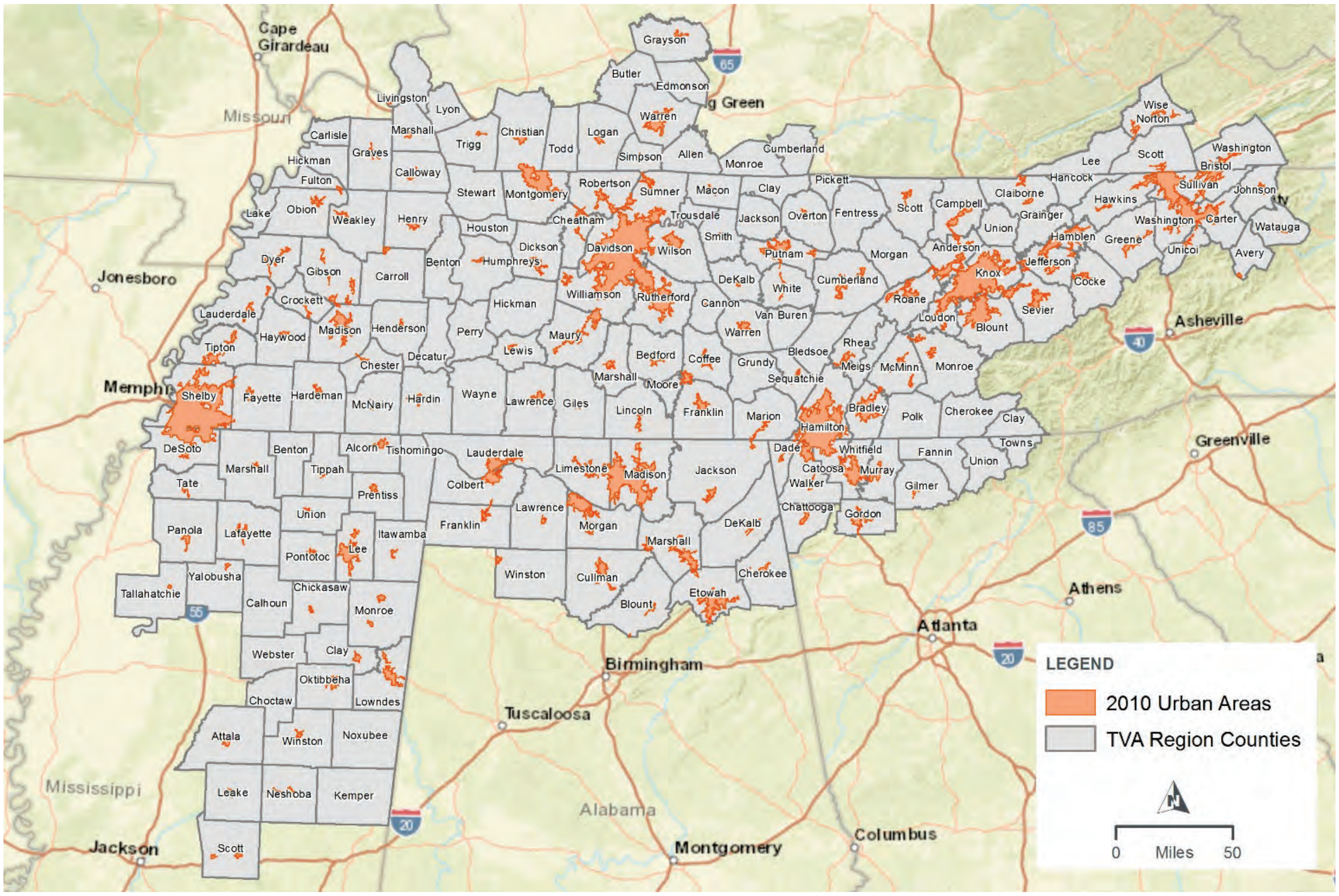

Figure 4-27: Urban and rural areas in the TVA PSA.

USCB considers all portions outside of designated urban areas to be rural areas (USCB 2016). In 2010, over 98 percent of the TVA PSA was considered rural, accounting for almost 42 percent of the population in the TVA PSA (see Figure 4-27). Nineteen percent of the U.S. population was considered rural in the same year (Ratcliff et al. 2016; USCB 2010).

According to the 2016 ACS, the three most populous counties in or partially within the TVA PSA were Shelby, Davidson, and Knox counties, Tennessee (Table 4-18). All of these counties had a population greater than 430,000 residents, and less than 11 percent of the land area of these counties was considered rural in the 2010 Census (USCB 2010). Nashville and portions of its metropolitan area encompass Davidson County, Tennessee, and Shelby County is primarily composed of the City of Memphis. Knox County is largely composed of the Knoxville metropolitan area. The population of Davidson County increased by 6.6 percent between 2010 and 2016, while Knox and Shelby increased by 3.7 and 1.0 percent, respectively.

According to the 2016 ACS data, the three least populous counties in or partially within the TVA PSA were Pickett County, Tennessee, and Carlisle and Hickman counties, Kentucky (Table 4-18). The entirety of these counties was considered rural areas in 2010, as defined by the USCB (USCB 2010). The population of Pickett County increased by approximately 0.4 percent between 2010 and 2016, while Carlisle and Hickman counties declined in population by 2.9 and 4.3 percent, respectively.

Table 4-18: Population data for the most/least populous counties in the TVA PSA.

Geography	2010 Population [a]	% Urban Population, 2010 [b]	2016 Population [c]	% Increase 2010 – 2016
Shelby County, TN	927,644	97.2	936,990	1.0
Davidson County, TN	626,681	96.6	667,885	6.6
Knox County, TN	432,226	89.1	448,164	3.7
Pickett County, TN	5,077	0	5,096	0.4
Carlisle County, KY	5,104	0	4,954	-2.9
Hickman County, KY	4,902	0	4,691	-4.3

Sources:
a 2010 Census DP01. Note that 2010 Census population data reported in April 2010, rather than the 2010 PEP mid-year estimates, were used in order to maintain comparability with urban and rural data, which were obtained during the 2010 Census.
b 2010 County Rurality Level
c 2012 – 2016 ACS 5-Year Estimates

4.8.3 Economics

In this subsection, major industries and employment and income data are presented for the TVA PSA, as compared with Division 6 and the U.S. TVA's contribution to state revenues through its tax equivalent payments is also provided.

4.8.3.1 Regional Economy

Based on the 2016 ACS, the top three industries for employment in the TVA PSA and Division 6, listed by rank highest to lowest, were: 1) educational services, health care, and social assistance industries; 2) manufacturing; and 3) retail trades. For the U.S., these were: 1) educational services, health care, and social assistance industries; 2) the retail trades; and 3) professional, scientific, management, administrative, and waste management industries.

In the TVA PSA and Division 6, the economy depends more on manufacturing than the U.S. as a whole. While the relative importance of manufacturing has been declining for a number of years, both nationally and regionally, in the TVA PSA, manufacturing jobs still employ almost 14 percent of the civilian working population, second among industrial sectors. Factors contributing to the high proportion of manufacturing include location with good access to markets in the Northeast, Midwest, Southwest, and the rest of the Southeast; good transportation; relatively low wages and cost of living; right-to-work laws; and abundant, relatively low-cost resources including land and electricity.

While the types of manufacturing industries vary considerably across the TVA PSA, there has been a continuing shift from non-durable goods, such as apparel, to durable goods, such as automobiles. In 1990, about 48 percent of manufacturing jobs were in durable goods. That share has increased to about 53 percent and this increase is expected to continue. Nondurable goods manufacturing peaked about 1993; the most notable decline has been in apparel and other textile products, which has declined from about 13 percent of regional manufacturing in 1990 to less than 2 percent. Nationally, there has been a slight increase in the share of non-durable goods, from about 40 percent in the year 2000 to a little more than 41 percent.

TVA plays an important role in the regional economy. This is evidenced by low cost, reliable power benefitting industrial customers and economic growth, as well as the amount of capital investment in the TVA PSA. Capital investments include investments in the overall power system such as funding for new and existing generating plants and general system improvements. Table 4-19 shows the amount of capital investment by

TVA for fiscal years 2012 through 2018. With the exception of 2015, TVA capital investment has increased during this period.

Table 4-19: TVA capital Investment between 2012 and 2018.

Fiscal Year	Capital Investment (in billions of U.S. dollars)
2012	$5.9
2013	$5.0
2014	$8.5
2015	$7.8
2016	$8.3
2017	$8.3
2018 (through April)	$9.3
Total	$53.1

Source: TVA Region Performance Highlights, 2012 – 2018

4.8.3.2 TVA-Contributions to State Economies and Revenues

TVA produces approximately 90 percent of the electricity generated in Tennessee, a state that ranks 31st in the nation for total energy production, and eighth in the nation for production of hydroelectric power (USEIA 2018b). TVA operations at Browns Ferry Nuclear Plant near Athens, Alabama is the major reason Alabama ranks fourth in the nation for nuclear power production (USEIA 2018d).

As required in the TVA Act, TVA makes tax equivalent payments, also known as payments in lieu of taxes, to states where TVA sells electricity or owns power system assets; these states are the seven TVA PSA states and Illinois, where TVA owns coal reserves. TVA also makes payments directly to local governments where TVA owns power facilities. The tax equivalent payments total 5 percent of gross proceeds from the sale of power in the prior fiscal year, with some exclusions.

Each state regulates how the payments are distributed to governmental entities across the state. In most of the eight states, the apportionment of funds is determined by the existence of TVA property and/or its value in proportion to the total value of TVA property in the state. Exceptions to this are in Alabama, Illinois, and Virginia. Illinois divides the majority of its funds among areas with TVA coal reserves. Rather than basing the distribution on the value of TVA property within its jurisdiction, Alabama and Virginia distribute payments to counties or cities receiving power services from TVA. Table 4-20 shows the amount of tax equivalent payments to states for TVA fiscal years 2015 through 2018.

Table 4-20: Tax equivalent payments by TVA to states where TVA produces power or acquired lands.

Geography	Tax Equivalent Payments (in millions of U.S. dollars, rounded)			
State	2015	2016	2017	2018
Alabama	$102.6	$94.2	$87.0	$87.5
Georgia	$9.1	$8.9	$8.4	$8.5
Illinois	$0.4	$0.4	$0.3	$0.4
Kentucky	$32.0	$35.1	$34.4	$36.2
Mississippi	$25.0	$40.3	$38.6	$39.7
North Carolina	$2.9	$2.8	$2.8	$2.8
Tennessee	$350.6	$351.9	$344.0	$347.4
Virginia	$1.3	$1.3	$1.2	$1.2

Sources: Illinois Department of Revenue 2017; TVA 2015d, 2016f, 2018j, 2018k

4.8.3.3 Employment

Based on 2016 ACS data, the potential working population in the TVA PSA, defined as people aged 16 years or more who are considered in the labor force, was estimated to be almost 4.8 million. Approximately 7.7 percent of this population was unemployed, slightly lower than the unemployment rates for Division 6 and somewhat higher than that for the U.S as a whole. There is considerable geographic variation in unemployment rates with adjacent counties sometimes having large differences. However, based on the 2016 ACS, the counties with the highest unemployment rates were concentrated in east-central Mississippi, in non-urban counties near the Mississippi River, and in the northern Cumberland Plateau in Tennessee. Unemployment rates across the TVA PSA range from a low of 3.7 percent in Williamson County, Tennessee, in the Nashville area, to a high of 18.2 percent in Hardeman County, Tennessee, a rural county east of Memphis.

As shown in Table 4-21, overall, the TVA PSA was similar to Division 6 in percentages of people employed in various occupations as estimated by the 2016 ACS.

While slightly less of its population was employed in management, business, science, and the arts than in the region or nation as a whole, the TVA PSA has a slightly higher percentage of employees in production, transportation, and material moving fields.

Table 4-21: Employment in occupations in the TVA PSA, Division 6, and U.S.

Geography	% Employed in:				
	Mgt., Business, Science, and Arts	Service	Sales and Office	Natural Res., Construction, Maint.	Production, Transportation, Material Moving
United States	37.0	18.1	23.8	8.9	12.2
Division 6	33.3	17	24.1	9.5	16.2
TVA PSA	32.9	16.8	24.1	9.4	16.8

Source: 2016 ACS S2405

TVA fosters job growth throughout its PSA by forming partnerships with economic development organizations. TVA Economic Development works with these organizations to attract new companies and support existing ones. TVA provides site selection services, incentives, and research and technical assistance to help new and existing businesses to operate in the Tennessee Valley (TVA 2018l). As shown in Table 4-22, job growth has moderated.

Table 4-22: TVA-assisted jobs between 2012 and 2018.

Fiscal Year	No. of Jobs
2012	48,000
2013	52,000
2014	60,300
2015	76,200
2016	72,100
2017	70,000
2018 (through April)	45,700

Source: TVA Region Performance Highlights 2012 – 2018

TVA employs a total of 5,189 people at 52 generating facilities throughout its PSA. Browns Ferry Nuclear Plant, near Athens, Alabama, accounts for just over 25 percent of the total number of TVA plant employees. Two other facilities, Watts Bar Nuclear Plant near Spring City in East Tennessee, and Sequoyah Nuclear Plant near Soddy-Daisy, Tennessee (north of Chattanooga), together account for an additional 36 percent of the total number of employees). The number of power plant employees has decreased in recent years as coal plants have been retired.

4.8.3.4 Income

Based on November 2018 USBEA estimates, derived in part from USCB data, per capita income in the TVA PSA is $42,578. This was approximately 1.9 percent higher than the Division 6 per capita income ($41,766) and 17.6 percent lower than that of the U.S. as a whole ($51,640). However, there was wide variation within the TVA PSA. Three counties had incomes above the national average, in descending order: Williamson County, Tennessee; Davidson County, Tennessee; and Fayette County, Tennessee. As previously indicated, Williamson and Davidson counties are within the Nashville metropolitan area. Fayette County, Tennessee is within the Memphis metropolitan area. Per capita income was below that in Division 6 and the nation in 166 counties and two independent cities in the TVA PSA, reflecting that higher per capita income concentrates in few areas in the TVA PSA. Figure 4-28 illustrates the differences in per capita income rates of TVA-region counties.

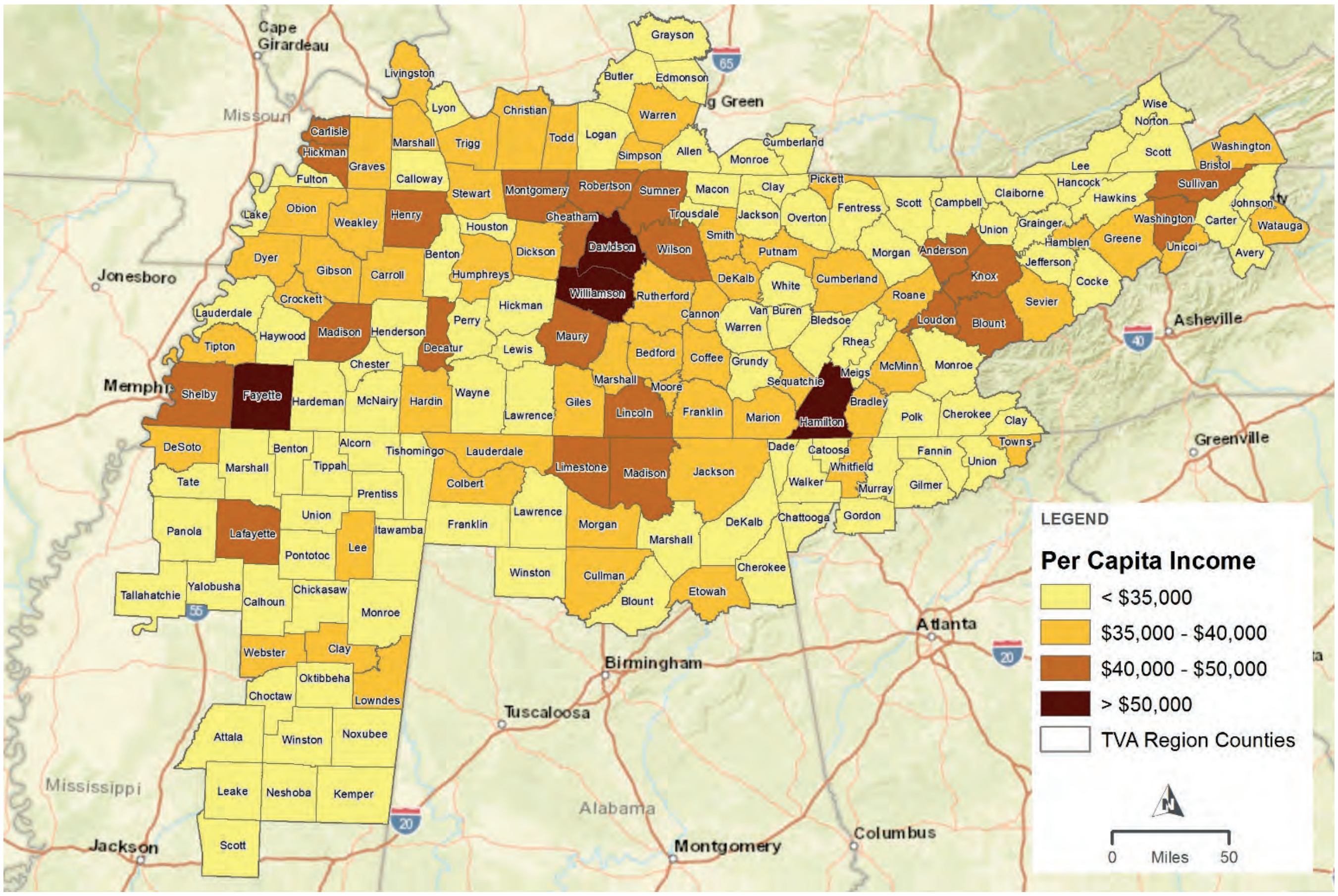

Figure 4-28: Per capita incomes of TVA PSA counties.

4.8.4 Socioeconomic Conditions at Facilities Identified for Future Retirement

Social and economic characteristics surrounding eight TVA plants identified for full or partial retirement during the 20-year IP study period are described in this section. The analyses for the four CT plants consider in detail labor market areas within a 5-mile radius surrounding each plant, as these plants employ few people. Counties within a 20-mile radius of each coal plant serve as the area for analyses of these plants, as they employ many more people. Data for associated states are included in each section for comparison purposes.

4.8.4.1 Allen Combustion Turbine Plant

The labor market area for Allen CT plant (herein, Allen) is defined as Shelby County, Tennessee, where the facility is located, and adjacent Crittenden County, Arkansas.

Population data for Allen-affected counties and associated states are provided in Table 4-23, based on the 2010 Census, 2016 ACS, and state data. From 2010 to 2016, population growth for both affected counties was less than the growth estimated for the associated states, and Crittenden County recorded population losses over that period. Based on the 2016 ACS and state population projections for 2025, both affected counties are expected to grow in population between 2016 and 2025, with Crittenden County likely to increase at rates substantially greater than Arkansas as a whole. Shelby County will likely grow at a lower rate than Tennessee as a whole.

Table 4-23: Population change and projections for Allen-affected counties.

Geography	2010 Census	2016 ACS Estimate	% Change (2010 – 2016)	2025 Projected Population	% Projected Change (2016 – 2025)
Tennessee	6,346,105	6,548,009	3.2	7,148,217	9.2
Shelby County, TN (Allen)	927,644	936,990	1.0	968,453	3.4
Arkansas	2,915,919	2,968,472	1.8	3,151,005	6.1
Crittenden County, AR	50,902	49,511	-2.7	59,113	19.4

Sources: 2010 Census; 2016 ACS; Tennessee Department of Health 2018; U.S. Department of Health and Human Services 2018; University of Arkansas 2003

Other demographic characteristics of the Allen-affected counties are summarized in Table 4-24, based on the 2010 Census and the 2016 ACS. The populations of the affected counties were less rural and younger than the populations of associated states. In Shelby County, there were higher percentages of people who were at least high school graduates and lower percentages of noninstitutionalized adults aged 18 to 64 years with disabilities than across Tennessee. In Crittenden County, higher percentages of people maintained the same residence between 2015 and 2016 than Arkansas as a whole.

Table 4-24: Demographic characteristics for Allen-affected counties.

Geography	% Rural Population	Median Age	% High School or Higher	% Noninst. Labor Force w/ Disability	% Diff. House 1 Yr. Ago
Tennessee	66.4	38.5	86.0	13.6	14.7
Shelby County, TN (Allen)	2.8	35.1	87.1	11.3	16.4
Arkansas	64.9	41.1	85.2	15	15.5
Crittenden County, AR	20.9	34.7	81.8	16.6	15.4

Sources: 2010 Census; 2016 ACS

Table 4-25 summarizes 2016 ACS data on employment and income for the affected counties. Both Allen-affected counties had higher percentages of people in the labor force and higher unemployment rates than their respective states. Based on data from the U.S. Bureau of Labor Statistics (USBLS), total employment in Shelby County was estimated by the USBLS to be 420,439 in 2017. Based on USBEA estimates and as shown in Table 4-25, per capita income in Crittenden County was lower than Arkansas, while Shelby County had higher per capita incomes than across Tennessee. The Allen average annual salary is approximately 2.4 times higher than the average of per capita income in affected counties, as estimated by the USBEA, and Allen directly employs eight people.

Table 4-25: Employment and income characteristics for Allen-affected counties.

Geography	% of 16+ Civ. Pop. in Labor Force	Unemployment Rate	% Employed in Educ. Svcs., Hlth. Care, and Social Assistance	% Employed in Transpo., Warehousing, and Utilities	Per Capita Income, USBEA
Tennessee	60.8	7.5	22.7	6.3	$45,517
Shelby County, TN (Allen)	65	9.4	23.0	11.8	$47,655
Arkansas	58.1	6.9	24.4	5.4	$41,046
Crittenden County, AR	60.5	9.1	26.3	9.9	$36,589

Sources: 2016 ACS; USBEA 2018

Pertinent civilian employment characteristics for the affected counties are also shown on Table 4-25. Of the affected counties, Shelby County had the highest percentages of civilians employed in utilities, transportation, and related industries, while both affected counties had higher percentages of this type of employment than their respective states. In Shelby County, the largest percentage of civilian workers was employed in educational services, health care, and social assistance (23.0%), followed by transportation, warehousing, and utilities (11.8%). The former category employed the largest percentages of civilian workers in Crittenden County and across Tennessee, as well.

4.8.4.2 Colbert Combustion Turbine Plant

The labor market area for Colbert Combustion Turbine Plant (herein, Colbert) is defined as Colbert County, Alabama, where the facility is located, and Lauderdale County, Alabama.

Population data for the Colbert-affected counties and Alabama are provided in Table 4-26, based on the 2010 Census, 2016 ACS, and state data. As shown, from 2010 to 2016, population declined in both affected counties, with each having a growth rate lower than the state. Based on the 2016 ACS and state population projections for 2025, both affected counties are expected to grow at rates lower than the rate across Alabama between 2016 and 2025, while Colbert County, where Colbert is located, is predicted to decline in population during that time period.

Table 4-26: Population change and projections for Colbert-affected counties.

Geography	2010 Census	2016 ACS Estimate	% Change (2010 – 2016)	2025 Projected Population	% Projected Change (2016 – 2025)
Alabama	4,779,753	4,841,164	1.3	5,030,870	3.9
Colbert County, AL (Colbert)	54,428	54,377	-0.1	54,026	-0.7
Lauderdale County, AL	92,709	92,641	-0.1	92,914	0.3

Sources: 2010 Census; 2016 ACS; U.S. Department of Health and Human Services 2018; University of Alabama 2018

Other demographic characteristics of the Colbert-affected counties are summarized in Table 4-27, based on the 2010 Census and the 2016 ACS. The populations of both affected counties were less rural and older than Alabama as a whole. In Colbert County, there were lower percentages of people who were at least high school graduates and higher percentages of noninstitutionalized adults aged 18 to 64 years with disabilities than in Lauderdale County or the state. For the most part, higher percentages of people in Colbert County maintained the same residence between 2015 and 2016 than across the state or in Lauderdale County.

Table 4-27: Demographic characteristics for Colbert-affected counties.

Geography	% Rural Population	Median Age	% High School or Higher	% Noninst. Labor Force w/ Disability	% Diff. House 1 Yr. Ago
Alabama	67.1	38.6	84.8	14.5	14.1
Colbert County, AL (Colbert)	43.9	42.4	83.4	17.4	11.4
Lauderdale County, AL	49.3	41.3	84.9	13.1	15.3

Sources: 2010 Census; 2016 ACS

Table 4-28 summarizes 2016 ACS data on employment and income for the affected counties. Both Colbert-affected counties had lower percentages of people in the labor force and lower unemployment rates than across the state. Based on data from USBLS, total employment in Colbert County was estimated by the USBLS to be 21,889 in 2017. Based on USBEA estimates and as shown in Table 4-28, per capita income in Colbert County was lower than in Alabama, while Lauderdale County exceeded that of the state. The Colbert average annual salary is approximately 2.7 times higher than the average of per capita income in affected counties, as estimated by the USBEA, and Colbert directly employs six people.

Table 4-28: Employment and income characteristics for Colbert-affected counties.

Geography	% of 16+ Civ. Pop. in Labor Force	Unemployment Rate	% Employed in Educ. Svcs., Hlth. Care, and Social Assistance	% Employed in Transpo., Warehousing, and Utilities	Per Capita Income, USBEA
Alabama	57.6	8.3	22.5	5.3	$40,805
Colbert County, AL (Colbert)	54.0	7.5	19.9	5.9	$37,602
Lauderdale County, AL	56.0	7.6	21.3	7.5	$36,448

Sources: 2016 ACS; USBEA 2018

Pertinent civilian employment characteristics for the affected counties are also shown on Table 4-28. Of the Colbert-affected counties, Lauderdale County had the highest percentage of civilians employed in utilities, transportation, and related industries, and this was a higher percentage of this type of employment than the state. In Colbert County, the largest percentage of civilian workers was employed in educational services, health care, and social assistance (19.9 percent), followed by manufacturing (18.5 percent). These industries employed the largest percentages of civilian workers in the other affected county and the state, as well.

4.8.4.3 Gallatin Combustion Turbine Plant and Gallatin Fossil Plant

The area of analysis for Gallatin Fossil Plant and Gallatin Combustion Turbine Plant (herein, Gallatin) is defined as Sumner County, Tennessee, where both facilities are located, and Davidson, Macon, Robertson, Rutherford, Smith, Trousdale, and Wilson counties, Tennessee. The discussion for these plants was combined due to being in the same physical location; however, the 20-mile labor market area for Gallatin serves as the area for analysis given its larger expanse. However, employee numbers and average salaries are presented for

Gallatin Combustion Turbine Plant only, due to its proposed retirement in the near-term.

Population data for the Gallatin-affected counties and Tennessee as a whole are provided in Table 4-29, based on the 2010 Census, 2016 ACS, and state data. As shown, from 2010 to 2016, population growth in half the affected counties was less than the growth estimated for Tennessee, while growth in Sumner County exceeded that of the state. Based on the 2016 ACS and state population projections for 2025, only one affected county is predicted to grow at rates less than the state, while the other seven counties, including Sumner County, will likely grow at rates substantially greater than Tennessee as a whole.

Table 4-29: Population change and projections for Gallatin-affected counties.

Geography	2010 Census	2016 ACS Estimate	% Change (2010 – 2016)	2025 Projected Population	% Projected Change (2016 – 2025)
Tennessee	6,346,105	6,548,009	3.2	7,148,217	9.2
Sumner County, TN (Gallatin/GCT)	160,645	172,786	7.6	205,787	19.1
Davidson County, TN	626,681	667,885	6.6	750,296	12.3
Macon County, TN	22,248	22,924	3.0	25,575	11.6
Robertson County, TN	66,283	67,905	2.4	76,459	12.6
Rutherford County, TN	262,604	290,289	10.5	376,248	29.6
Smith County, TN	19,166	19,176	0.1	20,473	6.8
Trousdale County, TN	7,870	7,970	1.3	9,098	14.2
Wilson County, TN	113,993	125,616	10.2	155,219	23.6

Sources:2010 Census; 2016 ACS; Tennessee Department of Health 2017; US Department of Health and Human Services 2018

Other demographic characteristics of the Gallatin-affected counties are summarized in Table 4-30, based on the 2010 Census and the 2016 ACS. The populations of three affected counties, excluding Sumner County, were more rural than the population of their respective states. In six affected counties, including Sumner County, the populations were more aged than that of the state. In three of the affected counties, not including Sumner County, there were lower percentages of people who were at least high school graduates and higher percentages of noninstitutionalized adults aged 18 to 64 years with disabilities than across the state. Higher percentages of people in five affected counties, excluding Sumner County, maintained the same residence between 2015 and 2016 than across the state.

Table 4-30: Demographic characteristics for Gallatin-affected counties.

Geography	% Rural Population	Median Age	% High School or Higher	% Noninst. Labor Force w/ Disability	% Diff. House 1 Yr. Ago
Tennessee	66.4	38.5	86.0	13.6	14.7
Sumner County, TN (Gallatin)	27.9	39.5	89.3	10.9	15.2
Davidson County, TN	3.4	34.2	87.5	10.4	18.2
Macon County, TN	79.6	39.6	75.7	18.4	13.1
Robertson County, TN	53.2	38.5	86.5	13	12.5
Rutherford County, TN	17.0	32.9	90.8	8.8	17.6
Smith County, TN	82.9	41.2	82.7	17.1	10.7
Trousdale County, TN	100.0	39.0	79.3	15.8	9.0
Wilson County, TN	38.5	40.3	89.8	10.8	13.2

Sources: 2010 Census; 2016 ACS

Table 4-31 summarizes 2016 ACS data on employment and income for the affected counties. Sumner County and four other Gallatin-affected counties had higher percentages of people in the labor force than Tennessee. The same five counties and two additional counties had lower unemployment rates than the state as a whole. Based on data from USBLS, total employment in Sumner County was estimated by the USBLS to be 92,939 in 2017. Based on USBEA estimates and as shown in Table 4-31, per capita income was higher in Sumner County and three other affected counties than across Tennessee. The Gallatin CT facility average annual salary is approximately 2.4 times higher than the average of per capita income in affected counties, as estimated by the USBEA, and Gallatin CT facility directly employs eight people. Gallatin Fossil Plant directly employs 174 people.

Table 4-31: Employment and income characteristics for Gallatin-affected counties.

Geography	% of 16+ Civ. Pop. in Labor Force	Unemployment Rate	% Employed in Educ. Svcs., Hlth. Care, and Social Assistance	% Employed in Transpo., Warehousing, and Utilities	Per Capita Income, USBEA
Tennessee	60.8	7.5	22.7	6.3	$45,517
Sumner County, TN (Gallatin/GCT)	65.7	5.3	20.9	6.2	$46,998
Davidson County, TN	69.9	6.2	24.1	4.4	$63,063
Macon County, TN	57.6	6.8	18.3	6.8	$33,041
Robertson County, TN	65.9	7.4	18.8	5.0	$40,463

Geography	% of 16+ Civ. Pop. in Labor Force	Unemployment Rate	% Employed in Educ. Svcs., Hlth. Care, and Social Assistance	% Employed in Transpo., Warehousing, and Utilities	Per Capita Income, USBEA
Rutherford County, TN	70.0	6.1	21.1	6.2	$39,968
Smith County, TN	57.2	4.2	19.4	6.7	$36,759
Trousdale County, TN	60.7	8.0	28.3	9.2	$31,893
Wilson County, TN	65.3	5.4	18.6	6.0	$47,335

Sources: 2016 ACS; USBEA 2018

Pertinent civilian employment characteristics for the affected counties are also shown on Table 4-31. Of the affected counties, Trousdale County, had the highest percentage of civilians employed in utilities, transportation, and related industries, while three affected counties, excluding Sumner County, had higher percentages of this type of employment than their respective states. In Sumner County, the largest percentage of civilian workers was employed in educational services, health care, and social assistance (20.9 percent), followed by the retail trade (12.9 percent). These industries employed the largest percentages of civilian workers in five other affected counties and the state.

4.8.4.4 Johnsonville Combustion Turbine Plant

The labor market area for Johnsonville Combustion Turbine Plant is defined as Humphreys County, Tennessee, where the facility is located, and Benton County, Tennessee.

Population data for the Johnsonville-affected counties and Tennessee as a whole are provided in Table 4-32, based on the 2010 Census, 2016 ACS, and state data. As shown, from 2010 to 2016, population declined in both affected counties, whereas the state grew. Based on the 2016 ACS and state population projections for 2025, this trend is predicted to continue, with both affected counties expected to grow at rates less than the state between 2016 and 2025.

Table 4-32: Population change and projections for Johnsonville-affected counties.

Geography	2010 Census	2016 ACS Estimate	% Change (2010 – 2016)	2025 Projected Population	% Projected Change (2016 – 2025)
Tennessee	6,346,105	6,548,009	3.2	7,148,217	9.2
Humphreys County, TN (Johnsonville)	18,538	18,216	-1.7	18,336	0.7
Benton County, TN	16,489	16,173	-1.9	15,669	-3.1

Sources: 2010 Census, 2016 ACS; US Department of Health and Human Services 2018; University of Tennessee 2009

Other demographic characteristics of the Johnsonville-affected counties are summarized in Table 4-33, based on the 2010 Census and the 2016 ACS. The populations of both affected counties were more rural and older than the population of the state as a whole. The county populations also had lower percentages of people who were at least high school graduates and higher percentages of noninstitutionalized adults aged 18 to 64 years with disabilities than across the state. Higher percentages of people in affected counties maintained the same residence between 2015 and 2016 than statewide.

Table 4-33: Demographic characteristics for Johnsonville-affected counties.

Geography	% Rural Population	Median Age	% High School or Higher	% Noninst. Labor Force w/ Disability	% Diff. House 1 Yr. Ago
Tennessee	66.4	38.5	86.0	13.6	14.7
Humphreys County, TN (Johnsonville)	82.5	41.7	83.2	19.1	12.8
Benton County, TN	78.5	46.6	81.7	21.6	8.5

Sources: 2010 Census; 2016 ACS

Table 4-34 summarizes 2016 ACS data on employment and income for the affected counties. Both Johnsonville-affected counties had lower percentages of people in the labor force and higher unemployment rates than the state as a whole. Based on data from USBLS, total employment in Humphreys County was estimated by the USBLS to be 8,462 in 2017. Based on USBEA estimates and as shown in Table 4-34, per capita income in both Johnsonville-affected counties was lower than across Tennessee. The Johnsonville average annual salary is nearly 3.0 times higher than the average of per capita income in affected counties, as estimated by the USBEA, and Johnsonville directly employs 28 people.

Table 4-34: Employment and income characteristics for Johnsonville-affected counties.

Geography	% of 16+ Civ. Pop. in Labor Force	Unemployment Rate	% Employed in Educ. Svcs., Hlth. Care, and Social Assistance	% Employed in Transpo., Warehousing, and Utilities	Per Capita Income, USBEA
Tennessee	60.8	7.5	22.7	6.3	$45,517
Humphreys County, TN (Johnsonville)	51.8	8.0	24.3	7.8	$38,686
Benton County, TN	49.3	11.1	22.1	9.4	$29,022

Sources: 2016 ACS; USBEA 2018

Pertinent civilian employment characteristics for the affected counties are also shown on Table 4-34. Both affected counties had higher percentages of civilians employed in utilities, transportation, and related industries than the state. In Humphreys County, the largest percentage of civilian workers was employed in educational services, health care, and social assistance (24.3 percent), followed by manufacturing (20.2 percent). These industries employed the largest percentages of civilian workers in the other affected county and the state, as well.

4.8.4.5 Cumberland Fossil Plant

The labor market area for Cumberland Fossil Plant is defined as Stewart County, Tennessee, where the facility is located, and Bention, Dickson, Henry, Houston, Humphreys, and Montgomery counties, Tennessee, and Christian and Trigg counties, Kentucky.

Population data for the Cumberland-affected counties and associated states are provided in Table 4-35, based on the 2010 Census, 2016 ACS, and state data. As shown, from 2010 to 2016, population growth in all affected counties except Montgomery County was less than the growth estimated for the associated states. Seven of the nine Cumberland-affected counties, including Stewart County, recorded population losses over that period. Of the Cumberland-affected counties, only Dickson and Montgomery counties recorded population gains over that period. While the populations of associated states are projected to increase between

2016 and 2025, seven of the Cumberland-affected counties are expected to increase over the same period, and two of these counties are projected to grow at greater rates than their respective states, as demonstrated in Table 4-35.

Table 4-35: Population change and projections for Cumberland-affected counties.

Geography	2010 Census	2016 ACS Estimate	% Change (2010 – 2016)	2025 Projected Population	% Projected Change (2016 – 2025)
Tennessee	6,346,105	6,548,009	3.2	7,148,217	9.2
Stewart County, TN (Cumberland)	13,324	13,257	-0.5	13,320	0.5
Benton County, TN	16,489	16,173	-1.9	15,669	-3.1
Dickson County, TN	49,666	50,926	2.5	57,196	12.3
Henry County, TN	32,330	32,291	-0.1	32,616	1.0
Houston County, TN	8,426	8,234	-2.3	8,144	-1.1
Humphreys County, TN	18,538	18,216	-1.7	18,336	0.7
Montgomery County, TN	172,331	189,709	10.1	233,603	23.1
Kentucky	4,339,367	4,411,989	1.7	4,886,381	10.8
Christian County, KY	73,955	73,936	-0.0	73,999	0.1
Trigg County, KY	14,339	14,267	-0.5	14,482	1.5

Sources: 2010 Census; 2016 ACS; Kentucky State Data Center 2016; U.S. Department of Health and Human Services 2018; University of Tennessee 2009

Other demographic characteristics of the Cumberland-affected counties, as compared with associated states, are summarized in Table 4-36, based on the 2010 Census and the 2016 ACS. The populations of affected counties were generally more rural and older than the state populations. The exceptions for this were in Montgomery and Christian counties, where the populations were less rural and younger than the associated states. In all but three counties, excluding Stewart County, there were lower percentages of people who were high school graduates or higher than the associated states. All seven Tennessee counties had higher percentages of noninstitutionalized adults aged 18 to 64 years with disabilities than across the state. For the most part, higher percentages of people in affected counties maintained the same residence between 2015 and 2016 than their associated states. The exceptions to this were Houston and Montgomery counties.

Table 4-36: Demographic characteristics for Cumberland-affected counties.

Geography	% Rural Population	Median Age	% High School or Higher	% Noninst. Labor Force w/ Disability	% Diff. House 1 Yr. Ago
Tennessee	66.4	38.5	86.0	13.6	14.7
Stewart County, TN (Cumberland)	100.00	43.4	86.3	17.8	11.3
Benton County, TN	78.5	46.6	81.7	21.6	8.5
Dickson County, TN	67.8	40.0	83.6	15.6	11.9

Geography	% Rural Population	Median Age	% High School or Higher	% Noninst. Labor Force w/ Disability	% Diff. House 1 Yr. Ago
Henry County, TN	66.8	45.1	84.3	21.2	12.5
Houston County, TN	100.0	43.5	76.9	23.3	14.8
Humphreys County, TN	82.5	41.7	83.2	19.1	12.8
Montgomery County, TN	19.7	30.3	92.2	14	21.6
Kentucky	41.6	38.6	84.6	15.8	15.1
Christian County, KY	28.6	28.3	86.0	15.1	14.7
Trigg County, KY	79.4	45.1	84.2	14.0	9.9

Sources: 2010 Census; 2016 ACS

Cumberland Fossil Plant directly employs 329 people. Table 4-37 summarizes 2016 ACS data on employment and income for the Cumberland-affected counties. All affected counties had lower percentages of people in the labor force than their respective states. Seven counties, including Stewart County, where Cumberland is located, had unemployment rates above that of the associated states. Based on data from USBLS, total employment in Stewart County was estimated to be 4,926 in 2017. Based on USBEA estimates, per capita income in all affected counties was lower than that of their respective state.

Table 4-37: Employment and income characteristics for Cumberland-affected counties.

Geography	% of 16+ Civ. Pop. in Labor Force	Unemployment Rate	% Employed in Educ. Svcs., Hlth. Care, and Social Assistance	% Employed in Transpo., Warehousing, and Utilities	Per Capita Income, USBEA
Tennessee	60.8	7.5	22.7	6.3	$45,517
Stewart County, TN (Cumberland)	49.0	8.7	20.0	6.9	$39,523
Benton County, TN	49.3	11.1	22.1	9.4	$33,164
Dickson County, TN	58.0	5.6	21.5	5.9	$39,055
Henry County, TN	53.2	7.9	20.9	8.0	$40,839
Houston County, TN	50.0	7.4	20.8	6.4	$32,297
Humphreys County, TN	51.8	8.0	24.3	7.8	$38,686
Montgomery County, TN	57.1	8.2	22.9	5.4	$40,633
Kentucky	59.0	7.6	24.0	6.0	$40,597
Christian County, KY	48.4	10.4	21.4	4.1	$37,622
Trigg County, KY	54.5	10.1	26.2	10.3	$36,130

Sources: 2016 ACS; USBEA 2018

Pertinent civilian employment characteristics for the affected counties are also shown on Table 4-37. Of the affected counties, Trigg County had the highest percentage of civilians employed in utilities, transportation, and related industries, while Stewart County and six other affected counties exceeded state percentages for this type of employment. All counties except Dickson and Montgomery counties had higher percentages of civilians employed in mining and related industries than the associated states. These industries employed the largest percentages of civilian workers in both associated states and eight of the nine affected counties.

4.8.4.6 Kingston Fossil Plant

The labor market area for Kingston Fossil Plant is defined as Roane County, Tennessee, where Kingston is located, and Anderson, Cumberland, Knox, Loudon, McMinn, Meigs, Monroe, Morgan, Rhea, and Scott counties, Tennessee.

Population data for the Kingston-affected counties and Tennessee are provided in Table 4-38, based on the 2010 Census, 2016 ACS, and state data. As shown, from 2010 to 2016, population growth in all except three affected counties was less than the growth estimated for the state. Three of the 11 affected counties, including Roane County, recorded population losses over that period. Based on state population projections for 2025, only three of the affected counties are projected to grow at greater rates than across Tennessee, and Roane County is expected to decline in population, as shown in Table 4-38.

Table 4-38: Population change and projections for Kingston-affected counties.

Geography	2010 Census	2016 ACS Estimate	% Change (2010 – 2016)	2025 Projected Population	% Projected Change (2016 – 2025)
Tennessee	6,346,105	6,548,009	3.2	7,148,217	9.2
Roane County, TN (Kingston)	54,181	52,983	-2.2	52,247	-1.4
Anderson County, TN	75,129	75,545	0.6	78,454	3.9
Cumberland County, TN	56,053	57,895	3.3	63,521	9.7
Knox County, TN	432,226	448,164	3.7	491,829	9.7
Loudon County, TN	48,556	50,637	4.3	56,835	12.2
McMinn County, TN	52,266	52,606	0.7	54,415	3.4
Meigs County, TN	11,753	11,804	0.4	12,445	5.4
Monroe County, TN	44,519	45,482	2.2	48,124	5.8
Morgan County, TN	21,987	21,688	-1.4	22,211	2.4
Rhea County, TN	31,809	32,461	2.1	33,990	4.7
Scott County, TN	22,228	22,029	-0.9	22,053	0.1

Sources: 2010 Census; 2016 ACS; Kentucky State Data Center 2016; US Department of Health and Human Services 2018; University of Tennessee 2009

Other demographic characteristics of the Kingston-affected counties, as compared with Tennessee, are summarized in Table 4-39, based on the 2010 Census and the 2016 ACS. The populations of six affected counties, including Roane County, were more urban than the state population, and the populations of eight affected counties, also including Roane County, were older. In all but two counties, including Roane County, there were lower percentages of people who were high school graduates or higher than across Tennessee. All except one affected county had higher percentages of noninstitutionalized adults aged 18 to 64 years with disabilities than the state as a whole. For the most part, higher percentages of people in affected counties maintained the same residence between 2015 and 2016 than the state. The exceptions for this are in Cumberland, Knox, Rhea and Monroe counties.

Table 4-39: Demographic characteristics for Kingston-affected counties.

Geography	% Rural Population	Median Age	% High School or Higher	% Noninst. Labor Force w/ Disability	% Diff. House 1 Yr. Ago
Tennessee	66.4	38.5	86.0	13.6	14.7
Roane County, TN (Kingston)	51.0	46.3	85.8	20.9	10.2
Anderson County, TN	34.7	43.3	85.5	18.9	13.2
Cumberland County, TN	60.9	50.1	83.6	21.5	15.4
Knox County, TN	10.9	37.3	90.6	13.0	16.0
Loudon County, TN	40.6	47.2	85.3	16.4	11.9
McMinn County, TN	60.3	42.9	83.2	16.1	13.8
Meigs County, TN	100.0	43.9	78.9	22.5	8.3
Monroe County, TN	76.1	43.1	79.1	21.9	17.2
Morgan County, TN	99.9	41.1	79.8	20.4	14.5
Rhea County, TN	68.0	40.3	75.9	21.9	17.2
Scott County, TN	80.6	38.8	77.3	24.5	10.8

Sources: 2010 Census; 2016 ACS

Kingston Fossil Plant directly employs 254 people. Table 4-40 summarizes 2016 ACS data on employment and income for the Kingston-affected counties. All affected counties had lower percentages of people in the labor force than across the state. Nine counties, including Roane County, where Kingston is located, had unemployment rates above the state.

Based on data from USBLS, total employment in Roane County was estimated by the USBLS to be 22,140 in 2017. Based on USBEA estimates, per capita income in Roane County and eight other counties was lower than that of Tennessee. Only Knox and Loudon counties had per capita incomes higher than the state.

Table 4-40: Employment and income characteristics for Kingston-affected counties.

Geography	% of 16+ Civ. Pop. in Labor Force	Unemployment Rate	% Employed in Educ. Svcs., Hlth. Care, and Social Assistance	% Employed in Transpo., Warehousing, and Utilities	Per Capita Income, USBEA
Tennessee	60.8	7.5	22.7	6.3	$45,517
Roane County, TN (Kingston)	52.1	9.3	22.1	6.8	$39,763
Anderson County, TN	49.0	7.4	21.1	5.1	$40,847
Cumberland County, TN	46.3	8.8	21.7	5.8	$36,038

Geography	% of 16+ Civ. Pop. in Labor Force	Unemployment Rate	% Employed in Educ. Svcs., Hlth. Care, and Social Assistance	% Employed in Transpo., Warehousing, and Utilities	Per Capita Income, USBEA
Knox County, TN	56.1	6.2	24.7	4.7	$48,160
Loudon County, TN	42.3	7.5	19.1	6.5	$46,183
McMinn County, TN	52.8	8.6	19.2	4.4	$35,084
Meigs County, TN	46.9	12.5	16.0	8.2	$33,347
Monroe County, TN	50.7	11.5	21.0	5.0	$32,283
Morgan County, TN	42.2	8.6	21.0	7.6	$28,699
Rhea County, TN	56.7	8.0	17.2	9.9	$34,267
Scott County, TN	49.0	13.4	21.7	8.0	$28,721

Sources: 2016 ACS; USBEA 2018

Pertinent civilian employment characteristics for the affected counties are also shown on Table 4-40. Of the affected counties, Rhea County had the highest percentage of civilians employed in utilities, transportation, and related industries, while six counties, including Roane County, exceeded state percentages for this type of employment. In Roane County, the largest percentage of civilian workers was employed in educational services, health care, and social assistance (22.1 percent), followed by the retail trade (13.9 percent). The former category likewise employed the largest percentage of civilian workers in the state and six of the remaining ten affected counties, while manufacturing employed the largest percentages of workers in four of the affected counties.

4.8.4.7 Shawnee Fossil Plant

The labor market area for Shawnee Fossil Plant is defined as McCracken County, Kentucky, where Shawnee is located, and all counties within a 20-mile radius of Shawnee, consisting of Ballard, Carlisle, Graves, Livingston, and Marshall counties, Kentucky, and Johnson, Massac, Pope, Pulaski, and Union counties, Illinois.

Population data for the Shawnee-affected counties and associated states are provided in Table 4-41, based on the 2010 Census, 2016 ACS, and state data. As shown, from 2010 to 2016, population growth in all affected counties except, Johnson County, was less than the growth estimated for the associated states. Nine of the affected counties, including McCracken County, recorded population losses over that period. Of the Shawnee-affected counties, only Graves and Johnson counties recorded small population gains over that period. While the populations of associated states are projected to increase between 2016 and 2025, only five of the 11 Shawnee-affected counties are expected to increase over the same period, and two of these counties are projected to grow at greater rates than their respective states, as shown in Table 4-41.

Table 4-41: Population change and projections for Shawnee-affected counties.

Geography	2010 Census	2016 ACS Estimate	% Change (2010 – 2016)	2025 Projected Population	% Projected Change (2016 – 2025)
Kentucky	4,339,367	4,411,989	1.7	4,886,381	10.8
McCracken County, KY (Shawnee)	65,565	65,292	-0.4	65,487	0.3
Ballard County, KY	8,249	8,216	-0.4	8,097	-1.4
Carlisle County, KY	5,104	4,954	-2.9	4,604	-7.1
Graves County, KY	37,121	37,379	0.7	38,243	2.3
Livingston County, KY	9,519	9,353	-1.7	8,889	-5.0
Marshall County, KY	31,448	31,213	-0.7	31,060	-0.5
Illinois	12,830,632	12,851,684	0.2	13,263,662	3.2
Johnson County, IL	12,582	12,866	2.3	13,889	8.0
Massac County, IL	15,429	14,883	-3.5	15,438	3.7
Pope County, IL	4,470	4,255	-4.8	4,314	1.4
Pulaski County, IL	6,161	5,792	-6.0	5,079	-12.3
Union County, IL	17,808	17,458	-2.0	17,130	-1.9

Sources: 2010 Census; 2016 ACS; Illinois Department of Public Health 2015; Kentucky State Data Center 2016

Other demographic characteristics of the Shawnee-affected counties, as compared with associated states, are summarized in Table 4-42, based on the 2010 Census and the 2016 ACS. The populations of affected counties were generally more rural and older than the state populations. The exceptions to this were in McCracken County, where Shawnee is located, and Massac County, where the populations were less rural than the associated states. In all but three counties, excluding McCracken County, there were lower percentages of people who were high school graduates or higher than the associated states. Livingston County, Kentucky, and all five Illinois counties had higher percentages of noninstitutionalized adults aged 18 to 64 years with disabilities than their respective states. For the most part, higher percentages of people in affected counties maintained the same residence between 2015 and 2016 than their associated states. The exception to this was Johnson County, Illinois.

Table 4-42: Demographic characteristics for Shawnee-affected counties.

Geography	% Rural Population	Median Age	% High School or Higher	% Noninst. Labor Force w/ Disability	% Diff. House 1 Yr. Ago
Kentucky	41.6	38.6	84.6	15.8	15.1
McCracken County, KY (Shawnee)	27.8	42.4	87.8	13.3	12
Ballard County, KY	100	42.9	86.2	10.6	8.2

Geography	% Rural Population	Median Age	% High School or Higher	% Noninst. Labor Force w/ Disability	% Diff. House 1 Yr. Ago
Carlisle County, KY	100	42.4	81.8	11.2	7.5
Graves County, KY	69.4	40.3	81.7	14.4	6.9
Livingston County, KY	95.4	46.5	82.5	18.8	7.2
Marshall County, KY	85.9	44.8	85.9	14.4	8.1
Illinois	51.1	37.4	88.3	8.5	12.7
Johnson County, IL	100	42.9	83.4	13.8	12.8
Massac County, IL	50.5	44	85	18.3	9.2
Pope County, IL	100	50.6	87.2	26.4	7.7
Pulaski County, IL	100	43.5	82.7	20.6	7.8
Union County, IL	65.9	43.7	85.6	15.5	7.2

Sources: 2010 Census; 2016 ACS

Shawnee Fossil Plant directly employs 241 people. Table 4-43 summarizes 2016 ACS data on employment and income for the Shawnee-affected counties. All affected counties had lower percentages of people in the labor force than their respective states. Five counties, excluding McCracken County, where Shawnee resides, had unemployment rates above that of the associated states. Based on data from USBLS, total employment in McCracken County was estimated by the USBLS to be 27,835 in 2017. Based on USBEA estimates, per capita income in all affected counties except McCracken and Carlisle counties was lower than their respective states.

Table 4-43: Employment and income characteristics for Shawnee-affected counties.

Geography	% of 16+ Civ. Pop. in Labor Force	Unemployment Rate	% Employed in Educ. Svcs., Hlth. Care, and Social Assistance	% Employed in Transpo., Warehousing, and Utilities	Per Capita Income, USBEA
Kentucky	59.0	7.6	24.0	6.0	$40,597
McCracken County, KY (Shawnee)	57.9	5.1	25.2	6.8	$48,797
Ballard County, KY	55.1	5.3	21.4	6.2	$36,849
Carlisle County, KY	56.7	7.9	20.7	8.1	$42,704
Graves County, KY	57.6	8.4	23.5	6.4	$36,685
Livingston County, KY	54.4	5.1	23.7	11.5	$36,412
Marshall County, KY	54.2	6.8	23.1	7.9	$39,039
Illinois	65.4	8.2	22.9	6	$54,203
Johnson County, IL	43.8	8.9	31.8	5.9	$32,881

Geography	% of 16+ Civ. Pop. in Labor Force	Unemployment Rate	% Employed in Educ. Svcs., Hlth. Care, and Social Assistance	% Employed in Transpo., Warehousing, and Utilities	Per Capita Income, USBEA
Massac County, IL	51.6	7.8	22.8	9.6	$36,835
Pope County, IL	40.3	8.5	26.9	8.1	$28,262
Pulaski County, IL	48.1	11.9	29.7	10.2	$36,215
Union County, IL	55.9	6.3	31.7	7.2	$41,756

Sources: 2016 ACS; USBEA 2018

Pertinent civilian employment characteristics for the affected counties are also shown on Table 4-43. Of the affected counties, Livingston County had the highest percentage of civilians employed in utilities, transportation, and related industries, and Mccracken County and all other affected counties except one exceeded state percentages for this type of employment. All counties except McCracken and Marshall counties had higher percentages of civilians employed in mining and related industries than across their respective states. In McCracken County, the largest percentage of civilian workers was employed in educational services, health care, and social assistance (25.2 percent), followed by the retail trade (13.1 percent). The former category employed the largest percentages of civilian workers in all other affected counties and both associated states.

4.9 Environmental Justice

Environmental justice-related impacts are analyzed in accordance with E.O. 12898 to identify and address as appropriate disproportionately high and adverse human health or environmental effects of federal programs, policies, and activities on minority populations and low-income populations. While TVA is not subject to this E.O., it routinely considers environmental justice impacts in its NEPA review processes.

Council of Environmental Quality (CEQ) guidance for applying E.O. 12898 under NEPA directs identification of minority populations when either the minority population of the affected area exceeds 50 percent or the minority population percentage of the study area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis (CEQ 1997). The CEQ guidance also specifies that low-income populations are to be identified using the annual statistical poverty threshold from the USCB Current Population Reports Series P-60 on Income and Poverty. The USCB-provided 2016 poverty threshold for an individual was $12,228 and the official poverty rate for the U.S. as a whole in 2016 was 12.7 percent (USCB 2017).

CEQ defines minority populations as people who identify themselves as Asian or Pacific Islander, American Indian or Alaskan Native, Black (not of Hispanic origin), or Hispanic. Due to necessarily including one of these minorities, those indicating two or more races are also considered minorities. Minority and low-income populations may be groups of people living in geographic proximity or scattered groups or individuals sharing common conditions. In addition, the CEQ guidelines direct identification of groups demonstrating differential patterns of consumption of natural resources among minority and low-income populations.

The TVA PSA considered for environmental justice consists of 180 counties and two independent cities in seven states, including all counties in Tennessee and portions of Alabama, Georgia, Kentucky, Mississippi, North Carolina, and Virginia (see Appendix C for a complete list of counties considered). Following CEQ guidance, those counties with a minority population that exceeds that of the TVA PSA as a whole are presented as the portions of the TVA PSA where the chance for disproportional environmental and human health effects may be the greatest. Minority populations were identified using 2012 – 2016 ACS 5-year census estimates (2016 ACS) compiled in DP 5 for each of the 182 counties or independent cities in the TVA PSA. Per CEQ guidelines, low-income populations were defined as those with poverty rates above the TVA PSA average rate of 19.71 percent. These populations were identified using the 2016 ACS results compiled in Demographic Profile 3 for each of the counties and independent cities. Additional low-income populations were identified at the census tract level using poverty rates reported in 2016 ACS DP 3 for each of the counties and independent cities. Additional low-income populations were identified at the census tract level using the same census data source.

Where relevant, TVA PSA-wide environmental justice data is compared with information from USCB Division 6, East South Central. Division 6 includes the majority of the TVA PSA, consisting of Alabama, Kentucky, Mississippi, and Tennessee (USCB 2018d).

4.9.1 Low-Income Populations

Based on the 2016 ACS, the percentage of the overall TVA PSA population living below the poverty level was 19.71 percent. Eighty-two counties and two independent cities in the TVA PSA had poverty rates above the PSA average, as illustrated in Figure 4-29; the 2016 ACS estimates for per capita income and the percentage of the population living in poverty for PSA counties are included in Appendix D-1.

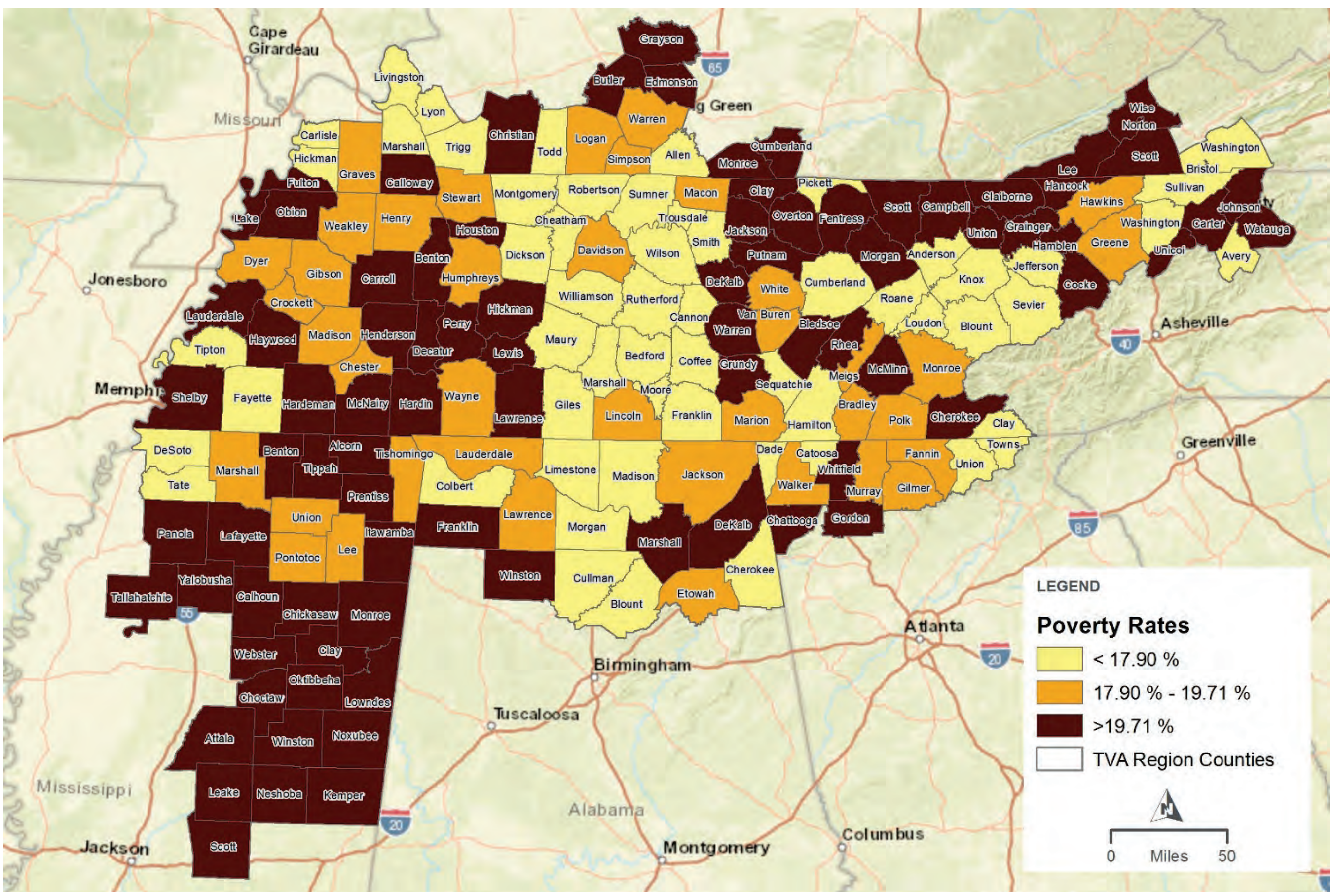

Figure 4-29: Poverty rates (proportion of population with annual income below $12,228) of Counties in the TVA PSA.

A total of 900 census tracts in 174 counties or independent cities and seven states had poverty rates above the TVA PSA average. Low-income census tracts are in all but eight counties of the TVA PSA. The per capita income levels and poverty rates from the 2016 ACS are included in Appendix D-2.

4.9.2 Minority Populations

Based on the 2016 ACS data, the minority population in the TVA PSA is estimated to be 21.3 percent. Eight counties in the PSA had minority populations that exceeded 50 percent, well above the average in the PSA as a whole (Figure 4-30). These included Haywood and Shelby counties in Tennessee and Clay, Kemper, Marshall, Noxubee, Panola, and Tallahatchie counties in Mississippi. The minority percentages of each are shown in Table 4-44 in comparison with those of Division 6 and the TVA PSA as a whole. In these areas, the African-American population composed the highest percentage of the population, averaging almost 55 percent. An additional 31 counties had a minority population greater than the TVA PSA average. All of the counties with minority percentages higher than the TVA PSA as a whole are listed in Appendix D-3.

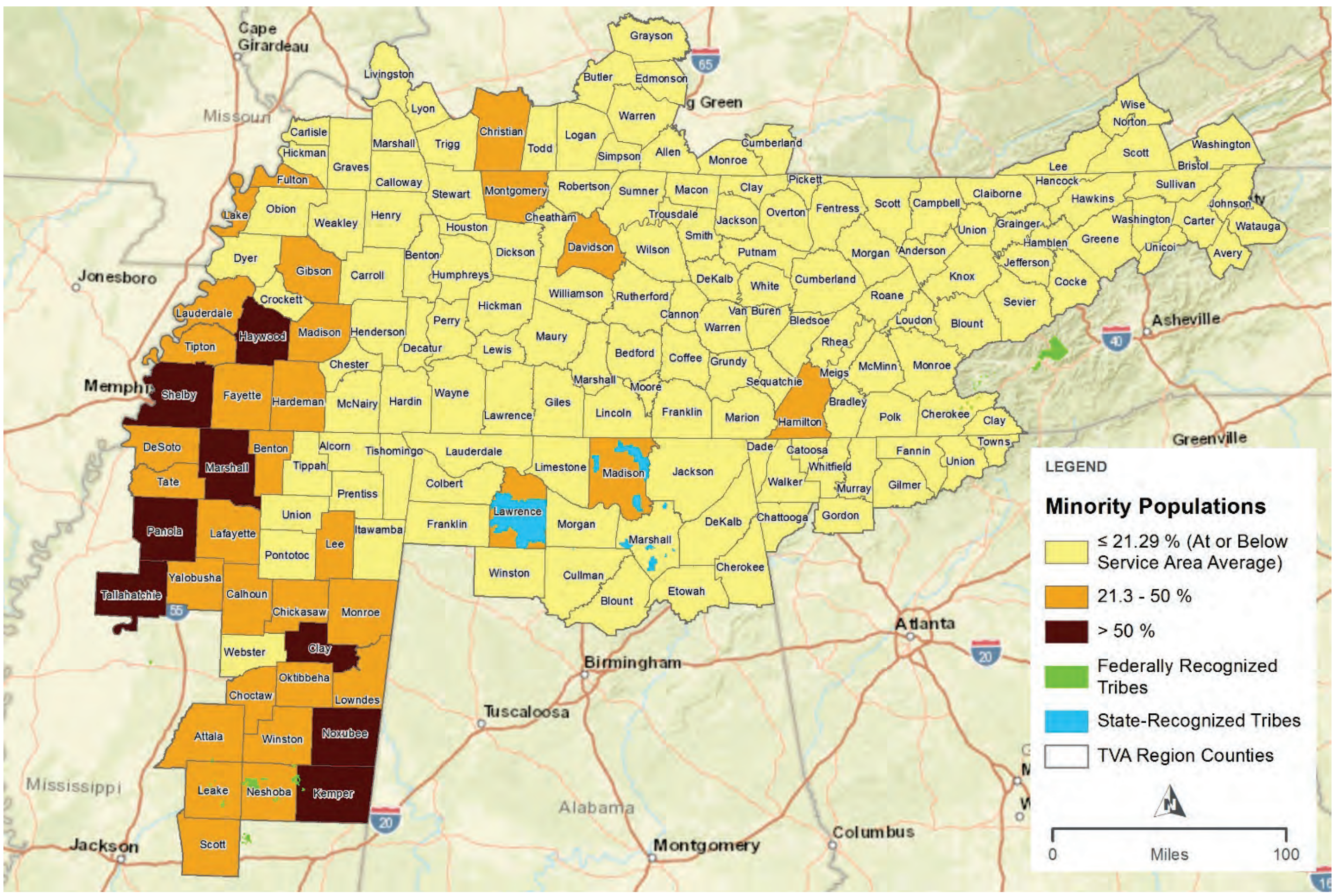

Figure 4-30: Minority populations at the county level in the TVA PSA.

Table 4-44: Counties in the TVA PSA with minority populations cxceeding 50 percent.

Geography	2016 Pop.	2016 Minority %	% African American	% Am. Indian / AK Native	% Asian	% Native Hawaiian / Other Pacific Islander	% Some Other Race	% Two or More Races	% Hispanic
Division 6	18,790,354	25.3	21.4	1.0	1.7	0.1	1.3	1.8	4.0
TVA PSA	10,042,431	21.3	17.0	1.1	1.8	0.1	1.2	1.9	5.2
TVA PSA Counties									
Noxubee County, MS	11,098	69.9	69.2	0.5	0.0	0.0	0.2	0.0	4.0
Kemper County, MS	10,128	64.5	60.8	3.7	0.0	0.0	0.0	0.5	1.5
Tallahatchie County, MS	14,776	62.3	46.7	0.6	1.6	0.4	13.3	0.4	15.2
Shelby County, TN	936,990	60.4	54.2	0.7	2.9	0.2	3.0	1.7	6.0
Clay County, MS	20,147	59.5	58.4	0.4	0.7	0.0	0.1	0.3	1.3
Haywood County, TN	18,129	54.0	51.1	0.6	0.2	0.5	2.6	1.1	4.2
Panola County, MS	34,319	51.5	51.0	0.2	0.1	0.1	0.2	1.0	1.6
Marshall County, MS	36,196	50.8	48.4	0.7	0.1	0.0	1.8	1.1	3.4

Source: 2016 ACS DP05

Three state-designated tribal statistical areas (SDTSA) are extant in the TVA PSA in northern Alabama and considered part of the minority population (USCB 2012). These consist of the Cherokee Tribe of Northeast Alabama SDTSA in Jackson County, Echota Cherokee SDTSA in Cullman, Lawrence, and Madison counties, and United Cherokee Ani-Yun-Wiya Nation SDTSA in Marshall County. Their locations are shown on Figure 4-30.

4.9.3 Federally Recognized Tribes

Two federally recognized tribes currently maintain reservations within the TVA PSA: the Eastern Band of Cherokee Indians (EBCI) in southwestern North Carolina and the Mississippi Band of Choctaw Indians (MBCI) in east central Mississippi, as shown on Figure 4-30. These sovereign nations are part of the minority population in the TVA PSA. Detailed USCB data is provided in an effort to better characterize these tribal populations and anticipate potential risks.

The EBCI is composed of 14,000 tribal members, while the resident population of the EBCI reservation, located in Cherokee, Graham, Jackson, and Swain counties, North Carolina, was estimated to be 9,613 for the period between 2012 and 2016 (EBCI 2016; USCB 2012). The ancestors of EBCI members either never made the journey to resettle in Oklahoma, which was mandated by the federal government in the Indian Removal Act of 1830, or made the trip and eventually returned to their homeland in and around western North Carolina (EBCI 2016).

Based on the 2016 ACS, the EBCI resident population had a median age of 32 years old, with approximately

37 percent between the ages 25 and 54 (USCB 2012). Within the population 25 years old and older, approximately 80 percent was estimated to be high school graduates or higher, and 11.4 percent was estimated to hold a bachelor's degree or higher. Of the civilian population 18 years old and older, almost 7 percent was classified as military veterans.

Approximately 97 percent of the EBCI population 16 years old or older in the labor force was employed, making the unemployment rate approximately 3.1 percent. Over 40 percent of the civilian employed population was employed in service occupations. According to the 2016 ACS data, the median household income was $32,379 and 25.3 percent of the resident population earned income amounts below the poverty level during the year prior to the estimates being made. Nearly 74 percent of occupied housing units was estimated to be owner-occupied, and the median housing unit value was $105,100. Over 66 percent of the civilian noninstitutionalized population had health insurance, with approximately one-third (33.6 percent) uninsured.

The MBCI reservation is located on 35,000 acres in east central Mississippi, in portions of Attala, Carroll, Kemper, Leake, Neshoba, Newton, and Winston counties (MBCI 2016). Approximately 10,000 people comprise the MBCI tribal membership, while the resident population of the MBCI reservation was estimated to be 7,735 for the period between 2012 and 2016 (MBCI 2016; USCB 2012). The ancestors of MBCI members were among a small percentage of Choctaws who did not relocate to Oklahoma when required to do so by the Indian Removal Act of 1830 (MBCI 2016).

Based on 2016 ACS estimates, the age groups between 5 and 9 years old and 24 and 34 years old composed the largest percentage of the MBCI resident population (over 28 percent), contributing to a relatively young median age of 25.3 years old (USCB 2012). Within the population 25 years old and older, approximately 70 percent was estimated to hold a high school diploma or higher, and 2.7 percent, to have completed a four-year college degree or higher.

Approximately 2.6 percent of the civilian population 18 years old and older was military veterans.

The unemployment rate among the MBCI resident population was estimated at approximately 13.7 percent. The largest occupational group for the MBCI resident population was service occupations, which employed approximately 47.6 percent of the civilian working population. The median household income was $35,732, and 33.5 percent of the resident population and 28.9 percent of families were estimated as having income amounts below the poverty level for the year prior to the estimates being made. The median housing unit value was $67,000, and almost 70 percent of occupied units were owner-occupied. Approximately 33.5 percent of the resident population was uninsured, with approximately two-thirds (66.5 percent) estimated to have health insurance.

4.9.4 TVA Programs Benefiting Minority and Low-Income Populations

In partnership with local power companies, TVA offers several programs directed at or involving low-income or minority populations in its PSA. These are summarized in this subsection.

The eScore residential energy efficiency program provides a customized path for making a residence energy efficient (see Section 2.5.1) and provides rebates for purchases of energy efficient appliances. Demographic information collected on over 70,000 participants in the program indicated that just under 40 percent of participants had household incomes under $50,000 and of that percent, nearly one in five were renters. Nearly 20 percent of participants were also over age 65.

TVA launched the Extreme Energy Makeovers program in 2015 using mitigation funds from the EPA Air Agreements funds. The program provided $42 million in grants to seven LPC teams to upgrade over 3,475 homes in low-income communities. These grants provide weatherization upgrades for electrically-heated, single family homes at no cost to income-qualified participants and achieved around 36 percent energy savings for less than $10 per square foot. With the average age of participating homes 58 years, upgrades included HVAC, ductwork, insulation and other measures to reduce energy consumption and energy costs. The teams included LPCs and local community partners (including resource agencies, local municipal offices) to develop community-based projects that best served the low-income residents within the LPC service area. Teams included Knoxville, TN (Knoxville Extreme Energy Makeover), Huntsville, AL (Huntsville Extreme Energy Makeover), Cleveland, TN, North Georgia, GA, Oak Ridge, TN, Columbus, MS, and 4-County, MS. This project ended in 2017.

TVA continues to examine ways to develop a sustainable, Valley-wide low-income weatherization program through the Home Uplift initiative. Home Uplift includes seven pilots to develop program and technical tools to support larger efforts to serve more residents. TVA has invested $5 million over two years to Home Uplift projects in Memphis, Chattanooga, Nashville, Knoxville, Huntsville, 4-County, MS, and West Kentucky to weatherize over 1,000 homes. Another objective of the pilots is to create a pool of participants for longer-term study on the non-energy benefits of home weatherization. This 2-year study will help quantify the health benefits of improved home with the objective of seeking local, state, federal and private community funding for future weatherization.

Other programs led by LPCs in partnership with TVA focus on economically-disadvantaged residents. For example, low-income Memphis, Light, Gas and Water (MLGW) residential customers have been recipients of various program benefits such as home weatherization grants and loans (DNV GL 2018). One such program, the Max Impact (MI) home weatherization loan program, provided on-bill financed low-interest loans up to $2,500 for home weatherization improvements for households with maximum annual incomes of $50,000. Another program is Share the Pennies – MLGW's Round up program where customers' bills are rounded to the next whole dollar, with the funds generated being used to weatherize qualified homes. With a $1 million dollar grant in 2018, TVA matches MLGW's investment dollar-for-dollar to increase the impact on participant's homes. MLGW offers several other program options for low-income, elderly, disabled, and other qualifying customers including grants, educational programs, pre-payment programs, budget billing (whereby payments are spread over a 12-month period), payment moratoriums, and home improvement initiatives.

TVA and the State of TN Weatherization Assistance Program (WAP) have partnered since 2008 to provide training for auditors and energy savings kits to WAP clients. These kits include direct install items such as LED light bulbs and educational materials. In 2018, TVA developed and launched a new technical tool to streamline the field and administrative processes which enabled full utilization of federal funding for low-income weatherization in Tennessee.

TVA also offers some grant assistance and special programming for areas termed Special Opportunities Counties (SOC). Only counties with the lowest per capita personal income, the highest percentage of residents below the poverty level, and the highest average annual unemployment rates are eligible for the SOC program. The list of eligible counties is updated annually. Figure 4-31 shows the counties considered SOC in 2018.

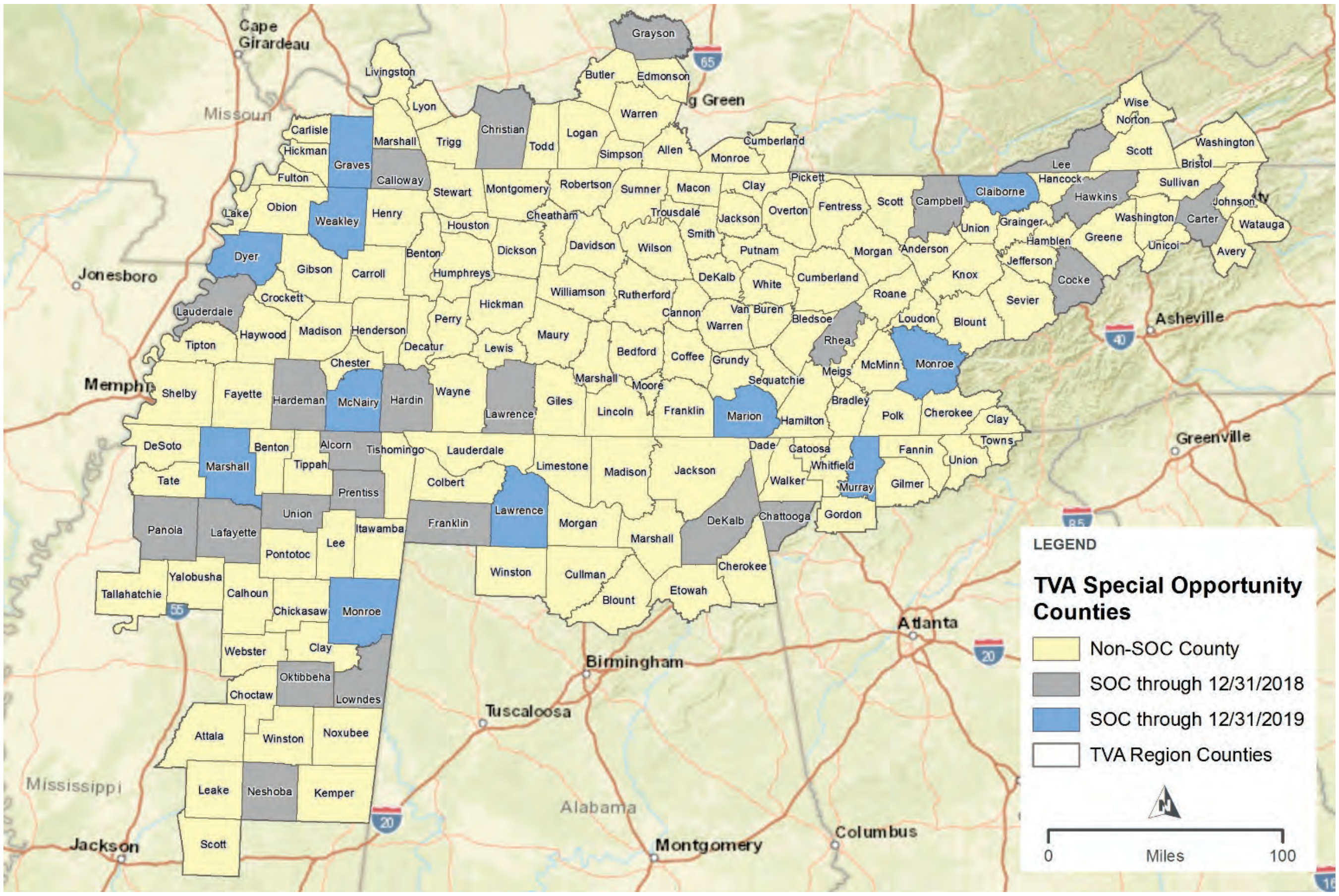

Figure 4-31: 2018 Special Opportunities Counties, as designated by TVA.

4.9.5 Environmental Justice Communities near TVA Power Plants

Demographic indicators for potential environmental justice concerns were obtained for a 3-mile radius surrounding TVA power plants, including the eight plants identified in the IRP for full or partial retirement over the 20-year study period. Indicators considered herein include minority, low-income, and linguistically isolated population percentages, as well as population percentages for children under 5 years of age and adults over 64 years of age. These data derive from the EPA's EJSCREEN database, which utilizes the most current ACS 5-year estimates (USEPA 2018e), as shown in Table 4-45. For comparison purposes, EJSCREEN data is also provided for associated states and the nation as a whole.

Table 4-45: Environmental justice demographic indicators for selected TVA power plants.

Geography / Plant	% Minority Pop.	% Low-Income Pop.	% Linguistically Isolated Pop.	% Pop. Under Age 5	% Pop. Over Age 64
US	38	34	4	6	14
Alabama	34	39	1	6	15
Bellefonte Nuclear	34	37	0	2	22
Colbert CT	16	26	0	2	21

Geography / Plant	% Minority Pop.	% Low-Income Pop.	% Linguistically Isolated Pop.	% Pop. Under Age 5	% Pop. Over Age 64
Kentucky	15	39	1	6	15
Shawnee Fossil	13	44	0	5	21
Mississippi	43	45	1	6	14
Ackerman CC	17	35	0	5	26
Caledonia CC	12	31	0	6	13
Magnolia CC	34	43	0	4	26
Southaven CC	74	48	1	7	13
Tennessee	25	38	1	6	15
Allen CC, CT	100	67	0	8	22
Cumberland Fossil	10	52	0	4	21
Gallatin Fossil, CT	6	18	3	6	13
John Sevier CC	9	51	0	6	17
Johnsonville CT	5	30	0	4	18
Kingston Fossil	7	39	0	5	21
Lagoon Creek CC	42	48	0	6	14
Sequoyah Nuclear	4	24	0	6	14
Watts Bar Nuclear	2	39	0	4	15

EJSCREEN data for the 18 plants considered in this analysis indicate that three plant locations have minority percentages that are higher than their associated states. These consist of the Allen CT and Lagoon Creek CC plants in Tennessee, and Southaven CC in Mississippi. Both Allen and Southaven CC are located in the Memphis metropolitan area, while Lagoon Creek CC is in Brownsville, Tennessee, approximately 60 miles northeast of Memphis. The same plant locations, along with John Sevier CC, located in the Appalachian region of northeastern Tennessee, demonstrate higher percentages of low-income populations than their associated states. Ten of the 18 plants have higher percentages of the population over the age of 64 than their respective states. This is reflective of the overall higher median age of the TVA PSA, as discussed in Section 4.8.1.2. For the most part, data indicate that the numbers of people under age 5 or considered linguistically isolated surrounding the plant locations are not significant in comparison with associated states. Appendix D-3 presents ethnicity percentages for each county in the TVA PSA, including those in which the 18 plants are located (see also Figure 1-1).

5 Anticipated Environmental Impacts

This chapter describes the anticipated environmental impacts of the alternative strategies and their associated portfolios. It first describes the general process Tennessee Valley Authority (TVA) uses to site new power facilities. It then describes the potential environmental impacts of the continued operation of TVA's generating facilities, facilities from which TVA purchases power through Power Purchase Agreements (PPAs), and the generating facilities that TVA is likely to own or purchase power from in the future. The chapter then describes the environmental impacts of distributed energy resources (DER), energy efficiency (EE) programs, and demand response (DR) programs. These are followed by a description of the environmental impacts of the construction and upgrading of the transmission system necessary to support future generating facilities. Finally, this chapter describes potential mitigation measures and commitment of resources.

5.1 Facility Siting and Review Processes

When planning new generating facilities, TVA uses several criteria to screen potential sites. Generating facilities are often needed in specific parts of the TVA power service area in order to support the efficient operation and reliability of the transmission system. Once a general area is identified, sites are screened by numerous engineering, environmental and financial criteria.

Specific screening criteria include regional geology and local terrain; proximity to major highways, railroads and barge access; proximity to major natural gas pipelines; proximity to high-voltage transmission lines; land use and land ownership; regional air quality; sources of process water; the presence of floodplains; proximity to parks and recreation areas; potential impacts to endangered and threatened species, wetlands, and historic properties; and potential impacts to minority and low-income populations. Through this systematic process, TVA attempts to minimize the potential environmental impacts of the construction and operation of new generating facilities.

New transmission facilities are typically required to transmit power between two defined points or to improve transmission capacity and/or reliability in a defined area. As with generating facilities, potential transmission line routes, substation locations, and switching station locations are screened by numerous engineering, environmental and financial criteria. Specific screening criteria include slope; the presence of highways, railroads and airports; land use and land ownership patterns; proximity to occupied buildings, parks and recreation areas; and potential impacts to endangered and threatened species, wetlands and historic properties. TVA also provides for and encourages participation by potentially affected landowners in this screening process.

TVA is not directly involved in the siting and operation of natural gas pipelines that may have to be built to serve new natural gas plants. Instead, TVA purchases natural gas service from contractors who are responsible for constructing and operating the pipeline. Construction and operation of a natural gas pipeline are subject to various state and federal environmental requirements depending on how and where constructed. If a pipeline is built specifically to serve TVA, TVA would evaluate the potential environmental impacts and take steps to ensure any associated impacts are acceptable.

The results of the site screening process, as well as the potential impacts of the construction and operation of the generating and transmission facilities at the screened alternative locations, are described in comprehensive environmental review documents made available to the public. During this environmental review process, TVA consults with the appropriate State Historic Preservation Officer on the potential impacts to historic properties and, as necessary, with the USFWS on the potential impacts to endangered and threatened species and their designated critical habitats.

Independent power producers (IPPs), from whom TVA purchases power under long-term PPAs, typically use a site screening process similar to the TVA process described above for new generating facilities. Depending on the location of the facility, approval by state and/or local authorities may also be necessary. The action by TVA of entering into a long-term PPA is subject to the requirements of the National Environmental Policy Act (NEPA) and other environmental laws and regulations, and TVA conducts comprehensive environmental reviews of generating facilities that IPPs propose to construct in order to provide power to TVA under long-term PPAs. TVA's criteria for approving a PPA typically include the requirement that, pending the outcome of the environmental review, TVA determines that the proposed facility is "environmentally acceptable" and would not result in significant environmental impacts.

5.2 Environmental Impacts of Supply-Side Resource Options

Because the locations of most future generating facilities are not known, this impact assessment focuses on impact areas that are generally not location-specific. These impact areas are described below.

Air Quality – The potential impacts to air quality are described by the direct emissions of the sulfur dioxide (SO_2), nitrogen oxide (NO_x), and mercury (Hg) and are quantified by the amounts emitted per unit of electricity generated and the total amounts emitted under each of the alternative strategies and portfolios during the 20-year planning period.

Greenhouse Gases (GHG) – As previously recommended by Council of Environmental Quality (CEQ 2016), GHG emissions are assessed for both the direct emissions of CO_2, from the combustion of non-renewable carbon-based fuels, and for the life cycle GHG emissions, which include direct and indirect emissions of CO_2, methane, nitrous oxide (N_2O), and other greenhouse gases. Life cycle GHG emissions include emissions from the construction, operation, and decommissioning of generating facilities; the extraction or production, processing and transportation of fuels; and the management of spent fuels and other wastes. Because life cycle GHG emissions have not been specifically determined for TVA's generating facilities, the estimates used in this assessment are based on published life cycle assessments (LCAs, e.g., Dolan and Heath 2012, Warner and Heath 2012, NETL 2016). Both direct CO_2 emissions and life cycle GHG emissions are quantified by the amount emitted per unit of electricity generated and the total amount emitted under each of the alternative strategies and portfolios during the 20-year planning period. Where distinguishable and unless otherwise stated, the LCA values described below do not include impacts associated with the transmission and distribution of the electricity generated by the various facilities. Life cycle GHG emissions are standardized to the 100-year global warming potentials adopted by the IPCC Fourth Assessment Report (Forster et al. 2007) or, for more recent LCAs, the IPCC Fifth Assessment Report (Myrhe et al. 2013)

Water Resources – The impacts of water pollutants discharged from a generating facility are highly dependent on site- and facility-specific design features, including measures to control or eliminate the discharge of water pollutants, which are not addressed here. The impacts of the process water used and consumed by a thermal generating facility (primarily for cooling) depend on the characteristics of the source area of water withdrawals and of the water bodies where process water is discharged. The quantities of process water used and consumed are indicators of the magnitude of these impacts. Facilities with open-cycle cooling systems withdraw and discharge large quantities of water. Facilities with closed-cycle cooling systems use less water but consume (typically by evaporation) a large proportion of it. Water use and consumption are quantified by the volumes used and consumed per unit of electricity generated and the total volumes used and consumed under each of the alternative strategies and portfolios. These water quantities are described for the TVA system as a whole, as well as by major river basin and whether from surface or groundwater sources.

Solid Waste – The potential for impacts from the generation and disposal of solid wastes are assessed by the quantities of coal ash, scrubber sludge (i.e., synthetic gypsum and related materials produced by flue gas desulfurization systems), and high-level radioactive waste (spent nuclear fuel). These are quantified by the amounts produced per unit of electricity generated and the total amounts under each of the alternative strategies and portfolios.

Fuel Consumption – The amount of fuel consumed relates to the potential impacts of the extraction or production, processing, and transportation of fuels. Fuel consumption is quantified by the amount consumed per unit of electricity generated and the total amount consumed under each of the alternative strategies and portfolios. In addition to coal, coal plants equipped with scrubbers or circulating fluidized bed boilers use limestone ($CaCO_3$) or slaked lime ($Ca(OH)_2$) as a reagent to reduce SO_2 emissions. The quantity of limestone or lime consumed is a function of the quantity and the SO_2 content of coal consumed. As with coal, the quarrying, processing and transportation of limestone and lime affects air, water and land resources.

Land Requirements – Land requirements for the alternative strategies and portfolios are quantified by both the facility land requirements and life cycle land requirements. These land requirements are indicators of the potential for impacts to land-based resources such as vegetation, wildlife, many endangered and threatened species, cultural resources such as archaeological sites and historic structures, land use, prime farmland, visual/aesthetic resources, recreation, and to aquatic resources from runoff and sedimentation. While this analysis assumes that the potential for impact increases with the land area affected, the kind of impact and its potential severity will vary depending on site-specific conditions and locations, as well as on the type of facility.

The facility land requirement is the land area permanently disturbed by the construction of the generating unit. It does not include adjacent lands that are part of the facility site and maintained in a natural or semi-natural state as buffers or exclusion zones. Facility land requirements were determined from a variety of sources, including characteristics of TVA facilities, both existing and under development; characteristics of comparable facilities recently constructed or proposed elsewhere in the country; and various published reports on this topic. The facility land requirement given for each strategy and portfolio is the total acreage permanently disturbed by the construction of new generating facilities during the planning period.

The life cycle land requirement is a measure of the land area transformed during the life cycle of a generating facility, expressed in terms of units of area per amount of electricity generated. This land includes the facility site; adjacent buffer areas; lands used for fuel extraction or production, processing, and transportation; and land used for managing spent fuels and other wastes. Some of the land areas, such as the facility site, are transformed for decades while others, such as some minelands, are transformed for shorter time periods. These differing time periods are considered in the development of the LCA. The estimates used in the following descriptions are based on published LCAs (e.g., Fthenakis and Kim 2009, Jordaan et al. 2017). Published life-cycle land requirement information is not available for some of the generating and storage facilities under consideration. For some other facilities, the available published information is based on facilities with substantial differences from current or proposed TVA facilities in important components such as the length of natural gas pipelines and therefore not readily applicable to TVA facilities.

Life cycle land requirements can also be expressed with a land-use metric that accounts for the total surface area occupied by the materials and products used by a facility, the time the land is occupied, and the total energy generated over the life of the facility (Spitzley and Keoleian 2005, AEFPERR 2009). The rank order by energy technology reported for a sample of U.S. facilities, from the smallest to the largest land requirements, is natural gas, coal, nuclear, wind, solar PV, conventional hydroelectric, and biomass. The large land requirements for hydroelectric include the reservoirs, which typically have other uses. The biomass land requirements are based on the use of dedicated woody or non-woody crops; the use of forest residues would also result in a somewhat lower land requirement. Biomass generation using landfill gas, mill residues, or other byproducts has a much smaller life cycle land requirement than biomass generation using other fuel. Relatively few LCAs address this type of land-use metric.

Following is a discussion of the environmental attributes of the generation options. Environmental characteristics of new supply-side resources selected in the capacity expansion plans are listed in Table 5-1. A few of the environmental characteristics listed in Table 5-1 are dependent on their location and on the detailed facility design and are difficult to quantify without more detailed engineering analyses. The various types of generating facilities are described in Section 5.2 of Volume I and Section 2.3 of Volume II. It is important to note there are comprehensive environmental laws and regulations that address almost all activities associated with the construction and operation of new industrial facilities, particularly energy generation facilities. This regulatory umbrella ensures the environmental impacts associated with energy resources are acceptable and in general, public health and the environment are adequately protected.

Table 5-1: Environmental characteristics of new supply-side resources included in alternative strategies.

	Summer Net Dependable Capacity, MW	Summer Full-Load Heat Rate, Btu/kWh	Storage Efficiency	SO2 emissions, lbs/MWh	NOx emissions, lbs/MWh	HG emissions, lbs/MWh	CO2 emissions, tons/GWh	GHG life cycle emissions, tons CO2-eq/GWh	Process water use, gallons/MWh	Process water consumption, gallons/MWh	Facility land requirement, permanently disturbed acres	Facility land requirements, acres/MW
Aeroderivative Combustion Turbine 6x (GE LMS 100)	576	9,350		0	0.337	0	547		0	0	45	0.0781
Combustion Turbine 3x (7FA)	703	10,132		0	0.365	0	593		0	0	68	0.0967
Combustion Turbine 4x (7FA)	934	10,132		0	0.365	0	593		0	0	68	0.0728
Combined Cycle 2x1	1,062	6,520		0	0.078	0	382		250	195	80	0.0502
Combined Cycle 2x1 Supplemental Duct Firing	120	8,656		0	0.104	0	507		250	195	0	0
Small Modular Reactors	600	10,046		0		0			1164	665	375	0.6250
Compressed Air Energy Storage	330	4,700	70%	0	0.169	0	275		0	0	80	0.2424
Utility-Scale Battery Storage	100		88%	0	0	0	0		0	0	4	0.1600

	Summer Net Dependable Capacity, MW	Summer Full-Load Heat Rate, Btu/kWh	Storage Efficiency	SO2 emissions, lbs/MWh	NOx emissions, lbs/MWh	HG emissions, lbs/MWh	CO2 emissions, tons/GWh	GHG life cycle emissions, tons CO2-eq/GWh	Process water use, gallons/MWh	Process water consumption, gallons/MWh	Facility land requirement, permanently disturbed acres	Facility land requirements, acres/MW
Utility-Scale Tracking Solar (20 Year PPA)	34 (50)*			0	0	0	0		0	0	365	7.300

5.2.1 Fossil-Fueled Generation

5.2.1.1 Coal – Existing Facilities

TVA currently operates 26 coal-fired generating units at 6 plant sites (see Section 2.3.1). Flue gas desulfurization (FGD) systems for SO_2 control and selective catalytic reduction (SCR) systems for NO_x emissions control have been installed at 19 of these units. The plants with these FGD and SCR systems include TVA's largest coal units and total about 7,000 MW of generating capacity. The remaining coal-fired units use other methods to reduce SO_2 and NO_x emissions including the use of low-sulfur coal, low-NO_x burners, and selective non-catalytic NO_x reduction systems.

While the life cycle GHG emissions for TVA coal plants have not been calculated, several studies have calculated these emissions for comparable coal plants. Spitzley and Keoleian (2005) found an emission rate of 1,060 tons CO_2-eq/GWh[4] for pulverized coal boilers without advanced emissions control systems, comparable to seven of the Shawnee units. NETL (2010a) calculated a life cycle GHG emission rate of 1,226 tons CO_2-eq/GWh (1,112 kg/MWh) for a pulverized coal plant equipped with an electrostatic precipitator, SCR, and scrubber, comparable to Kingston, Gallatin, and two Shawnee units. For a supercritical pulverized coal plant (SCPC) equipped with an electrostatic precipitator, FGD and SCR, comparable to Bull Run, Cumberland and Paradise Unit 3, NETL (2010b) calculated a life cycle GHG emission rate of 1,045 tons CO_2-eq/GWh (948 kg/MWh).

The largest source of life cycle GHG emissions from coal plants similar to TVA's is CO_2 from coal combustion, which typically accounts for between 80 and 90 percent of GHG emissions (Kim and Dale 2005, Odeh and Cockerill 2008, Cuéllar-Franca and Azapagic 2015). The next highest source is methane emissions from coal mining; these emissions are higher for underground than surface mines. Methane emissions from underground mining of Illinois Basin coal, which accounted for 39 percent of TVA's 2017 coal supply and 46 percent of the 2018 coal supply, are several times those from mining Powder River Basin (PRB) coal (NETL 2014). This difference is attributable to both the higher methane content of bituminous coals (such as Illinois Basin coal), and to the greater rate of PRB coal bed methane recovery and utilization as part of the natural gas supply. Coal preparation and transport typically account for less than 1 percent of GHG emissions (NETL 2010b). Other GHG sources include limestone mining and transport, lime processing for FGD systems using slaked lime such as the systems at Gallatin and on two Shawnee units. GHG emissions from plant construction, decommissioning and other processes are relatively small.

All TVA coal plants, except Paradise, use only open-cycle cooling and thus have high water use rates but low water consumption rates (see Section 4.4). Paradise uses closed-cycle cooling much of the year causing lower water use and higher water consumption rates. As a result, the amount of heat discharged to the Green River at Paradise is relatively low.

The Red Hills plant in Mississippi burns lignite coal from an adjacent surface mine. Relative to the average for TVA's coal plants, the Red Hills CO_2 emission rate is high due to the low heat rate of the plant and low fuel energy content. Like the TVA coal plants with FGD systems, Red Hills uses limestone to reduce SO_2 emissions. The plant occupies about 320 acres and its fuel cycle disturbs about 275 acres/year, equivalent to 0.09 acre/GWh of energy generated. It uses groundwater in a closed-cycle cooling system with no discharges to receiving water bodies.

Coal mining has the potential to adversely impact large areas, depending on the mining method and area being mined. The impacts are greatest from surface mining, particularly by mountain- top removal, in Appalachia (U.S. Environmental Protection Agency (EPA) 2005, Palmer et al. 2010). In recent years TVA has greatly reduced its use of coal from Appalachian surface mines and currently uses no coal from this source. Impacts from surface mining include removal of forests and other plant communities, disruption of wildlife habitat, alteration of streams and associated aquatic communities, and long-term alterations of the mine area topography. Impacts from underground mining are typically less than those of surface mining.

Coal plants produce large quantities of ash and, if equipped with FGD systems, calcium-based residues (see Section 4.7). Although some of these coal combustion residuals (CCRs) are recycled for a range of beneficial uses, large quantities are typically permanently stored in impoundments or landfills at or near coal plants. These facilities can occupy tens to hundreds of acres.

5.2.1.2 Coal – New Facilities

The new coal facilities available for selection during the portfolio modeling are an integrated gasification combined cycle (IGCC) plant with and without carbon capture and sequestration (CCS), and two configurations of supercritical pulverized coal (SCPC) plants with and without CCS (see Volume 1 Section 5.2.2). The environmental impacts of constructing and operating an IGCC plant without CCS, the Mesaba Energy Project, are described in USDOE (2009). The environmental impacts of constructing and operating IGCC plants with CCS are described for the FutureGen plant in USDOE (2007) and for the Kemper County, Mississippi, IGCC Project in USDOE (2010). Life cycle impacts of SCPC and IGCC plants with and without CCS are described by Odeh and Cockerill (2008), NETL (2010b, 2012), and Cuéllar-Franca and Azapagic (2015). Life cycle GHG emissions of SCPC plants with CCS vary according to the technology used to capture CO_2, with emissions from plants utilizing oxy-fuel combustion up to about a quarter lower than plants utilizing post-combustion capture (Cuéllar-Franca and Azapagic 2015).

Relative to conventional SCPC coal plants, emissions of priority air pollutants from an IGCC plant without CCS are low, especially for SO_2. Projected life cycle GHG emissions for an IGCC plant without CCS are comparable to or somewhat higher than those of a SCPC plant (NETL 2012, Cuéllar-Franca and Azapagic 2015). Assuming a 90 percent carbon capture rate, adding CCS to a new SCPC plant would reduce life cycle GHG emissions from approximately 1,045 to 283 tons CO_2-eq/GWh, and adding CCS to an IGCC plant would reduce life cycle GHG emissions to about 190 to 242 tons CO_2-eq/GWh (NETL 2012, Cuéllar-Franca and Azapagic 2015). For both SCPC and IGCC plants, adding CCS increases the proportion of life cycle GHG emissions attributable to coal mining and processing from about 8 percent to 41–43 percent.

New SCPC and IGCC plants are assumed to have closed-cycle cooling systems. Adding CCS to a SCPC plant increases water consumption by the generating facility by about 70 percent to around 920 gallons/MWh (NETL 2010b). For an IGCC plant, CCS raises water consumption by around 25 percent to 413 gallons/MWh (NETL 2012). Other estimates for IGCC plants with CCS, closed-cycle cooling systems, and zero liquid discharge include 469 gallons/MWh for the Kemper County plant (USDOE 2010) and 655 gallons/MWh for the FutureGen plant (USDOE 2007). Instead of the fly ash, bottom ash, and scrubber sludge produced by a SCPC plant, IGCC plants produce a glassy, inert slag during the gasification process. The projected slag production rate for the FutureGen plant, using Illinois Basin coal, is 47.3 tons/GWh (USDOE 2007).

Projected facility surface land requirements for IGCC plants with CCS include 200 acres for the 275-MW FutureGen plant (USDOE 2007) and 550 acres for the 582-MW Kemper plant (USDOE 2010). The average land requirement for these two plants is 0.84 acres/MW. The 1,200-MW Mesaba IGCC plant, without CCS, is projected to occupy 300 acres (USDOE 2009). The IGCC plant without CCS option considered in this IRP process is assumed to require 400 acres and the IGCC plant with CCS option is assumed to require 450 acres. The difference is due to the land requirements for CCS components, particularly CO_2 pipelines and injection wells. Published life cycle land requirements are not available and would vary with the type of coal being used, mining method, CCR disposal method, and distance from the generating facility to the carbon sequestration site.

TVA's SCPC plants occupy land areas of 730 to 3,000 acres, with an average of 0.83 acres/MW. Recently constructed SCPC and advanced ultra-supercritical plants in the U.S. (John W. Turk, Jr. in Arkansas, Longview in West Virginia, Sandy Creek in Texas, and Prairie State in Illinois) occupy an average of 0.91 acres/MW. Based on these averages, and because the correlation between plant land area and capacity is weak, a new 800-MW SCPC plant is assumed to occupy 725 acres and a new 1,600-MW SCPC is assumed to occupy 1,100 acres. Due to the land requirements for CCS components, adding CCS to the SCPC plants is assumed to require an additional 50 acres.

Life cycle land requirements for coal plants without CCS range from about 0.037 to 0.099 acres/GWh (Fthenakis and Kim 2009). The type of mining of the coal used to fuel a coal plant is the largest source of variation, with surface mining affecting a larger land area. The time required to reclaim the mined area also affects the life cycle land requirements.

5.2.1.3 Natural Gas – Existing Facilities

The construction and operational impacts of TVA's recently constructed frame-type combustion turbine (CT) and combined cycle (CC) plants (e.g., Lagoon Creek CT, John Sevier CC, Paradise CC, Allen CC) are described in several EISs and environmental assessments (e.g., TVA 2000, TVA 2010a, TVA 2013b, TVA 2014b). Natural gas-fired plants do not emit SO_2 or mercury, and direct emissions of NO_x (usually controlled by water or steam injection and/or SCR systems) and CO_2 are low relative to other fossil plants. CT plants require minimal amounts of process water.

TVA's CC plants use closed-cycle cooling, as do most other CC plants elsewhere. The average land area for TVA CT plants is about 90 acres (0.153 acres/MW). TVA CC plants occupy an average of about 87 acres (0.108 acres/MW).

Life cycle GHG emissions have not been calculated for TVA's gas-fired plants. NETL (2016) reported life cycle GHG emissions of about 514 and 560 tons CO_2-eq/GWh for U.S. fleet CC plants operated in baseload and load-following modes, respectively. For advanced class combustion turbines, similar to those at TVA's newest CC plants, NETL (2016) reported life cycle GHG emission rates of 497 tons CO_2-eq/GWh. The life cycle GHG emissions for the U.S. fleet of CT plants was reported by NETL (2016) to be 747 tons CO_2-eq/GWh. This emission rate is probably close to that of the TVA CT plants which are comprised of a mix of older, lower capacity turbines and more recent, higher capacity advanced class turbines.

About 20 to 22 percent of the GHG emissions from CC and CT plants reported by NETL (2016) results from the extraction, processing and transport of natural gas. These emissions are dominated by methane. The natural gas supply analyzed in this study was based on the 2012 U.S. mix of domestic sources, including 34 percent "conventional" gas sources (23 percent onshore, 5 percent offshore, and 6 percent associated) and 66 percent "unconventional" gas sources (20 percent tight, 39 percent shale, and 6 percent coal bed methane) (NETL 2016). The GHG emission rate during gas production and transport to gas plants averaged

12.7 grams CO_2-eq/megajoule (MJ, equivalent to 948 BTU) of natural gas.

GHG emission rates were somewhat higher for unconventional tight (21.0 grams CO_2-eq/MJ), Barnett shale (12.4 grams CO_2-eq/MJ), and Marcellus shale (14.5 grams CO_2-eq/MJ) gas production than for conventional onshore (10.3 grams CO_2-eq/MJ gas production. When the full life-cycle GHG emissions are considered, including those from combustion in the power plant, the differences between attributable to the gas source are minimal and less than 1 percent of total life-cycle GHG emissions (Heath et al. 2014).

One of several areas of concern over the environmental impacts of shale gas production by hydraulic fracturing has been over fugitive emissions of methane. Hydraulic fracturing, used in the production of shale and “tight” gas, as well as coal-bed methane, involves the injection of pressurized fluids (predominantly water with gels and chemical additives) and sand into the well borehole to fracture the gas-bearing rock formation and increase its permeability. Howarth et al. (2011) suggested that high methane emissions during shale gas production resulted in higher overall GHG emissions than coal. Other studies have shown the life cycle carbon footprint of electricity generation from shale gas is similar to (Weber and Clavin 2012) or somewhat (11 percent) greater than (Hultman et al. 2011) generation from conventional gas. Even when accounting for higher emissions from the use of shale gas, Hultman et al. (2011) and NETL (2014) concluded that electricity generation from shale gas had a much lower GHG emissions than generation from coal.

In a review of published studies, Heath et al. (2014) found GHG emission rates were somewhat higher for unconventional tight (21.0 grams CO_2-eq/MJ), Barnett shale (12.4 grams CO_2-eq/MJ), and Marcellus shale (14.5 grams CO_2-eq/MJ) gas production than for conventional onshore (10.3 grams CO_2-eq/MJ gas production. When the full life-cycle GHG emissions are considered, including those from combustion in the power plant, the differences attributable to the gas source are minimal and less than 1 percent of total life-cycle GHG emissions.

Several other areas of concern over the environmental impacts of shale gas production have been identified and the risk to water resources is the subject of numerous studies. In a Congressionally mandated study of the impact of fracking on water resources, USEPA (2016) identified the following areas of concern: water withdrawals in times or areas of low water availability; spills that result in large volumes or high concentrations of chemicals reaching groundwater resources; leakage of gas or injected liquids from wells into groundwater resources; injection of hydraulic fracturing fluids directly into groundwater resources; discharge of inadequately treated wastewater into surface water resources; and the disposal of wastewater into unlined pits, resulting in contamination of groundwater resources. An assessment of the frequency and severity of the resulting impacts was limited by data gaps and uncertainties in the available data. Vengosh et al. (2014) identified additional risks to water resources and recommend several mitigation measures to reduce these risks. Some of these measures have been the subject of various regulatory and industry initiatives.

Other areas of risk include decreased air quality, induced seismicity (earthquakes) from hydraulic fracturing and disposal of fracturing fluids and produced water by deep injection, habitat loss and fragmentation, noise and light pollution, public health, and socioeconomic and community effects. Some of these risk areas are not as well-known as those related to water resources and methane emissions (Small et al. 2014, Souther et al. 2014). Recently published studies have shown an increase in earthquakes in the central U.S. attributable to the deep underground injection of wastewater. Much of this wastewater is saline produced water from oil and gas wells. Relatively few induced earthquakes are directly attributable to hydraulic fracturing (Rubenstein and Mahani 2015, Weingarten et al. 2015).

5.2.1.4 Natural Gas – New Facilities

The new natural gas facilities available for selection during the portfolio modeling are three configurations of reciprocating internal combustion engine (RICE) generating sets, three configurations of aeroderivative CT plants, two configurations of frame-type CT plants, three configurations of CC plants without carbon capture and storage, and a CC plant with CCS (see Volume 1 Section 5.2.2). The CT and CC plant configurations are based on advanced F-class combustion turbines. The environmental characteristics of these plants are generally similar to those of existing recent gas plants characterized above by NETL (2016), although the new frame-type F-class turbines are somewhat more efficient and thus have somewhat lower emission rates. Land area requirements for frame-type CT and CC plants are based on those of TVA's newest frame-type CT and CC plants, which show little correlation between land area and capacity. Land area requirements for RICE and aeroderivative CT plants are based on published reports or calculated from aerial photographs of existing plants elsewhere in North America. Little published data on the life cycle impacts, including life cycle GHG emissions, of these plants is available. The GHG life cycle emission rate of the aeroderivative CTs is likely about 10 percent lower than that of the frame-type 7FA CTs given the approximately 10 percent lower heat rate and higher efficiency of the aeroderivative CTs.

Fthenakis and Kim (2009) estimated a life cycle land requirement of approximately 0.076 acres/GWh for a natural gas-fired plant using gas from conventional sources. Jordaan et al. (2017) found a life cycle land requirement of 0.153 acres/GWh in an analysis of several CC and CT plants in Texas fueled by natural gas from the Barnett Shale area in Texas. The largest contributor to the land requirement was the pipeline infrastructure, which accounted for about 74 percent of the land requirement. Gathering pipelines, which connect well sites with transmission pipelines, were the largest component of the pipeline infrastructure. The power plant was also a large contributor to the land requirement, with lower efficiency CT plants requiring more land than higher efficiency CC plants.

5.2.2 Nuclear Generation

5.2.2.1 Nuclear – Existing Facilities

The impacts of operating TVA's existing nuclear plants are described in previous EISs and other reports (e.g., TVA 2007b). Nuclear power generation does not directly emit regulated air pollutants or GHGs. The largest variable in life cycle GHG emissions of a nuclear plant, aside from the operating lifetime, electrical output, and capacity factor, are related to the uranium fuel cycle and include the uranium concentration in the ore, the type of uranium enrichment process, and the source of power for enrichment facilities. Almost all past uranium enrichment in the U.S. used the energy-intensive gaseous diffusion process largely powered by fossil fuels. No gaseous diffusion enrichment facilities are currently operating or likely to operate in the future in the U.S. Commercial enrichment by the centrifuge process began in the U.S. at a plant in New Mexico in 2010. This process, widely used outside the U.S., can require less than 3 percent the energy of the gaseous diffusion process.

Construction of other U.S. centrifuge process enrichment plants is currently on hold. Laser enrichment processes would further reduce energy requirements; commercial development of this technology in the U.S. has slowed due to the recent low demand for nuclear fuel. The use of highly enriched uranium from surplus U.S. Department of Energy (USDOE) inventories diluted to commercial reactor fuel also reduces GHG emissions.

The life cycle GHG emissions of TVA's nuclear plants have not been determined. In a recent international survey of nuclear electric generation life cycle studies, Warner and Heath (2012) reported a median GHG emission rate of 13.2 tons CO_2-eq/GWh (12 grams CO_2-eq/kWh) and an interquartile range (the 75th percentile value minus the 25th percentile value) of 18.7 tons CO_2-eq/GWh. Boiling water reactors, such as TVA's Browns Ferry plant, tend to have slightly higher life cycle GHG emissions than pressurized water reactors such as TVA's Sequoyah and Watts Bar plants. Fthenakis and Kim (2007) reported life cycle GHG emissions of 17.6 to 60.6 tons CO_2-eq/GWh for U.S. nuclear plants. Part of the difference in emission rates between the 2012 international survey and the 2007 U.S. study is the greater U.S. reliance on the more energy-intensive gaseous diffusion enrichment process. Fthenakis and Kim (2007) predicted a decrease in life cycle GHG emissions to about 13.2

tons CO_2-eq/GWh with exclusive use of centrifuge enrichment.

TVA's nuclear plants occupy an average of 1,114 acres each and about 80 percent of this area is developed. Life cycle land metrics have not been determined for TVA's nuclear plants.

Fthenakis and Kim (2009) estimated a life cycle land transformation of 0.023 acres/GWh for nuclear power. About half of this transformed land is the power plant site. Due to the evolving approach to the long-term disposal of spent fuel, the land required for offsite spent fuel disposal is excluded from this estimate. Use of the Yucca Mountain, Nevada, site for long-term disposal would increase the estimate by about a third.

5.2.2.2 Nuclear – New Facilities

The new nuclear generation options available for selection during the portfolio modeling are a 1,260-MW pressurized water reactor, a 1,117-MW advanced pressurized water reactor (characterized by the AP1000 design), and a 600-MW multiple unit small modular reactor (see Volume 1 Section 5.2.2.1). The impacts of constructing and operating a one- or two-unit pressurized water reactor nuclear plant at the Bellefonte site in northeast Alabama are described in a 1974 EIS (TVA 1974).

In 2008, TVA completed an environmental report (TVA 2008b) for a combined license application to the Nuclear Regulatory Commission for the construction and operation of a two-unit AP1000 nuclear plant on the Bellefonte site adjacent to two partially built pressurized water reactors. Most operational impacts would be comparable to those of TVA's existing nuclear plants with the exception of water use and water consumption. A new advanced pressurized water reactor would operate with closed cycle cooling; water use would be relatively low and water consumption relatively high compared to TVA's other thermoelectric plants. The environmental impacts of constructing and operating similar advanced pressurized water reactors at other sites in the U.S. have been described in EISs issued by the Nuclear Regulatory Commission. These include, for example, Vogtle Units 3 and 4 in Georgia and V. C. Summer Units 2 and 3 in South Carolina (NRC 2018a).

The impacts of constructing and operating a small modular reactor (SMR) plant would be generally similar to those of TVA's existing nuclear plants and the other new nuclear generation options, but proportionately less due to the lower capacity of the small modular reactor plant. These impacts have recently been described in NRC (2018b) for a new SMR plant at TVA's Clinch River Site in Roane County. The use of modular construction for major plant components would reduce construction impacts at the plant site compared to a conventional pressurized water or advanced pressurized water reactor.

5.2.3 Renewable Generation

TVA's current renewable energy portfolio is dominated by the hydroelectric facilities at its dams and power purchase agreements for wind energy. Power purchase agreements for solar generation are a small but rapidly growing component of the portfolio (see Sections 3.3 and 3.4). Following is an overview of the environmental impacts of renewable generation from hydroelectric, wind, solar, and biomass facilities.

5.2.3.1 Hydroelectric – Existing Facilities

Impacts of the operation of TVA's hydroelectric facilities are described in the *Reservoir Operations Study* (TVA 2004). Hydropower generation does not directly emit GHGs and its life cycle GHG emissions are among the lowest of the various types of generation. Although not studied for TVA facilities, reported GHG emission rates from other hydroelectric facilities vary greatly and are frequently greatest shortly after the reservoir is initially filled. These emissions are primarily methane from the decomposition of flooded biomass. Scherer and Pfister (2016) modeled GHG emissions from hydroelectric reservoirs based on measured GHG emissions from a variety of reservoirs with different characteristics. The best predictors of GHG emissions were the ratio of reservoir area to electricity generation, the age of the reservoir, and the local maximum temperature. Reservoir productivity has also been identified as a predictor of GHG emissions (Deemer et al. 2016). Calculated GHG emissions from 15 TVA hydroelectric reservoirs ranged from -5 kg CO_2-eq/KWh for

Apalachia (indicating this small, run-of-river reservoir is a carbon sink rather than a carbon source) to 32 kg CO_2-eq/KWh for Fontana to 208 kg CO_2-eq/kWh for Kentucky (Scherer and Pfister 2016). Their average of 74 kg CO_2-eq/kWh is lower than the U.S. average of 148 kg CO_2-eq/kWh. Hydroelectric reservoirs are frequently constructed to serve multiple purposes, including flood control, navigation, water supply and recreation; these purposes other than hydropower offset some of the GHG emissions. Scherer and Pfister (2016) considered these multiple uses in their analysis and adjusted their estimates according to the ranking of hydropower among the multiple purposes of each reservoir. Consequently, their estimates reflect emissions attributable to the reservoir's hydropower use.

5.2.3.2 Hydroelectric – New Facilities

Under all the alternatives, TVA would continue to modernize its hydroelectric units as part of its normal maintenance activities. The impacts of these upgrades have been described in environmental assessments for many facilities (e.g., TVA 2005a). While the upgrades generally do not change the volume of water used on a daily cycle, they can increase the rate of water passing through the turbines and result in small, periodic increases in downstream velocities. A potential consequence of the increased velocity is increased downstream bank erosion, which TVA mitigates as necessary by protecting stream banks with riprap or other techniques. Other environmental impacts of hydro modernization are minimal and there is typically no additional long-term conversion of land.

Two options for new hydroelectric generation involve adding turbines to existing TVA hydroelectric dams. One option is adding a 40-MW turbine to a main-stem dam where water is regularly spilled (passed over the dam through floodgates during high flow periods) to utilize the energy potential in the spilled water. The other option is adding a 30-MW turbine where there is adequate existing space for the turbine. Both of these would be relatively major construction projects, although most construction activities would occur on the dam reservations.

An additional option for new hydroelectric generation is the development of run-of-river generating facilities. Run-of-river facilities could include the addition of turbines to existing, non- power dams and in-stream turbines not requiring a dam. One type of run-of-river generating facility is adding turbines to existing run-of-river dams, such as old mill dams. The construction of the generating facilities could result in major modifications to the dams and transmission upgrades, and at some sites would require additional land. The dams would continue to operate in a run-of-river mode, which would lessen some potential environmental impacts. Provisions for fish passage, however, could be required at some dams. See Section 5.2.2.5 of Volume I for descriptions of potential sites. Other run-of-river projects would use very small or no reservoirs. One class of these would divert part of the stream flow into a raceway to a downstream generator without totally blocking the stream channel. Potential environmental impacts include alterations of the streambed and stream banks, removal of riparian vegetation, and, for at least a short stretch of the stream, reduction of stream flow (Electric Power Research Institute (EPRI) 2010). Another type of run-of-river facility is in-stream generators mounted on the streambed or suspended from a barge or other structure. These could interfere with boating and other recreational uses of the stream. At this time, their potential impacts on fish and other aquatic life are poorly known, although a few studies have suggested they are not significant. Land requirements vary with the type of run-of-river facility and for this analysis are assumed to be 0.5 acres/MW. Life-cycle GHG emissions from all of the new hydroelectric options would be low because, with the possible exception of very small reservoirs for some run-of-river projects, the options do not include the construction of new reservoirs.

5.2.3.3 Wind – Existing Facilities

A significant portion of TVA's renewable generation portfolio is wind generation from the Cumberland Mountains of Tennessee, the upper Midwest, and the Great Plains (Table 3-6). TVA currently purchases power from eight wind farms with a total of 757 turbines. The hub heights of these turbines range from 78–100 m and the rotor diameters range from 77–100

m. TVA completed environmental assessments for wind farms in Tennessee and Kansas (TVA 2011b, 2011c).

Impacts of wind farm construction include the clearing and grading of access roads and turbine sites and excavation for turbine foundations and electrical connections. Denholm et al. (2009) reported an average direct permanent impact area of 0.74 acres/MW, and a direct average temporary impact area of 1.73 acres/MW. These impact areas average somewhat smaller in mid-western croplands and somewhat larger in Great Plains grasslands/herbaceous areas and forested Appalachian ridges. A review of wind farms supplying TVA purchased power (Table 2-6) showed that their average direct impact area is close to that of Denholm et al. (2009).

The total wind farm area tends to be much larger than the direct impact areas and nationwide averages 84 acres/MW or a capacity density of 1 MW/82 acres (Denholm et al. 2009). This density, while low relative to most other types of electrical generation, varies greatly due to different leasing practices by wind farm developers. Using a different analysis technique that incorporated capacity factor, Miller and Keith (2018) calculated an energy density of 1MW/494 acres for windfarms constructed between 1998 and 2016. A very small proportion of this wind farm area is directly disturbed and most land use practices can continue on the remainder of the area. Land clearing and road and transmission line development for wind farms can, however, result in habitat fragmentation. Operational impacts include turbine noise, which can be audible for distances of a quarter mile or more, and the visual impacts of the turbines which can dominate the skyline. Operating turbines can also cause shadow flicker, the flickering effect caused when rotating wind turbine blades periodically cast shadows through constrained openings such as the windows on neighboring properties. The scale of the problem depends on a number of factors such as turbine height, wind speed and direction, position of the sun, distance from the turbine, local terrain and amount of cloud cover; modeling tools have been developed to quantify shadow flicker associated with existing and proposed windfarms. Shadow flicker has been reported to cause headaches and increase stress for some individuals.

Impacts to biological resources include habitat fragmentation, displacement of wildlife that avoid tall structures, and mortality of birds and bats from collision with turbines. Bats can also die from trauma induced by air pressure changes caused by the rotating turbines (BLM 2005, Baerwald et al. 2008). Loss et al. (2013) and Erickson et al. (2014) compiled information on bird collision mortality at wind farms across North America. Loss et al. (2013) estimated mean annual mortality rates of 6.86 birds/turbine (3.86 birds/MW) for the eastern U.S. (including Tennessee and Illinois) and 2.92 birds/turbine (1.81 birds/MW) for the Great Plains (including Iowa and Kansas). This study also found an increase in mortality rate with turbine hub height. Erickson et al. (2014) estimated annual mortality rates for songbirds (passerines) of 2.58–3.83 birds/MW for the eastern U.S. (including Tennessee) and 2.15–3.96 birds/MW for the Plains region (including Illinois, Iowa, and Kansas). In comparing total estimated wind farm mortality of individual species of songbirds with their estimated continent-wide populations, Erickson et al. (2014) concluded less than 0.045 percent of the entire population of each species suffered mortality from collisions with turbines.

While the impacts of bird mortality are probably not significant in most areas, the impacts of bat mortality have a greater potential for concern. The highest annual bat mortality rates, 20.8–69.6 bats/turbine (14.9–53.3 bats/MW) have been reported at wind farms on forested ridges in the eastern U.S. (Arnett et al. 2008, Hayes 2013). Annual rates at Midwest wind farms (i.e., much of the potential MISO area) are lower, between 2.0 and 7.8 bats/turbine (2.7–8.7 bats/MW). Very limited bat mortality information is available from wind farms in the southern Great Plains (i.e., much of the potential Southwest Power Pool (SPP) and high voltage direct current (HVDC) wind resource areas), where one study found a mortality rate of 1.2 bats/turbine/year (0.8/MW) (Arnett et al. 2008, USDOE 2015). Common patterns detected in bat mortality studies include the following: 1) most fatalities occur in later summer and early fall; 2) most fatalities are of migratory, foliage- and tree-roosting species; and 3) most fatalities occur on nights with low wind speed (<6 meters/second) and 4) fatalities increase immediately before and after the passage of storm fronts (Arnett et al. 2008).

The U.S. Fish and Wildlife Service has developed guidelines (USFWS 2012) for the siting, development, and operation of wind farms. These voluntary guidelines include preliminary site screening, detailed site characterization studies, post-construction studies, and potential impact reduction and mitigation measures. Reducing the operation of wind turbines during periods of low wind speeds at night during seasons when bats are most active has been shown to be an effective measure for reducing bat mortality while having minimal effect on power generation (Arnett et al. 2011).

Wind turbines produce no direct emissions of air pollutants or GHGs. In a recent international survey of land-based, utility-scale wind power generation life cycle studies, Dolan and Heath (2012) found a median GHG emission rate of 12 tons CO_2-eq/GWh (11 grams CO_2-eq/KWh) and an interquartile range (the 75th percentile value minus the 25th percentile value) of 11 tons CO_2-eq/GWh. The largest contributor to variation in the life cycle GHG emission rate was the turbine capacity factor.

5.2.3.4 Wind – New Facilities

The EIS for the Plains & Eastern Clean Line Transmission Project (USDOE 2016) describes the potential impacts of constructing and operating this HVDC transmission line (see Section 5.2.3). TVA was a cooperating agency in the development of this EIS, which also programmatically describes the potential impacts of constructing and operating wind farms in the Oklahoma and Texas Panhandle area from which TVA could purchase power under the HVDC and SPP wind power options. Most of the potential HVDC wind farm area is rangeland. Potential wind farm sites in other portions of the SPP service area are also dominated by rangeland. Potential wind farm sites in the MISO area are primarily agricultural land with an increasing proportion of rangeland in the Dakotas.

TVA anticipates the developers of wind farms will follow USFWS guidelines on windfarms (USFWS 2012). Land area requirements, based on the direct permanent impact area, are conservatively assumed to be 1 acre/MW for wind farms in the TVA service area and 0.8 acre/MW for wind farms elsewhere. Larger areas are affected by the noise and visual impacts of wind turbines, as well as shadow flicker.

5.2.3.5 Solar – Existing Facilities

TVA operates 14 small solar PV installations. TVA also purchases energy generated from numerous PV facilities up to 101 MW_{DC} in size (see Section 2.4).

TVA assessed the potential impacts of small PV facilities in a programmatic environmental assessment (TVA 2014c). Most completed ground-mounted PV facilities have been constructed on previously cleared areas, frequently pasture, hayfield, or crop land, and most have required little grading to smooth or level the site. Several have been constructed on land classified under the Farmland Protection Policy Act as prime farmland. Although the construction and operation of the PV facility eliminates agricultural production on the area, it typically does not adversely affect soil productivity or the ability to resume agricultural production once the PV facilities are removed. The construction of the PV facility frequently affects local scenery, but this affect is often minor because of the low profile of the PV components and vegetative screening, either existing or planted as part of the PV facility development.

PV facilities produce no direct emissions of air pollutants or GHGs. In a recent international survey of crystalline silicon power generation life cycle studies, Hsu et al. (2012) found a median GHG emission rate for chrystalline silicon PV panels of 50 tons CO_2-eq/GWh (45 grams CO_2-eq/KWh) and an interquartile range (the 75th percentile value minus the 25th percentile value) of 11 tons CO_2-eq/GWh (10 g/kWh). These rates are based an annual solar insolation of 1,700 kWh/m^2/year, within the range of 1,460–1,825 kWh/m^2/year (4–5 kWh/m^2/day) found across most of the TVA region (see Figure 4-21, Section 4.6.2). The largest contributor to variation in the life cycle GHG emission rate was the insolation level. Facilities using thin-film PV panels based on cadmium-telluride (CdTe), which are often used in large utility-scale PV facilities, have a life cycle GHG emission rate of 22 tons CO_2-eq/GWh (20 grams

CO_2-eq/kWh; Kim et al. 2012). Few PV facilities using thin-film PV panels had been built in the TVA service area; some currently proposed large-capacity PV facilities would use thin-film PV panels.

Land requirements for PV facilities vary greatly and depend on the type of installation. Building- mounted systems require no additional land. Ground-mounted systems may be on canopies that provide shelter and thus, do not negatively impact land use. Land requirements for stand-alone ground-mounted systems vary with the type of mounting system. Fixed systems (with panels that do not move to track the movement of the sum) require less land than those with 1- or 2-axis tracking. The generation by tracking systems, however, is greater than from fixed systems. Ong et al. (2013) surveyed land requirements of U.S. PV projects between 1 and 20 MW capacity. Fixed-tilt systems required an average of 5.5 acres/MW_{AC} and single-axis tracking systems required an average of 6.3 acres/MW_{AC}. Based on the analysis of Ong et al. (2013) and a review of 13 operating and proposed PV facilities in the TVA service area, as well as 23 PV facilities elsewhere in the Southeast, new ground-mounted PV facilities are assumed to require 6.1 acres/MW_{DC} (7.2 acres/MW_{AC})[5] for fixed-tilt systems and 7.3 acres/MW_{DC} (8.6 acres/MW_{AC}) for single-axis tracking systems.

5.2.3.6 Solar – New Facilities

The impacts of new solar generating facilities included in the capacity expansion plans are expected to be similar to those described above for existing facilities. New building-mounted PV facilities would not require additional land and would have few other impacts. Future utility-scale PV facilities in the TVA region are likely to be multi-MW in size. An increasing proportion of recently constructed and proposed multi-MW solar facilities in the TVA region use single-axis tracking systems. These systems require relatively flat ground and can be built on brownfield, cropland, or other greenfield sites. An increasing proportion of PV facilities have been and are expected to be constructed on cropland, where the amount of grading required to prepare the site is low relative to other land types.

5.2.3.7 Biomass – Existing Facilities

TVA purchases electricity generated from landfill gas and wood waste (see Section 2.4). 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. The generating facilities have typically been built on heavily disturbed landfill or other industrial sites and occupy small land areas.

5.2.3.8 Biomass – New Facilities

The alternative strategies include the two options for new biomass generation, a 115-MW dedicated biomass facility, and a 124-MW repowered coal unit. Under the repowered coal unit option, TVA would convert one or more of its existing smaller coal-fired units, such as at the Shawnee Fossil Plant, to exclusively burn biomass. The conversion would require changes to the boilers, changes to or replacement of the boiler coal feed system, and construction of a biomass fuel receiving and processing facility. The land requirements for these vary and are plant-specific. Most of the components could likely be sited on the existing plant reservations on areas previously disturbed by other plant operations. Life cycle land requirements would increase over those of a coal facility if there are multiple, dispersed fuel sourcing areas. Emission rates would likely be similar to those of a new dedicated biomass facility described below. Water use and consumption rates would be somewhat less than those of the coal unit.

Potential fuels for the biomass-fueled generating facilities include forest wood (trees harvested for use as biomass feedstock), forest residues, mill residues, wood waste, and dedicated biomass crops. These fuels and their availability in the TVA region are described in Section 4.6.4.

A dedicated biomass facility could be constructed at one of TVA's existing or former plant sites or at a

[5] The DC to AC conversion is based on a 0.85 derate factor as used by Ong et al. (2013).

greenfield site. Plant capacity for biomass generating facilities can be limited due to fuel delivery constraints and plants larger than 50 MW are uncommon (EPRI 2014). A few larger plants have been proposed or begun construction in recent years. The amount of fuel consumed per unit of generation varies with the type of biomass, its moisture content, and the plant technology (e.g., stoker boiler, circulating fluidized bed boiler, or gasification). Fuel consumption rates reported at several dedicated facilities range from 2–5 tons/MWh (Wiltsee 2000, EPRI 2014). Facility land requirements vary; reported values include 17 acres for a 36- MW plant, 31 acres for a 40-MW plant, 39 acres for a 50-MW plant, and 200 acres for a 100- MW plant (Wiltsee 2000, EPRI 2010). This impact analysis assumes 100 acres are required for a 115-MW plant. Life cycle land requirements vary greatly with the fuel feedstock. They are relatively small for mill residues and waste wood. For biomass fuel crops, land requirements would be high and likely among the highest ofany of the resource options under consideration.

Biomass-fueled generating plants emit no mercury and only minimal amounts of SO_2; NO_x emissions vary with the type of facility and NO_x emission reduction systems are typically required. Biomass-fueled generating plants are frequently described as being carbon neutral because the CO_2 they emit is not of fossil origin. Plants used as biomass fuel feedstock takeup (sequester) CO_2 from the atmosphere during photosynthesis; this CO_2 is then emitted to the atmosphere when they are burned. The CO_2 emission rate from the combustion of biomass for generating electricity is typically higher than for fossil fuels (EPRI 2014) due to the low energy content of biomass fuels and the low efficiency (high heat rate) of biomass generating plants.

The issue of whether biomass-fueled power generation is carbon neutral, however, is controversial as the combustion of forest-derived biomass emits a large pulse of CO_2 that can require decades to be sequestered by growing trees (Walker et al. 2010). Consequently, there is a lag time of many years for the CO_2 emitted by the combustion to be sequestered by new forest growth. In April 2018, the USEPA, after years of deliberation, issued a policy statement that forest biomass would be treated as carbon neutral in any future regulatory actions when used for energy generation at stationary sources (e.g., electric generating plants; USEPA 2018f). This determination is based on the assumption that the forest biomass was harvested from a managed forest and the harvested area is not converted to a non-forest use. The issue, however, remains controversial (e.g., Science News Staff 2018) and the USEPA, in the policy statement, acknowledged that its scientific advisors were divided on the issue and that the statement was issued, in part, in response to Congressional direction and recent Executive Orders.

Aside from direct CO_2 emissions, GHGs are emitted during several process steps of biomass- fueled power generation. Many published studies of life cycle GHG emissions from electrical generation with biomass fuels assume that combustion of biomass does not result in the direct emission of CO_2 and therefore, some studies have concluded that life cycle GHG emissions are negative. Spath and Mann (2004), for example, calculated a life cycle GHG emission rate of -452 tons CO_2-eq/GWh for a 60-MW direct-fired boiler using wood waste. Spitzley and Keoleian (2005) reported rates of 58 tons CO_2-eq/GWh for a 50-MW direct-fired boiler fueled with willow grown as an energy crop. In a survey of published LCAs, EPRI (2013) found a median GHG emission rate of 39 tons CO_2-eq/GWh (35 grams CO_2-eq/KWh) and an interquartile range (the 75^{th} percentile value minus the 25^{th} percentile value) of 33 tons CO_2-eq/GWh (30 g/kWh) for direct combustion biomass generating facilities. Facilities burning mill and forest residues had lower life cycle GHG emission rates than those burning dedicated woody and herbaceous crops. These differences are largely attributable to increased energy inputs for crop production, including fertilizer applications (EPRI 2013). These life cycle GHG emission estimates do not include emissions resulting from any land use conversion associated with fuel acquisition.

The harvesting and transportation of trees for use as fuel can result in adverse environmental impacts. These impacts are similar to those that can result from harvesting trees for other purposes. Potential impacts include 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. The severity of these impacts varies with the use of appropriate best management practices, the proportion or quantity of trees harvested from a stand, whether the harvested stand is a plantation, post- harvest site treatment and other factors.

5.2.4 Energy Storage

5.2.4.1 Existing Facilities

TVA's Raccoon Mountain facility occupies about 1,050 acres and utilizes approximately 386,470 gallons of water per MWh of generation. Denholm and Kulcinski (2004) analyzed life cycle GHG emissions of pumped storage facilities. The construction, operation (excluding pumping), and decommissioning of the facility produce life cycle GHG emissions of approximately 5.5 tons of CO_2-eq/GWh of storage capacity, a small proportion of the total life cycle GHG emissions. GHG emissions from generation are a function of the GHG intensity of the electricity used in the pumping mode. Based on the 80 percent efficiency of energy conversion at Raccoon Mountain and 5 percent transmission loss factor (a function of distance from the energy source and load center), GHG emissions are approximately 1.3 times the energy source emissions. At TVA's 2017 CO_2 intensity of 426 tons/GWh, the operation of Raccoon Mountain, as well as that of a future pumped storage facility, would emit about 554 tons of CO_2/GWh. This emission rate will decrease with the reduction in CO_2 intensity occurring under the action alternatives.

Although Raccoon Mountain uses a large volume of water, none of this water is consumed except for the small quantity that evaporates from the upper storage reservoir.

5.2.4.2 New Facilities

The operational impacts of a new 850-MW pumped storage plant are expected to be similar to those of the Raccoon Mountain plant. Construction impacts would include the construction of the upper reservoir, excavation of the powerhouse and the tunnel connecting the upper and lower reservoirs, and construction of the discharge structure in the lower reservoir. If the lower reservoir is an existing reservoir, dredging of the discharge area and construction of an enclosure around the discharge structure would likely be required. If a new lower reservoir is required, additional impacts would result from the construction of the dam and reservoir and diversion of existing streams around or into the reservoirs. These impacts could be substantial. A new pumped storage plant is assumed to operate with an efficiency of 81 percent.

Because there are few operating compressed air energy storage (CAES) plants, information on their environmental impacts is limited. Based on a TVA study of potential CAES facility configurations in northeast Mississippi during the 1990s, a 330-MW CAES facility would require about 80 acres for the air injection/withdrawal wells, connecting pipelines, and the CAES plant. Operation of the plant would require about 2,300 gallons per minute of water to operate the plant cooling system. A portion of this water would likely be provided by well air/water separators. The plant is assumed to operate with an efficiency of 70 percent.

The utility-scale battery storage facility is assumed to resemble current systems using lithium-ion batteries. Such facilities typically consist of batteries, supervisory and power management system, HVAC system, and fire prevention system in modular shipping-style containers on a concrete pad with spill containment. Other components include electrical switching equipment and transformers. They are often constructed in association with a wind or solar generating facility or adjacent to an existing substation.

The impacts of constructing and operating a utility-scale lithium-ion battery storage facilities in association with southern California solar facilities have been described by County of Imperial (2016 and BLM (2018). NYSPSD and NYSERDA (2018) describes the environmental impacts of the State of New York's initiative to deploy at least 1,500 MW of energy storage by 2025. The New York EIS reviewed various types of battery storage, including lithium-ion, as well as thermal and flywheel storage technologies. The land area required for battery storage facilities is typically only a few acres and construction-related impacts are minimal. Operational impacts are also minimal with adherence to typical mitigation measures including RCRA regulations and best management practices.

Several analyses of the life cycle impacts of the use of lithium-ion batteries in electric vehicles are available, relatively few had addressed utility-scale battery storage facilities. Baumann et al. (2017) found life-cycle CO_2 emissions of lithium-ion batteries of between 0.45 and 0.51 kilograms $CO_{2\text{-eq}}$/kWh of storage capacity for different types of lithium-ion batteries powered by the European electricity mix. Life-cycle emissions of the batteries when powered by PV-generated electricity were considerably lower, 0.13 to 0.20 kilograms $CO_{2\text{-eq}}$/kWh of storage capacity. These values were for batteries operated to shift the time of availability of energy. Their CO_2 emissions varied when operated to provide other grid services. Vandepaer et al. (2017) reported life-cycle CO_2 emissions of 101.8 grams $CO_{2\text{-eq}}$/Wh of storage capacity for a 6-MWh grid-connected lithium-ion battery and 130.7 grams $CO_{2\text{-eq}}$/Wh for a 75-kWh lithium-ion battery in distributed grid configuration. Both of these batteries were powered by wind energy and used for electric time shifts. In each of these studies, As illustrated by these studies, life cycle CO_2 emissions vary greatly with the source of the energy used to charge them. The construction of lithium-ion batteries is alwo relatively energy-intensive, and has the potential to produce several pollutants (Vandepaer et al. 2017).

5.3 Environmental Impacts of Energy Efficiency and Demand Response Resource Options

The sources of environmental impacts from the proposed expansion of TVA's EEDR programs under the alternative strategies include the following:

- The reduction in or avoidance of generation (collectively reduction") resulting from energy efficiency measures. This reduction is incorporated into the alternative strategies and portfolios assessed in Section 5.5.
- The change in the type of generation due to changes from on-peak to off-peak energy use resulting from demand response programs. This change in load shape, and the resulting change in peak demand, is incorporated into the alternative strategies and portfolios assessed in Section 5.5. Historically, most demand response has been in emergency situations and shifted the time of electrical use with little net change in use and little environmental impact. More widespread employment of demand response is likely to result in a small net reduction in electrical use and the associated impacts from its generation (Huber et al. 2011).
- The impacts of the generation of renewable electricity by end users participating in the Green Power Providers, biodiesel generation, and non-renewable clean generation programs are included in the discussion Section 5.5.
- The generation of solid waste resulting from building retrofits and the replacement of appliances, heating and air conditioning (HVAC) equipment, and other equipment to reduce energy use.
- Adverse impacts to historic buildings from building retrofits that result in changes in their external appearance and associated historic integrity.

Building retrofits to reduce energy use, such as replacing windows and doors, produce solid wastes which are often disposed of in landfills. The disposition of old appliances, HVAC equipment, water heaters, and other equipment varies across the region with the local availability of recycling facilities. Old refrigerators and HVAC equipment may also contain hydro chloroflourocarbon refrigerants (“freon”) whose use and disposal is regulated due to their harmful effects on stratospheric ozone (“the ozone layer”) and because of their high global warming potential. To reduce these harmful effects, HVAC contractors are required to reclaim and recycle these refrigerants from HVAC equipment being replaced.

The activities associated with building retrofits and other residential, commercial, and industrial EE measures are unlikely to have disproportionately high adverse impacts on low income and minority populations. Household energy efficiency efforts can result in reductions of cold-related illnesses and associated stress by making it easier for residents to heat their homes. Reduced ventilation rates, can, however, adversely affect indoor air quality. In a recent review of this topic, Maidment et al. (2014) concluded that household EE measures have a net positive impact on health and the benefits are greatest for low income populations. Due to the structure of the EE programs, however, low-income residents frequently have less ability to participate in them. Most EE programs require that participating individuals and organizations pay a portion of the costs of their energy efficiency measures. Low-income residents typically have a reduced ability to pay these costs. In addition, many low-income residents live in rental housing and there are few EE programs targeting rental single-family and multi-family housing.

Programmatic environmental reviews of EE programs have been conducted by USDOE (2015a) for the Hawai'i Clean Energy Program and by the Rural Utilities Service (USDA 2012) for their Energy Efficiency and Conservation loan program. USDOE (2015a) concluded that EE programs would result in beneficial impacts from reduction of GHG emissions and the potential for adverse impacts from EE actions is low with adherence to applicable regulations and best management practices. The Rural Utility Service (USDA 2012) identified a few areas of concern including the potential presence of lead-based paint and asbestos containing material which would be mitigated with adherence to applicable regulations. The potential for adverse impacts to historic properties was low but some EE activities resulting in the modification of the exterior of buildings would require additional project-specific reviews.

5.4 Environmental Impacts of Transmission Facility Construction and Operation

As described in Chapter 3 of Volume I, all of the alternative strategies would require the construction of new or upgraded transmission facilities. Following is a listing of generic impacts of these construction activities (Table 5-2). This listing was compiled by reviewing the EISs (e.g., TVA 2005b), environmental assessments (e.g., TVA 2013c), and other project planning documents for TVA transmission construction activities completed from 2005 through mid-2018. A total of 298 projects was included in this review. Thirty-nine projects involved construction or expansion of a new or existing substation or switching station. One-hundred forty-three projects, including some of the substation/switching station projects, involved the construction of new transmission lines totaling about 623 miles in length. One-hundred twenty-eight projects involved modifications to existing transmission lines.

Table 5-2: Generic impacts of transmission system construction activities determined from a review of project planning documents of 298 transmission construction projects*, 2005-2018.

	Transmission Lines	Substations and Switching Stations
Land Use Impacts		
Land requirements	Average of 13.1 acres/line mile, range 3.5 – 39	Average of 10.8 acres, range 1 – 73 Median for 500 kV: 49.5 acres
		Median for <500 kV: 5.5 acres
Floodplain fill	0	Average of 0.1 acres, range 0 – 4 5% affected floodplains
Prime farmland converted	0	Average of 6.9 acres, range 0 – 29.1 64% affected prime farmland

	Transmission Lines	Substations and Switching Stations
Land Cover Impacts		
Forest cleared	Average of 5.5 acres/line mile for new lines, range 0 – 30.5	Average of 4.5 acres, range 0 – 50 29% cleared forest
Wetland Impacts		
Area affected	Average of 0.9 acres/line mile for new line, range 0 – 22.2, 55% affected wetlands	Average of 0.1 acres, range 0 – 1.8 15% affected wetlands
	Average of 0.9 acres/line mile of existing line, range 0 – 18.3, 52% affected wetlands	
Forested wetland area cleared	Average of 0.3 acres/line mile of new line, range 0 – 6.3, 48% affected forested wetlands	-
	Average of 0.02 acres/line mile of existing line, range 0 – 0.5, 17% affected forest wetlands	
Stream Impacts		
Stream crossings	Average of 2.9 per mile of new line, range 0 – 50, 76% crossed streams	n/a
	Average of 1.5 per mile of existing line, range 0 – 5.6, 64% crossed streams	
Forested stream crossings	Average of 1.0 per mile of new line, range 0 – 17.6, 48 crossed forested streams	n/a
	Average of 0.1 per mile of existing line, range 0 – 2.5, 8% crossed forested streams	
Endangered and Threatened Species	32 (11%) of 256 projects affected federally listed endangered or threatened species, or species proposed or candidates for listing 63 (22%) of 290 projects affected state-listed endangered, threatened, or special concern species	
Historic Properties	41 (14%) of 288 projects affected historic properties	
Parks and Public Lands	40 (16%) of 249 projects affected parks and public lands	

*Note: Because some project planning documents did not contain all of the environmental data, the sample sizes for the various categories differ.

The anticipated amount of construction of new or upgraded transmission facilities varies among the alternative strategies. All new generating facilities would require connections to the transmission system, either directly or through an interconnection with an LPC. The length of connecting transmission lines and the need for new substations and switching stations depend on the location and capacity of the facilities. The retirement of generating facilities, such as coal plants, can also result in the need for new or upgraded transmission facilities in order to maintain adequate power supply and reliability. The importation of wind energy from outside the TVA region would likely require transmission facility construction. Potential impacts of transmission facility construction associated with the HVDC wind resource option are described in a 2015 EIS (USDOE 2015b).

5.5 Environmental Impacts of Alternative Strategies and Associated Capacity Expansion Plans

While the total amount of energy generated during the 2019-2038 planning period is, by design, similar across the alternative strategies for each scenario, the manner in which this energy is generated varies across strategies (Figures 3-3, 3-4). This is a result of the differences between the alternative strategy designs and the constraints on different energy resources and targets as described in Section 3.2 and Volume I Section 6.1.2. The environmental impacts, averaged across scenarios, are generally greater for Strategies A and B than for Strategies C, D, and E. An exception to this is for land use, where the land required for new energy resources is greatest for Strategies C, D, and E due to their larger amounts of new solar capacity. Within each strategy, the environmental impacts are generally greater for Scenario 3 and lowest for Scenario 5.

Alternative Strategies:
- A – Base Case (No Action)
- B – Promote DER
- C – Promote Resiliency
- D – Promote Efficient Load Shape
- E – Promote Renewables

Scenarios:
- 1 – Current Outlook
- 2 – Economic Downturn
- 3 – Valley Load Growth
- 4 – Decarbonization
- 5 – Rapid DER Adoption
- 6 – No Nuclear Extensions

Following is a discussion of the impacts of each alternative strategy on air quality, greenhouse gas emissions and climate change, water withdrawals and water use, waste generation, fuel consumption, facility land requirements, and TVA-region economics over the 20-year, 2019-2038 planning period. The bar charts and time-series graphs illustrate the average of the values for the six scenarios for each alternative strategy. The whisker bars on the bar charts show the range of the values of the six scenarios associated with each strategy. Because of the lack of applicable published information applicable to the full suite of TVA's current and proposed future energy resources, life cycle impacts of the alternative strategies are not quantified in the following sections.

5.5.1 Air Quality

All alternative strategies will result in significant long-term reductions in total emissions and emission rates of sulfur dioxide (SO_2), nitrogen oxides (NO_x), and mercury (Table 5-4, Figures 5-1, 5-2, 5-3). A large portion of these reductions, especially for SO2 and mercury, result from the full or partial retirement of coal plants. Under most cases, Paradise is retired in 2020 and Bull Run is retired in 2023; these common retirements account for the similarity in emissions through 2023 portrayed in Figures 5-1, 5-2, and 5-3. After 2023, emission trends diverge due to increased differences between the strategies. Overall coal generation stays relatively steady or slightly increases during this period due to increasing natural gas prices relative to coal prices. The effects on air quality from the partial and entire retirement of CT and coal facilities are included in the following discussion.

The increase in emissions of SO_2 and mercury in 2031 to 2033 is due to fewer regularly scheduled coal plant outages during this period and, under Scenario 6, the retirement of a Browns Ferry Nuclear Plant unit in 2033. This increase is followed by sharp decreases in 2034 of 43 to 51 percent for SO_2 and 18 to 26 percent for mercury, largely resulting from the retirement of the seven Shawnee units that lack modern emission controls. NOx emissions also decrease in 2034 due to the Shawnee retirements. Late in the planning period the emission trends for SO_2 again converge. Within each strategy, there is a large variation in emissions among the associated scenarios (Figures 5-4, 5-5, 5-6) and this variation is much larger than the differences between the strategies. Emissions are greatest under Scenario 3, followed closely by Scenario 6 and lowest under Scenario 5, followed closely by Scenario 4.

The overall reductions in emissions under each strategy, averaged across the associated scenarios, show relatively little variation (Table 5-3). Emission reductions under Strategy A, the No Action Alternative, are somewhat less than those of the other strategies for SO_2 and NOx and noticeably less for mercury. The largest reductions for SO_2 and mercury occur under Strategy C, which has the least amount of coal-fired generation. NOx reductions, however, are greatest for Strategies C, D and E; this is largely due to fossil-fueled generation being displaced by the larger amounts of renewable generation under these strategies.

The reductions in SO_2, NOx and mercury emissions will continue recent trends in emissions of these air pollutants. By 2038, TVA emissions of SO_2 will have decreased since 1995 by about 99.3 percent under all alternative strategies. This would result in further small decreases in regional ambient concentrations of SO_2 and sulfate (a component ofacid deposition), regional haze, and fine particulates. TVA emissions of NOx will also have decreased since their 1995 peak by about 99 percent under all strategies. Although this continued decrease will likely result in reductions in regional NOx and ozone concentrations, the air quality effect may be small as TVA emissions make up an increasingly small proportion of regional NOx emissions.

Table 5-3: Average total, annual, and 2019-2038 percent reduction of emissions of SO2, NOx, and mercury by alternative strategy.

	Alternative Strategy				
	A – No Action	B	C	D	E
SO_2					
Total emissions 2019-2038, tons	177,342	173,774	159,984	164,521	162,730
Annual emissions, tons	8,867	8,689	7,999	8,226	8,132
Percent reduction 2019-2038	56.9	58.9	63.0	60.6	60.0
NOx					
Total emissions 2019-2038, tons	169,736	165,165	159,414	159,723	159,397
Annual emissions, tons	8,487	8,258	7,971	7,986	7,970
Percent reduction 2019-2038	53.5	56.1	55.3	58.5	57.4
Mercury					
Total emissions 2019-2038, pounds	3,909	3,818	3,596	3,713	3,656
Annual emissions, pounds	195	191	180	186	183
Percent reduction 2019-2038	18.3	21.3	30.1	26.0	24.0

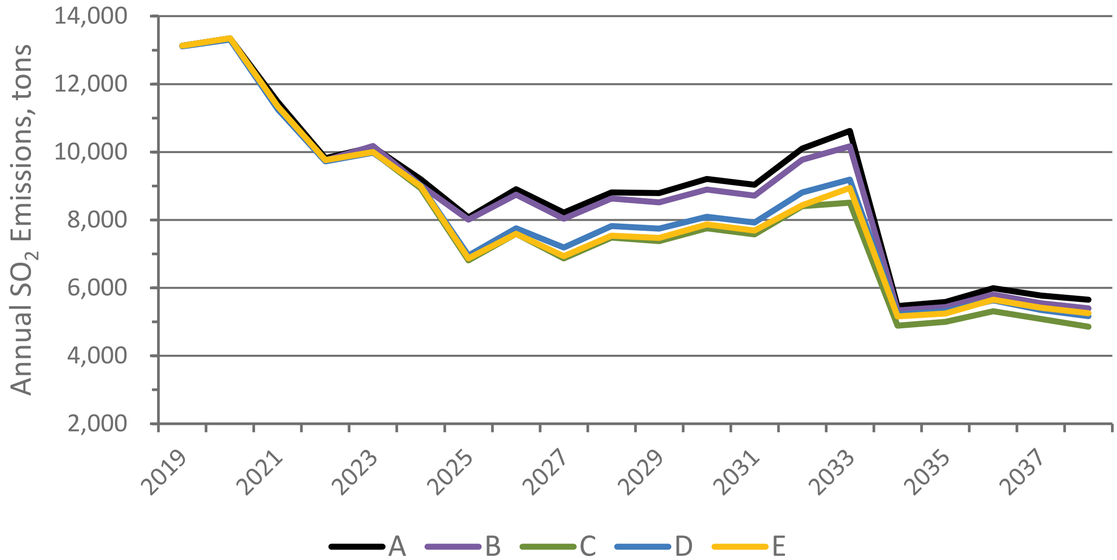

Figure 5-1: Trends in emissions of sulfur dioxide (SO2) by alternative strategy based on averages of the six scenarios.

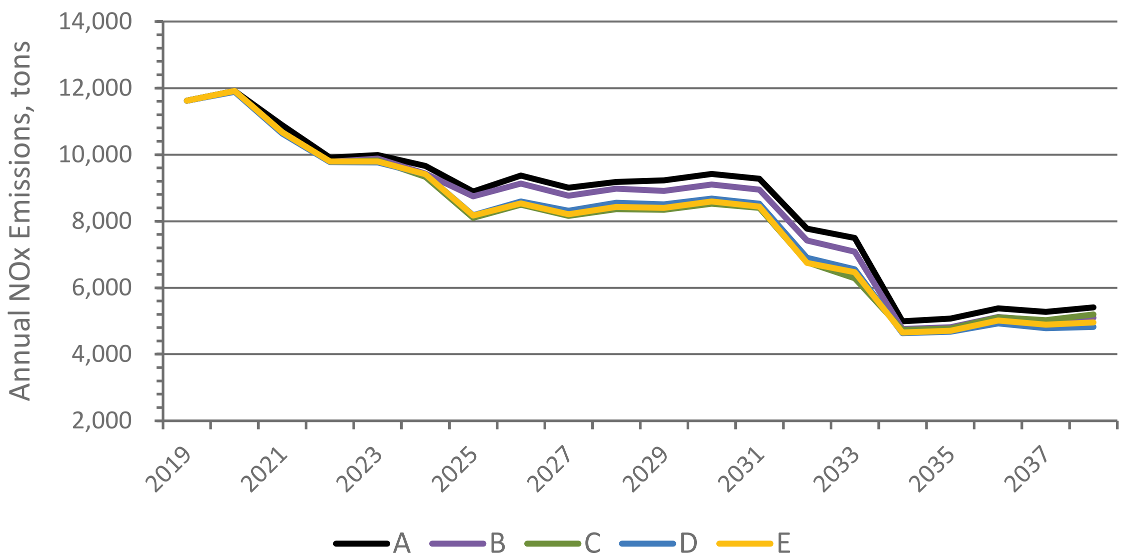

Figure 5-2: Trends in emissions of nitrogen oxides (NOx) by alternative strategy based on averages of the six scenarios.

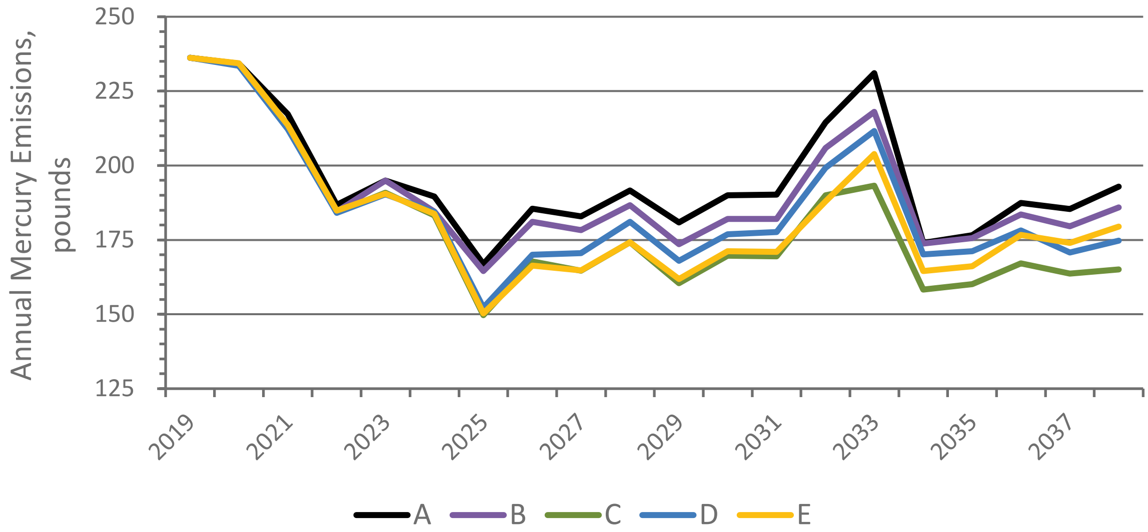

Figure 5-3: Trends in emissions of mercury by alternative strategy based on averages of the six scenarios.

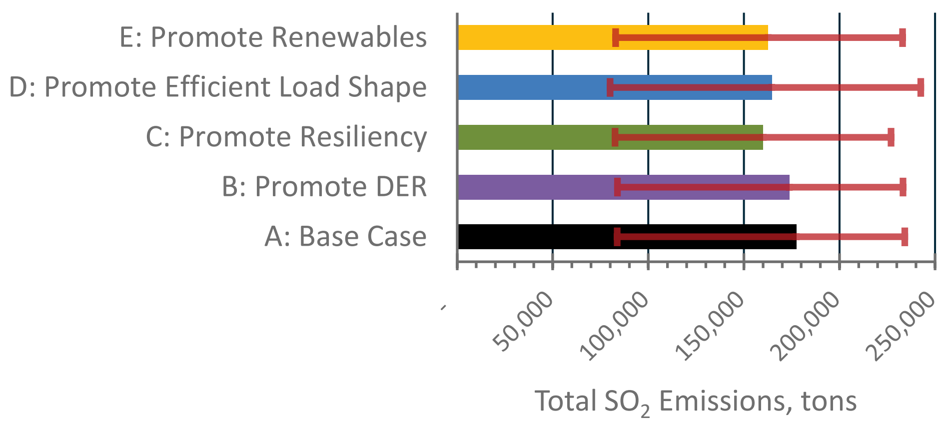

Figure 5-4: Average 2019–2038 total emissions of sulfur dioxide (SO_2) by alternative strategy. The error bars indicate the maximum and minimum values for the scenarios associated with each alternative strategy.

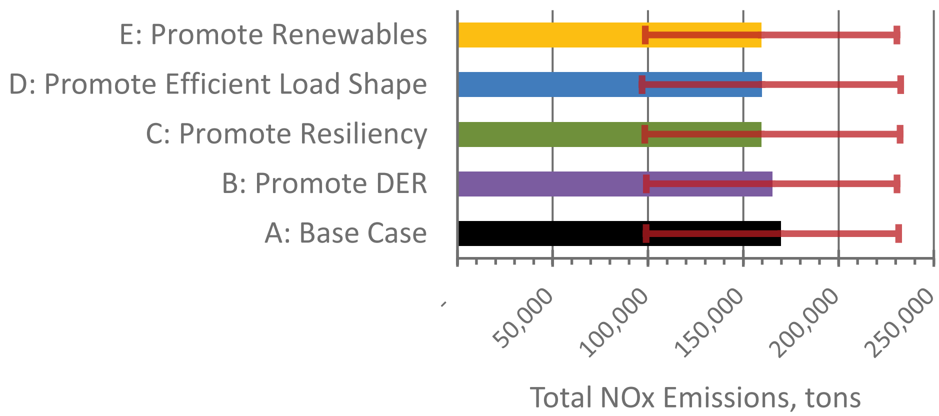

Figure 5-5: Average 2019–2038 total emissions of nitrogen oxides (NOx) by alternative strategy. The error bars indicate the maximum and minimum values for the scenarios associated with each alternative strategy.

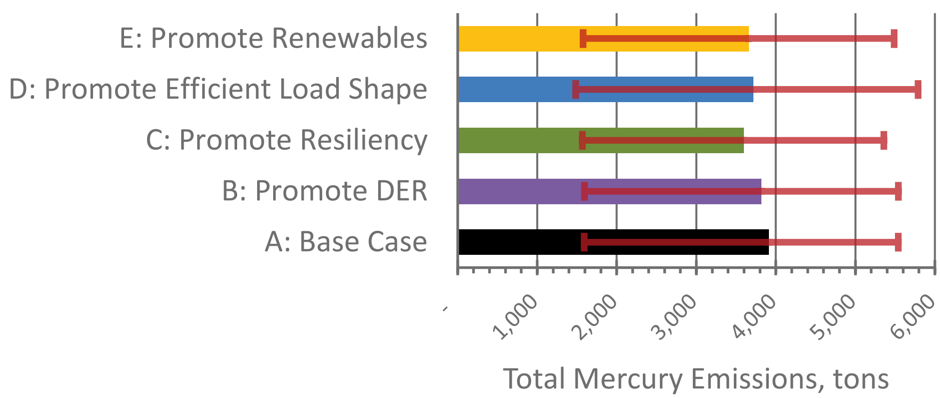

Figure 5-6: Average 2019–2038 total emissions (left) of mercury by alternative strategy. The error bars indicate the maximum and minimum values for the scenarios associated with each alternative strategy.

5.5.1.1 Impacts of Potential Facility Retirements

The changes in emissions of air pollutants that would result from the near-term retirement of the CT units listed in Section 3.2.3 were determined by modeling the future operation of the TVA generating assets with and without the retirement of the CT units by the end of 2020. This analysis is based on TVA's current power supply plan as reflected by Strategy A – Base Case and Scenario 1 – Current Outlook. The peaking generation currently provided by the CTs would be replaced by other peaking resources. During the decade following the retirements, i.e., 2021–2030, annual average system-wide emissions of SO_2 would decrease by 1.6 percent, NOx emissions would decrease by 1.0 percent, and mercury emissions would decrease by 2.4 percent. SO_2 and mercury emissions are produced by coal units and not natural gas-fired units. With the retirement of the CTs, more energy efficiency measures would be implemented sooner than otherwise; this, along with reduced electrification results in reduced energy demand and small reductions in coal- and gas-fired generation.

5.5.2 Climate and Greenhouse Gases

Total and annual direct emissions of CO_2, as well as CO_2 emission rates – also referred to as CO_2 intensity – decrease under all alternative strategies (Table 5-4; Figures 5-7, 5-9). The variation among the strategies for both CO_2 emissions and emissions rates is relatively small and much less than the variation among the scenarios associated with each strategy (Figures 5-8, 5-10). Strategy A has the greatest CO_2 emissions and CO_2 emissions rate and the least reductions. Strategy C has the lowest CO_2 emissions and emission rates. Within each strategy, Scenario 3 has the highest CO_2 emissions and emission rates, followed closely by Scenarios 1 and 6. Scenario 5 has the lowest rate, followed closely by Scenario 4.

Table 5-4: Average CO_2 emissions and emissions rates, percent emissions reductions, and percent emission rate reductions by alternative strategy.

	Alternative Strategy				
	A – No Action	B	C	D	E
Total CO_2 emissions 2019-2038, million tons	799	785	764	777	777
Annual CO_2 emissions, thousand tons	39,957	39,234	38,220	38,857	38,864
Percent CO_2 emissions reduction, 2019-2038	16.5	18.9	23.4	21.5	20.6
CO2 emissions rate, lbs/MWh	501	492	479	486	486
Percent CO_2 emission rate reduction, 2019-2038	21.1	23.4	28.1	26.4	25.4

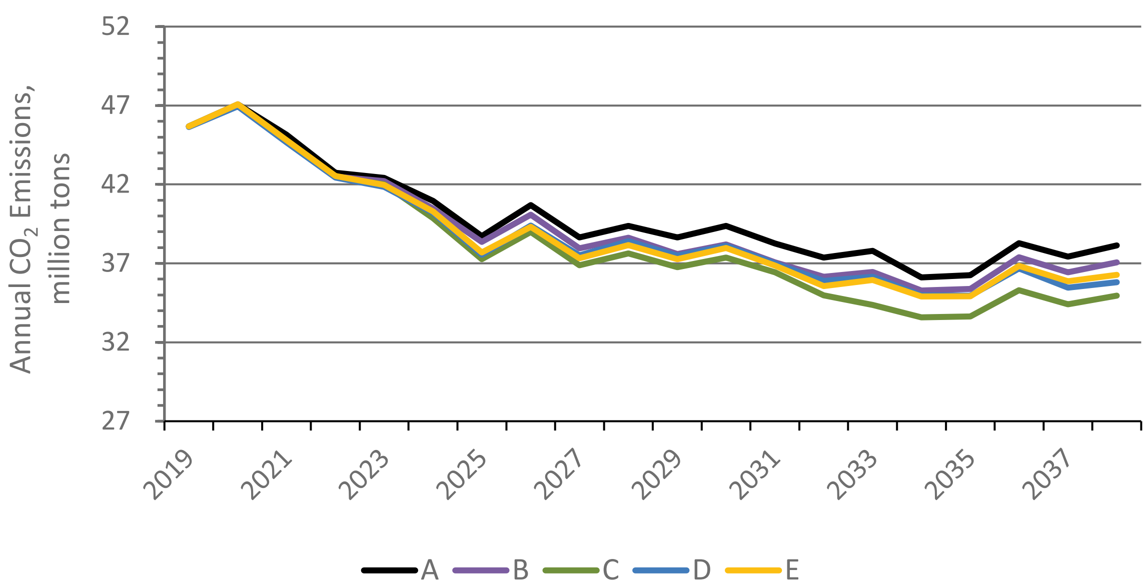

Figure 5-7: Trends in emissions of CO_2 by alternative strategy based on averages of the six scenarios.

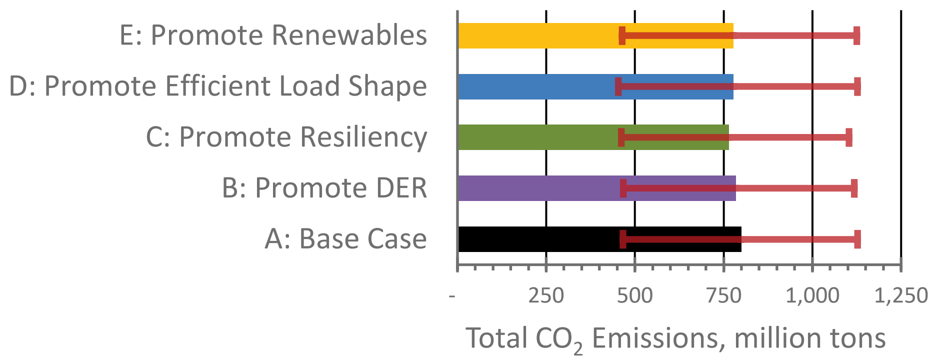

Figure 5-8: Average 2019–2038 total emissions of CO_2 by alternative strategy. The error bars indicate the maximum and minimum values for the scenarios associated with each alternative strategy.

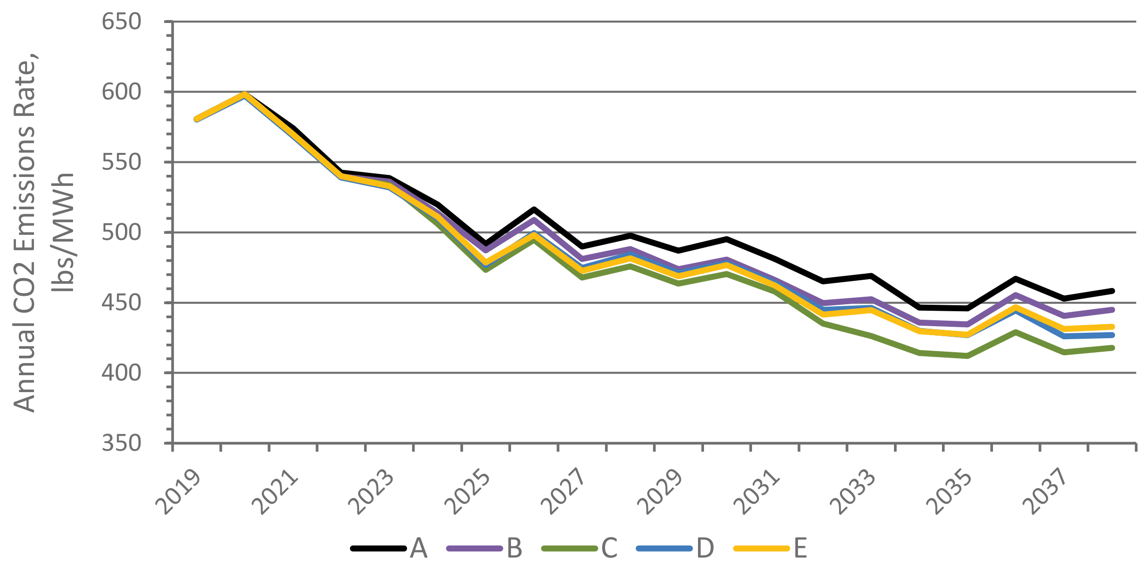

Figure 5-9: Trends in CO_2 emissions rate by alternative strategy based on averages of the six scenarios.

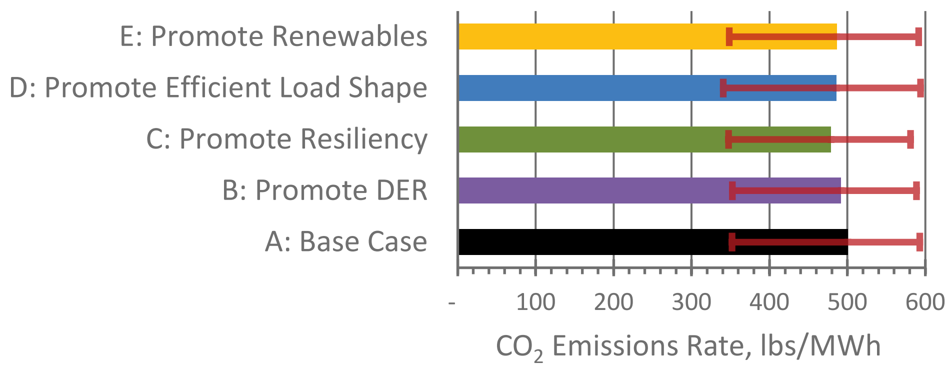

Figure 5-10: Average 2019–2038 CO_2 emissions rates by alternative strategy. The error bars indicate the maximum and minimum values for the scenarios associated with each alternative strategy.

Overall trends for both CO_2 emissions and emission rates are very similar, with the percent reductions somewhat greater for emission rates. All strategies show a small increase in 2020 followed by a decline through 2025 driven largely by coal plant retirements. They then increase in 2026; this increase is due to increased coal generation resulting from fewer than average regularly scheduled coal plant maintenance outages during the year. The decrease in in 2033 is due to the expiration of the PPA with the Red Hills lignite-fueled plant, which has relatively high CO_2 emissions, under all scenarios and other coal retirements under some scenarios. Between 2035 and 2038, the strategies show overall increases in CO_2 emissions and emission rates. These increases are largely due to increased fossil-fueled generation following the retirement of the three Browns Ferry Nuclear Plant units under Scenario 6.

5.5.2.1 Impacts of Potential Facility Retirements

The change in CO_2 emissions that would result from the near-term retirement of the CT units listed in Section 3.2.3 were determined in the same manner as described in Section 5.5.1.1 for other air pollutants. During the decade following the retirements, i.e., 2021–2030, annual average system-wide emissions of CO_2 would decrease by 1.0 percent.

5.5.2.2 GHG Emissions, Climate Change, and Adaptation

In addition to the forecast reductions in GHG emissions from power generation, TVA has specific targets related to GHG emissions (TVA 2017f). These include a 31 percent reduction in Scope 1 and Scope 2 GHG emissions by 2025 and a 21 percent reduction in Scope 3 GHG emissions by 2025. Scope 1 GHG emissions are direct emissions from applicable sources owned or controlled by TVA, including vehicles. Scope 2 GHG emissions are indirect emissions from the generation of power used by TVA. Scope 3 GHG emissions are from sources not owned or controlled by TVA but related to TVA activities and include, among other things, business travel, employee commuting and contracted waste disposal. At the end of fiscal year 2016, Scope 1 and 2 GHG emissions had been reduced by 22.2 percent and TVA was on track to meet the 2025 target. Scope 3 emissions were reduced by 24.5 percent by the end of 2016. Additional TVA targets include reducing the energy intensity of buildings by 2.5 percent annually through 2025, relative to a 2015 baseline, and increasing the proportion of renewable energy to at least 30 percent of total electric energy consumed by 2025.

All alternative strategies will result in the continued, significant, long-term reductions in CO_2 emissions from the generation of power marketed by TVA. By the end of the planning period, CO_2 emissions will have been reduced by between approximately 67 percent (Strategy A) and 69 percent (Strategy C) from 1995, and between approximately 64 percent (Strategy A) and 67 percent since 2005. The climate change impacts of GHG emissions, including CO_2 emissions, have been recently described in the Fourth National Climate Assessment (USGCRP 2018). Chapter 19 of this assessment focuses on the Southeast US, where the predicted impacts include increases in temperature and extreme precipitation and, in urban areas, more frequent and longer summer heat waves, increased risk of vector-borne diseases, reduced air quality, and stresses on infrastructure. Other impacts include changes to ecosystems and agriculture from altered precipitation and temperature regimes and the continued northward movement of tropical and subtropical species, including problematic invasive species, and increased wildfire risk. Some of these impacts are likely to be greatest on low-income and vulnerable populations, particularly in rural areas. Other climate assessments, including the recent Intergovernmental Panel on Climate Change Special Report on Global Warming of 1.5° (IPCC 2018), describe impacts worldwide.

The reduction in CO_2 emissions will have small but beneficial impacts on the potential for associated climate change. The actual effects on climate in the TVA region and elsewhere would be small and difficult to quantify. In its Climate Adaptation Action Plan (TVA 2016g), TVA identified the following climate change risks relevant to the TVA power system:

- Increased demand for power due to increased cooling-season temperatures
- Altered reservoir operations and hydropower generation due to increased demands for water and altered precipitation patterns and evaporative losses
- Effects of changing runoff and water temperatures
- Increased frequency of extreme weather events, including extreme precipitation events and drought
- Increased temperatures and number of days exceeding 95°F
- Increased geographic and temporal variation in rainfall
- Increased ozone and particulate matter ($PM_{2.5}$) concentrations

Recent and projected trends in temperature and precipitation in the TVA region are described above in Section 4.3 and, for the larger southeastern U.S., in USGCRP (2018). Projected trends from climate change models include increases in average temperature, the number of days over 95°F, and the number of nights over 75°F, and decreases in number of days below 32°F. Predicted trends in precipitation have greater uncertainty and include increases in winter, spring and fall precipitation, and an increase in the frequency of heavy precipitation events.

The EPRI and TVA (2009) report described the effects of the forecast climate change based on the 2007 IPCC report in the TVA region. The effects are likely to be relatively modest over the next decade and increase in magnitude by mid-century. Potential effects on water resources include increased water temperatures, increased stratification of reservoirs, reduced dissolved oxygen levels, and increased water demand for crop irrigation. Potential effects on agriculture include increased plant evapotranspiration, altered pest and pathogen regimes, changes in the types of crops grown, and increased demand for electricity by confined livestock and poultry operations.

Potential effects on forest resources include increased tree growth, altered disturbance regimes, changes in forest community composition with declines in species currently at the southern limit of their ranges, and expansion of the oak-hickory and oak-pine forest types. Potential effects on fish and wildlife include range retractions and expansions, altered community composition, loss of cool to cold aquatic habitats and associated species such as brook trout, and increased threats to many endangered and threatened species.

The modeled higher air temperatures, the associated higher water temperatures, and the altered precipitation patterns that could result from climate change likely would affect the operation of TVA generating facilities. One likely effect is an increase in the demand for electricity. Warmer summer temperatures would result in more electricity used for air conditioning; this increase would likely be greater than the reduction in electricity used for space heating resulting from warmer winter temperatures. TVA's coal and nuclear plants predominantly use open-cycle cooling and discharge heated water to the river system (see Section 4.4.3). NPDES permits, required for the discharge of cooling water into rivers and reservoirs, prescribe the maximum temperature of discharged water. Warmer gross river and reservoir temperatures would make meeting thermal discharge limits more difficult. The NRC also sets safety limits at nuclear plants on the maximum temperature of intake water used in essential auxiliary and emergency cooling systems. When cooling water intake temperatures are high, power plants must reduce power production (derate) or use cooling towers (if available) to reduce the temperature of the discharged water and avoid non-compliance with thermal limits. If intake temperatures reach their limits, NRC requires the plants to shut down. Consequently, elevated water temperatures can reduce thermal generation by causing forced deratings, additional use of cooling towers (which reduces net generation), and/or nuclear plant shutdown.

Increased air and water temperatures also influence the operation of thermal power plants with cooling towers. TVA's CC plants and the Red Hills lignite-fueled plant use cooling towers as the primary cooling systems and its nuclear plants use cooling towers as auxiliary cooling systems. Increased condenser cooling water temperatures reduce the efficiency of power generation. Hotter, more humid air also reduces evaporation potential and the performance of cooling towers. A 1993 TVA study (Miller et al. 1993) analyzed the relationships between extreme air and water temperatures and power plant operations based on historical meteorological and operational data.

In the upper Tennessee River drainage, for each 1°F increase in air temperature from April through October, water temperatures increased by 0.25°F to almost 0.5°F, depending upon year and location in the TVA reservoir system. In general, air temperature effects cascade down the reservoir system. In the Tennessee River system, for both closed- and open-cycle plants in Tennessee (on or upstream of Chickamauga Reservoir) and in Alabama (on Wheeler Reservoir), this study found that the incremental impacts to operations from increased temperature were greatest during hot-dry years. Operation of most thermal power plants in the TVA power system was resilient to temperature increases during cold-wet and average meteorological years. The dominant meteorological variables affecting thermal plant performance were water temperature, and, for plants using cooling towers, humidity.

Changes in the operation of the Tennessee River system implemented in the ROS (TVA 2004) provide TVA flexibility to adapt to some climate change impacts while minimizing the effects on thermal generation. The analyses in the ROS were based on historical conditions and assume unusually high air temperatures and/or changes in precipitation last a relatively short time and are not long-term changes (cf. Milly et al. 2008). TVA recently installed additional cooling capacity at the Browns Ferry Nuclear Plant and further adaptation, such as the installation of increased cooling capacity at other thermal plants, may be necessary in the future given the forecast long-term increases in temperature.

While water resources are relatively abundant in the TVA service area, climate stressors could change that abundance, either locally or region-wide, leading to impacts and the need for adaptive measures by other sectors of the economy, as well as other aspects of the energy system (EPRI and TVA 2009). Increased precipitation during storms will increase flood risk, expand flood hazard areas, increase the variability of stream flows (i.e., higher high flows and lower low flows) and increase the velocity of water during high flow periods, thereby increasing erosion. These changes will have adverse effects on water quality and aquatic ecosystem health. Climate change also has the potential to affect outdoor recreation, including reservoir and stream-based recreation.

A 2014 Government Accountability Office report described a number of measures to help reduce climate-related risks and adapt the nation's energy systems to weather and climate-related impacts (USGAO 2014). These measures generally fall into two categories—hardening and resiliency. Hardening involves making physical changes that improve the durability and stability of specific pieces of infrastructure—for example, elevating and sealing water-sensitive equipment—making it less susceptible to damage. In contrast, resiliency measures allow energy systems to continue operating after damage and allows them to recover more quickly; for example, installing back-up generators to restore electricity more quickly after severe weather events. TVA is continually evaluating the need for, and where necessary, implementing measures to increase the hardening and resiliency of its power system.

5.5.3 Water Resources

The coal-fired, nuclear, and natural gas-fired CC plants comprising most of TVA's energy supply require water to operate plant cooling systems and, particularly for coal plants, other plant processes. For each of these generating plants, the required quantity of water is directly proportional to the amount of power they generate (see Section 4.7). CT plants have very low water requirements and wind and solar generating facilities do not require water to operate. Potential impacts to water resources, with the exception of discharges of cooling water, are generally greater from coal-fired generation than from other types of generation due to the various liquid waste streams from coal-fired plants and the potentially adverse water quality impacts from coal mining and processing. Under all alternative strategies, TVA would continue to comply with the Clean Water Act by meeting State water quality standards and through compliance with NPDES permit requirements.

The volume of water used by thermal generating facilities, (i.e., nuclear, coal, and CC facilities) decreases between 2019 and 2038 under all alternative strategies (Figure 5-11). The decreases, averaged across the scenarios associated with each strategy, range from 9.3 percent for the Strategy A to 14.4 percent for Strategy C. Strategy C has the lowest water use during most of the planning period due to its relatively high amount of renewable generation that replaces thermal generation.

The annual average volume of water used varies by less than 3 percent among the strategies, much less than the variation among the scenarios associated with each strategy (Figure 5-12). Cumberland Fossil Plant and the Sequoyah and Browns Ferry Nuclear Plants use the most cooling water and the water use trends closely track the generation by these plants. Water use generally decreases due to retirements of coal plants under several scenarios. Temporary spikes in water use occur due to projected timing of maintenance and refueling outages. The decreases late in the planning period are largely due to coal retirements and the retirement of the three Browns Ferry units beginning in 2033 under Scenario 6. The replacement generation has lower water use rates.

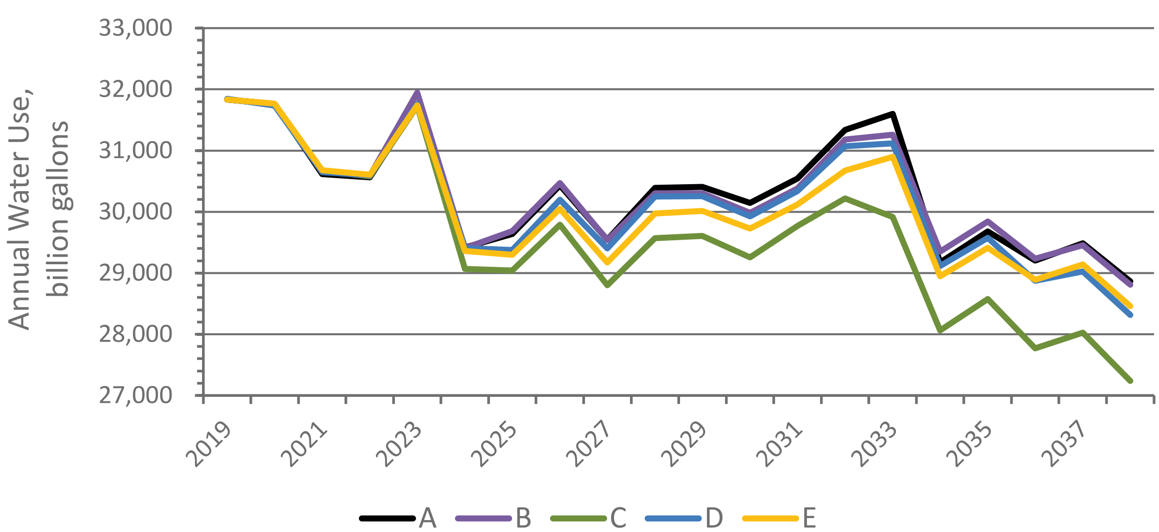

Figure 5-11: Trends in water use by alternative strategy based on averages of the six scenarios.

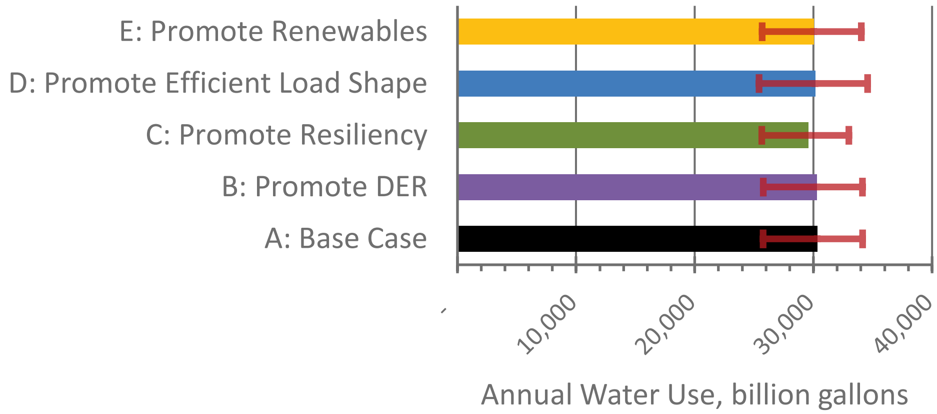

Figure 5-12: Average annual 2019–2038 water use by the alternative strategy. The error bars indicate the maximum and minimum values for the scenarios associated with each alternative strategy.

The error bars indicate the maximum and minimum values for the scenarios associated with each alternative strategy. The reductions in water use would result in localized beneficial impacts to aquatic ecosystems. The volume of water used by hydroelectric facilities is not included in Figures 5-11 and 5-12.

Figures 5-13 and 5-14 show the 2019–2038 trends and annual averages of water consumption by alternative strategy. The volume of water consumed is the quantity of water withdrawn from a water body, including both surface and groundwater sources, and evaporated in the closed-cycle cooling systems of thermal generating facilities instead of being discharged to a water body. This volume is typically less than 2 percent of the total quantity of water used under each alternative strategy. The reductions, averaged across scenarios associated with each alternative strategy, range from 8.3 percent under Strategy A to 11.5 percent under Strategy C. The variation in average annual water consumption (Figure 5-14) among alternative strategies is small and much less than the variation among the scenarios associated with each strategy. Scenario 3 consistently has the highest water consumption and Scenario 5 has the lowest water consumption.

The reductions in water consumption would have beneficial impacts; these impacts would generally be small and vary with the characteristics of the source area of the water withdrawal.

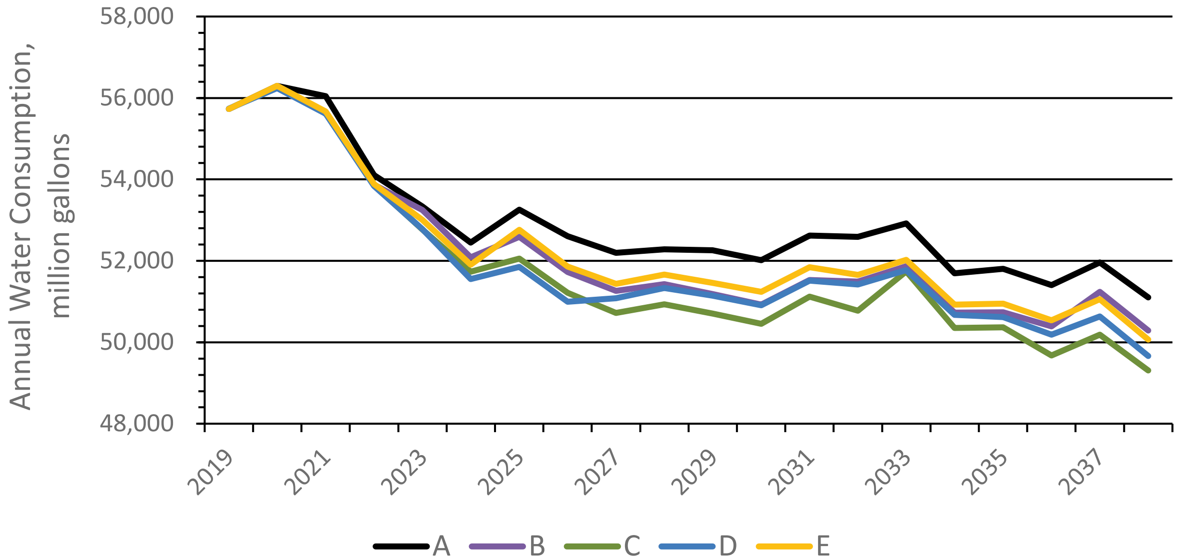

Figure 5-13: Trends in average annual water consumption by alternative strategy based on averages of the six scenarios.

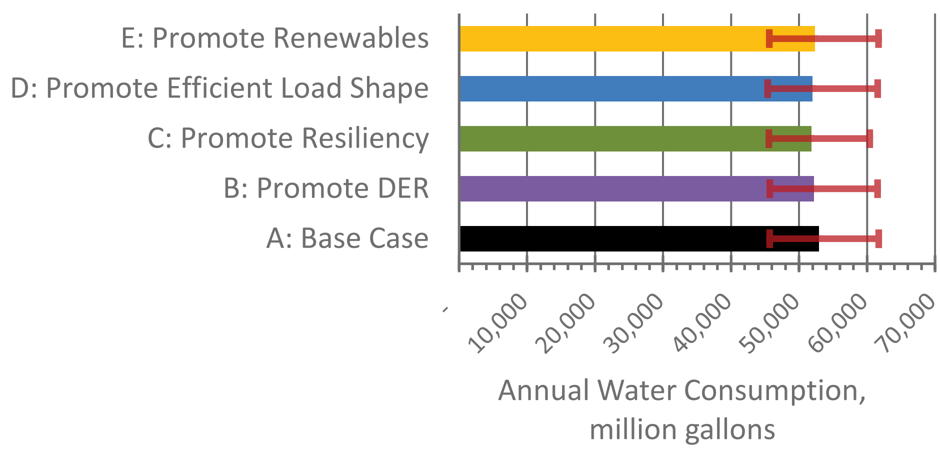

Figure 5-14: Average annual 2019–2038 water consumption by alternative strategy. The error bars indicate the maximum and minimum values for the scenarios associated with each alternative strategy.

The error bars indicate the maximum and minimum values for the scenarios associated with each alternative strategy. Figure 5-15 shows 2019-2038 water consumption by major river basin. A majority of the thermal plants providing power to TVA and consuming water are located in the Tennessee River basin and this accounts for its high volume of water consumption. Almost all of the water consumed in the Tennessee, Cumberland, Ohio, and Green River basins is from surface water sources. Groundwater sources are primarily used in the Mississippi, Pearl, and Tombigbee River basins.

Chapter 5: Anticipated Environmental Impacts

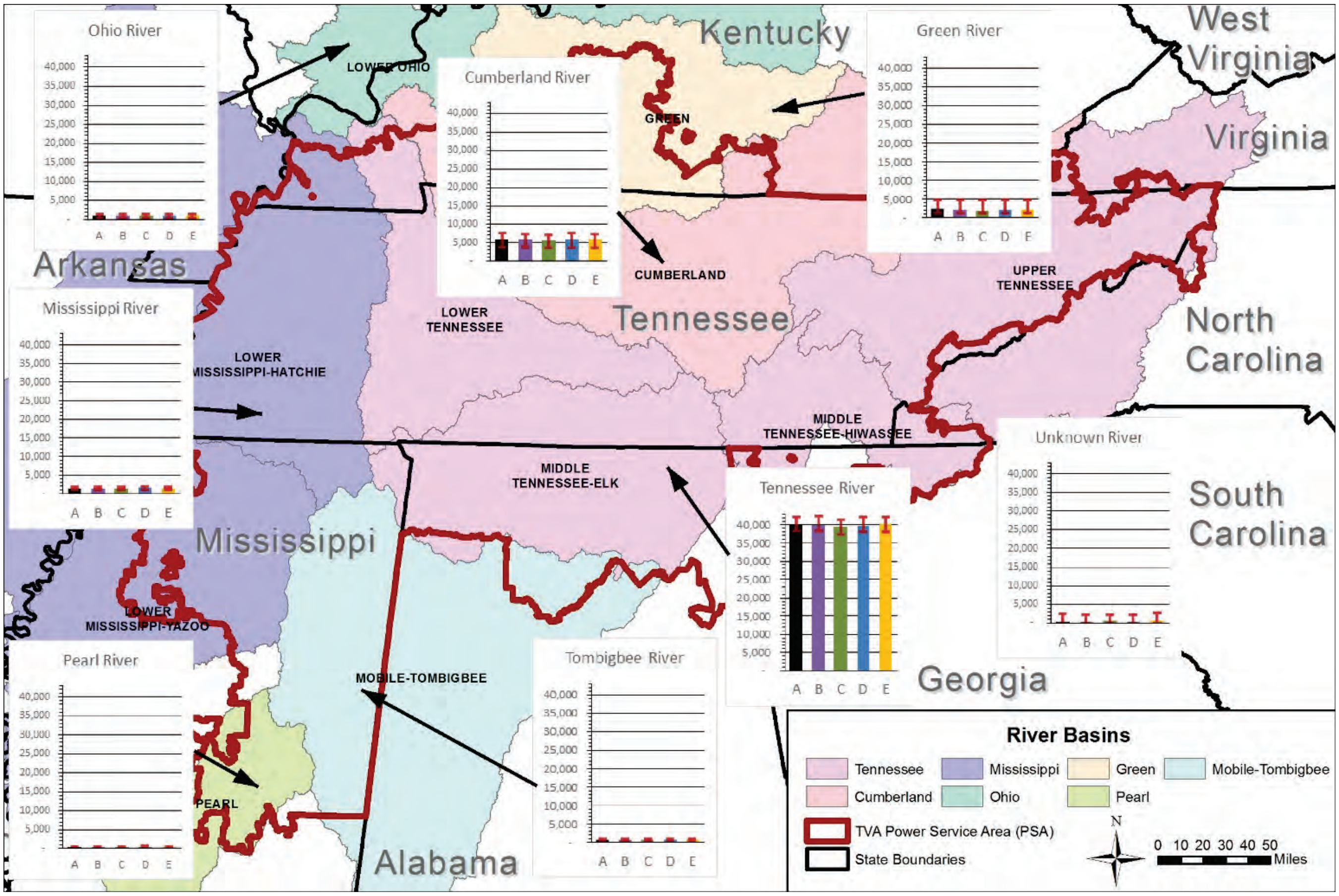

Figure 5-15: Water consumption by alternative strategy and major river basin. The error bars indicate the maximum and minimum values for the scenarios associated with each alternative strategy.

The error bars indicate the maximum and minimum values for the scenarios associated with each alternative strategy. Unknown River refers to future generating facilities whose locations are presently unknown.

5.5.3.1 Impacts of Potential Facility Retirements

The following section describes the water resources impacts from the retirement of the facilities discussed in Section 3.2.3. The retirement of coal plants (Cumberland, Gallatin, Kingston, and Shawnee) would cease coal burning operations and result in a substantial reduction of water withdrawals and wastewater discharges, including thermal discharges, into the adjacent rivers described in Section 4.4.2.4.

TVA would implement all of the planned actions related to the current and future management and storage of CCRs at these facilities, which have either been reviewed or will be in subsequent NEPA analysis.

Upon closure and repurposing of impoundments and landfills, it is expected that most discharge would cease. The remaining discharge flows would come from raw cooling water, fire protection water, main station sumps/unwatering sumps, storm water flows, and from ponds and landfills until closed. Decreased discharge flows would impact the adjacent rivers by decreasing any impacts of thermal discharges as well as the constituent concentrations of the discharges. Surface water discharges would be expected to see direct, indirect, and cumulative beneficial impacts due to the decrease in metals loading.

The elimination of withdrawals of cooling water as a result of cessation of coal-burning operations would reduce impingement and entrainment impacts, and have other beneficial impacts from reduced water consumption. Long-term, direct, and minor beneficial impacts to the aquatic life communities in the adjacent rivers would occur.

Because facility buildings, structures, and facilities would remain in place until a decision regarding future use of the site is made, there would be a long-term potential for direct discharges of chemicals, hazardous waste, and solid waste, including but not limited to friable asbestos releases, to receiving streams through sump discharges, storm water releases, and directly to adjacent surface waters. Periodic inspections and maintenance of the remaining facilities would be performed as needed to ensure that any contaminated equipment would not impact surface water quality. The implementation of best management practices, protocols to respond to on-site spills prior to discharge, and site clean-up would help to reduce the potential for any releases to surface waters.

With the use of proper best management practices and compliance with all federal, state, and local regulations and guidelines, surface water impacts associated with direct, indirect or cumulative impacts would be expected to be temporary and minor.

Additionally, surface water flow, underseepage, and groundwater migration from impoundments to surface waters would be reduced subsequent to closure. Closure work would be done in compliance with applicable regulations, permits, and best management practices; therefore, potential direct and indirect impacts of the potential retirements on surface waters would be negligible. However, long-term effects from contaminated groundwater may persist after closure of impoundments, but are regulated under the CCR Rule and applicable state regulatory programs to protect human health and the environment. A more detailed discussion of groundwater quality at each of the coal plants considered for retirement is presented in Section 4.4.1.4.

The potential retirement of CTs at Allen (20 turbines), Colbert (8 turbines), Gallatin (4 turbines), and Johnsonville (16 turbines) plants would have no effect on water resources, including groundwater. CTs require no cooling water, and therefore, operation and/or retirement of CTs does not affect surface water at these facilities.

5.5.4 Fuel Consumption

The major fuels used for generating electricity would continue to be coal, enriched uranium and natural gas in all of the alternative strategies. Coal-fired generation and coal consumption under the alternative strategies closely track CO_2 emissions illustrated above in Figure 5-7. The variation in coal consumption among the alternative strategies is relatively small (Figure 5-16). Coal consumption by the lignite-fueled Red Hills Power Project, from which TVA acquires all of the power generated, is predicted to remain relatively constant at about 4.5 million tons/year until 2032 when TVA's PPA expires under all combinations of strategies and scenarios.

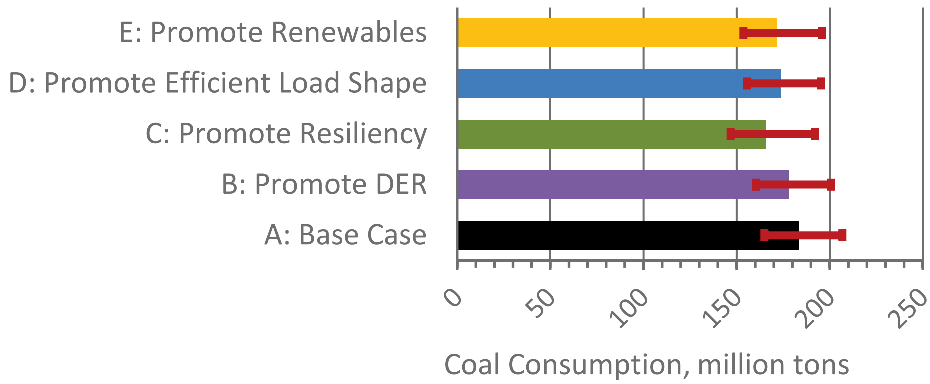

Figure 5-16: Average total 2019–2038 coal consumption by TVA plants by alternative strategy. The error bars indicate the maximum and minimum values for the scenarios associated with each alternative strategy.

The error bars indicate the maximum and minimum values for the scenarios associated with each alternative strategy. Although the future sources of coal purchased by TVA cannot be accurately predicted, the anticipated decrease in coal consumption would reduce the adverse impacts associated with coal mining. The majority of coal use by TVA in the future is likely to continue to be from the Illinois and Powder River Basin coalfields.

TVA presently uses about 154 tons/year of enriched uranium in its nuclear plants. Use of enriched uranium remains relatively constant throughout most of the planning period for all strategies. Under Scenario 6, the three Browns Ferry Nuclear Plant units would be retired between 2033 and 2036, resulting in a decrease in the use of uranium late in the planning period. Under Strategy C, this decrease would be partially offset by the use of uranium in the two small modular reactors constructed to replace approximately one of the Browns Ferry units.

Environmental impacts from producing the nuclear fuel include land disturbance, air emissions (including the release of radioactive materials), and discharge of water pollutants from uranium mining, processing, tailings disposal, and fuel fabrication. The magnitude of these impacts is difficult to predict with certainty due to the great variability in potential sources for nuclear fuel. Any future use of surplus highly enriched uranium would also reduce overall uranium fuel cycle impacts as it would reduce the need for uranium mining and enrichment.

About 297 billion standard cubic feet (SCF) of natural gas were used in 2018 by TVA gas-fueled generating facilities and by gas facilities from which TVA purchased power under PPAs. Natural gas consumption during the 2019-2038 planning period varies little between the alternative strategies (Figure 5-17 and Figure 5-18). Across the strategies, gas consumption is consistently highest under Scenario 3 and lowest under Scenario 5, with Scenario 5 volumes less than half those of Scenario 3.

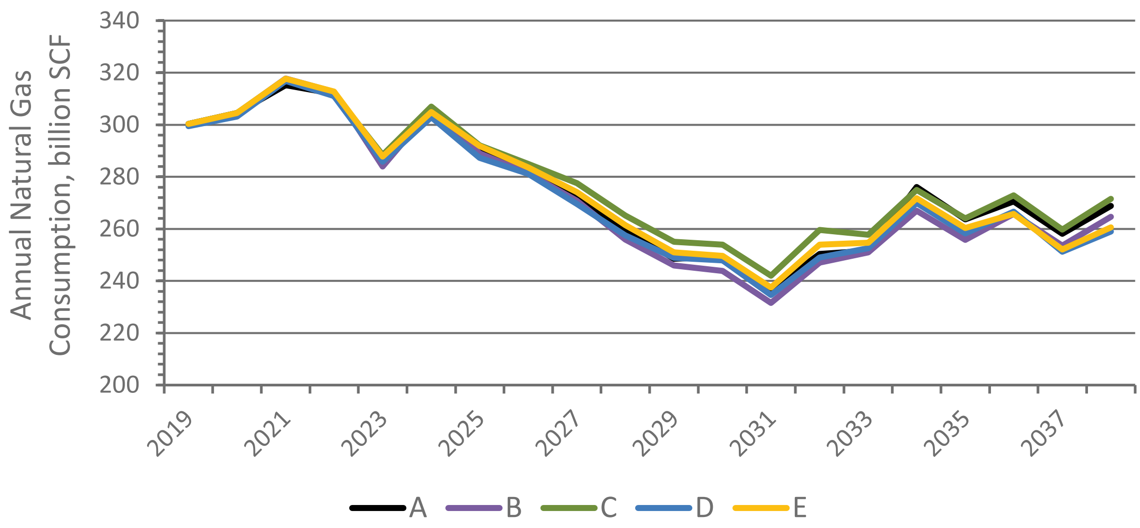

Figure 5-17: Trends in average annual natural gas consumption by alternative strategy based on averages of the six scenarios. The volume is based on the heat content of 1,033 Btu/cubic foot of natural gas used by the electric power sector in 2017 (USEIA 2018e).

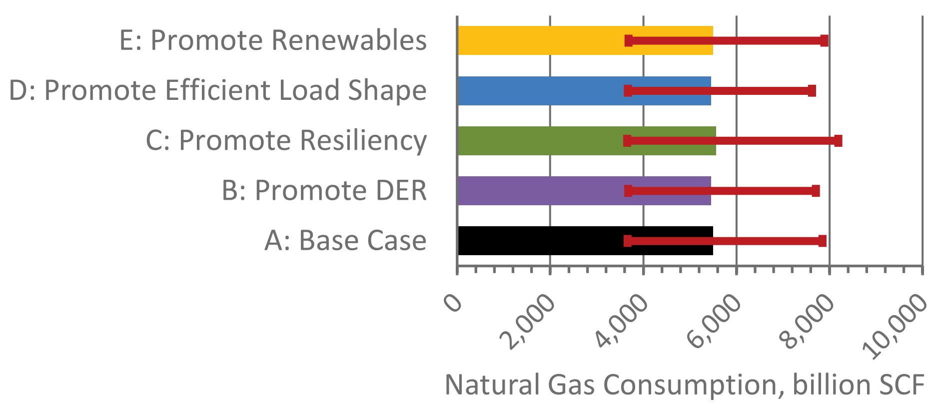

Figure 5-18: 2019–2038 natural gas consumption by alternative strategy. The error bars indicate the maximum and minimum values for the scenarios associated with each alternative strategy.

5.5.4.1 Coal Combustion Solid Wastes

All alternative strategies will result in long-term reductions in the production of CCRs due to the retirement of coal plants/units (Figure 5-19). CCR production closely tracks coal generation and the largest decrease occurs between 2030 and 2034 when coal plants are retired under many strategies and scenarios. The PPA for the Red Hills plant, which produces a large quantity of ash relative to its generation, also expires during this period. The quantity of CCR produced during the 2019-2038 planning period shows little variation between alternative strategies (Figure 5-20). It varies much more between the scenarios associated with each strategy and is greatest with Scenario 3 and lowest with Scenario 5.

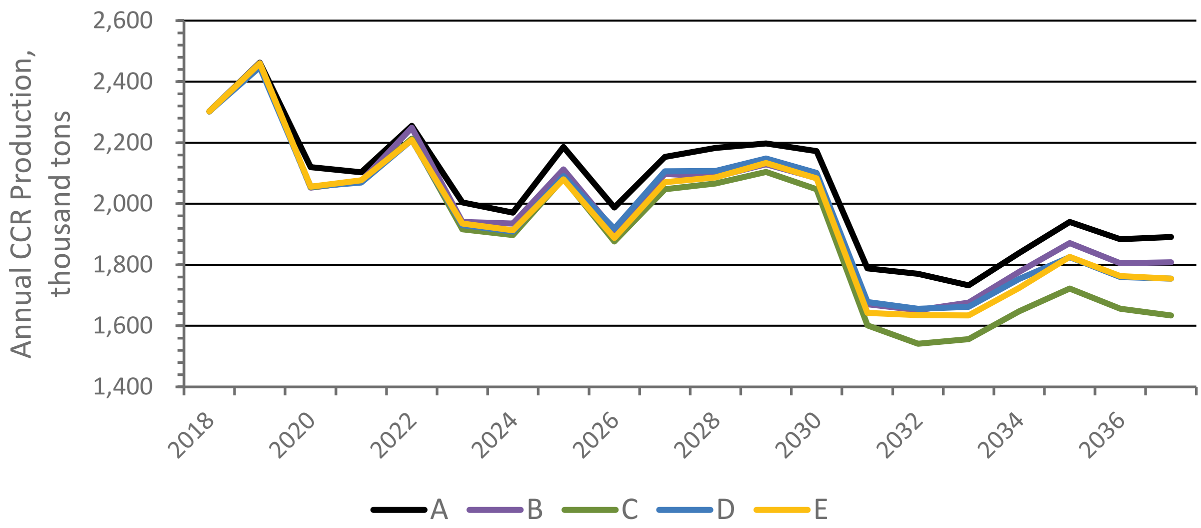

Figure 5-19: Trends in average annual coal combustion residual (combined ash and FGD residue) alternative strategy based on averages of the six scenarios.

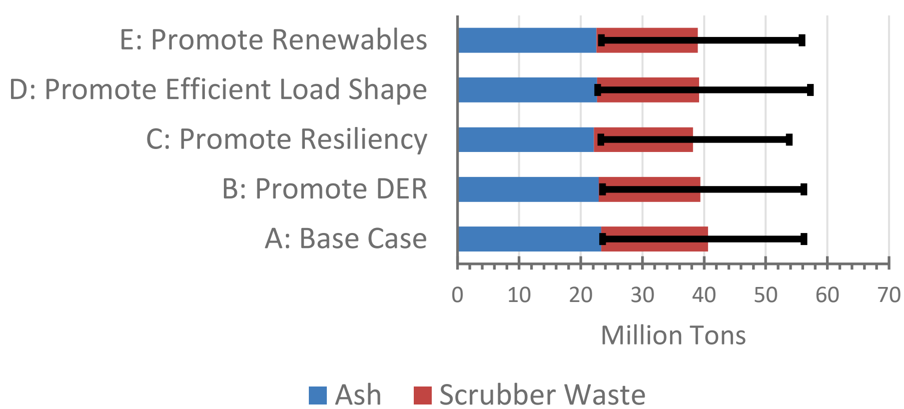

Figure 5-20: 2019–2038 coal combustion residual by alternative strategy. The error bars indicate the maximum and minimum values for the scenarios associated with each alternative strategy.

The error bars indicate the maximum and minimum values for the scenarios associated with each alternative strategy. TVA has increased the proportion of CCRs produced at its coal plant that is marketed for beneficial use (Section 4.7.1). This effort reduces many of the environmental impacts of managing CCRs in landfills. In accordance with the EPA's 2015 CCR rule, TVA is taking several actions related to its management of CCRs as described in Section 4.7.1. The construction-related and long-term environmental impacts of many of these actions are described in EAs and EISs listed in Section 1.3.2.

5.5.4.2 Nuclear Waste

The trends in the production of high-level waste, which is primarily spent nuclear fuel and other fuel assembly components, parallel those of nuclear fuel requirements and are very similar for all alternative strategies. TVA anticipates continuing to store spent fuel on the nuclear plant sites in spent fuel pools and dry casks until a centralized facility for long-term disposal and/or reprocessing is operating. TVA has recently constructed additional dry cask storage capacity to store more spent fuel on its nuclear plant sites. The production of low-level nuclear waste is expected to remain relatively constant.

5.5.4.3 Impacts of Potential Facility Retirements

The following section describes the solid and hazardous waste impacts that could occur if TVA retires the facilities discussed in Section 3.2.3. The retirement of coal plants (Cumberland, Gallatin, Kingston, and Shawnee) would cease coal burning operations and no additional CCR solid wastes would be produced. Residual ash and coal dust would be washed from equipment and areas and managed through the ash handling system. TVA would implement supplemental mitigation measures at Cumberland and Kingston for the CCR units at those site as determined to be required pursuant to the 2015 TDEC Order as well as closure plans approved by TDEC, which could include additional monitoring, assessment, corrective action programs, or other actions deemed appropriate.

Any lighting ballasts containing would be removed and properly disposed offsite during preliminary activities after power termination and during the early stages of demolition. Other materials that are removed and typically recycled in early retirement activities include used oils, glycols, and refrigerants. Consumer commodities (lubricants, aerosols, cleaners, etc.) are reused if possible, or sent for disposal if an outlet cannot be found. Laboratory chemicals would be evaluated for reuse or disposal on a case-by-case basis. Fuels would be used elsewhere or sent for recycling. Bulk chemicals/materials are typically recycled, or disposed as applicable. Mercury devices, batteries, light bulbs and e-waste are recycled.

Asbestos-containing materials in building structures and systems would be remediated as necessary to be protective of environment and worker health and safety, but full abatement would not occur until demolition activities are initiated.

Given that TVA would manage the removal and disposal of solid and hazardous wastes in accordance with local, state, and federal regulations, and recycle these wastes to the maximum extent possible, retirement of the coal facilities would improve the overall quality of environmental media.

CT plants produce very small quantities of solid waste during normal operation and therefore the potential retirement of the CT units at Allen, Colbert, Gallatin, and Johnsonville would not affect solid and hazardous wastes.

5.5.5 Land Resources

TVA's existing power plant reservations have a total area of about 25,000 acres. This total does not include conventional hydroelectric plants, most of which are closely associated with multi-purpose dams and reservoirs, or the approximately 1600-acre Bellefonte site. Many of the power plant reservations have large, relatively undisturbed areas and the actual area disturbed by facility construction and operation (the "facility footprint") totals about 18,000 acres. The generating facilities from which TVA purchases power under PPAs (excluding hydroelectric plants) have a total area of about 4,300 acres; about 1,900 acres of this is solar facilities.

Land requirements for new generating and storage facilities, excluding behind-the-meter distributed energy resources, were determined from the capacity expansion plans and the resource type- and facility-specific land requirements given in Section 5.2. For long-term natural gas PPAs, half of the facilities were assumed to be existing and half new. Where the indicated capacities translated to fractional facilities, the number of facilities was rounded up to the nearest whole number. Behind-the-meter solar facilities are assumed to be mostly building-mounted and would not result in additional land requirements. A small portion of these facilities could be ground-mounted; most of these are assumed to be on developed commercial or industrial sites and would result in minimal additional land requirements.

The partial and/or entire retirement of CT and coal plants would not result in any immediate changes in land use. After facilities are retired, TVA would conduct a comprehensive review of the long-term management of the plant site, including the potential reuse or demolition of plant buildings and redevelopment of the site.

Land requirements for new generating and storage facilities, averaged across scenarios, range from about 41,900 acres for Strategy B to 59,100 acres for Strategy D (Figure 5-22). The land requirement for Strategy E is very close to that of Strategy D, and both Strategy D and Strategy E have little variation across scenarios. Strategy B has the largest variation in land requirements across scenarios, with the land requirement for Scenario 3 about three times the land requirement for Scenario 2 (Figure 5-21, Figure 5-22). Land requirements vary by less than two percent among the scenarios associated with both Strategy D and Strategy E. Scenario 3 has the largest land requirement for all strategies except Strategy C, where the land requirement for Scenario 6 is slightly larger than that for Scenario 3.

For all combinations of strategies and scenarios (Figure 5-22), at least 97 percent of the land required for new generating and storage facilities is for utility-scale, single-axis tracking solar facilities. Relative to other types of generation, solar PV facilities have a high land requirement in relation to their generating capacity. Smaller land areas would be occupied by natural gas-fired and storage facilities. Most of the selected storage facilities are utility-scale batteries, which have relatively small land requirements and are often located at existing power plants or substations. A few cases include compressed air storage facilities which have larger land requirements and would likely be constructed on relatively undisturbed sites.

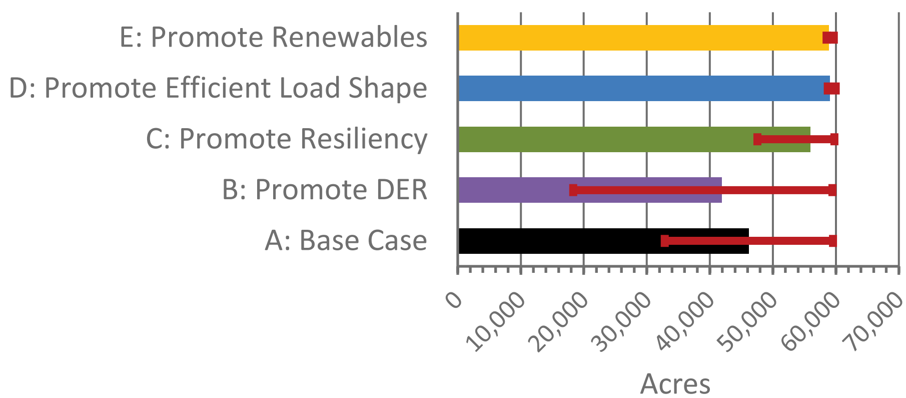

Figure 5-21: Average total land area for all new generating facilities by alternative strategy. The error bars indicate the maximum and minimum values for the scenarios associated with each alternative strategy.

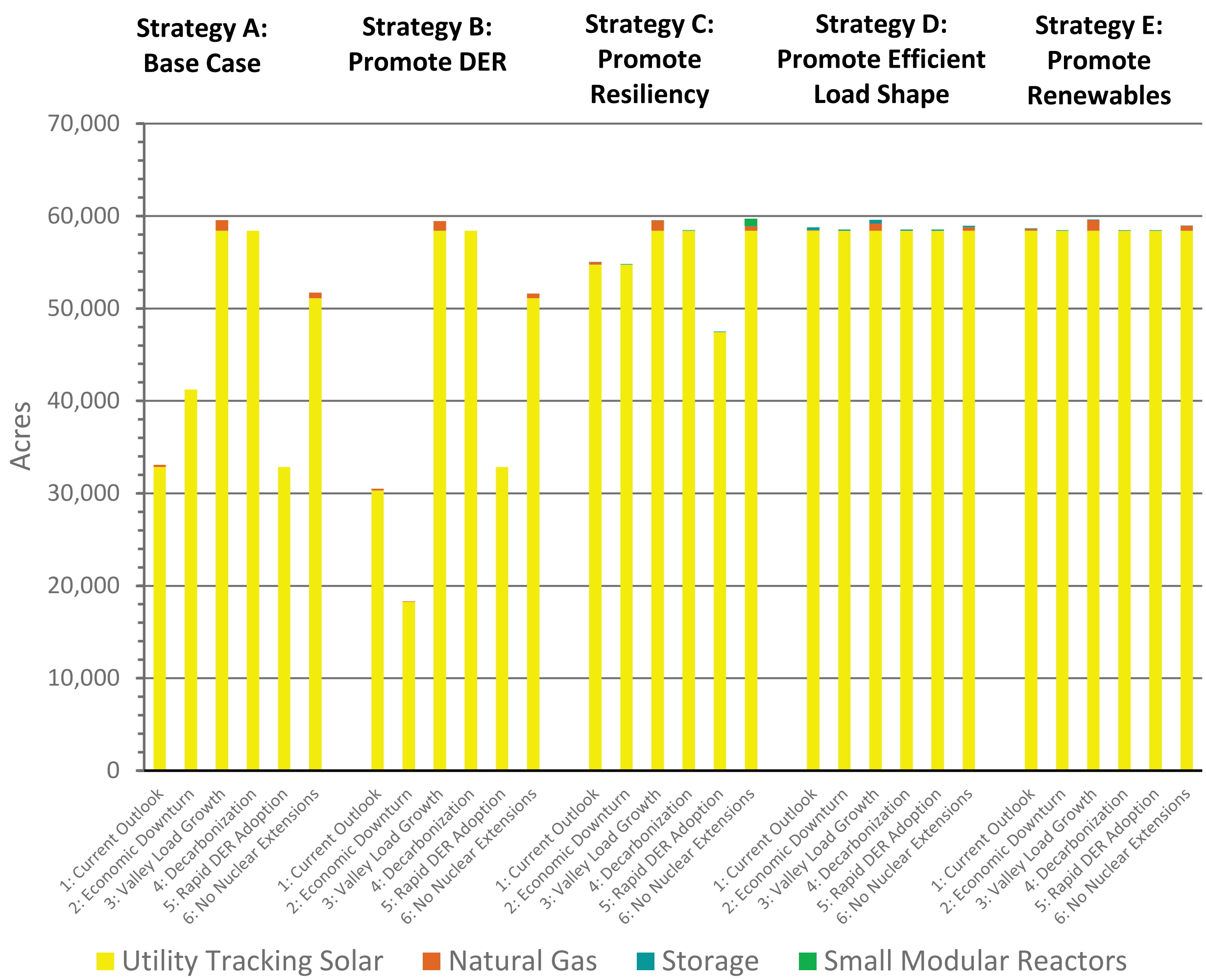

Figure 5-22: Land requirements for new generating facilities by type of generation, alternative strategy, and scenario.

Over 90 percent of the land area occupied by utility-scale solar facilities constructed in the TVA service area to date was previously in agricultural use. Most of the remaining land area was previously forested. The majority of these solar facilities have been in western Tennessee and northwest Alabama; solar proposals recently received by TVA indicate a continued interest in developing solar facilities in these areas as well as in Mississippi. The preference for this region is due to the presence of large tracts of relatively flat land in large ownerships and its better solar resource relative to the rest of the TVA region (see Section 4.6.2).

Despite the large land requirements of utility-scale solar facilities, which typically displace agricultural operations including grazing or, to a much smaller extent forest, the impacts of solar facilities on the land are low relative to other types of generating facilities. The construction of solar facilities typically does not require extensive excavation and solar facilities have little associated permanent or semi-permanent infrastructure that hinders restoration of the site after the facility is dismantled. While the approximately 18,300–58,400 acres occupied by new solar facilities under the portfolios shown in Figure 5-22 is a large land area, it comprises 0.03–0.10 percent of the TVA service area.

The land requirements illustrated in Figure 5-21 and Figure 5-22 only include those for the generating and storage facility footprints and associated access roads.

They do not include undisturbed portions of the power plant reservations or the land area needed for extraction (e.g., mining, drilling), processing, and transportation of fuels or long-term disposal of wastes.

5.5.6 Socioeconomics

Potential socioeconomic impacts of the alternative strategies were assessed by the real per-capita income and non-farm employment metrics described in Volume I, Section 6.3. These metrics were calculated using the PI+ Model by Regional Economic Models, Inc. This model is described in detail in Volume 1, Appendix J. The numerous inputs to the model include employment, wage, income, and population data, costs associated with the energy resource options, and labor and capital requirements. Real per-capita income reflects the general economic well-being of area residents and the net effect of each strategy's change in expenditures and electricity bills. Increases in TVA expenditures to operate the power system stimulate the area economy in select areas, but can also increase all customers' electricity bills and reduce their discretionary income. These impacts tend to be generally offsetting.

Changes in real per-capita income and employment are described for the TVA service area. Because the IRP is programmatic and does not address the future siting and construction of generating facilities, site-specific analyses of socioeconomic impacts, including potential site- specific disproportionate impacts to minority and low income populations, are not possible at this time. An exception to this is the projected retirement of generating facilities, where some local area-specific impacts are described below.

The differences in annual real per capita income and employment of residents of the TVA service area were compared to Strategy A for each scenario (Tables 5-5, 5-6). The differences in real per capita income are small; averaged across scenarios, there would be no change under Strategies B and E and small decreases under Strategies C and D. The small magnitude of the changes are due in large part to the small proportion of the TVA region's economy (about $440 billion in 2018) comprised by TVA revenues ($11.2 billion in 2018). The real per capita income metric does not reflect the effects of TVA expenditures outside its service area which are mostly for fuels and purchased power. Most of the fuel used to supply power to TVA is purchased from sources outside the service area; the major exceptions to this are coal from Muhlenberg County, Kentucky and Choctaw County Mississippi. None of the portfolios include significant new PPAs from sources outside the service area and out-of-area PPAs for wind energy expire in the early 2030s.

Table 5-5: Changes in real per capita income by alternative strategy relative to Strategy A – Base Case.

Strategy	Scenario 1	2	3	4	5	6	Strategy Average
A: Base Case	--	--	--	--	--	--	--
B: Promote DER	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%
C: Promote Resiliency	-0.01%	0.00%	-0.01%	0.00%	0.00%	-0.03%	-0.01%
D: Promote Efficient Load Shape	-0.01%	-0.02%	-0.04%	-0.02%	-0.02%	-0.01%	-0.02%
E: Promote Renewables	0.00%	0.00%	-0.01%	0.00%	-0.01%	0.00%	0.00%

Table 5-6: Changes in employment by alternative strategy relative to Strategy A – Base Case.

Strategy	Scenario 1	2	3	4	5	6	Strategy Average
A: Base Case	--	--	--	--	--	--	--
B: Promote DER	0.01%	0.00%	0.01%	0.01%	0.10%	0.00%	0.02%
C: Promote Resiliency	0.01%	0.01%	0.01%	0.01%	0.10%	0.01%	0.02%
D: Promote Efficient Load Shape	0.02%	0.01%	0.01%	0.01%	0.11%	0.00%	0.03%
E: Promote Renewables	0.01%	0.01%	0.00%	0.00%	0.10%	0.00%	0.02%

As with real per capita income, the differences in employment between the alternative strategies are small. Strategies B, C, D, and E would all result in small increases in employment. Most of these increases are attributable to Scenario 5: Rapid DER Adoption. Under this scenario, TVA's revenue requirements decrease by about 10 to 12 percent relative to Strategy A, stimulating regional economic growth and associated employment. Smaller increases under other scenarios are due in part to employment increases proportional to population increases.

Before implementing a specific resource option, TVA will conduct a review of its potential socioeconomic impacts. This review will, as appropriate, focus on resource- and/or site-specific socioeconomic issues such as impacts on employment rates, housing, schools, emergency services, water supply and wastewater treatment capacity, and local government revenues including TVA tax equivalent payments.

5.5.6.1 Impacts of Potential Facility Retirements

The following section describes the socioeconomic impacts that could occur if TVA retires the facilities discussed in Section 3.2.3.

The potential retirement of a CT or coal facility would result in the loss of a local employment option, and people currently employed at these facilities may become temporarily unemployed. The CT facilities employ a relatively small number of people (Allen = 8, Colbert = 6, Gallatin = 8, Johnsonville = 28). While this decrease in employment represents less than 0.01 percent of total employment in the counties in which the facilities are located, minor direct adverse economic impacts to the area surrounding the CT facility could result.

The coal facilities employ more people (Cumberland = 329, Gallatin = 174, Kingston = 254, Shawnee = 241), and the loss of employment would result in a direct adverse economic impact to the surrounding areas . Employees and associated family members may also temporarily or permanently relocate to different locations in the state or beyond for employment or other reasons, and these changes may affect familial and community relations. The retirement of coal facilities would result in indirect employment impacts to associated mining, transportation, and by-product industries, as well as businesses providing other materials and services. Adverse economic impacts could occur within these industries and associated affected counties.

TVA would help offset this employment loss by placing some interested employees in available positions across the TVA PSA. As described in Section 4.8.4, there are several other fields in the vicinity of the CT and coal facilities, including educational services, health care, and social assistance; manufacturing; transportation; retail trade; and warehousing. Employees at these facilities may find alternative employment in these other industries. However, the average annual salary is approximately 2.4 to 3.0 times higher than the average of per capita income in affected counties. For Allen CT facility and Johnsonville CT facility, the proximity to more urbanized areas such as Memphis and Nashville, TN may help offset the need for employees and associated family members to relocate. Therefore, the potential retirement of these facilities would result in minor, direct, adverse socioeconomic impacts.

The potential retirement of these facilities would also affect TVA's tax equivalent payments, also known as payments in lieu of taxes, to each state where the facility is located. Each state regulates how the payments are distributed to governmental entities across the state.

5.5.7 Environmental Justice

All of the capacity expansion plans associated with the alternative strategies and scenarios include the construction and operation of new generating facilities and, for many plans, new energy storage facilities. The potential impacts on minority and low income populations from the construction and operation of these facilities, whose locations are, with a few exceptions, not known at this time and will be determined in future environmental analyses. The potential impacts of the retirement of generating facilities on low income and minority populations are described below in Section 5.5.8.1.

Future rate increases could affect low income populations more than other populations. Low income populations also have limited ability to participate in energy efficiency programs that could reduce their future power bills. TVA is working with the local power companies to develop programs benefiting low income homeowners and renters. Strategies B – Promote DER and D – Promote Efficient Load Shape include energy efficiency programs targeting low income customers.

5.5.7.1 Impacts of Facility Retirements

Demographic indicators for potential environmental justice concerns were obtained using EJSCREEN for a 3-mile radius surrounding TVA power plants, including the eight facilities being considered for full or partial retirement (see Section 4.9.5). Allen CT Plant has minority percentages and low-income population percentages higher than the state of Tennessee. Allen CT Plant, Colbert CT Plant, Shawnee Fossil Plant, Cumberland Fossil Plant, and Johnsonville CT Plant have higher percentages of the population over the age of 64 compared to their respective states.

The potential retirement of these facilities would not result in significant environmental justice-related impacts. TVA would help offset this employment loss by placing some interested employees in available positions across the TVA PSA. Because of the lack of significant environmental impacts as described in Section 5.5.7, no disproportionate impacts to disadvantaged populations are projected. Minor positive indirect effects to minority and low-income populations may occur due to beneficial changes to local air quality from coal facility retirements.

5.6 Potential Mitigation Measures

As previously described, TVA's siting processes for generation and transmission facilities, as well as practices for modifying these facilities, are designed to avoid and/or minimize potential adverse environmental impacts. Potential impacts are also reduced through pollution prevention measures and environmental controls such as air pollution control systems, wastewater treatment systems, and thermal generating plant cooling systems. Other potentially adverse impacts can be mitigated by measures such as compensatory wetlands mitigation, payments to in-lieu stream mitigation programs and related conservation initiatives, enhanced management of other properties, documentation and recovery of cultural resources, and infrastructure improvement assistance to local communities.

5.7 Unavoidable Adverse Environmental Impacts

The adoption of an alternative strategy for meeting the long-term electrical needs of the TVA region has no direct environmental impacts. The implementation of the strategy, however, would have adverse environmental impacts. The nature and potential significance of the impacts will depend on the energy resource options eventually implemented under the strategy. Resource options in each strategy have associated adverse impacts that cannot be realistically avoided but which can often be minimized.

Under every alternative strategy, TVA would continue to operate most of its existing generating units for the duration of the 20-year planning period. The exceptions are the coal plants/units that would be retired, a few of the older CT units, and, under Scenario 6, the Browns Ferry Nuclear Plant. The operation of the generating units would continue to result in the release of various air and/or water pollutants, depending on the kind of unit, and to generate wastes.

The construction and operation of new generating facilities would unavoidably result in changes in land use unless new facilities are located at existing plant sites. The conversion of land from a non-industrial use to an industrial use would unavoidably affect land resources such as farmland, wildlife habitat and scenery.

5.8 Relationship Between Short-Term Uses and Long-Term Productivity of the Human Environment

The adoption and implementation of a long-term energy resource strategy would have various short- and long-term consequences. These depend, in part, on the actual energy resource options implemented. Option-specific and/or site-specific environmental reviews will be conducted before final implementation decisions are made to use certain energy resources and will examine potential environmental consequences in more detail.

In both the short and long term, TVA would continue to generate electrical energy to serve its customers and the public. The availability of adequate, reliable, low-priced electricity will continue to sustain and increase the economic well-being of the TVA region. The availability of electricity also has been recognized as enhancing public health and welfare.

The generation of electricity has both short- and long-term environmental impacts. Short-term impacts include those associated with facility construction and operational impacts, such as the consequences of exposure to the emission of air pollutants and consequences of thermal discharges. Potential long-term impacts include land alterations for facility construction and fuel extraction, and the generation of nuclear waste that requires safe storage for an indefinite period.

5.9 Irreversible and Irretrievable Commitments of Resources

The continued generation of electricity by TVA will irreversibly consume various amounts of non-renewable fuels (coal, natural gas, diesel, fuel oil, and uranium). The continued maintenance of TVA's existing generating facilities and the construction of new generating facilities will irreversibly consume energy and materials. The siting of most new energy facilities, except for wind and PV facilities, will irretrievably commit the sites to industrial use because of the substantial alterations of the sites and the relative permanence of the structures. The continued generation of nuclear power will produce nuclear wastes; therefore, a site or sites will have to be devoted to the safe storage of these wastes. Any such site would essentially be irretrievably committed to long-term storage of nuclear waste.

The alternative strategies contain varying amounts of EEDR and renewable generation. Reliance on these resources lessens the irreversible commitment of non-renewable fuel resources, but would still involve the irreversible commitment of energy and materials and, depending on the type of renewable generation, the irreversible commitment of generating sites.

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Education: B.S., Electrical Engineering; Professional Engineer in Tennessee
Experience: 32 years TVA experience in nuclear systems engineering, resource planning, price forecasting, and financial analysis
Role: Integrated expansion, production cost, and financial modeling. Application of stochastic and risk analysis

Kyle Lawson (TVA)
Education: M.S. and B.S., Economics;
Experience: 10 years in planning, forecasting, implementation, and measurement of energy efficiency and demand response programs
Role: Energy efficiency and demand response program accomplishments, current programs, and program plans

Ed Liebsch (HDR)
Education: M.S., Meteorology; B.S., Earth Science w/Chemistry Minor
Experience: 38 years in air dispersion analysis, 28 years in air quality permitting and NEPA air quality analysis
Role: Air Quality, Climate and Greenhouse Gases

Tanya Mathur (TVA)
Education: B.S., Electrical Engineering; B.S., Neuroscience
Experience: 14 years in reliability engineering and operations, energy management systems, advanced power applications, transmission reliability and engineering controls, resource planning and fleet strategy
Role: Capacity planning, financial modeling, expansion modeling and analysis; document preparation

Al Myers (HDR)
Education: Completed credits toward B.S. Business Administration
Experience: 22 years in administration
Role: Formatting, editing of EIS and IRP

Charles P. Nicholson (HDR)
Education: Ph.D., Ecology and Evolutionary Biology; M.S., Wildlife Management; B.S., Wildlife and Fisheries Science
Experience: 23 years in NEPA compliance, 17 years in wildlife and endangered species management
Role: Project Manager, NEPA compliance, EIS preparation

Roger Pierce (TVA)
Education: M.B.A.; B.S.M.E., Mechanical Engineering
Experience: 10 years TVA experience in resource planning.
Project Role: Expansion and production cost modeling

Ashley Pilakowski (TVA)
Education: B.S., Environmental Management
Experience: 7 years in environmental planning and policy and NEPA compliance
Project Role: TVA Project Manager, TVA NEPA Coordinator, NEPA Compliance

Kim Pilarski-Hall (TVA)
Education: M.S., Geography, Minor Ecology
Experience: 24 years in wetlands assessment, delineation, and mitigation
Role: Wetlands

Erin E. Pritchard (TVA)
Education: M.A., Anthropology
Experience: 24 years in archaeology and cultural resource management
Role: Cultural Resources

Harriet L. Richardson Seacat (HDR)
Education: M.A. and B.A., Anthropology
Experience: 17 years in anthropology, archaeology, history, and NHPA and NEPA documentation

Role: Document preparation, GIS mapping (Socioeconomics and Environmental Justice)

Bob Roth (TVA)
Education: M.S. Economics; B.S. Economics
Experience: 33 years of energy industry experience, with 17 years of utility industry experience in economic and load forecasting, marketing, and rates
Role: Economic forecasting, Socioeconomics, Environmental Justice

Marylee Sauder (TVA contractor)
Education: BA, English and Journalism
Experience: 24 years in corporate communications
Role: IRP project communications

Timothy D. Sorrell (TVA)
Education: M.S., Mechanical Engineering; B.S., Nuclear Engineering; M.B.A.
Experience: 28 years utility experience in forecasting, system planning, commodity trading, nuclear fuel
Role: Economic impact, load forecasting, commodity price forecasting

Miles Spenrath (HDR)
Education: B.S., Environment and Natural Resources
Experience: 6 years in NEPA compliance
Role: Aquatic Life, Vegetation and Wildlife, Endangered and Threatened Species, Wetlands

Amanda K. Turk (TVA)
Education: M.S., Environmental Engineering; B.S., Civil Engineering
Experience: 9 years in water supply investigations, watershed hydrology, and surface water quality analysis
Role: Water Supply

E. Blair Wade (HDR)
Education: M.E.M., Environmental Management; B.S., Integrated Sciences and Technology (Environmental Science and GIS)
Experience: 14 years in environmental permitting and NEPA compliance
Role: Assistant Project Manager, NEPA compliance, EIS preparation

A. Chevales Williams (TVA)
Education: B.S., Environmental/Chemical Engineering
Experience: 13 years of experience in water quality monitoring and compliance; 12 years in NEPA planning and environmental services
Project Role: Surface Water

Carrie C. Williamson, P.E., CFM (TVA)
Education: M.S., Civil Engineering; B.S., Civil Engineering
Experience: 6 years in Floodplains and Flood Risk; 3 years in River Forecasting; 11 years in Compliance Monitoring
Role: Floodplains and Flood Risk

Daniel A. Woolley (TVA)
Education: B.S., Finance
Experience: 11 years of experience in financial and risk analysis and modeling, resource planning
Role: Capacity expansion and financial modeling

Cassandra L. Wylie (TVA)
Education: M.S., Forestry and Statistics; B.S., Forestry
Experience: 30 years in air quality analyses and studying the effects of air pollution on forests
Role: Air Quality

Elizabeth F. Upchurch (TVA)
Education: BA Geography, University of Tennessee
Experience: 15 years Utility Experience. 10 years Project Management and Stakeholder Engagement
Role: Stakeholder Engagement / IRP

Karen R. Utt (TVA)
Education: B.A., Biology; J.D.
Experience: 25 years of experience with environmental compliance, specializing in carbon risk management and climate change adaptation planning
Role: Greenhouse gas and climate change analyses

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8 EIS Recipients

Following is a list of the agencies, organizations, and persons who have received copies of the draft EIS or notices of its availability with instructions on how to access the EIS on the IRP project webpage.

8.1 Federal Agencies

USDA Forest Service, Region 8, Atlanta, GA
USDA Forest Service, Montgomery, AL
U.S. Environmental Protection Agency, Washington, DC
U.S. Environmental Protection Agency, Region 4, Atlanta, GA
Department of Interior, Washington, DC
U.S. Fish and Wildlife Service, Southeast Region Office, Atlanta, GA
U.S. Fish and Wildlife Service, Frankfort, KY
U.S. Fish and Wildlife Service, Asheville, NC
U.S. Fish and Wildlife Service, Abingdon, VA
U.S. Fish and Wildlife Service, Cookeville, TN
U.S. Fish and Wildlife Service, Gloucester, VA
U.S. Fish and Wildlife Service, Daphne, AL
U.S. Fish and Wildlife Service, Athens, GA
U.S. Army Corps of Engineers, Savannah District
U.S. Army Corps of Engineers, Louisville District
U.S. Army Corps of Engineers, Nashville District
U.S. Army Corps of Engineers, Norfolk District
U.S. Army Corps of Engineers, Memphis District
U.S. Army Corps of Engineers, Mobile District
U.S. Army Corps of Engineers, Wilmington District
U.S. Army Corps of Engineers, Raleigh Regulatory Field Office and Asheville Regulatory Field Office
U.S. Army Corps of Engineers, Vicksburg District
Economic Development Administration, Atlanta, GA
Advisory Council on Historic Preservation

8.2 State Agencies

8.2.1 Alabama

Alabaman Forestry Commission
Department of Agriculture and Industries
Department of Conservation and Natural Resources
Department of Economic and Community Affairs
Department of Environmental Management
Department of Transportation
Alabama Historical Commission
Top of Alabama Regional Council of Governments
North-Central Alabama Regional Council of Governments
Northwest Alabama Council of Local Governments
Decatur-Morgan County Port Authority

8.2.2 Georgia

Department of Natural Resources: Historic Preservation Division
Department of Economic Development
Department of Community Affairs
Department of Natural Resources
Department of Wildlife Resources

8.2.3 Kentucky

Kentucky State Clearinghouse
Kentucky Heritage Council

8.2.4 Mississippi

Northeast Mississippi Planning and Development District
Mississippi Development Authority
Department of Finance and Administration
Department of Environmental Quality
Department of Archives and History: Historic Preservation Division
Natchez Trace Parkway Superintendent

8.2.5 North Carolina

North Carolina State Clearinghouse
Office of Archives and History: Historic Preservation Office

8.2.6 Tennessee

Tennessee State Clearinghouse
Department of Environment and Conservation
Division of Archaeology: State Historic Preservation Office
East Tennessee Development District
Southeast Tennessee Development District
Upper Cumberland Development District
South Central Tennessee Development District

Southwest Tennessee Development District
Northwest Tennessee Development District
Tellico Reservoir Development Agency
Beech River Development Authority
Duck River Development Agency

8.2.7 Virginia

Office of Environmental Review Clearinghouse
Department of Historic Resources

8.3 Federally Recognized Tribes

Absentee Shawnee Tribe of Indians of Oklahoma
Alabama-Coushatta Tribe of Texas
Alabama-Quassarte Tribal Town
Cherokee Nation
The Chickasaw Nation
The Choctaw Nation of Oklahoma
Coushatta Tribe of Louisiana
Delaware Nation
Eastern Band of Cherokee Indians
Eastern Shawnee Tribe of Oklahoma
Jena Band of Choctaw Indians
Kialegee Tribal Town
Mississippi Band of Choctaw Indians
The Muscogee (Creek) Nation
The Osage Nation
Poarch Band of Creek Indians
The Seminole Nation of Oklahoma
Shawnee Tribe
Thlopthlocco Tribal Town
United Keetoowah Band of Cherokee Indians in Oklahoma

8.4 Individuals and Organizations

The following individuals provided comments during Scoping and received notification of the availability of the Draft EIS.

Last Name	First Name	Organization	City	State
Alexander	Tonya		Mount Juliet	TN
Ammons	Wayne		Nashville	TN
Beard	Glen	Choctaw County School District	Ackerman	MS
Bowman	Lara	The Enterprise of Mississippi	Eupora	MS
Brice	Logan		Stevens Point	WI
Bryant	Nola	NAACP	Ackerman	MS
Sanders	Joe	Central Electric Power Association	Carthage	MS
Childress	Don		Knoxville	TN
Clevenger	Keith		Tuscaloosa	AL
Cockerham	John		Johnson City	TN
Crowder	Marty	4-County Electric Power Association	Columbus	MS
De Jong	Perrin	Center for Biological Diversity	Asheville	NC
Dickerson	Steven	Dickerson Petroleum	Kosciusko	MS
Diedrich	Joe		Knoxville	TN
Embrey	Dustin		Gurley	AL
Emerson	Jill		Jackson	TN
Fletcher	Jeremy	Hydra Service, Inc.	Pelahatchie	MS
Garcia	Amanda	Southern Environmental Law Center	Nashville	TN
Garrone	Angela	Southern Alliance for Clean Energy	Knoxville	TN
Gaw	Jack		Cookeville	TN
Gilbert	Tim			
Good	Tim	Maxam Tire North America	Danvers	MA
Goodson	Chuck	Industrial Lubricant Company	Tyler	TX
Gorenflo	Louise	Tennessee Interfaith Power & Light	Knoxville	TN
Griffin	Elroy		Dover	TN
Hall	Greg			
Hardin	Anne	Tennessee Interfaith Power & Light	Knoxville	TN
Harrell	Clyde			
Hartley	Jay		Nashville	TN
Hartline	Brian	Hartline Supply, Inc.	Jasper	AL
Henri	Joseph	ForeFront Power	San Francisco	CA

Last Name	First Name	Organization	City	State
Hively	Chase		Knoxville	TN
Huddleston	Michael		Cunningham	TN
Hyche	Kenneth		Cullman	AL
Irvin	Joanne			
JD				
Jerkins	James		Florence	AL
Johnson	Lyndon		Hilham	TN
Johnson	Robert		Calvert City	KY
Keeling	Jack			
Koczaja	Catherine			
Kornrich	Bill		Sneedville	TN
Kruger	Fritz	FlowTech Fueling, LLC	Moorcroft	WY
Lawrence	Steve	Thompson Machinery	Nashville	TN
Liffrig	David	Mississippi Lignite Mining Company	Ackerman	MS
Livengood	Kerry			
Lowe	Reginald		Clarksville	TN
Mahan	Simon	Southern Renewable Energy Association	Lafayette	LA
Mayer	Aimee		Nashville	TN
McIntosh	JoAnn		Clarksville	TN
Meehan	Colin	First Solar, Inc.	Tempe	AZ
Moon	Jay	Mississippi Manufacturers Association	Jackson	MS
Moore	Derek		Knoxville	TN
Newton	Perry		Amory	MS
Obrien	Vince			
Piper	Cortney	Tennessee Advanced Energy Business Council	Knoxville	TN
Pritts	Jeremy		Huntingdon	PA
Roberts	Jim		Hopkinsville	KY
Robertson	Grace		Nashville	TN
Rutledge	Nicholas	TVA Transmission Engineering - System Protection	Chattanooga	TN
Schiller	Joseph		Clarksville	TN
Schweighardt	Amanda		Nashville	TN
Slentz	Paul		Knoxville	TN
Smith	Colleen	Capital Power Corporation	Boston	MA
Smith	R. Steve		Kodak	TN

Chapter 8: EIS Recipients

Last Name	First Name	Organization	City	State
Sparkman	Alan		Nashville	TN
Stein	Jeffrey	American Petroleum Institute	Washington	DC
Stephenson	Joey	Choctaw County Board of Supervisors	Ackerman	MS
Temple	Parker	Newell Paper Company	Meridian	MS
Beasley	Matt	Tennessee Solar Energy Industries Association	Nashville	TN
Trent	Larry		Loudon	TN
Troyani	Anthony		Palmyra	TN
Upchurch	Sandra	NAACP	Memphis	TN
Walton	Michael		Chattanooga	TN
Watzman	Bruce	National Mining Association	Washington	DC
Wedertz	Scott	L&H Industrial	Franklin	TN
West	Kristin		Whites Creek	TN
Westerholm	Jennifer		Nashville	TN
Williams	Ernie		Wildersville	TN
Williams	Jeff			
Wilson	Arlene		Nashville	TN
Wilson	Harold		Telford	TN
Wohlgemuth	Jim		Nashville	TN

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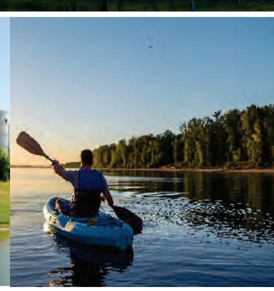
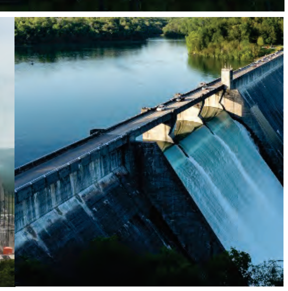
2019 Integrated Resource Plan

VOLUME II - DRAFT EIS APPENDICES





TENNESSEE VALLEY AUTHORITY

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Appendix A - Federally Listed Species near TVA Generation Facilities

Appendix A - Federally Listed Species near TVA Generation Facilities

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Federally Listed Species near TVA Generation Facilities

Facilities Considered for Retirement

NAME	SCIENTIFIC_NAME	COMMON_NAME	ST_RANK	ST_STATUS	FED_STATUS
Allen					
	Sterna antillarum athalassos	Interior Least Tern	S2S3B	END	LE
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Charadrius melodus	Piping Plover	<null>	<null>	LT
Apalachia					
	Pityopsis ruthii	Ruth's Golden Aster	S1	END	LE
	Epioblasma florentina walkeri	Tan Riffleshell	S1	END	LE
	Pleuronaia dolabelloides	Slabside Pearlymussel	S2	<null>	LE
	Cryptobranchus alleganiensis	Hellbender	S3	NMGT	PS
	Villosa trabalis	Cumberland Bean	S1	END	LE
Blue Ridge Dam					
	Cryptobranchus alleganiensis	Hellbender	S2	RARE	PS
Browns Ferry					
	Campeloma decampi	Slender Campeloma	S1	SP	LE
Bull Run					
	Dromus dromas	Dromedary Pearlymussel	S1	END	LE
	Lampsilis abrupta	Pink Mucket	S2	END	LE
	Fusconaia cuneolus	Fine-rayed Pigtoe	S1	END	LE
	Cumberlandia monodonta	Spectaclecase	S2S3	<null>	LE
	Cryptobranchus alleganiensis	Hellbender	S3	NMGT	PS
	Hemistena lata	Cracking Pearlymussel	S1	END	LE
	Dromus dromas	Dromedary Pearlymussel	S1	END	LE
	Fusconaia cor	Shiny Pigtoe Pearlymussel	S1	END	LE
	Plethobasus cooperianus	Orange-foot Pimpleback	S1	END	LE
	Plethobasus cicatricosus	White Wartyback	S1	END	LE
Caledonia					
	Lampsilis perovalis	Orange-nacre Mucket	S1	END	LT
	Pleurobema perovatum	Ovate Clubshell	S1	END	LE
Chatuge Dam					
	Cryptobranchus alleganiensis	Hellbender	S2	RARE	PS
	Sarracenia oreophila	Green Pitcher Plant	S1	END	LE
	Haliaeetus leucocephalus	Bald Eagle	S3B,S3N	THR	DM
Cherokee Dam					
	Cumberlandia monodonta	Spectaclecase	S2S3	<null>	LE
	Plethobasus cicatricosus	White Wartyback	S1	END	LE
	Fusconaia cor	Shiny Pigtoe Pearlymussel	S1	END	LE
	Dromus dromas	Dromedary Pearlymussel	S1	END	LE
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
Chickamauga Dam					
	Percina tanasi	Snail Darter	S2S3	THR	LT

NAME	SCIENTIFIC_NAME	COMMON_NAME	ST_RANK	ST_STATUS	FED_STATUS
	Lampsilis abrupta	Pink Mucket	S2	END	LE
	Pleurobema plenum	Rough Pigtoe	S1	END	LE
	Plethobasus cooperianus	Orange-foot Pimpleback	S1	END	LE
	Scutellaria montana	Large-flowered Skullcap	S4	THR	LT
Colbert					
	Palaemonias alabamae	Alabama Blind Cave Shrimp	S1	SP	LE
	Myotis grisescens	Gray Bat	S2	SP	LE
	Plethobasus cyphyus	Sheepnose	S1	SP	LE
	Cumberlandia monodonta	Spectaclecase	S1	SP	LE
	Lampsilis abrupta	Pink Mucket	S1	SP	LE
	Pleuronaia dolabelloides	Slabside Pearlymussel	S1	SP	LE
	Pleurobema plenum	Rough Pigtoe	S1	SP	LE
	Cyprogenia stegaria	Fanshell	S1	SP	LE
	Fusconaia cor	Shiny Pigtoe Pearlymussel	S1	SP	LE
	Quadrula cylindrica cylindrica	Smooth Rabbitsfoot	S1	SP	LT
	Dromus dromas	Dromedary Pearlymussel	S1	SP	LE
	Athearnia anthonyi	Anthony's River Snail	S1	SP	LE
	Lemiox rimosus	Birdwing Pearlymussel	S1	SP	LE
	Plethobasus cicatricosus	White Wartyback	S1	SP	LE
	Speoplatyrhinus poulsoni	Alabama Cavefish	S1	SP	LE
	Toxolasma cylindrellus	Pale Lilliput	S1	SP	LE
	Epioblasma brevidens	Cumberlandian Combshell	S1	SP	LE
	Elassoma alabamae	Spring Pygmy Sunfish	S1	SP	LT
	Haliaeetus leucocephalus	Bald Eagle	S4B	SP	DM
Cumberland					
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Quadrula cylindrica	Rabbitsfoot	<null>	<null>	LT
Douglas Dam					
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Percina tanasi	Snail Darter	S2S3	THR	LT
Fontana Dam					
	Myotis septentrionalis	Northern Long-eared Bat	S2	SR	LT
	Myotis sodalis	Indiana Bat	S1S2	END	LE
Fort Loudoun Dam					
	Cryptobranchus alleganiensis	Hellbender	S3	NMGT	PS
	Plethobasus cooperianus	Orange-foot Pimpleback	S1	END	LE
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Percina tanasi	Snail Darter	S2S3	THR	LT
	Lampsilis abrupta	Pink Mucket	S2	END	LE
Ft Patrick Henry Dam					
	Pegias fabula	Little-wing Pearlymussel	S1	END	LE
	Quadrula intermedia	Cumberland Monkeyface	S1	END	LE

NAME	SCIENTIFIC_NAME	COMMON_NAME	ST_RANK	ST_STATUS	FED_STATUS
Gallatin					
	Lesquerella perforata	Spring Creek Bladderpod	S1	END	LE
	Myotis grisescens	Gray Bat	S2	END	LE
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
Great Falls Dam					
	Myotis grisescens	Gray Bat	S2	END	LE
	Cryptobranchus alleganiensis	Hellbender	S3	NMGT	PS
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
Guntersville Dam					
	Haliaeetus leucocephalus	Bald Eagle	S4B	SP	DM
	Cryptobranchus alleganiensis	Hellbender	S2	SP	PS
	Myotis grisescens	Gray Bat	S2	SP	LE
	Lampsilis abrupta	Pink Mucket	S1	SP	LE
	Cyprogenia stegaria	Fanshell	S1	SP	LE
	Myotis sodalis	Indiana Bat	S2	SP	LE
Hiwassee Dam					
	Myotis septentrionalis	Northern Long-eared Bat	S2	SR	LT
	Myotis sodalis	Indiana Bat	S1S2	END	LE
	Cryptobranchus alleganiensis	Hellbender	S3	SC	PS
John Sevier					
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Lemiox rimosus	Birdwing Pearlymussel	S1	END	LE
	Fusconaia cuneolus	Fine-rayed Pigtoe	S1	END	LE
	Quadrula intermedia	Cumberland Monkeyface	S1	END	LE
	Villosa perpurpurea	Purple Bean	S1	END	LE
Johnsonville					
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Lampsilis abrupta	Pink Mucket	S2	END	LE
	Plethobasus cooperianus	Orange-foot Pimpleback	S1	END	LE
	Pleurobema plenum	Rough Pigtoe	S1	END	LE
	Obovaria retusa	Ring Pink	S1	END	LE
	Charadrius melodus	Piping Plover	<null>	<null>	LT
Kentucky Dam					
	Haliaeetus leucocephalus	Bald Eagle	S2	THR	DM
	Lampsilis abrupta	Pink Mucket	S1	END	LE
	Quadrula cylindrica cylindrica	Smooth Rabbitsfoot	S2	THR	LT
	Plethobasus cooperianus	Orange-foot Pimpleback	S1	END	LE
	Plethobasus cyphyus	Sheepnose	S1	END	LE
	Quadrula cylindrica	Rabbitsfoot	<null>	<null>	LT
Kingston					
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Plethobasus cooperianus	Orange-foot Pimpleback	S1	END	LE
	Erysimum capitatum	Western Wallflower	S1S2	END	PS

NAME	SCIENTIFIC_NAME	COMMON_NAME	ST_RANK	ST_STATUS	FED_STATUS
	Villosa perpurpurea	Purple Bean	S1	END	LE
	Lampsilis virescens	Alabama Lampmussel	S1	END	LE
	Fusconaia cuneolus	Fine-rayed Pigtoe	S1	END	LE
	Erimonax monachus	Spotfin Chub	S2	THR	LT
Magnolia					
	Myotis sodalis	Indiana Bat	S1B	END	LE
Marshall					
	Quadrula cylindrica cylindrica	Smooth Rabbitsfoot	S2	THR	LT
	Plethobasus cyphyus	Sheepnose	S1	END	LE
	Obovaria retusa	Ring Pink	S1	END	LE
	Lampsilis abrupta	Pink Mucket	S1	END	LE
	Plethobasus cooperianus	Orange-foot Pimpleback	S1	END	LE
	Cyprogenia stegaria	Fanshell	S1	END	LE
	Quadrula cylindrica	Rabbitsfoot	<null>	<null>	LT
Melton Hill Dam					
	Myotis grisescens	Gray Bat	S2	END	LE
	Obovaria retusa	Ring Pink	S1	END	LE
	Cyprogenia stegaria	Fanshell	S1	END	LE
	Plethobasus cyphyus	Sheepnose	S2S3	<null>	LE
	Lampsilis abrupta	Pink Mucket	S2	END	LE
	Plethobasus cooperianus	Orange-foot Pimpleback	S1	END	LE
	Cryptobranchus alleganiensis	Hellbender	S3	NMGT	PS
Nickajack Dam					
	Platanthera integrilabia	White Fringeless Orchid	S2	SLNS	LT
	Myotis grisescens	Gray Bat	S2	SP	LE
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Myotis sodalis	Indiana Bat	S1	END	LE
	Lampsilis abrupta	Pink Mucket	S2	END	LE
	Cyprogenia stegaria	Fanshell	S1	END	LE
	Dromus dromas	Dromedary Pearlymussel	S1	END	LE
	Percina tanasi	Snail Darter	S2S3	THR	LT
	Athearnia anthonyi	Anthony's River Snail	S1	END	LE
Norris Dam					
	Cumberlandia monodonta	Spectaclecase	S2S3	<null>	LE
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Lampsilis abrupta	Pink Mucket	S2	END	LE
	Dromus dromas	Dromedary Pearlymussel	S1	END	LE
	Fusconaia cuneolus	Fine-rayed Pigtoe	S1	END	LE
	Erimystax cahni	Slender Chub	S1	THR	LT
	Lampsilis virescens	Alabama Lampmussel	S1	END	LE
	Fusconaia cor	Shiny Pigtoe Pearlymussel	S1	END	LE
	Athearnia anthonyi	Anthony's River Snail	S1	END	LE
	Pleurobema plenum	Rough Pigtoe	S1	END	LE

NAME	SCIENTIFIC_NAME	COMMON_NAME	ST_RANK	ST_STATUS	FED_STATUS
	Epioblasma florentina walkeri	Tan Riffleshell	S1	END	LE
	Cyprogenia stegaria	Fanshell	S1	END	LE
	Cryptobranchus alleganiensis	Hellbender	S3	NMGT	PS
	Myotis sodalis	Indiana Bat	S1	END	LE
	Myotis grisescens	Gray Bat	S2	END	LE
	Myotis septentrionalis	Northern Long-eared Bat	S1S2	<null>	LT
Nottely Dam					
	Cryptobranchus alleganiensis	Hellbender	S3	SC	PS
	Myotis septentrionalis	Northern Long-eared Bat	S2	SR	LT
Ocoee No.1 Dam					
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Percina tanasi	Snail Darter	S2S3	THR	LT
Ocoee No.2					
	Pityopsis ruthii	Ruth's Golden Aster	S1	END	LE
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Myotis septentrionalis	Northern Long-eared Bat	S1S2	<null>	LT
Ocoee No.3					
	Cryptobranchus alleganiensis	Hellbender	S3	NMGT	PS
	Myotis septentrionalis	Northern Long-eared Bat	S1S2	<null>	LT
	Pityopsis ruthii	Ruth's Golden Aster	S1	END	LE
Paradise					
	Lampsilis abrupta	Pink Mucket	S1	END	LE
	Pleurobema plenum	Rough Pigtoe	S1	END	LE
Pickwick Landing Dam					
	Cyprogenia stegaria	Fanshell	S1	END	LE
	Plethobasus cooperianus	Orange-foot Pimpleback	S1	END	LE
	Plethobasus cicatricosus	White Wartyback	S1	END	LE
	Obovaria retusa	Ring Pink	S1	END	LE
	Lampsilis abrupta	Pink Mucket	S2	END	LE
	Cumberlandia monodonta	Spectaclecase	S2S3	<null>	LE
	Cryptobranchus alleganiensis	Hellbender	S3	NMGT	PS
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Pleuronaia dolabelloides	Slabside Pearlymussel	S2	<null>	LE
	Plethobasus cyphyus	Sheepnose	S2S3	<null>	LE
Raccoon Mtn Pumped Storage					
	Scutellaria montana	Large-flowered Skullcap	S4	THR	LT
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Quadrula intermedia	Cumberland Monkeyface	S1	END	LE
	Dromus dromas	Dromedary Pearlymussel	S1	END	LE
	Plethobasus cooperianus	Orange-foot Pimpleback	S1	END	LE
	Myotis grisescens	Gray Bat	S2	END	LE

NAME	SCIENTIFIC_NAME	COMMON_NAME	ST_RANK	ST_STATUS	FED_STATUS
	Platanthera integrilabia	White Fringeless Orchid	S2S3	END	LT
S Holston Dam					
	Erimonax monachus	Spotfin Chub	S2	THR	LT
	Etheostoma marmorpinnum	Marbled Darter	S1	END	LE
	Epioblasma florentina walkeri	Tan Riffleshell	S1	END	LE
Sequoyah					
	Scutellaria montana	Large-flowered Skullcap	S4	THR	LT
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Dromus dromas	Dromedary Pearlymussel	S1	END	LE
Shawnee					
	Plethobasus cyphyus	Sheepnose	S1	END	LE
	Quadrula cylindrica	Rabbitsfoot	<null>	<null>	LT
	Myotis sodalis	Indiana Bat	S1S2	END	LE
	Plethobasus cooperianus	Orange-foot Pimpleback	S1	END	LE
	Lampsilis abrupta	Pink Mucket	S1	END	LE
Tims Ford Dam					
	Pleuronaia dolabelloides	Slabside Pearlymussel	S2	<null>	LE
	Fusconaia cor	Shiny Pigtoe Pearlymussel	S1	END	LE
	Quadrula intermedia	Cumberland Monkeyface	S1	END	LE
	Ptychobranchus subtentum	Fluted Kidneyshell	S2	<null>	LE
	Epioblasma florentina walkeri	Tan Riffleshell	S1	END	LE
	Fusconaia cuneolus	Fine-rayed Pigtoe	S1	END	LE
	Myotis grisescens	Gray Bat	S2	END	LE
Watauga Dam					
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Cryptobranchus alleganiensis	Hellbender	S3	NMGT	PS
Watts Bar					
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Lampsilis abrupta	Pink Mucket	S2	END	LE
	Cyprogenia stegaria	Fanshell	S1	END	LE
	Dromus dromas	Dromedary Pearlymussel	S1	END	LE
	Myotis septentrionalis	Northern Long-eared Bat	S1S2	<null>	LT
	Myotis grisescens	Gray Bat	S2	END	LE
	Pleurobema plenum	Rough Pigtoe	S1	END	LE
	Percina tanasi	Snail Darter	S2S3	THR	LT
	Cryptobranchus alleganiensis	Hellbender	S3	NMGT	PS
	Plethobasus cyphyus	Sheepnose	S2S3	<null>	LE
Watts Bar Dam					
	Myotis septentrionalis	Northern Long-eared Bat	S1S2	<null>	LT
	Myotis grisescens	Gray Bat	S2	END	LE
	Cyprogenia stegaria	Fanshell	S1	END	LE
	Lampsilis abrupta	Pink Mucket	S2	END	LE
	Percina tanasi	Snail Darter	S2S3	THR	LT
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM

NAME	SCIENTIFIC_NAME	COMMON_NAME	ST_RANK	ST_STATUS	FED_STATUS
	Cryptobranchus alleganiensis	Hellbender	S3	NMGT	PS
	Plethobasus cyphyus	Sheepnose	S2S3	<null>	LE
	Pleurobema plenum	Rough Pigtoe	S1	END	LE
	Dromus dromas	Dromedary Pearlymussel	S1	END	LE
Wheeler Dam					
	Haliaeetus leucocephalus	Bald Eagle	S4B	SP	DM
	Myotis grisescens	Gray Bat	S2	SP	LE
Widows Creek					
	Haliaeetus leucocephalus	Bald Eagle	S4B	SP	DM
	Athearnia anthonyi	Anthony's River Snail	S1	SP	LE
Wilbur Dam					
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Cryptobranchus alleganiensis	Hellbender	S3	NMGT	PS
Wilson Dam					
	Myotis grisescens	Gray Bat	S2	SP	LE
	Cumberlandia monodonta	Spectaclecase	S1	SP	LE
	Lampsilis abrupta	Pink Mucket	S1	SP	LE
	Plethobasus cyphyus	Sheepnose	S1	SP	LE
	Dromus dromas	Dromedary Pearlymussel	S1	SP	LE
	Fusconaia cuneolus	Fine-rayed Pigtoe	S1	SP	LE
	Fusconaia cor	Shiny Pigtoe Pearlymussel	S1	SP	LE
	Quadrula cylindrica cylindrica	Smooth Rabbitsfoot	S1	SP	LT
	Pleurobema plenum	Rough Pigtoe	S1	SP	LE
	Haliaeetus leucocephalus	Bald Eagle	S4B	SP	DM
	Lampsilis virescens	Alabama Lampmussel	S1	SP	LE
	Athearnia anthonyi	Anthony's River Snail	S1	SP	LE
	Lemiox rimosus	Birdwing Pearlymussel	S1	SP	LE
	Epioblasma triquetra	Snuffbox	S1	PSM	LE
	Epioblasma brevidens	Cumberlandian Combshell	S1	SP	LE
	Cryptobranchus alleganiensis	Hellbender	S2	SP	PS
	Etheostoma wapiti	Boulder Darter	S1	SP	LE

B

Appendix B - Solid and Hazardous Waste

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	Bull Run Fossil Plant				Cumberland Fossil Plant				Gallatin Fossil Plant			Kingston Fossil Plant			
Month	Actual Production Fly Ash (Tons)	Actual Production Bottom Ash (Tons)	Actual Production Gypsum (Tons)	Average Actual Ash Production (Tons)	Actual Production Fly Ash (Tons)	Actual Production Bottom Ash (Tons)	Actual Production Gypsum (Tons)	Average Actual Ash Production (Tons)	Actual Production Dry Scrubber Product (Tons)	Actual Production Bottom Ash (Tons)	Average Actual Ash Production (Tons)	Actual Production Fly Ash (Tons)	Actual Production Bottom Ash (Tons)	Actual Production Gypsum (Tons)	Average Actual Ash Production (Tons)
FY12 Total	25,585	6,091	18,496	31,676	407,490	69,701	746,092	477,190	0	0	0	91,619	22,509	127,887	114,128
FY13 Total	50,785	12,254	43,157	63,039	495,644	105,861	806,071	601,505	0	0	0	148,882	36,163	194,598	185,045
FY14 Total	77,281	18,524	61,822	95,805	487,727	97,137	942,286	584,864	0	0	0	157,610	38,221	1,225,475	195,831
FY15 Total	81,778	30,969	74,133	112,747	519,275	87,284	987,684	606,559	52,934	42,581	95,515	136,613	27,198	209,368	163,811
FY16 Total	65,830	15,398	46,713	81,228	396,664	54,257	850,637	450,921	198,818	27,650	226,468	132,506	15,786	209,018	148,292
FY17 Total	88,010	28,068	66,148	116,077	253,813	38,591	738,475	292,404	236,487	31,658	268,145	175,814	5,955	224,514	181,769
FY18 Total	51,674	17,284	38,428	68,958	341,575	70,634	695,696	412,210	248,308	38,424	286,732	116,658	16,463	171,590	133,121
Average	62,992	18,370	49,842	81,361	414,598	74,781	823,849	489,379	184,137	35,078	219,215	137,100	23,185	337,493	160,285

	Bull Run Fossil Plant				Cumberland Fossil Plant				Gallatin Fossil Plant			Kingston Fossil Plant			
Month	Forecasted Production Fly Ash (Tons)	Forecasted Production Bottom Ash (Tons)	Forecasted Production Gypsum (Tons)	Average Forecasted Ash Production (Tons)	Forecasted Production Fly Ash (Tons)	Forecasted Production Bottom Ash (Tons)	Forecasted Production Gypsum (Tons)	Average Forecasted Ash Production (Tons)	Forecasted Production Dry Scrubber Product (Tons)	Forecasted Production Bottom Ash (Tons)	Average Forecasted Ash Production (Tons)	Forecasted Production Fly Ash (Tons)	Forecasted Production Bottom Ash (Tons)	Forecasted Production Gypsum (Tons)	Average Forecasted Ash Production (Tons)
FY19 Total	15,262	1,638	10,353	16,901	222,010	54,823	604,680	276,833	99,885	12,984	112,869	49,445	12,098	75,295	61,544
FY20 Total	0	0	0	0	193,319	47,738	526,536	241,057	52,063	6,066	58,128	50,789	12,427	77,341	63,216
FY21 Total	461	49	313	510	169,666	41,897	462,114	211,564	33,862	3,699	37,561	50,407	12,334	76,759	62,741
FY22 Total	3,941	423	2,673	4,364	188,973	46,665	514,698	235,637	35,295	3,919	39,214	52,816	12,923	80,427	65,739
FY23 Total	16,345	1,755	11,087	18,100	304,829	75,274	830,252	380,103	38,354	4,174	42,528	50,882	12,450	77,482	63,332
FY24 Total	53,415	5,734	36,232	59,149	266,126	65,717	724,836	331,842	33,423	3,416	36,839	16,183	3,960	24,644	20,143
FY25 Total	56,664	6,083	38,436	62,747	251,372	62,073	684,651	313,445	35,278	3,916	39,194	9,755	2,387	14,855	12,142
FY26 Total	68,703	7,375	46,603	76,078	229,253	56,611	624,409	285,865	39,455	4,343	43,798	11,831	2,895	18,015	14,725
FY27 Total	80,111	8,600	54,341	88,711	321,522	79,396	875,716	400,918	43,102	4,904	48,006	12,977	3,175	19,761	16,152
FY28 Total	122,174	13,116	82,873	135,289	364,270	89,952	992,148	454,222	68,991	8,667	77,657	23,061	5,643	35,118	28,704
FY29 Total	113,746	12,211	77,157	125,957	399,653	98,689	1,088,518	498,342	76,688	9,635	86,323	25,696	6,287	39,129	31,983
FY30 Total	155,417	16,684	105,423	172,101	391,681	96,721	1,066,806	488,402	104,245	13,654	117,899	35,445	8,673	53,975	44,118
Average	57,187	6,139	38,791	63,326	275,223	67,963	749,614	343,186	55,053	6,615	61,668	32,441	7,938	49,400	40,378

	Paradise Fossil Plant				Shawnee Fossil Plant		
Month	Actual Production U3 Scrubber Sludge (Tons)	Actual Production Sluiced Fly Ash (to Peabody, Estimated Tons)	Actual Production Slag Rejects (Tons)	Average Actual Ash Production (Tons)	Actual Production Dry Scrubber Product Units 1 & 4 and Fly Ash Units 2-3 & 5-9 (Tons)	SHF Actual Production Bottom Ash (Tons)	Average Actual Ash Production (Tons)
FY12 Total	427,145	Not Measured	278,365	705,510	239,177	27,414	266,591
FY13 Total	323,660	Not Measured	285,079	608,739	226,599	26,289	252,888
FY14 Total	323,660	Not Measured	285,079	608,739	226,255	25,463	251,718
FY15 Total	320,820	Not Measured	252,205	573,025	181,564	34,137	215,701
FY16 Total	319,992	Not Measured	225,621	545,613	206,490	9,080	215,571
FY17 Total	318,968	Not Measured	80,437	399,405	206,312	34,837	241,149
FY18 Total	332,636	Not Measured	61,752	394,388	218,660	33,238	251,898
Average	338,126	Not Measured	209,791	547,917	215,008	27,208	242,216

	Paradise Fossil Plant				Shawnee Fossil Plant		
Month	Forecasted Production U3 Scrubber Sludge (Tons)	Forecasted Production Sluiced Fly Ash (to Peabody, Estimated Tons)	Forecasted Production Slag Rejects (Tons)	Average Forecasted Ash Production (Tons)	Forecasted Production Dry Scrubber Product Units 1 & 4 and Fly Ash Units 2-3 & 5-9 (Tons)	Forecasted Production Bottom Ash (Tons)	Average Forecasted Ash Production (Tons)
FY19 Total	125,034	18,972	55,311	199,317	216,344	44,405	260,748
FY20 Total	109,667	16,640	48,513	174,820	228,101	46,150	274,250
FY21 Total	94,949	14,407	42,002	151,357	181,160	36,549	217,709
FY22 Total	78,985	11,985	34,940	125,910	114,958	22,859	137,817
FY23 Total	154,088	23,380	68,163	245,632	108,091	22,416	130,507
FY24 Total	230,642	34,996	102,028	367,667	115,134	23,612	138,746
FY25 Total	274,447	41,643	121,406	437,496	131,087	26,482	157,568
FY26 Total	304,894	46,263	134,875	486,032	160,882	31,156	192,038
FY27 Total	346,742	52,612	153,386	552,740	198,672	38,983	237,655
FY28 Total	416,031	63,126	184,038	663,195	235,108	47,386	282,493
FY29 Total	393,589	59,721	174,110	627,420	122,946	19,887	142,833
FY30 Total	408,751	62,021	180,817	651,589	97,582	12,416	109,998
Average	244,818	37,147	108,299	390,265	159,172	31,025	190,197

C

Appendix C - Socioeconomics

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Appendix C: Counties and Independent Cities in the TVA Service Area as Considered for Socioeconomics and Environmental Justice

State	County and City Name
Alabama	
	Blount County
	Cherokee County
	Colbert County
	Cullman County
	DeKalb County
	Etowah County
	Franklin County
	Jackson County
	Lauderdale County
	Lawrence County
	Limestone County
	Madison County
	Marshall County
	Morgan County
	Winston County
Georgia	
	Catoosa County
	Chattooga County
	Dade County
	Fannin County
	Gilmer County
	Gordon County
	Murray County
	Towns County
	Union County
	Walker County
	Whitfield County
Kentucky	
	Allen County
	Butler County
	Calloway County
	Carlisle County
	Christian County
	Cumberland County
	Edmonson County
	Fulton County
	Graves County
	Grayson County
	Hickman County
	Livingston County
	Logan County
	Lyon County

State	County and City Name
Tennessee	
	Anderson County
	Bedford County
	Benton County
	Bledsoe County
	Blount County
	Bradley County
	Campbell County
	Cannon County
	Carroll County
	Carter County
	Cheatham County
	Chester County
	Claiborne County
	Clay County
	Cocke County
	Coffee County
	Crockett County
	Cumberland County
	Davidson County
	Decatur County
	DeKalb County
	Dickson County
	Dyer County
	Fayette County
	Fentress County
	Franklin County
	Gibson County
	Giles County
	Grainger County
	Greene County
	Grundy County
	Hamblen County
	Hamilton County
	Hancock County
	Hardeman County
	Hardin County
	Hawkins County
	Haywood County
	Henderson County
	Henry County
	Hickman County
	Houston County
	Humphreys County
	Jackson County

Kentucky (continued)

Marshall County
Monroe County
Simpson County
Todd County
Trigg County
Warren County

Mississippi

Alcorn County
Attala County
Benton County
Calhoun County
Chickasaw County
Choctaw County
Clay County
De Soto County
Itawamba County
Kemper County
Lafayette County
Leake County
Lee County
Lowndes County
Marshall County
Monroe County
Neshoba County
Noxubee County
Oktibbeha County
Panola County
Pontotoc County
Prentiss County
Scott County
Tallahatchie County
Tate County
Tippah County
Tishomingo County
Union County
Webster County
Winston County
Yalobusha County

North Carolina

Avery County
Cherokee County
Clay County
Watauga County

Tennessee (continued)

Jefferson County
Johnson County
Knox County
Lake County
Lauderdale County
Lawrence County
Lewis County
Lincoln County
Loudon County
McMinn County
McNairy County
Macon County
Madison County
Marion County
Marshall County
Maury County
Meigs County
Monroe County
Montgomery County
Moore County
Morgan County
Obion County
Overton County
Perry County
Pickett County
Polk County
Putnam County
Rhea County
Roane County
Robertson County
Rutherford County
Scott County
Sequatchie County
Sevier County
Shelby County
Smith County
Stewart County
Sullivan County
Sumner County
Tipton County
Trousdale County
Unicoi County
Union County
Van Buren County
Warren County
Washington County

Virginia

Lee County
Scott County
Washington County
Bristol city
Wise County
Norton city

Tennessee (continued)

Wayne County
Weakley County
White County
Williamson County
Wilson County

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D

Appendix D – Environmental Justice

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Appendix D1: Environmental Justice

Limited-Income Counties in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
DeKalb County, Alabama	55,542	18,685	19.8
Franklin County, Alabama	24,674	18,193	22.3
Marshall County, Alabama	73,792	21,767	20.5
Winston County, Alabama	19,621	19,299	20.6
Chattooga County, Georgia	20,336	17,381	22.4
Gordon County, Georgia	43,680	20,009	20.6
Butler County, Kentucky	10,272	20,591	24.6
Calloway County, Kentucky	32,008	21,109	24.9
Christian County, Kentucky	54,921	19,962	20.3
Cumberland County, Kentucky	5,530	18,362	22.3
Edmonson County, Kentucky	10,018	20,194	21.9
Fulton County, Kentucky	5,141	18,067	26.7
Grayson County, Kentucky	20,539	20,783	24.2
Monroe County, Kentucky	8,450	19,969	26.1
Alcorn County, Mississippi	29,363	20,006	19.9
Attala County, Mississippi	14,741	20,283	24.4
Benton County, Mississippi	6,682	20,261	22.7
Calhoun County, Mississippi	11,562	17,203	26.3
Chickasaw County, Mississippi	13,523	18,514	27.2
Choctaw County, Mississippi	6,630	18,434	24.5
Clay County, Mississippi	15,763	19,097	26.0
Itawamba County, Mississippi	18,970	19,707	20.2
Kemper County, Mississippi	8,275	14,715	29.9
Lafayette County, Mississippi	43,721	23,833	25.3
Leake County, Mississippi	17,446	18,178	27.1
Lowndes County, Mississippi	46,976	22,143	21.9
Monroe County, Mississippi	28,445	19,905	20.6
Neshoba County, Mississippi	22,077	19,030	22.3
Noxubee County, Mississippi	8,662	16,108	32.4
Oktibbeha County, Mississippi	41,416	20,128	32.6
Panola County, Mississippi	26,449	20,098	22.4
Prentiss County, Mississippi	20,101	18,313	22.7
Scott County, Mississippi	21,581	17,203	26.5
Tallahatchie County, Mississippi	12,083	12,747	28.2
Tippah County, Mississippi	17,100	19,453	23.5
Webster County, Mississippi	7,800	20,722	21.5
Winston County, Mississippi	14,635	21,943	28.3
Yalobusha County, Mississippi	9,893	18,802	21.6
Watauga County, North Carolina	46,619	22,892	31.3
Benton County, Tennessee	13,464	20,504	22.6
Bledsoe County, Tennessee	11,648	18,962	23.7
Campbell County, Tennessee	32,827	19,948	22.4

Appendix D1: Environmental Justice

Limited-Income Counties in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Carroll County, Tennessee	23,008	19,851	19.8
Carter County, Tennessee	47,053	20,118	23.9
Claiborne County, Tennessee	26,306	19,215	22.3
Clay County, Tennessee	6,446	16,470	24.8
Cocke County, Tennessee	28,719	18,959	26.1
Decatur County, Tennessee	9,507	21,977	20.9
DeKalb County, Tennessee	15,410	25,273	22.2
Fentress County, Tennessee	14,430	17,487	23.3
Grainger County, Tennessee	18,659	19,850	20.2
Grundy County, Tennessee	10,881	16,132	28.0
Hamblen County, Tennessee	50,268	20,642	21.2
Hancock County, Tennessee	5,387	16,351	27.3
Hardeman County, Tennessee	21,396	16,178	23.7
Hardin County, Tennessee	21,132	22,928	22.2
Haywood County, Tennessee	14,404	19,956	21.0
Henderson County, Tennessee	22,140	20,479	20.7
Hickman County, Tennessee	19,678	18,410	22.9
Houston County, Tennessee	6,603	18,256	20.9
Jackson County, Tennessee	9,612	17,675	25.0
Johnson County, Tennessee	15,147	17,834	26.9
Lake County, Tennessee	6,647	13,330	29.2
Lauderdale County, Tennessee	21,611	16,217	24.7
Lewis County, Tennessee	9,571	19,877	20.4
McNairy County, Tennessee	20,929	18,285	23.1
Morgan County, Tennessee	17,938	18,281	23.6
Obion County, Tennessee	24,863	21,650	21.1
Overton County, Tennessee	17,725	19,827	20.0
Perry County, Tennessee	6,346	18,611	28.6
Putnam County, Tennessee	60,866	22,555	24.0
Rhea County, Tennessee	25,802	20,888	22.9
Scott County, Tennessee	17,331	21,011	27.7
Shelby County, Tennessee	725,360	26,963	21.4
Unicoi County, Tennessee	15,004	20,958	21.0
Union County, Tennessee	15,309	19,030	23.5
Warren County, Tennessee	31,668	20,749	20.7
Lee County, Virginia	20,789	17,820	26.1
Scott County, Virginia	18,589	20,935	20.1
Wise County, Virginia	32,904	20,896	21.2
Bristol city, Virginia	13,988	21,865	20.6
Norton city, Virginia	3,200	19,522	26.5
	Averages	**19,473**	**23.7**

Appendix D2: Environmental Justice

Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 503, Blount County, Alabama	4,068	18,268	22.6
Census Tract 504, Blount County, Alabama	3,620	19,952	24.1
Census Tract 505, Blount County, Alabama	5,665	18,487	20.9
Census Tract 9557.02, Cherokee County, Alabama	2,987	19,431	25.9
Census Tract 201, Colbert County, Alabama	3,050	18,235	28.2
Census Tract 202, Colbert County, Alabama	1,854	22,417	22.3
Census Tract 203, Colbert County, Alabama	1,289	18,429	46.0
Census Tract 209.01, Colbert County, Alabama	3,553	20,435	21.0
Census Tract 9641, Cullman County, Alabama	4,746	18,032	20.2
Census Tract 9644, Cullman County, Alabama	3,639	22,746	22.6
Census Tract 9648, Cullman County, Alabama	3,667	18,701	28.6
Census Tract 9654.02, Cullman County, Alabama	3,365	19,328	22.9
Census Tract 9657, Cullman County, Alabama	2,175	17,014	23.2
Census Tract 9602, DeKalb County, Alabama	2,652	19,160	20.9
Census Tract 9603, DeKalb County, Alabama	5,896	19,437	20.5
Census Tract 9606, DeKalb County, Alabama	4,857	18,352	20.2
Census Tract 9607, DeKalb County, Alabama	6,529	14,696	23.3
Census Tract 9608, DeKalb County, Alabama	3,959	15,123	27.0
Census Tract 9609, DeKalb County, Alabama	2,973	17,358	28.5
Census Tract 9613, DeKalb County, Alabama	3,827	16,310	28.1
Census Tract 9614, DeKalb County, Alabama	3,262	23,077	25.5
Census Tract 2, Etowah County, Alabama	3,074	14,435	27.2
Census Tract 3, Etowah County, Alabama	1,884	12,755	37.4
Census Tract 6, Etowah County, Alabama	1,498	14,001	32.3
Census Tract 7, Etowah County, Alabama	726	17,139	51.5
Census Tract 8, Etowah County, Alabama	921	13,110	35.6
Census Tract 9, Etowah County, Alabama	2,417	12,737	36.1
Census Tract 10, Etowah County, Alabama	1,176	13,313	32.8
Census Tract 12, Etowah County, Alabama	2,716	23,580	22.2
Census Tract 13, Etowah County, Alabama	1,998	16,223	32.2
Census Tract 16, Etowah County, Alabama	3,150	18,316	22.6
Census Tract 17, Etowah County, Alabama	1,458	17,231	26.1
Census Tract 101, Etowah County, Alabama	1,665	17,103	26.3
Census Tract 104.01, Etowah County, Alabama	2,626	22,803	27.2
Census Tract 104.02, Etowah County, Alabama	4,180	25,310	19.8
Census Tract 108, Etowah County, Alabama	2,297	19,757	20.4
Census Tract 111, Etowah County, Alabama	3,963	15,949	30.4
Census Tract 112, Etowah County, Alabama	1,839	12,795	39.6
Census Tract 9730, Franklin County, Alabama	4,176	14,212	32.9
Census Tract 9732, Franklin County, Alabama	3,140	18,129	30.4
Census Tract 9734, Franklin County, Alabama	2,038	16,806	25.3

Appendix D2: Environmental Justice
Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 9737, Franklin County, Alabama	4,757	16,284	22.0
Census Tract 9501, Jackson County, Alabama	4,577	22,127	20.4
Census Tract 9502, Jackson County, Alabama	2,705	19,742	23.4
Census Tract 9503, Jackson County, Alabama	4,533	18,136	23.0
Census Tract 9504, Jackson County, Alabama	1,669	19,083	20.6
Census Tract 9508, Jackson County, Alabama	3,779	20,039	23.5
Census Tract 9511, Jackson County, Alabama	5,542	17,763	25.8
Census Tract 101, Lauderdale County, Alabama	1,783	10,600	32.8
Census Tract 102, Lauderdale County, Alabama	1,636	22,533	35.5
Census Tract 103, Lauderdale County, Alabama	798	12,295	41.8
Census Tract 104, Lauderdale County, Alabama	2,939	22,389	25.2
Census Tract 106, Lauderdale County, Alabama	2,652	17,362	43.3
Census Tract 107, Lauderdale County, Alabama	1,393	9,515	50.9
Census Tract 108, Lauderdale County, Alabama	3,139	16,861	27.8
Census Tract 109, Lauderdale County, Alabama	6,038	24,568	23.5
Census Tract 110, Lauderdale County, Alabama	3,767	18,766	29.6
Census Tract 113, Lauderdale County, Alabama	1,592	19,030	19.9
Census Tract 9794, Lawrence County, Alabama	3,756	19,939	25.3
Census Tract 9796, Lawrence County, Alabama	4,181	22,512	20.0
Census Tract 9799, Lawrence County, Alabama	1,548	20,863	22.3
Census Tract 201.01, Limestone County, Alabama	3,587	20,669	22.5
Census Tract 202.01, Limestone County, Alabama	3,907	17,136	25.2
Census Tract 204.02, Limestone County, Alabama	4,268	22,965	19.8
Census Tract 206, Limestone County, Alabama	3,830	14,575	28.7
Census Tract 207, Limestone County, Alabama	1,815	21,439	30.0
Census Tract 2.01, Madison County, Alabama	716	13,433	46.0
Census Tract 2.02, Madison County, Alabama	3,534	8,175	42.3
Census Tract 3.01, Madison County, Alabama	3,026	17,907	24.1
Census Tract 3.02, Madison County, Alabama	2,666	17,793	22.4
Census Tract 5.02, Madison County, Alabama	1,827	18,904	22.9
Census Tract 6.01, Madison County, Alabama	1,248	23,068	22.4
Census Tract 6.02, Madison County, Alabama	1,806	17,190	27.3
Census Tract 7.01, Madison County, Alabama	2,236	19,933	38.1
Census Tract 7.02, Madison County, Alabama	2,100	21,483	31.4
Census Tract 12, Madison County, Alabama	2,090	8,487	65.2
Census Tract 13.01, Madison County, Alabama	2,733	15,918	37.5
Census Tract 13.02, Madison County, Alabama	1,606	25,343	22.4
Census Tract 14.02, Madison County, Alabama	4,173	27,608	23.9
Census Tract 15, Madison County, Alabama	3,932	15,651	27.8
Census Tract 21, Madison County, Alabama	2,190	10,720	57.3
Census Tract 22, Madison County, Alabama	1,772	19,414	37.4

Appendix D2: Environmental Justice

Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 23, Madison County, Alabama	3,792	15,608	45.0
Census Tract 24, Madison County, Alabama	3,233	17,566	29.4
Census Tract 25.01, Madison County, Alabama	2,566	11,135	54.9
Census Tract 25.02, Madison County, Alabama	2,431	14,222	38.7
Census Tract 30, Madison County, Alabama	2,251	16,233	38.9
Census Tract 31, Madison County, Alabama	4,001	27,756	29.2
Census Tract 106.22, Madison County, Alabama	8,958	30,435	28.0
Census Tract 301, Marshall County, Alabama	2,290	20,357	31.1
Census Tract 304.01, Marshall County, Alabama	3,751	23,322	21.5
Census Tract 306, Marshall County, Alabama	5,282	28,951	24.1
Census Tract 307.01, Marshall County, Alabama	2,551	26,753	23.4
Census Tract 308.01, Marshall County, Alabama	3,948	18,504	29.1
Census Tract 308.02, Marshall County, Alabama	5,409	16,726	43.6
Census Tract 309.03, Marshall County, Alabama	4,754	15,252	22.1
Census Tract 309.04, Marshall County, Alabama	4,122	16,581	21.1
Census Tract 310, Marshall County, Alabama	4,308	16,544	24.2
Census Tract 311, Marshall County, Alabama	4,125	14,606	28.8
Census Tract 1, Morgan County, Alabama	3,333	17,342	35.5
Census Tract 6, Morgan County, Alabama	2,275	11,405	56.7
Census Tract 7, Morgan County, Alabama	2,896	13,022	39.3
Census Tract 8, Morgan County, Alabama	2,394	19,935	29.3
Census Tract 9, Morgan County, Alabama	3,843	14,529	36.4
Census Tract 51.09, Morgan County, Alabama	3,228	17,213	27.1
Census Tract 9655.01, Winston County, Alabama	1,960	19,071	20.0
Census Tract 9655.02, Winston County, Alabama	2,145	21,053	25.5
Census Tract 9657, Winston County, Alabama	3,628	18,582	21.3
Census Tract 9658, Winston County, Alabama	3,523	17,853	25.3
Census Tract 307, Catoosa County, Georgia	6,490	21,106	20.1
Census Tract 102, Chattooga County, Georgia	4,696	15,911	23.6
Census Tract 103, Chattooga County, Georgia	2,389	21,665	21.9
Census Tract 104, Chattooga County, Georgia	4,293	17,124	25.1
Census Tract 105, Chattooga County, Georgia	5,279	13,479	21.1
Census Tract 106, Chattooga County, Georgia	1,976	22,422	20.9
Census Tract 403, Dade County, Georgia	3,673	21,294	23.2
Census Tract 504, Fannin County, Georgia	5,612	21,340	23.8
Census Tract 803, Gilmer County, Georgia	4,854	17,416	23.4
Census Tract 804, Gilmer County, Georgia	7,436	21,138	23.9
Census Tract 9703, Gordon County, Georgia	6,905	17,058	31.5
Census Tract 9704, Gordon County, Georgia	4,079	20,247	24.0
Census Tract 9705, Gordon County, Georgia	3,408	19,991	21.6
Census Tract 9706, Gordon County, Georgia	4,588	18,625	27.8

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Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 101, Murray County, Georgia	2,563	17,060	25.1
Census Tract 102.01, Murray County, Georgia	1,455	18,525	25.1
Census Tract 106, Murray County, Georgia	3,006	16,351	27.1
Census Tract 107, Murray County, Georgia	4,596	16,088	23.3
Census Tract 1.01, Union County, Georgia	2,106	19,788	22.7
Census Tract 201, Walker County, Georgia	5,480	19,994	27.3
Census Tract 202, Walker County, Georgia	2,844	15,471	30.9
Census Tract 203.01, Walker County, Georgia	3,905	17,344	27.1
Census Tract 205.02, Walker County, Georgia	5,288	21,235	21.8
Census Tract 207, Walker County, Georgia	5,698	16,317	23.5
Census Tract 3.01, Whitfield County, Georgia	3,152	17,355	23.5
Census Tract 4, Whitfield County, Georgia	5,820	15,447	31.1
Census Tract 5.02, Whitfield County, Georgia	5,425	13,376	30.8
Census Tract 10, Whitfield County, Georgia	3,102	12,682	24.7
Census Tract 11, Whitfield County, Georgia	3,880	18,074	21.0
Census Tract 12, Whitfield County, Georgia	5,682	14,421	27.2
Census Tract 13, Whitfield County, Georgia	3,074	11,102	37.8
Census Tract 9204, Allen County, Kentucky	3,507	17,121	23.4
Census Tract 9302, Butler County, Kentucky	1,305	15,801	27.3
Census Tract 9303, Butler County, Kentucky	3,693	20,734	35.1
Census Tract 103.01, Calloway County, Kentucky	3,218	4,842	39.0
Census Tract 103.02, Calloway County, Kentucky	5,603	15,633	52.4
Census Tract 104, Calloway County, Kentucky	1,924	15,070	37.6
Census Tract 105, Calloway County, Kentucky	2,627	20,167	26.3
Census Tract 9602, Carlisle County, Kentucky	1,500	22,902	20.8
Census Tract 2001, Christian County, Kentucky	3,242	16,115	30.3
Census Tract 2002, Christian County, Kentucky	3,174	15,702	37.8
Census Tract 2003, Christian County, Kentucky	2,699	12,617	51.7
Census Tract 2004, Christian County, Kentucky	1,933	13,515	37.5
Census Tract 2008, Christian County, Kentucky	2,000	13,167	35.8
Census Tract 2011, Christian County, Kentucky	3,004	18,309	21.7
Census Tract 2013.02, Christian County, Kentucky	5,348	17,016	27.0
Census Tract 9501, Cumberland County, Kentucky	3,146	16,185	23.1
Census Tract 9502, Cumberland County, Kentucky	2,384	21,282	21.1
Census Tract 9202, Edmonson County, Kentucky	3,737	18,714	22.7
Census Tract 9204, Edmonson County, Kentucky	4,828	21,660	20.9
Census Tract 9801, Edmonson County, Kentucky	277	2,588	90.3
Census Tract 9601, Fulton County, Kentucky	2,701	19,168	22.2
Census Tract 9602, Fulton County, Kentucky	2,440	16,692	33.2
Census Tract 201, Graves County, Kentucky	3,097	17,894	26.5
Census Tract 202, Graves County, Kentucky	3,671	17,446	25.6

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Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 203, Graves County, Kentucky	4,892	16,489	28.4
Census Tract 9501, Grayson County, Kentucky	2,246	19,208	25.3
Census Tract 9503, Grayson County, Kentucky	3,479	18,813	29.8
Census Tract 9504, Grayson County, Kentucky	5,303	24,523	24.4
Census Tract 9506, Grayson County, Kentucky	3,078	16,760	28.0
Census Tract 9507, Grayson County, Kentucky	1,930	21,403	21.6
Census Tract 401, Livingston County, Kentucky	2,456	20,255	20.1
Census Tract 9603, Logan County, Kentucky	4,725	18,752	21.1
Census Tract 9605, Logan County, Kentucky	3,252	20,239	25.7
Census Tract 9302, Monroe County, Kentucky	1,784	18,563	33.9
Census Tract 9303, Monroe County, Kentucky	1,868	17,817	30.4
Census Tract 9304, Monroe County, Kentucky	3,465	19,692	23.3
Census Tract 9703, Simpson County, Kentucky	3,739	21,526	23.8
Census Tract 9704, Simpson County, Kentucky	4,907	17,257	21.3
Census Tract 9503, Todd County, Kentucky	2,012	18,053	26.6
Census Tract 9504, Todd County, Kentucky	1,082	24,306	21.3
Census Tract 9702, Trigg County, Kentucky	5,282	22,432	20.5
Census Tract 9801, Trigg County, Kentucky	21	2,381	100.0
Census Tract 101, Warren County, Kentucky	2,208	16,893	47.2
Census Tract 102, Warren County, Kentucky	2,917	10,749	51.0
Census Tract 103, Warren County, Kentucky	3,335	12,425	48.1
Census Tract 104, Warren County, Kentucky	5,698	4,773	55.3
Census Tract 105, Warren County, Kentucky	2,353	17,052	37.2
Census Tract 106, Warren County, Kentucky	3,025	29,362	20.0
Census Tract 107.01, Warren County, Kentucky	3,921	25,440	31.1
Census Tract 108.03, Warren County, Kentucky	4,825	21,375	22.4
Census Tract 110.01, Warren County, Kentucky	3,334	14,313	42.6
Census Tract 110.02, Warren County, Kentucky	4,809	17,027	25.2
Census Tract 112, Warren County, Kentucky	3,712	13,161	36.1
Census Tract 113, Warren County, Kentucky	3,287	19,870	20.6
Census Tract 9503, Alcorn County, Mississippi	3,118	20,250	25.6
Census Tract 9505, Alcorn County, Mississippi	5,004	16,211	34.6
Census Tract 9506, Alcorn County, Mississippi	3,340	16,698	22.8
Census Tract 603, Attala County, Mississippi	2,461	15,676	28.9
Census Tract 605, Attala County, Mississippi	2,638	24,820	27.0
Census Tract 606, Attala County, Mississippi	2,823	15,001	41.9
Census Tract 9501, Benton County, Mississippi	4,622	21,707	20.0
Census Tract 9502, Benton County, Mississippi	2,060	17,013	28.5
Census Tract 9502, Calhoun County, Mississippi	1,270	18,252	42.0
Census Tract 9504, Calhoun County, Mississippi	2,605	16,610	28.7
Census Tract 9505, Calhoun County, Mississippi	2,173	13,939	38.8

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Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 9501, Chickasaw County, Mississippi	3,371	15,797	29.9
Census Tract 9502, Chickasaw County, Mississippi	2,730	19,368	31.4
Census Tract 9503, Chickasaw County, Mississippi	3,344	16,667	28.0
Census Tract 9504, Chickasaw County, Mississippi	4,078	21,700	21.6
Census Tract 9502, Choctaw County, Mississippi	3,025	18,866	28.4
Census Tract 9503, Choctaw County, Mississippi	1,290	17,143	31.8
Census Tract 9501, Clay County, Mississippi	4,408	19,899	22.1
Census Tract 9502, Clay County, Mississippi	1,832	15,853	21.0
Census Tract 9503, Clay County, Mississippi	2,795	15,760	33.8
Census Tract 9504, Clay County, Mississippi	3,654	16,320	34.4
Census Tract 703.25, DeSoto County, Mississippi	2,366	16,900	25.1
Census Tract 704.11, DeSoto County, Mississippi	1,295	18,355	20.3
Census Tract 704.12, DeSoto County, Mississippi	3,189	18,011	19.7
Census Tract 704.22, DeSoto County, Mississippi	1,848	16,761	20.9
Census Tract 706.10, DeSoto County, Mississippi	2,364	17,844	26.7
Census Tract 9501, Itawamba County, Mississippi	3,753	20,258	23.6
Census Tract 9503, Itawamba County, Mississippi	2,820	15,997	23.1
Census Tract 9504, Itawamba County, Mississippi	4,274	20,890	24.8
Census Tract 301, Kemper County, Mississippi	4,449	12,866	44.8
Census Tract 9502.01, Lafayette County, Mississippi	3,022	27,604	29.8
Census Tract 9502.02, Lafayette County, Mississippi	4,597	22,042	35.5
Census Tract 9503.01, Lafayette County, Mississippi	6,351	4,971	71.5
Census Tract 9503.02, Lafayette County, Mississippi	3,333	28,733	26.2
Census Tract 9504.01, Lafayette County, Mississippi	6,054	33,710	22.3
Census Tract 9504.02, Lafayette County, Mississippi	2,907	21,032	25.2
Census Tract 9505.03, Lafayette County, Mississippi	6,115	21,457	35.6
Census Tract 401, Leake County, Mississippi	2,308	19,789	24.6
Census Tract 404, Leake County, Mississippi	5,278	20,609	22.1
Census Tract 406, Leake County, Mississippi	4,309	15,946	37.9
Census Tract 407, Leake County, Mississippi	3,055	14,620	32.0
Census Tract 9501.02, Lee County, Mississippi	3,332	20,023	22.3
Census Tract 9504.01, Lee County, Mississippi	3,176	25,766	26.4
Census Tract 9505, Lee County, Mississippi	4,813	25,759	31.4
Census Tract 9506.02, Lee County, Mississippi	3,299	16,743	26.5
Census Tract 9507, Lee County, Mississippi	2,529	17,468	25.0
Census Tract 9508, Lee County, Mississippi	2,395	19,162	26.4
Census Tract 9509.01, Lee County, Mississippi	2,240	23,797	22.3
Census Tract 9509.02, Lee County, Mississippi	3,584	22,048	27.1
Census Tract 9510.02, Lee County, Mississippi	2,894	14,303	31.2
Census Tract 1.02, Lowndes County, Mississippi	2,042	20,844	23.2
Census Tract 4.01, Lowndes County, Mississippi	5,827	22,167	21.3

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Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 4.03, Lowndes County, Mississippi	3,208	18,126	26.6
Census Tract 6, Lowndes County, Mississippi	2,708	12,445	37.6
Census Tract 7, Lowndes County, Mississippi	4,325	14,862	40.0
Census Tract 8, Lowndes County, Mississippi	2,177	14,668	39.2
Census Tract 9, Lowndes County, Mississippi	4,306	21,450	30.0
Census Tract 11, Lowndes County, Mississippi	1,351	16,143	37.7
Census Tract 9504.01, Marshall County, Mississippi	2,000	14,651	45.6
Census Tract 9504, Monroe County, Mississippi	2,459	15,344	34.5
Census Tract 9505.02, Monroe County, Mississippi	3,316	16,531	21.3
Census Tract 9506, Monroe County, Mississippi	2,311	18,435	23.8
Census Tract 9507, Monroe County, Mississippi	1,982	20,838	23.8
Census Tract 9508, Monroe County, Mississippi	2,392	14,532	35.9
Census Tract 104, Neshoba County, Mississippi	2,863	19,183	26.6
Census Tract 105, Neshoba County, Mississippi	2,389	20,912	33.9
Census Tract 106, Neshoba County, Mississippi	3,776	17,640	27.0
Census Tract 107, Neshoba County, Mississippi	3,694	18,455	22.3
Census Tract 9401, Neshoba County, Mississippi	2,881	12,675	27.7
Census Tract 9501, Noxubee County, Mississippi	4,347	16,128	30.4
Census Tract 9502, Noxubee County, Mississippi	2,600	17,716	27.1
Census Tract 9503, Noxubee County, Mississippi	1,715	13,723	45.7
Census Tract 9501, Oktibbeha County, Mississippi	7,339	16,575	37.2
Census Tract 9502, Oktibbeha County, Mississippi	4,958	23,633	28.6
Census Tract 9503, Oktibbeha County, Mississippi	2,633	18,381	36.2
Census Tract 9504, Oktibbeha County, Mississippi	7,469	11,420	43.9
Census Tract 9505, Oktibbeha County, Mississippi	3,734	23,898	30.7
Census Tract 9506.01, Oktibbeha County, Mississippi	4,358	27,222	32.9
Census Tract 9506.02, Oktibbeha County, Mississippi	4,564	21,161	35.4
Census Tract 9507, Oktibbeha County, Mississippi	6,361	23,167	22.1
Census Tract 9501, Panola County, Mississippi	6,064	17,212	22.6
Census Tract 9502, Panola County, Mississippi	2,145	15,373	36.1
Census Tract 9503, Panola County, Mississippi	3,806	26,790	22.1
Census Tract 9504, Panola County, Mississippi	3,973	20,390	19.7
Census Tract 9506, Panola County, Mississippi	5,015	23,000	23.1
Census Tract 9501.02, Pontotoc County, Mississippi	4,349	19,319	19.8
Census Tract 9502, Pontotoc County, Mississippi	4,280	17,997	22.2
Census Tract 9503, Pontotoc County, Mississippi	4,184	21,419	19.7
Census Tract 9502, Prentiss County, Mississippi	4,530	25,083	23.3
Census Tract 9503, Prentiss County, Mississippi	5,083	12,477	34.3
Census Tract 9505, Prentiss County, Mississippi	1,586	15,924	42.1
Census Tract 201, Scott County, Mississippi	4,720	17,811	29.5
Census Tract 202, Scott County, Mississippi	3,525	15,412	31.0

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Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 204, Scott County, Mississippi	2,529	13,654	24.4
Census Tract 205, Scott County, Mississippi	3,887	17,074	29.5
Census Tract 206, Scott County, Mississippi	3,009	18,264	28.4
Census Tract 9501, Tallahatchie County, Mississippi	3,019	19,996	22.1
Census Tract 9502, Tallahatchie County, Mississippi	1,675	13,705	31.5
Census Tract 9503, Tallahatchie County, Mississippi	5,655	6,320	28.8
Census Tract 9504, Tallahatchie County, Mississippi	1,734	16,880	34.5
Census Tract 9501, Tate County, Mississippi	4,107	17,995	19.9
Census Tract 9503.01, Tate County, Mississippi	3,123	16,817	24.6
Census Tract 9504, Tate County, Mississippi	4,945	18,290	21.8
Census Tract 9501, Tippah County, Mississippi	3,713	18,579	32.1
Census Tract 9502, Tippah County, Mississippi	4,960	19,352	23.5
Census Tract 9503, Tippah County, Mississippi	2,076	15,530	29.5
Census Tract 9502, Tishomingo County, Mississippi	1,923	17,097	24.3
Census Tract 9504, Tishomingo County, Mississippi	6,200	17,889	19.7
Census Tract 9501, Union County, Mississippi	3,781	17,580	21.7
Census Tract 9502, Union County, Mississippi	3,912	16,996	25.8
Census Tract 9504, Union County, Mississippi	3,383	21,421	22.5
Census Tract 9506, Union County, Mississippi	2,990	19,123	21.1
Census Tract 9503, Webster County, Mississippi	1,359	18,348	47.3
Census Tract 9501, Winston County, Mississippi	2,613	22,282	24.3
Census Tract 9503, Winston County, Mississippi	2,915	15,430	40.5
Census Tract 9504, Winston County, Mississippi	2,817	21,531	38.8
Census Tract 9505, Winston County, Mississippi	3,141	29,644	21.7
Census Tract 9501, Yalobusha County, Mississippi	2,536	19,161	20.8
Census Tract 9502, Yalobusha County, Mississippi	3,130	18,739	24.5
Census Tract 9503, Yalobusha County, Mississippi	4,227	18,630	20.0
Census Tract 9303.02, Avery County, North Carolina	2,435	16,943	23.0
Census Tract 9301, Cherokee County, North Carolina	3,671	16,228	22.1
Census Tract 9303, Cherokee County, North Carolina	1,915	17,051	21.9
Census Tract 9304, Cherokee County, North Carolina	4,964	20,089	21.7
Census Tract 9306.02, Cherokee County, North Carolina	3,598	18,988	20.9
Census Tract 9201, Watauga County, North Carolina	4,036	22,645	21.9
Census Tract 9203, Watauga County, North Carolina	2,129	22,829	20.2
Census Tract 9204, Watauga County, North Carolina	8,217	16,599	58.0
Census Tract 9205, Watauga County, North Carolina	6,928	7,308	58.8
Census Tract 9206.01, Watauga County, North Carolina	5,070	16,631	53.0
Census Tract 9206.02, Watauga County, North Carolina	1,972	28,696	37.8
Census Tract 201, Anderson County, Tennessee	2,548	22,898	29.5
Census Tract 204, Anderson County, Tennessee	3,703	20,270	31.8
Census Tract 205, Anderson County, Tennessee	2,744	17,317	30.0

Appendix D2: Environmental Justice

Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 207, Anderson County, Tennessee	1,246	17,398	25.1
Census Tract 208, Anderson County, Tennessee	3,600	16,665	24.6
Census Tract 210, Anderson County, Tennessee	4,732	19,548	34.9
Census Tract 212.02, Anderson County, Tennessee	4,289	24,493	20.6
Census Tract 9504.02, Bedford County, Tennessee	5,187	19,940	24.9
Census Tract 9505, Bedford County, Tennessee	4,673	22,225	20.3
Census Tract 9507, Bedford County, Tennessee	2,066	23,355	20.9
Census Tract 9630, Benton County, Tennessee	2,751	20,658	25.2
Census Tract 9632, Benton County, Tennessee	1,842	16,576	25.4
Census Tract 9633, Benton County, Tennessee	3,111	20,193	25.9
Census Tract 9634, Benton County, Tennessee	3,244	18,921	22.9
Census Tract 9530, Bledsoe County, Tennessee	2,923	20,386	20.0
Census Tract 9531, Bledsoe County, Tennessee	4,765	22,095	23.3
Census Tract 9532, Bledsoe County, Tennessee	3,960	13,689	28.2
Census Tract 101, Blount County, Tennessee	2,295	13,797	38.7
Census Tract 102, Blount County, Tennessee	4,891	23,119	21.1
Census Tract 108, Blount County, Tennessee	2,236	15,554	30.4
Census Tract 103, Bradley County, Tennessee	2,332	15,497	36.6
Census Tract 104, Bradley County, Tennessee	2,410	9,986	51.8
Census Tract 105, Bradley County, Tennessee	3,382	15,592	28.2
Census Tract 107, Bradley County, Tennessee	3,803	10,537	42.8
Census Tract 108, Bradley County, Tennessee	2,321	17,876	40.6
Census Tract 114.02, Bradley County, Tennessee	2,235	21,756	21.3
Census Tract 115, Bradley County, Tennessee	6,887	23,514	19.9
Census Tract 9501, Campbell County, Tennessee	2,531	15,156	31.8
Census Tract 9502, Campbell County, Tennessee	1,974	19,291	33.3
Census Tract 9503, Campbell County, Tennessee	1,424	16,908	30.5
Census Tract 9506, Campbell County, Tennessee	3,489	16,341	22.9
Census Tract 9507, Campbell County, Tennessee	3,929	24,581	31.5
Census Tract 9509, Campbell County, Tennessee	2,347	20,352	24.4
Census Tract 9601, Cannon County, Tennessee	3,240	20,438	21.0
Census Tract 9620, Carroll County, Tennessee	3,304	17,286	23.1
Census Tract 9621, Carroll County, Tennessee	5,444	20,093	20.5
Census Tract 9622.01, Carroll County, Tennessee	2,612	18,520	23.5
Census Tract 703, Carter County, Tennessee	4,795	21,947	30.7
Census Tract 704, Carter County, Tennessee	1,686	16,294	29.3
Census Tract 706, Carter County, Tennessee	2,183	16,481	26.4
Census Tract 709, Carter County, Tennessee	3,080	26,236	25.7
Census Tract 710, Carter County, Tennessee	2,428	18,567	26.0
Census Tract 712, Carter County, Tennessee	3,152	19,346	32.3
Census Tract 713, Carter County, Tennessee	6,042	16,019	27.5

Appendix D2: Environmental Justice

Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 714, Carter County, Tennessee	2,625	19,028	24.9
Census Tract 715, Carter County, Tennessee	1,719	15,862	25.3
Census Tract 716, Carter County, Tennessee	1,224	25,814	29.8
Census Tract 717, Carter County, Tennessee	3,172	19,825	24.5
Census Tract 703, Cheatham County, Tennessee	2,748	21,084	24.3
Census Tract 9702, Chester County, Tennessee	4,770	15,193	31.5
Census Tract 9703, Claiborne County, Tennessee	3,648	17,611	29.8
Census Tract 9704, Claiborne County, Tennessee	587	16,167	35.3
Census Tract 9705, Claiborne County, Tennessee	2,275	21,336	22.1
Census Tract 9707, Claiborne County, Tennessee	4,470	18,025	22.7
Census Tract 9708, Claiborne County, Tennessee	3,177	16,987	26.2
Census Tract 9709, Claiborne County, Tennessee	3,702	18,001	27.1
Census Tract 9550, Clay County, Tennessee	4,372	16,413	23.5
Census Tract 9551, Clay County, Tennessee	2,074	16,591	27.7
Census Tract 9201, Cocke County, Tennessee	3,178	17,900	20.3
Census Tract 9202, Cocke County, Tennessee	4,595	15,409	29.9
Census Tract 9203, Cocke County, Tennessee	3,459	20,003	20.4
Census Tract 9204, Cocke County, Tennessee	1,515	19,664	31.3
Census Tract 9205.01, Cocke County, Tennessee	4,613	17,007	35.8
Census Tract 9206, Cocke County, Tennessee	3,584	18,105	31.3
Census Tract 9207, Cocke County, Tennessee	3,520	19,268	22.0
Census Tract 9709, Coffee County, Tennessee	2,889	14,584	35.7
Census Tract 9611, Crockett County, Tennessee	3,155	19,643	22.4
Census Tract 9612, Crockett County, Tennessee	1,454	25,592	19.8
Census Tract 9704, Cumberland County, Tennessee	4,935	15,354	33.7
Census Tract 9705.02, Cumberland County, Tennessee	3,090	16,286	38.2
Census Tract 101.06, Davidson County, Tennessee	2,464	18,282	21.6
Census Tract 103.02, Davidson County, Tennessee	1,484	19,946	32.6
Census Tract 104.02, Davidson County, Tennessee	4,559	12,218	38.4
Census Tract 106.02, Davidson County, Tennessee	2,816	18,339	22.2
Census Tract 107.01, Davidson County, Tennessee	3,242	17,833	23.9
Census Tract 107.02, Davidson County, Tennessee	2,702	15,624	29.0
Census Tract 109.03, Davidson County, Tennessee	3,727	13,789	36.2
Census Tract 109.04, Davidson County, Tennessee	2,198	16,852	33.5
Census Tract 110.01, Davidson County, Tennessee	4,080	15,351	27.3
Census Tract 110.02, Davidson County, Tennessee	2,119	21,112	21.6
Census Tract 113, Davidson County, Tennessee	4,420	18,150	26.6
Census Tract 118, Davidson County, Tennessee	2,081	14,971	42.7
Census Tract 119, Davidson County, Tennessee	1,915	21,932	35.3
Census Tract 126, Davidson County, Tennessee	1,624	14,500	44.1
Census Tract 127.01, Davidson County, Tennessee	4,220	15,436	44.1

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Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 127.02, Davidson County, Tennessee	2,177	23,196	19.7
Census Tract 128.01, Davidson County, Tennessee	4,193	16,737	36.6
Census Tract 128.02, Davidson County, Tennessee	3,504	15,380	28.0
Census Tract 133, Davidson County, Tennessee	3,376	20,273	23.1
Census Tract 135, Davidson County, Tennessee	1,699	33,102	22.2
Census Tract 136.01, Davidson County, Tennessee	2,478	13,660	46.3
Census Tract 136.02, Davidson County, Tennessee	1,854	6,940	42.9
Census Tract 137, Davidson County, Tennessee	4,462	20,519	38.1
Census Tract 138, Davidson County, Tennessee	1,531	14,676	40.0
Census Tract 139, Davidson County, Tennessee	1,369	11,983	48.9
Census Tract 142, Davidson County, Tennessee	2,046	11,788	50.7
Census Tract 143, Davidson County, Tennessee	1,507	15,376	24.7
Census Tract 144, Davidson County, Tennessee	970	17,584	34.3
Census Tract 148, Davidson County, Tennessee	1,565	6,570	75.0
Census Tract 156.15, Davidson County, Tennessee	3,501	15,505	31.9
Census Tract 156.23, Davidson County, Tennessee	4,040	23,396	21.9
Census Tract 158.02, Davidson County, Tennessee	4,889	18,840	25.1
Census Tract 158.03, Davidson County, Tennessee	1,822	14,309	24.5
Census Tract 159, Davidson County, Tennessee	2,560	12,315	56.7
Census Tract 160, Davidson County, Tennessee	736	18,618	35.5
Census Tract 161, Davidson County, Tennessee	1,734	24,548	25.9
Census Tract 162, Davidson County, Tennessee	2,506	18,689	43.9
Census Tract 163, Davidson County, Tennessee	1,939	22,589	48.2
Census Tract 164, Davidson County, Tennessee	4,101	20,961	27.3
Census Tract 165, Davidson County, Tennessee	4,432	19,008	35.1
Census Tract 166, Davidson County, Tennessee	2,655	47,543	25.8
Census Tract 172, Davidson County, Tennessee	1,302	22,213	25.8
Census Tract 173, Davidson County, Tennessee	2,691	18,196	27.7
Census Tract 174.02, Davidson County, Tennessee	4,800	23,558	29.1
Census Tract 175, Davidson County, Tennessee	2,311	20,076	31.2
Census Tract 181.01, Davidson County, Tennessee	4,331	22,936	25.1
Census Tract 189.01, Davidson County, Tennessee	2,251	27,986	21.3
Census Tract 189.04, Davidson County, Tennessee	2,927	19,240	26.0
Census Tract 190.03, Davidson County, Tennessee	3,382	18,728	32.7
Census Tract 190.04, Davidson County, Tennessee	3,596	14,033	30.0
Census Tract 190.05, Davidson County, Tennessee	2,553	14,850	30.4
Census Tract 190.06, Davidson County, Tennessee	4,063	18,660	23.7
Census Tract 191.05, Davidson County, Tennessee	4,412	23,483	32.1
Census Tract 191.08, Davidson County, Tennessee	2,412	16,243	24.6
Census Tract 191.10, Davidson County, Tennessee	3,234	17,348	20.6
Census Tract 192, Davidson County, Tennessee	2,983	30,397	26.2

Appendix D2: Environmental Justice
Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 193, Davidson County, Tennessee	1,896	7,769	76.3
Census Tract 194, Davidson County, Tennessee	3,662	47,449	27.5
Census Tract 195, Davidson County, Tennessee	5,984	48,494	25.0
Census Tract 9550.01, Decatur County, Tennessee	1,656	21,286	25.5
Census Tract 9550.02, Decatur County, Tennessee	3,683	21,320	23.0
Census Tract 9201.01, DeKalb County, Tennessee	1,910	30,600	26.6
Census Tract 9201.02, DeKalb County, Tennessee	3,929	22,485	24.8
Census Tract 9202, DeKalb County, Tennessee	5,481	27,415	23.6
Census Tract 606.01, Dickson County, Tennessee	3,121	19,270	27.0
Census Tract 606.02, Dickson County, Tennessee	4,898	19,426	28.3
Census Tract 9643, Dyer County, Tennessee	4,340	18,567	25.0
Census Tract 9644, Dyer County, Tennessee	4,827	18,063	28.7
Census Tract 603, Fayette County, Tennessee	2,451	20,389	27.7
Census Tract 605.01, Fayette County, Tennessee	3,348	23,053	29.3
Census Tract 606, Fayette County, Tennessee	3,391	21,976	20.1
Census Tract 9650, Fentress County, Tennessee	2,698	21,350	21.5
Census Tract 9651, Fentress County, Tennessee	3,506	13,339	35.0
Census Tract 9601, Franklin County, Tennessee	2,901	20,122	21.5
Census Tract 9605, Franklin County, Tennessee	3,096	21,675	21.1
Census Tract 9606, Franklin County, Tennessee	3,504	20,628	27.0
Census Tract 9607, Franklin County, Tennessee	3,721	20,403	24.0
Census Tract 9662, Gibson County, Tennessee	3,128	19,027	25.2
Census Tract 9663, Gibson County, Tennessee	2,112	17,293	25.1
Census Tract 9665, Gibson County, Tennessee	4,302	20,370	23.8
Census Tract 9667, Gibson County, Tennessee	4,811	18,975	27.6
Census Tract 9669, Gibson County, Tennessee	2,222	14,276	26.5
Census Tract 9202, Giles County, Tennessee	3,917	16,747	24.0
Census Tract 9208, Giles County, Tennessee	2,435	21,875	21.2
Census Tract 5001, Grainger County, Tennessee	3,161	16,786	29.1
Census Tract 5003, Grainger County, Tennessee	5,289	17,791	23.7
Census Tract 5004.01, Grainger County, Tennessee	2,228	18,972	23.6
Census Tract 901, Greene County, Tennessee	4,939	16,456	41.8
Census Tract 907, Greene County, Tennessee	2,378	17,461	20.0
Census Tract 910, Greene County, Tennessee	5,898	18,684	20.1
Census Tract 913, Greene County, Tennessee	3,912	17,185	21.7
Census Tract 914, Greene County, Tennessee	2,269	22,077	25.5
Census Tract 915, Greene County, Tennessee	2,670	18,413	27.7
Census Tract 9550, Grundy County, Tennessee	2,464	12,310	33.7
Census Tract 9552, Grundy County, Tennessee	3,229	16,432	21.2
Census Tract 9553, Grundy County, Tennessee	3,883	15,867	32.9
Census Tract 1001, Hamblen County, Tennessee	5,195	14,882	32.9

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Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 1002, Hamblen County, Tennessee	4,083	18,589	27.1
Census Tract 1003, Hamblen County, Tennessee	2,294	11,553	46.5
Census Tract 1004, Hamblen County, Tennessee	5,186	20,874	32.0
Census Tract 1005, Hamblen County, Tennessee	2,401	24,941	19.7
Census Tract 1007, Hamblen County, Tennessee	4,647	17,800	21.8
Census Tract 1008, Hamblen County, Tennessee	2,692	21,961	32.2
Census Tract 4, Hamilton County, Tennessee	2,914	12,908	22.8
Census Tract 8, Hamilton County, Tennessee	1,480	28,134	24.1
Census Tract 11, Hamilton County, Tennessee	1,504	18,437	38.7
Census Tract 12, Hamilton County, Tennessee	2,685	14,404	45.2
Census Tract 13, Hamilton County, Tennessee	1,294	13,690	48.5
Census Tract 14, Hamilton County, Tennessee	1,490	15,964	31.8
Census Tract 16, Hamilton County, Tennessee	1,821	8,452	71.4
Census Tract 19, Hamilton County, Tennessee	2,783	12,277	54.6
Census Tract 20, Hamilton County, Tennessee	1,140	28,815	26.6
Census Tract 23, Hamilton County, Tennessee	1,062	11,441	45.6
Census Tract 24, Hamilton County, Tennessee	3,850	12,068	47.9
Census Tract 25, Hamilton County, Tennessee	3,018	15,748	45.6
Census Tract 26, Hamilton County, Tennessee	1,727	16,806	39.5
Census Tract 29, Hamilton County, Tennessee	2,146	25,201	23.1
Census Tract 30, Hamilton County, Tennessee	2,098	22,228	19.7
Census Tract 31, Hamilton County, Tennessee	1,708	37,791	27.7
Census Tract 104.33, Hamilton County, Tennessee	3,776	25,371	20.4
Census Tract 104.35, Hamilton County, Tennessee	4,783	27,359	22.7
Census Tract 107, Hamilton County, Tennessee	2,308	25,298	25.4
Census Tract 108, Hamilton County, Tennessee	3,492	24,290	22.5
Census Tract 109.02, Hamilton County, Tennessee	762	27,253	30.6
Census Tract 122, Hamilton County, Tennessee	1,918	10,685	43.4
Census Tract 123, Hamilton County, Tennessee	3,835	16,376	32.8
Census Tract 124, Hamilton County, Tennessee	6,061	14,752	41.9
Census Tract 9606, Hancock County, Tennessee	3,154	16,567	37.0
Census Tract 9502, Hardeman County, Tennessee	5,721	9,852	23.2
Census Tract 9504, Hardeman County, Tennessee	4,277	17,309	31.8
Census Tract 9505, Hardeman County, Tennessee	3,210	17,815	23.0
Census Tract 9506, Hardeman County, Tennessee	2,420	14,193	27.5
Census Tract 9202, Hardin County, Tennessee	3,693	23,562	22.2
Census Tract 9204, Hardin County, Tennessee	3,826	13,549	41.2
Census Tract 502, Hawkins County, Tennessee	3,799	18,570	26.3
Census Tract 503.01, Hawkins County, Tennessee	3,522	22,348	25.2
Census Tract 505.02, Hawkins County, Tennessee	2,608	22,451	28.5
Census Tract 508, Hawkins County, Tennessee	3,942	16,868	30.3

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Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 9302, Haywood County, Tennessee	1,351	17,202	29.3
Census Tract 9303.01, Haywood County, Tennessee	3,526	22,090	26.6
Census Tract 9303.02, Haywood County, Tennessee	2,343	15,923	28.8
Census Tract 9752, Henderson County, Tennessee	4,164	22,801	22.8
Census Tract 9754, Henderson County, Tennessee	3,176	17,040	29.9
Census Tract 9755, Henderson County, Tennessee	3,156	16,743	25.9
Census Tract 9690, Henry County, Tennessee	3,873	21,842	22.7
Census Tract 9693, Henry County, Tennessee	2,836	13,948	36.6
Census Tract 9694, Henry County, Tennessee	1,499	17,423	37.6
Census Tract 9698, Henry County, Tennessee	1,674	24,972	20.3
Census Tract 9502, Hickman County, Tennessee	5,209	17,054	33.0
Census Tract 9503.01, Hickman County, Tennessee	2,269	17,343	22.8
Census Tract 1202, Houston County, Tennessee	1,654	19,025	21.8
Census Tract 1203, Houston County, Tennessee	2,297	16,625	28.1
Census Tract 1302, Humphreys County, Tennessee	1,631	19,653	20.5
Census Tract 1303, Humphreys County, Tennessee	4,067	22,662	20.0
Census Tract 9601, Jackson County, Tennessee	1,566	20,220	19.7
Census Tract 9602, Jackson County, Tennessee	2,042	17,151	23.8
Census Tract 9603, Jackson County, Tennessee	4,210	18,328	23.5
Census Tract 9604, Jackson County, Tennessee	1,794	14,718	34.3
Census Tract 9560, Johnson County, Tennessee	833	20,036	22.1
Census Tract 9561, Johnson County, Tennessee	3,837	14,215	23.4
Census Tract 9563, Johnson County, Tennessee	4,726	18,072	31.0
Census Tract 9564, Johnson County, Tennessee	4,066	18,356	28.3
Census Tract 1, Knox County, Tennessee	2,107	42,443	29.4
Census Tract 8, Knox County, Tennessee	3,099	13,805	52.2
Census Tract 9.01, Knox County, Tennessee	1,789	1,917	(no data)
Census Tract 9.02, Knox County, Tennessee	4,063	4,218	63.5
Census Tract 14, Knox County, Tennessee	1,807	7,729	69.9
Census Tract 17, Knox County, Tennessee	1,920	22,024	27.6
Census Tract 19, Knox County, Tennessee	1,297	13,901	46.6
Census Tract 20, Knox County, Tennessee	2,708	14,089	45.0
Census Tract 21, Knox County, Tennessee	2,317	16,164	37.3
Census Tract 22, Knox County, Tennessee	2,838	19,841	24.8
Census Tract 23, Knox County, Tennessee	2,922	22,845	33.7
Census Tract 24, Knox County, Tennessee	3,282	15,615	32.8
Census Tract 26, Knox County, Tennessee	1,922	13,115	50.6
Census Tract 27, Knox County, Tennessee	2,039	14,682	29.1
Census Tract 28, Knox County, Tennessee	3,616	13,667	48.8
Census Tract 29, Knox County, Tennessee	2,896	13,744	49.1
Census Tract 30, Knox County, Tennessee	3,842	21,340	21.9

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Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 32, Knox County, Tennessee	2,290	16,927	30.3
Census Tract 35, Knox County, Tennessee	4,090	28,471	27.1
Census Tract 37, Knox County, Tennessee	2,152	30,465	24.9
Census Tract 38.01, Knox County, Tennessee	3,834	21,896	29.7
Census Tract 39.02, Knox County, Tennessee	2,414	18,867	24.2
Census Tract 40, Knox County, Tennessee	3,741	21,495	21.1
Census Tract 46.15, Knox County, Tennessee	3,215	24,269	31.5
Census Tract 54.02, Knox County, Tennessee	2,516	22,050	20.9
Census Tract 65.02, Knox County, Tennessee	2,513	18,234	22.3
Census Tract 66, Knox County, Tennessee	3,070	24,669	35.3
Census Tract 67, Knox County, Tennessee	2,814	13,569	37.9
Census Tract 68, Knox County, Tennessee	4,338	12,498	51.6
Census Tract 69, Knox County, Tennessee	7,037	8,427	69.1
Census Tract 70, Knox County, Tennessee	2,027	13,434	51.6
Census Tract 9601, Lake County, Tennessee	4,644	9,031	31.0
Census Tract 9602, Lake County, Tennessee	2,003	22,122	27.4
Census Tract 501, Lauderdale County, Tennessee	3,774	7,747	20.2
Census Tract 502, Lauderdale County, Tennessee	2,765	18,629	25.4
Census Tract 505.04, Lauderdale County, Tennessee	2,311	16,547	34.0
Census Tract 505.05, Lauderdale County, Tennessee	2,573	14,540	45.3
Census Tract 505.06, Lauderdale County, Tennessee	1,948	20,298	20.7
Census Tract 9603, Lawrence County, Tennessee	4,250	13,521	43.3
Census Tract 9605.01, Lawrence County, Tennessee	3,273	14,545	32.9
Census Tract 9702, Lewis County, Tennessee	6,096	19,013	24.4
Census Tract 9753, Lincoln County, Tennessee	4,887	20,426	24.8
Census Tract 9754, Lincoln County, Tennessee	3,392	27,885	20.7
Census Tract 9755, Lincoln County, Tennessee	3,998	19,350	23.9
Census Tract 602.02, Loudon County, Tennessee	5,769	15,763	27.2
Census Tract 607, Loudon County, Tennessee	2,431	21,126	20.0
Census Tract 9702, McMinn County, Tennessee	5,161	13,902	35.7
Census Tract 9703, McMinn County, Tennessee	2,691	16,510	22.9
Census Tract 9705, McMinn County, Tennessee	3,218	18,008	20.7
Census Tract 9706, McMinn County, Tennessee	5,935	18,438	22.2
Census Tract 9301, McNairy County, Tennessee	3,409	15,364	22.7
Census Tract 9302, McNairy County, Tennessee	1,764	16,185	24.6
Census Tract 9303, McNairy County, Tennessee	2,329	16,949	23.4
Census Tract 9304, McNairy County, Tennessee	1,681	22,860	20.7
Census Tract 9305, McNairy County, Tennessee	6,274	17,723	30.2
Census Tract 9701, Macon County, Tennessee	3,788	15,388	29.3
Census Tract 2, Madison County, Tennessee	4,672	20,680	33.3
Census Tract 3, Madison County, Tennessee	3,902	20,787	22.5

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Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 4, Madison County, Tennessee	2,701	16,408	33.3
Census Tract 5, Madison County, Tennessee	3,137	12,814	46.7
Census Tract 6, Madison County, Tennessee	1,649	17,779	23.7
Census Tract 7, Madison County, Tennessee	1,936	15,116	32.3
Census Tract 8, Madison County, Tennessee	1,385	8,858	63.8
Census Tract 9, Madison County, Tennessee	1,776	13,214	43.6
Census Tract 10, Madison County, Tennessee	1,620	11,826	41.1
Census Tract 11, Madison County, Tennessee	747	13,383	40.1
Census Tract 14.01, Madison County, Tennessee	1,525	16,546	27.5
Census Tract 16.05, Madison County, Tennessee	2,617	24,113	26.5
Census Tract 501.02, Marion County, Tennessee	4,736	19,969	23.5
Census Tract 503.01, Marion County, Tennessee	4,461	19,577	28.2
Census Tract 9553, Marshall County, Tennessee	3,277	13,519	38.2
Census Tract 105, Maury County, Tennessee	3,443	16,145	36.9
Census Tract 106, Maury County, Tennessee	3,859	17,217	23.4
Census Tract 107, Maury County, Tennessee	3,596	18,372	28.8
Census Tract 108.02, Maury County, Tennessee	5,594	17,806	26.7
Census Tract 110.02, Maury County, Tennessee	5,578	18,650	23.7
Census Tract 9601, Meigs County, Tennessee	2,477	21,047	20.0
Census Tract 9603, Meigs County, Tennessee	3,355	18,750	20.4
Census Tract 9251, Monroe County, Tennessee	6,600	18,385	22.5
Census Tract 9254, Monroe County, Tennessee	6,668	17,635	26.2
Census Tract 9255.01, Monroe County, Tennessee	2,643	17,913	22.8
Census Tract 1001, Montgomery County, Tennessee	1,181	14,711	47.2
Census Tract 1002, Montgomery County, Tennessee	1,321	17,746	19.8
Census Tract 1003, Montgomery County, Tennessee	4,367	19,634	26.5
Census Tract 1004, Montgomery County, Tennessee	2,564	12,595	38.9
Census Tract 1007, Montgomery County, Tennessee	1,051	23,956	27.0
Census Tract 1008, Montgomery County, Tennessee	2,217	11,933	50.7
Census Tract 1009, Montgomery County, Tennessee	1,668	22,831	30.2
Census Tract 1010.01, Montgomery County, Tennessee	3,127	16,377	20.0
Census Tract 1011.01, Montgomery County, Tennessee	1,942	17,587	22.7
Census Tract 1011.02, Montgomery County, Tennessee	5,918	21,861	23.0
Census Tract 1012.01, Montgomery County, Tennessee	1,580	19,792	21.9
Census Tract 1013.04, Montgomery County, Tennessee	3,962	16,602	21.1
Census Tract 1013.07, Montgomery County, Tennessee	1,878	17,041	26.4
Census Tract 1016, Montgomery County, Tennessee	4,442	22,511	21.1
Census Tract 1101, Morgan County, Tennessee	2,156	18,302	28.4
Census Tract 1103, Morgan County, Tennessee	5,394	10,994	22.5
Census Tract 1104, Morgan County, Tennessee	3,813	23,353	23.7
Census Tract 1105, Morgan County, Tennessee	3,987	19,731	25.4

Appendix D2: Environmental Justice

Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 9654, Obion County, Tennessee	3,558	21,795	21.8
Census Tract 9655, Obion County, Tennessee	1,859	15,422	29.0
Census Tract 9656, Obion County, Tennessee	2,822	14,586	35.5
Census Tract 9657, Obion County, Tennessee	3,845	24,604	21.1
Census Tract 9659, Obion County, Tennessee	1,007	19,664	20.2
Census Tract 9501, Overton County, Tennessee	1,459	18,083	26.3
Census Tract 9503.02, Overton County, Tennessee	2,393	20,517	24.8
Census Tract 9505, Overton County, Tennessee	4,945	19,945	20.6
Census Tract 9506, Overton County, Tennessee	2,063	18,301	19.8
Census Tract 9301, Perry County, Tennessee	2,489	22,115	33.7
Census Tract 9302, Perry County, Tennessee	3,857	16,330	25.2
Census Tract 9501, Polk County, Tennessee	1,219	21,535	26.4
Census Tract 9502.01, Polk County, Tennessee	1,662	21,969	23.4
Census Tract 9504, Polk County, Tennessee	3,105	21,289	20.1
Census Tract 1, Putnam County, Tennessee	4,207	18,496	27.3
Census Tract 3.02, Putnam County, Tennessee	5,682	14,172	49.7
Census Tract 3.03, Putnam County, Tennessee	1,839	18,196	30.9
Census Tract 5, Putnam County, Tennessee	1,818	24,663	34.5
Census Tract 6, Putnam County, Tennessee	3,189	26,947	21.7
Census Tract 7, Putnam County, Tennessee	2,953	13,863	39.6
Census Tract 8, Putnam County, Tennessee	5,409	8,457	46.7
Census Tract 9750, Rhea County, Tennessee	4,062	21,562	27.0
Census Tract 9753, Rhea County, Tennessee	4,640	16,884	26.1
Census Tract 9754.01, Rhea County, Tennessee	5,762	15,935	29.8
Census Tract 305, Roane County, Tennessee	3,422	14,112	37.8
Census Tract 306, Roane County, Tennessee	3,057	24,625	19.8
Census Tract 308, Roane County, Tennessee	4,966	16,183	25.1
Census Tract 803.01, Robertson County, Tennessee	1,966	19,484	21.6
Census Tract 803.02, Robertson County, Tennessee	2,073	18,573	32.1
Census Tract 804.01, Robertson County, Tennessee	3,801	16,627	29.1
Census Tract 403.05, Rutherford County, Tennessee	1,929	16,467	26.8
Census Tract 404.03, Rutherford County, Tennessee	5,588	19,665	25.2
Census Tract 411.02, Rutherford County, Tennessee	2,283	21,924	28.7
Census Tract 414.01, Rutherford County, Tennessee	3,861	37,325	20.4
Census Tract 414.02, Rutherford County, Tennessee	5,069	19,360	32.4
Census Tract 414.03, Rutherford County, Tennessee	7,404	21,383	33.5
Census Tract 415, Rutherford County, Tennessee	2,713	3,147	62.5
Census Tract 416, Rutherford County, Tennessee	5,359	18,571	29.7
Census Tract 418, Rutherford County, Tennessee	3,420	14,974	31.1
Census Tract 419, Rutherford County, Tennessee	3,270	15,072	35.7
Census Tract 421, Rutherford County, Tennessee	8,041	18,513	32.1

Appendix D2: Environmental Justice
Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 9750, Scott County, Tennessee	2,874	16,101	26.7
Census Tract 9751, Scott County, Tennessee	5,477	31,104	27.0
Census Tract 9752, Scott County, Tennessee	5,058	14,363	34.5
Census Tract 9753, Scott County, Tennessee	1,642	16,008	23.1
Census Tract 601.02, Sequatchie County, Tennessee	1,914	19,023	25.7
Census Tract 805, Sevier County, Tennessee	4,128	21,876	22.3
Census Tract 808.01, Sevier County, Tennessee	2,330	14,409	39.7
Census Tract 811.01, Sevier County, Tennessee	1,661	26,753	22.6
Census Tract 2, Shelby County, Tennessee	665	9,578	53.4
Census Tract 3, Shelby County, Tennessee	788	12,041	32.1
Census Tract 4, Shelby County, Tennessee	1,206	9,329	50.6
Census Tract 6, Shelby County, Tennessee	1,710	12,884	37.0
Census Tract 7, Shelby County, Tennessee	3,478	17,284	41.2
Census Tract 8, Shelby County, Tennessee	1,660	8,460	56.7
Census Tract 9, Shelby County, Tennessee	2,107	10,964	47.4
Census Tract 11, Shelby County, Tennessee	2,129	14,498	41.7
Census Tract 12, Shelby County, Tennessee	2,959	17,974	22.5
Census Tract 13, Shelby County, Tennessee	2,619	15,387	54.6
Census Tract 14, Shelby County, Tennessee	1,209	10,770	37.9
Census Tract 15, Shelby County, Tennessee	1,205	15,159	27.1
Census Tract 19, Shelby County, Tennessee	1,115	13,351	23.4
Census Tract 20, Shelby County, Tennessee	1,360	11,839	44.4
Census Tract 21, Shelby County, Tennessee	1,055	24,603	50.1
Census Tract 24, Shelby County, Tennessee	1,716	13,055	46.4
Census Tract 25, Shelby County, Tennessee	2,332	23,981	31.8
Census Tract 27, Shelby County, Tennessee	1,566	18,532	41.7
Census Tract 28, Shelby County, Tennessee	2,431	14,943	45.8
Census Tract 30, Shelby County, Tennessee	2,979	21,796	25.8
Census Tract 32, Shelby County, Tennessee	3,493	26,478	20.9
Census Tract 34, Shelby County, Tennessee	2,170	32,182	26.0
Census Tract 36, Shelby County, Tennessee	1,591	27,938	35.9
Census Tract 37, Shelby County, Tennessee	1,115	14,899	50.3
Census Tract 38, Shelby County, Tennessee	1,081	17,316	43.0
Census Tract 39, Shelby County, Tennessee	1,175	16,031	52.1
Census Tract 45, Shelby County, Tennessee	429	10,070	58.2
Census Tract 46, Shelby County, Tennessee	1,063	16,330	40.8
Census Tract 50, Shelby County, Tennessee	759	8,444	55.2
Census Tract 53, Shelby County, Tennessee	2,450	13,635	33.9
Census Tract 55, Shelby County, Tennessee	1,882	14,634	32.8
Census Tract 56, Shelby County, Tennessee	3,087	16,529	25.4
Census Tract 57, Shelby County, Tennessee	1,925	12,963	30.8

Appendix D2: Environmental Justice
Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 58, Shelby County, Tennessee	730	11,123	52.6
Census Tract 59, Shelby County, Tennessee	1,871	10,117	43.9
Census Tract 60, Shelby County, Tennessee	1,650	12,820	36.1
Census Tract 62, Shelby County, Tennessee	1,610	19,290	27.9
Census Tract 64, Shelby County, Tennessee	1,645	19,915	34.4
Census Tract 65, Shelby County, Tennessee	1,940	17,550	45.0
Census Tract 66, Shelby County, Tennessee	1,897	25,243	31.0
Census Tract 67, Shelby County, Tennessee	2,404	10,423	58.5
Census Tract 68, Shelby County, Tennessee	1,769	12,668	44.4
Census Tract 69, Shelby County, Tennessee	2,698	14,203	44.1
Census Tract 70, Shelby County, Tennessee	2,923	14,362	34.4
Census Tract 73, Shelby County, Tennessee	4,798	20,448	38.7
Census Tract 74, Shelby County, Tennessee	2,766	24,165	31.0
Census Tract 75, Shelby County, Tennessee	1,203	11,058	39.8
Census Tract 78.10, Shelby County, Tennessee	1,886	13,054	42.3
Census Tract 78.21, Shelby County, Tennessee	4,099	12,045	52.2
Census Tract 78.22, Shelby County, Tennessee	1,316	12,117	46.9
Census Tract 79, Shelby County, Tennessee	4,421	14,143	30.6
Census Tract 80, Shelby County, Tennessee	4,100	17,663	26.2
Census Tract 81.10, Shelby County, Tennessee	2,045	12,799	41.8
Census Tract 81.20, Shelby County, Tennessee	3,368	18,035	32.2
Census Tract 82, Shelby County, Tennessee	3,638	11,034	52.1
Census Tract 87, Shelby County, Tennessee	3,451	20,879	23.9
Census Tract 88, Shelby County, Tennessee	5,043	10,453	44.0
Census Tract 89, Shelby County, Tennessee	3,121	9,368	50.6
Census Tract 91, Shelby County, Tennessee	1,981	11,816	35.7
Census Tract 97, Shelby County, Tennessee	2,046	18,673	26.1
Census Tract 98, Shelby County, Tennessee	2,719	16,410	28.0
Census Tract 99.01, Shelby County, Tennessee	2,092	14,842	48.9
Census Tract 99.02, Shelby County, Tennessee	1,934	17,446	49.0
Census Tract 100, Shelby County, Tennessee	5,282	13,807	29.4
Census Tract 101.10, Shelby County, Tennessee	5,024	8,233	61.3
Census Tract 101.20, Shelby County, Tennessee	3,301	10,339	52.2
Census Tract 102.10, Shelby County, Tennessee	4,136	13,357	36.3
Census Tract 102.20, Shelby County, Tennessee	5,302	14,985	41.0
Census Tract 103, Shelby County, Tennessee	1,132	9,644	54.6
Census Tract 105, Shelby County, Tennessee	1,336	13,426	34.9
Census Tract 106.10, Shelby County, Tennessee	4,810	12,515	34.4
Census Tract 106.20, Shelby County, Tennessee	2,442	11,829	36.3
Census Tract 106.30, Shelby County, Tennessee	2,568	9,969	55.3
Census Tract 107.10, Shelby County, Tennessee	3,660	17,289	26.0

Appendix D2: Environmental Justice

Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 107.20, Shelby County, Tennessee	2,878	15,287	41.7
Census Tract 108.10, Shelby County, Tennessee	4,606	15,594	34.1
Census Tract 108.20, Shelby County, Tennessee	3,390	18,906	22.3
Census Tract 110.10, Shelby County, Tennessee	3,237	16,022	35.1
Census Tract 110.20, Shelby County, Tennessee	981	19,092	27.0
Census Tract 111, Shelby County, Tennessee	1,278	15,362	42.9
Census Tract 112, Shelby County, Tennessee	1,248	11,775	55.0
Census Tract 113, Shelby County, Tennessee	1,172	17,224	47.0
Census Tract 114, Shelby County, Tennessee	4,640	8,968	69.0
Census Tract 115, Shelby County, Tennessee	2,135	10,565	43.7
Census Tract 116, Shelby County, Tennessee	2,014	9,110	46.3
Census Tract 117, Shelby County, Tennessee	1,172	13,000	49.3
Census Tract 118, Shelby County, Tennessee	4,354	17,115	31.9
Census Tract 201.01, Shelby County, Tennessee	3,049	21,207	34.9
Census Tract 203, Shelby County, Tennessee	4,451	23,303	32.1
Census Tract 205.12, Shelby County, Tennessee	3,940	22,064	36.6
Census Tract 205.21, Shelby County, Tennessee	2,658	10,501	45.7
Census Tract 205.23, Shelby County, Tennessee	2,233	11,838	40.8
Census Tract 205.24, Shelby County, Tennessee	3,370	18,193	30.3
Census Tract 205.41, Shelby County, Tennessee	4,446	21,863	20.5
Census Tract 205.42, Shelby County, Tennessee	3,910	14,070	37.6
Census Tract 211.11, Shelby County, Tennessee	2,913	19,624	21.9
Census Tract 212, Shelby County, Tennessee	3,958	4,815	(no data)
Census Tract 216.20, Shelby County, Tennessee	2,666	25,271	30.3
Census Tract 217.10, Shelby County, Tennessee	2,047	17,670	29.0
Census Tract 217.21, Shelby County, Tennessee	3,659	14,230	40.0
Census Tract 217.25, Shelby County, Tennessee	3,586	20,253	20.4
Census Tract 217.26, Shelby County, Tennessee	3,236	15,575	37.3
Census Tract 217.31, Shelby County, Tennessee	1,921	15,462	36.7
Census Tract 217.32, Shelby County, Tennessee	4,314	18,810	29.4
Census Tract 217.41, Shelby County, Tennessee	5,791	16,142	40.4
Census Tract 217.47, Shelby County, Tennessee	2,784	19,781	20.1
Census Tract 217.54, Shelby County, Tennessee	3,135	21,992	20.9
Census Tract 219, Shelby County, Tennessee	3,959	15,136	32.0
Census Tract 220.22, Shelby County, Tennessee	2,234	10,483	51.0
Census Tract 220.23, Shelby County, Tennessee	1,445	24,128	22.9
Census Tract 220.24, Shelby County, Tennessee	2,583	22,828	24.9
Census Tract 221.11, Shelby County, Tennessee	4,102	15,620	29.6
Census Tract 221.12, Shelby County, Tennessee	4,957	14,483	34.0
Census Tract 221.22, Shelby County, Tennessee	3,027	18,814	25.3
Census Tract 221.30, Shelby County, Tennessee	4,585	20,381	28.8

Appendix D2: Environmental Justice

Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 222.10, Shelby County, Tennessee	3,622	14,130	36.9
Census Tract 222.20, Shelby County, Tennessee	3,047	17,186	21.7
Census Tract 223.10, Shelby County, Tennessee	4,186	13,953	41.0
Census Tract 223.22, Shelby County, Tennessee	3,241	18,457	25.9
Census Tract 223.30, Shelby County, Tennessee	3,656	14,977	22.3
Census Tract 225, Shelby County, Tennessee	3,766	18,736	25.3
Census Tract 226, Shelby County, Tennessee	3,083	17,074	24.3
Census Tract 227, Shelby County, Tennessee	5,089	13,177	27.3
Census Tract 9801, Shelby County, Tennessee	65	8,348	78.5
Census Tract 9804, Shelby County, Tennessee	494	4,765	(no data)
Census Tract 9751, Smith County, Tennessee	2,306	23,051	24.2
Census Tract 1106, Stewart County, Tennessee	2,338	20,222	21.2
Census Tract 1107, Stewart County, Tennessee	3,948	21,828	20.0
Census Tract 402, Sullivan County, Tennessee	2,266	18,742	29.3
Census Tract 403, Sullivan County, Tennessee	2,265	19,963	21.5
Census Tract 405, Sullivan County, Tennessee	3,584	14,556	37.3
Census Tract 406, Sullivan County, Tennessee	2,459	14,154	42.9
Census Tract 408, Sullivan County, Tennessee	2,720	15,845	26.0
Census Tract 411, Sullivan County, Tennessee	2,056	24,442	20.7
Census Tract 417, Sullivan County, Tennessee	2,704	16,866	22.4
Census Tract 418, Sullivan County, Tennessee	3,781	17,589	24.8
Census Tract 420, Sullivan County, Tennessee	2,889	20,569	19.7
Census Tract 427.01, Sullivan County, Tennessee	3,770	17,435	22.0
Census Tract 428.02, Sullivan County, Tennessee	3,756	16,625	30.1
Census Tract 430, Sullivan County, Tennessee	3,861	17,648	22.5
Census Tract 431, Sullivan County, Tennessee	2,609	19,636	22.2
Census Tract 433.02, Sullivan County, Tennessee	5,058	19,314	22.8
Census Tract 434.01, Sullivan County, Tennessee	4,261	25,239	26.9
Census Tract 201.01, Sumner County, Tennessee	3,045	21,311	22.4
Census Tract 203, Sumner County, Tennessee	3,752	15,423	26.1
Census Tract 207, Sumner County, Tennessee	3,743	18,771	26.9
Census Tract 208, Sumner County, Tennessee	5,378	13,723	22.9
Census Tract 401, Tipton County, Tennessee	4,058	21,881	20.7
Census Tract 406.01, Tipton County, Tennessee	3,981	18,836	21.0
Census Tract 407, Tipton County, Tennessee	3,829	17,052	31.8
Census Tract 802, Unicoi County, Tennessee	5,565	17,424	26.0
Census Tract 804, Unicoi County, Tennessee	2,954	21,394	21.7
Census Tract 401, Union County, Tennessee	5,307	18,383	21.7
Census Tract 402.01, Union County, Tennessee	3,244	17,118	20.3
Census Tract 402.02, Union County, Tennessee	4,623	18,629	29.7
Census Tract 9250, Van Buren County, Tennessee	2,104	21,090	20.0

Appendix D2: Environmental Justice
Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 9304, Warren County, Tennessee	4,899	18,342	24.4
Census Tract 9305, Warren County, Tennessee	4,239	15,158	30.0
Census Tract 9306, Warren County, Tennessee	3,143	17,687	26.6
Census Tract 601, Washington County, Tennessee	2,997	18,897	40.7
Census Tract 605.01, Washington County, Tennessee	3,960	22,652	26.6
Census Tract 606, Washington County, Tennessee	6,400	21,873	27.5
Census Tract 607, Washington County, Tennessee	1,945	6,358	(no data)
Census Tract 608, Washington County, Tennessee	2,670	18,472	37.7
Census Tract 609, Washington County, Tennessee	4,701	13,798	45.6
Census Tract 610, Washington County, Tennessee	1,750	14,392	38.5
Census Tract 612, Washington County, Tennessee	2,826	23,339	24.6
Census Tract 620, Washington County, Tennessee	3,111	21,394	24.8
Census Tract 9504, Wayne County, Tennessee	2,504	17,685	24.9
Census Tract 9681.01, Weakley County, Tennessee	2,718	19,832	30.5
Census Tract 9682.02, Weakley County, Tennessee	2,591	3,775	80.4
Census Tract 9682.03, Weakley County, Tennessee	2,465	16,722	36.4
Census Tract 9685, Weakley County, Tennessee	3,390	19,090	19.7
Census Tract 9350, White County, Tennessee	3,390	18,511	20.2
Census Tract 9352, White County, Tennessee	3,077	17,933	21.1
Census Tract 9354, White County, Tennessee	3,162	14,112	22.1
Census Tract 9355, White County, Tennessee	2,763	15,909	28.0
Census Tract 508, Williamson County, Tennessee	5,052	34,235	20.3
Census Tract 305, Wilson County, Tennessee	4,887	17,277	21.5
Census Tract 307, Wilson County, Tennessee	2,422	14,483	38.1
Census Tract 9501, Lee County, Virginia	2,391	15,912	25.1
Census Tract 9502, Lee County, Virginia	3,608	22,046	21.1
Census Tract 9503, Lee County, Virginia	4,588	14,204	32.3
Census Tract 9504, Lee County, Virginia	2,582	14,307	32.2
Census Tract 9505, Lee County, Virginia	4,133	19,563	24.3
Census Tract 9506, Lee County, Virginia	3,487	20,095	23.4
Census Tract 302, Scott County, Virginia	3,508	17,461	21.7
Census Tract 303, Scott County, Virginia	2,813	18,514	21.9
Census Tract 304, Scott County, Virginia	3,041	21,301	25.5
Census Tract 105.02, Washington County, Virginia	3,650	17,269	32.1
Census Tract 9307, Wise County, Virginia	2,821	15,463	20.2
Census Tract 9311, Wise County, Virginia	2,083	15,589	32.8
Census Tract 9312, Wise County, Virginia	5,509	19,394	26.1
Census Tract 9315, Wise County, Virginia	3,838	18,198	25.9
Census Tract 9316, Wise County, Virginia	2,224	17,596	26.3
Census Tract 9317, Wise County, Virginia	1,724	20,592	21.1
Census Tract 202, Bristol city, Virginia	4,079	22,120	27.7

Appendix D2: Environmental Justice

Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 203, Bristol city, Virginia	2,153	14,950	40.8
Census Tract 9601, Norton city, Virginia	3,200	19,522	26.5

Appendix D3: Environmental Justice
Minority Populations in the TVA Service Area

Geography	2016 Population	% Minority Pop.	% White Alone	% Black/African American	% American Indian/Alaska Native	% Asian	% Native Hawaiian/Other Pacific Islander	% Some Other Race Alone	% Two or More Races	% Hispanic/Latino of Any Race
Blount County, Alabama	57,704	4.6	95.4	2	1.2	0.5	0.1	0.9	1.6	8.7
Cherokee County, Alabama	25,897	6.7	93.3	5	1.3	0.4	0	0	1	1.6
Colbert County, Alabama	54,377	20.2	79.8	17	1.3	0.8	0.1	1.4	2.3	2.4
Cullman County, Alabama	81,316	4.1	95.9	1.5	1.2	0.6	0	0.8	1.1	4.2
DeKalb County, Alabama	70,937	12.8	87.2	2	2.7	0.4	0.7	7	2.2	14
Etowah County, Alabama	103,363	18.7	81.3	16.1	1.1	0.9	0.1	0.6	1.5	3.6
Franklin County, Alabama	31,573	10.9	89.1	5	1.3	0.6	0.1	4.4	1.1	16
Jackson County, Alabama	52,608	8.9	91.1	4	3.2	0.6	0.1	1.2	3.2	2.7
Lauderdale County, Alabama	92,641	13	87	10.9	0.9	0.8	0.1	0.4	1.8	2.4
Lawrence County, Alabama	33,433	21.9	78.1	12.2	9.1	0.4	0.2	0.4	5.5	2.1
Limestone County, Alabama	90,257	18.5	81.5	14	1.3	1.8	0.1	1.6	2.5	5.7
Madison County, Alabama	349,973	31.2	68.8	25.5	1.8	3.3	0.3	1.2	2.9	4.7
Marshall County, Alabama	94,534	7.5	92.5	2.8	1.4	0.8	0	2.7	1.8	12.9
Morgan County, Alabama	119,555	18.1	81.9	13.2	1.9	0.9	0	2.3	2.4	7.8
Winston County, Alabama	24,013	3.4	96.6	0.5	2.3	0.3	0	0.2	1.8	2.9
Catoosa County, Georgia	65,645	6.8	93.2	3.4	1	1.9	0	0.8	1.8	2.7
Chattooga County, Georgia	25,046	13.3	86.7	11.1	0.6	0.7	0.1	1.1	0.9	4.6
Dade County, Georgia	16,356	4.8	95.2	1	1.1	1.6	0.6	0.7	1.4	2.1
Fannin County, Georgia	24,017	2.8	97.2	0.3	1.7	0.7	0.1	0.1	1.5	2
Gilmer County, Georgia	28,956	9.6	90.4	1.2	3.2	0.8	0	4.5	1.3	10.9
Gordon County, Georgia	56,079	10.2	89.8	4.9	1.5	1.2	0.2	2.8	1.4	15
Murray County, Georgia	39,358	3.3	96.7	1.2	0.6	0.5	0	1	0.8	14
Towns County, Georgia	10,976	3.5	96.5	1.4	1.5	0.2	0	0.3	1	2.4
Union County, Georgia	22,033	3	97	0.7	1.3	0.8	0	0.3	0.5	2.9
Walker County, Georgia	68,143	7.5	92.5	5.1	0.8	0.7	0	1	1.7	1.9
Whitfield County, Georgia	103,653	11.7	88.3	4.5	1.2	1.7	0.2	4.5	1.7	33.5
Allen County, Kentucky	20,421	3.5	96.5	2	0.3	0.4	0	0.9	0.8	1.9
Butler County, Kentucky	12,828	3.6	96.4	1.3	1	0	0	1.3	0.8	3.4
Calloway County, Kentucky	38,302	8.5	91.5	4.9	0.9	2.3	0.1	0.5	2.7	2.5
Carlisle County, Kentucky	4,954	3.5	96.5	2.4	0.6	0.1	0	0.4	0.9	2.2
Christian County, Kentucky	73,936	28.2	71.8	23.2	1.4	2.2	1	1.2	4.2	7.3
Cumberland County, Kentucky	6,780	5.4	94.6	4.5	0.1	0.8	0	0	1.7	0.2
Edmonson County, Kentucky	12,086	3.7	96.3	2.7	0.9	0.3	0.1	0.3	1.7	1.2
Fulton County, Kentucky	6,323	28.8	71.2	27.4	0.9	0.3	0.1	0.4	2	0.6
Graves County, Kentucky	37,379	9.1	90.9	5.5	1	0.6	0.5	1.7	2.1	5.9
Grayson County, Kentucky	26,092	3.8	96.2	1.7	0.7	0.2	0.1	1.1	0.8	1.2

Appendix D3: Environmental Justice

Minority Populations in the TVA Service Area

Geography	2016 Population	% Minority Pop.	% White Alone	% Black/African American	% American Indian/Alaska Native	% Asian	% Native Hawaiian/Other Pacific Islander	% Some Other Race Alone	% Two or More Races	% Hispanic/Latino of Any Race
Hickman County, Kentucky	4,691	11.8	88.2	9.9	0.4	1.4	0	0.2	1.8	0.9
Livingston County, Kentucky	9,353	2.5	97.5	0.7	1.7	0.1	0	0	1.6	1.5
Logan County, Kentucky	26,757	9.4	90.6	8.2	0.4	0.1	0	0.8	2.2	2.6
Lyon County, Kentucky	8,325	7.8	92.2	6.2	0.8	0.5	0.2	0.4	1.3	1.4
Marshall County, Kentucky	31,213	2	98	1	0.3	0.5	0	0.3	0.9	1.3
Monroe County, Kentucky	10,692	3.9	96.1	3	0.2	0.1	0	0.6	0.6	2.9
Simpson County, Kentucky	17,856	14.3	85.7	11.1	0.9	0.5	0	2	1.5	2.1
Todd County, Kentucky	12,465	13.5	86.5	9	0.8	0.2	0	3.7	1.8	3.9
Trigg County, Kentucky	14,267	9.9	90.1	9.2	0.1	0.7	0	0.2	0.7	1.9
Warren County, Kentucky	121,066	17.9	82.1	10.4	0.8	3.5	0.4	3.3	1.9	5
Alcorn County, Mississippi	37,309	15.3	84.7	12.8	0.6	0.7	0	1.5	2	3.1
Attala County, Mississippi	19,085	45	55	43.7	0.5	0.5	0	0.7	1.4	1.9
Benton County, Mississippi	8,378	38.9	61.1	37	0.5	0	0	1.4	0.2	2.3
Calhoun County, Mississippi	14,724	32.5	67.5	28.5	0.1	0.1	0.6	3.3	1.4	5.5
Chickasaw County, Mississippi	17,357	45.6	54.4	44.1	0.6	0.8	0.3	0.8	1.2	4.2
Choctaw County, Mississippi	8,320	32.2	67.8	31.7	0.3	0.1	0.2	0.1	0.3	0.3
Clay County, Mississippi	20,147	59.5	40.5	58.4	0.4	0.7	0	0.1	0.3	1.3
DeSoto County, Mississippi	170,890	29.3	70.7	25.7	0.6	1.7	0	1.5	1.8	4.7
Itawamba County, Mississippi	23,511	8.6	91.4	7.4	0.2	0.4	0	0.7	0.9	1.4
Kemper County, Mississippi	10,128	64.5	35.5	60.8	3.7	0	0	0	0.5	1.5
Lafayette County, Mississippi	52,193	27.8	72.2	24.4	0.2	2.5	0.2	0.7	1.2	2.4
Leake County, Mississippi	23,011	48.3	51.7	42	6	0.4	0	0.1	0.3	4.3
Lee County, Mississippi	85,281	31.5	68.5	29.2	0.6	1.1	0	1	1.2	2.4
Lowndes County, Mississippi	59,785	46.1	53.9	44.2	0.4	1.1	0.1	0.5	1	1.9
Marshall County, Mississippi	36,196	50.8	49.2	48.4	0.7	0.1	0	1.8	1.1	3.4
Monroe County, Mississippi	36,029	32	68	31.1	0.6	0.2	0	0.1	1.3	1.1
Neshoba County, Mississippi	29,474	39.9	60.1	21.8	17.5	0.8	0	0.3	1.8	1.9
Noxubee County, Mississippi	11,098	69.9	30.1	69.2	0.5	0	0	0.2	0	4
Oktibbeha County, Mississippi	49,424	42	58	37.6	0.5	3.6	0.1	0.8	1.4	1.6
Panola County, Mississippi	34,319	51.5	48.5	51	0.2	0.1	0.1	0.2	1	1.6
Pontotoc County, Mississippi	30,862	19.4	80.6	15.7	0.6	0.4	0	2.9	1.3	6.1
Prentiss County, Mississippi	25,339	16.1	83.9	15	0.2	0.2	0	0.7	1.8	1.3
Scott County, Mississippi	28,268	42	58	37.8	0.8	1.1	0	2.3	0	10.8
Tallahatchie County, Mississippi	14,776	62.3	37.7	46.7	0.6	1.6	0.4	13.3	0.4	15.2
Tate County, Mississippi	28,338	33	67	31.6	0.5	0.3	0.2	0.5	1.6	2.5
Tippah County, Mississippi	22,061	19.2	80.8	17.7	0.2	0.6	0.1	0.9	1.1	4.8

Appendix D3: Environmental Justice
Minority Populations in the TVA Service Area

Geography	2016 Population	% Minority Pop.	% White Alone	% Black/African American	% American Indian/Alaska Native	% Asian	% Native Hawaiian/Other Pacific Islander	% Some Other Race Alone	% Two or More Races	% Hispanic/Latino of Any Race
Tishomingo County, Mississippi	19,503	5.1	94.9	3.2	0.5	0.2	0	1.3	0.9	2.7
Union County, Mississippi	27,989	17.8	82.2	15.6	0.6	0.9	0.1	0.8	1.7	4.4
Webster County, Mississippi	9,922	20.9	79.1	19.9	0.5	0.4	0	0.3	1.1	1.4
Winston County, Mississippi	18,519	48.8	51.2	48	0.5	0	0	0.4	0.1	1.1
Yalobusha County, Mississippi	12,380	41.3	58.7	40	0.6	0.2	0.1	0.4	0.3	1.5
Avery County, North Carolina	17,633	8.1	91.9	4.3	1	0.9	0.1	2	1.4	5
Cherokee County, North Carolina	27,226	6.3	93.7	1.9	3	0.8	0	0.8	2.1	2.9
Clay County, North Carolina	10,730	0.8	99.2	0.4	0	0.1	0	0.2	0.2	3.2
Watauga County, North Carolina	52,745	6	94	1.7	1.4	1.4	0	1.6	2.4	3.4
Anderson County, Tennessee	75,545	8.2	91.8	5	1.1	1.6	0.1	0.6	2.3	2.5
Bedford County, Tennessee	46,331	16.2	83.8	9.8	1.4	0.5	0.3	4.7	2.8	11.5
Benton County, Tennessee	16,173	4.8	95.2	3	1	0.7	0	0.1	0.8	2.2
Bledsoe County, Tennessee	14,073	8.3	91.7	4.5	3.4	0.1	0	0.3	3.8	2.1
Blount County, Tennessee	126,192	5.9	94.1	3.6	1	1.1	0.1	0.3	1.7	3
Bradley County, Tennessee	102,860	8.2	91.8	5.4	0.9	1.2	0	0.8	1.6	5.6
Campbell County, Tennessee	40,008	2.2	97.8	0.7	1.1	0.3	0.1	0.1	1	1.2
Cannon County, Tennessee	13,855	4.8	95.2	1.8	1.2	1.2	0	0.8	1.4	1.9
Carroll County, Tennessee	28,417	13.2	86.8	11.5	1.1	0.4	0	0.4	1.8	2.4
Carter County, Tennessee	56,707	3.4	96.6	1.9	0.8	0.5	0	0.2	1.3	1.6
Cheatham County, Tennessee	39,575	5.1	94.9	2	1	0.8	0.3	1.2	1.6	2.6
Chester County, Tennessee	17,355	13.4	86.6	9.9	0.1	1.3	0.1	2	1.1	2.3
Claiborne County, Tennessee	31,701	3.6	96.4	1.4	1	0.8	0.2	0.4	1.7	1.1
Clay County, Tennessee	7,769	3.2	96.8	1.4	1	0.4	0	0.3	0.3	2.2
Cocke County, Tennessee	35,256	4.8	95.2	2.9	1.2	0.3	0.1	0.3	2.4	2.1
Coffee County, Tennessee	53,808	9.1	90.9	2.9	2.9	1.3	0.1	2.1	3.6	4
Crockett County, Tennessee	14,558	19.7	80.3	14.5	1	0.2	0	4.2	2.4	9.9
Cumberland County, Tennessee	57,895	3	97	0.8	1	0.7	0.1	0.5	1.4	2.7
Davidson County, Tennessee	667,885	37	63	28.8	0.7	4.1	0.2	3.6	2.3	10
Decatur County, Tennessee	11,703	5	95	3.5	0.6	0.6	0.1	0.3	1.9	3.1
DeKalb County, Tennessee	19,159	5.5	94.5	2.3	0.7	0.6	0.1	1.8	1.4	7.2
Dickson County, Tennessee	50,926	7.5	92.5	5.3	0.9	0.7	0.1	0.6	2	3.1
Dyer County, Tennessee	37,970	17.6	82.4	14.9	0.8	0.8	0.2	1	2.3	3.1
Fayette County, Tennessee	39,071	30.5	69.5	28	0.6	0.8	0	1.1	0.9	2.4
Fentress County, Tennessee	17,936	2.1	97.9	0.6	0.4	0.7	0	0.3	1	1.3
Franklin County, Tennessee	41,348	9.8	90.2	4.5	2.5	1	0.1	1.9	3.6	2.9
Gibson County, Tennessee	49,511	21.5	78.5	19.2	0.6	0.4	0.1	1.1	1.8	2.5

Appendix D3: Environmental Justice

Minority Populations in the TVA Service Area

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Giles County, Tennessee	29,034	13.8	86.2	11.1	1.1	0.7	0.1	1	2.5	2.1
Grainger County, Tennessee	22,813	2.1	97.9	1.1	0.4	0.6	0	0.1	0.9	2.9
Greene County, Tennessee	68,502	5	95	2.9	0.7	0.6	0	0.9	1.5	2.7
Grundy County, Tennessee	13,494	19.5	80.5	0.8	18.2	0.5	0.2	0.1	18.1	0.2
Hamblen County, Tennessee	63,203	12	88	5.7	0.7	1	0.1	4.8	2.8	11.2
Hamilton County, Tennessee	351,305	24.7	75.3	20.7	0.7	2.4	0.1	1	1.9	5.1
Hancock County, Tennessee	6,609	2	98	0.9	0.9	0.1	0	0.1	0.8	0.7
Hardeman County, Tennessee	25,975	43.9	56.1	42.2	0.5	0.8	0	0.3	1.1	1.6
Hardin County, Tennessee	25,839	5.8	94.2	4.5	0.9	0.1	0.1	0.2	1.5	2.1
Hawkins County, Tennessee	56,567	3.8	96.2	1.8	0.8	0.6	0.1	0.5	1.4	1.3
Haywood County, Tennessee	18,129	54	46	51.1	0.6	0.2	0.5	2.6	1.1	4.2
Henderson County, Tennessee	27,952	10.9	89.1	9.4	0.6	0.2	0.1	0.9	2.1	2.2
Henry County, Tennessee	32,291	10.4	89.6	8.9	0.8	0.4	0	0.2	1.2	2.2
Hickman County, Tennessee	24,251	8.2	91.8	5.4	1.5	0.2	0	1.1	1.9	2.2
Houston County, Tennessee	8,234	5.6	94.4	4.3	1.3	0.3	0	0	1.9	2.1
Humphreys County, Tennessee	18,216	5.4	94.6	3.8	1.2	0.3	0.1	0.5	0.9	2.1
Jackson County, Tennessee	11,526	2.9	97.1	0.7	1.4	0.1	0	0.7	2.2	1.8
Jefferson County, Tennessee	52,851	4.9	95.1	2.9	0.9	0.3	0.1	0.9	1.6	3.4
Johnson County, Tennessee	17,923	6.8	93.2	4.4	1.5	0.3	0	0.9	1.4	1.8
Knox County, Tennessee	448,164	14.4	85.6	10	0.9	2.5	0.2	1.1	2.1	3.8
Lake County, Tennessee	7,643	31.6	68.4	29.8	0.6	0.5	0.1	1	1.4	2.1
Lauderdale County, Tennessee	27,261	38.2	61.8	35.6	1	0.7	0.1	1.2	1.6	2.4
Lawrence County, Tennessee	42,406	4.8	95.2	2.2	1	0.7	0.1	1	1.3	1.9
Lewis County, Tennessee	11,907	5.1	94.9	2.4	0.2	2	0	0.8	1	2.2
Lincoln County, Tennessee	33,582	10.7	89.3	6.2	3.6	0.3	0	1.2	4.2	3.1
Loudon County, Tennessee	50,637	5	95	1.8	0.8	0.9	0.1	1.5	1.4	7.9
Macon County, Tennessee	22,924	2	98	0.5	0.7	0.1	0	0.7	0.9	4.8
Madison County, Tennessee	98,128	40.4	59.6	38.1	0.6	1.3	0	0.5	1.4	3.6
Marion County, Tennessee	28,363	6.5	93.5	2.1	3.5	0.7	0.1	0.3	3.8	1.7
Marshall County, Tennessee	31,335	10	90	7.7	0.9	0.8	0	0.7	1.5	4.8
Maury County, Tennessee	85,767	15.9	84.1	13	0.8	1.1	0	1.2	2.1	5.3
McMinn County, Tennessee	52,606	7.1	92.9	4.5	1.2	0.9	0.1	0.6	2.1	3.6
McNairy County, Tennessee	26,057	8.1	91.9	6.7	0.8	0.3	0	0.3	1.6	1.9
Meigs County, Tennessee	11,804	3.8	96.2	2.7	1.4	0.2	0	0	2.3	1.5
Monroe County, Tennessee	45,482	4.9	95.1	2.6	1.5	0.6	0.2	0.2	1.5	3.9
Montgomery County, Tennessee	189,709	28.4	71.6	21.8	1.4	3.6	0.7	2.1	4.2	9.5

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Moore County, Tennessee	6,314	6.1	93.9	3.5	2.4	0	0	0.1	1	0.3
Morgan County, Tennessee	21,688	5.7	94.3	4.9	0.5	0.1	0.1	0.3	0.6	1.1
Obion County, Tennessee	30,900	14.3	85.7	11.5	0.6	0.4	0	1.8	1.9	3.8
Overton County, Tennessee	22,090	2.3	97.7	1	0.9	0.7	0	0.2	1.2	1.3
Perry County, Tennessee	7,891	5.2	94.8	3.3	1.6	0.2	0	0.2	1.7	2.2
Pickett County, Tennessee	5,096	2.6	97.4	0.9	1.7	0	0	0	1.9	0.6
Polk County, Tennessee	16,697	3.1	96.9	0.4	1.8	0.3	0	0.7	1.9	1.8
Putnam County, Tennessee	74,652	5.6	94.4	2.7	0.8	1.6	0.2	0.5	1.7	5.8
Rhea County, Tennessee	32,461	5.1	94.9	3.1	1.1	0.3	0.1	0.8	1.8	4.4
Roane County, Tennessee	52,983	5.5	94.5	3.3	1.1	0.8	0	0.4	2	1.6
Robertson County, Tennessee	67,905	11.5	88.5	8.2	0.7	0.7	0	2	1.6	6.1
Rutherford County, Tennessee	290,289	20.8	79.2	15.2	1	3.8	0.2	1.1	2.9	7.2
Scott County, Tennessee	22,029	1.8	98.2	0.8	0.8	0.1	0	0.1	0.9	0.7
Sequatchie County, Tennessee	14,710	11.2	88.8	1.4	9.5	0.6	0	0.3	10.1	3.4
Sevier County, Tennessee	94,537	5.4	94.6	1.3	0.9	1.4	0	1.9	1.6	5.4
Shelby County, Tennessee	936,990	60.4	39.6	54.2	0.7	2.9	0.2	3	1.7	6
Smith County, Tennessee	19,176	5	95	3.1	1	0.1	0	0.9	1.2	2.5
Stewart County, Tennessee	13,257	6.5	93.5	2.4	1.7	1.3	0.6	1.4	3.3	2.5
Sullivan County, Tennessee	156,644	5.3	94.7	2.9	0.9	0.9	0.1	0.8	1.9	1.7
Sumner County, Tennessee	172,786	11.3	88.7	7.6	0.7	1.7	0.1	1.2	1.8	4.3
Tipton County, Tennessee	61,558	21.9	78.1	19.4	0.9	1	0.4	0.4	1.7	2.6
Trousdale County, Tennessee	7,970	13.9	86.1	11.8	0.2	2	0	0	0.6	0.4
Unicoi County, Tennessee	17,945	2.5	97.5	1	0.3	0.5	0	0.7	0.6	4.3
Union County, Tennessee	19,081	2	98	0.5	1.2	0.3	0	0.2	1.2	1.5
Van Buren County, Tennessee	5,641	3.4	96.6	0.4	2.1	0.1	0	0.7	2.9	0.9
Warren County, Tennessee	40,099	8.1	91.9	1.7	3	0.9	0.1	2.7	3.8	8.5
Washington County, Tennessee	126,044	8.1	91.9	5.1	0.9	1.7	0.1	0.6	1.8	3.2
Wayne County, Tennessee	16,842	8.3	91.7	6.9	0.5	0.4	0	0.5	0.4	1.9
Weakley County, Tennessee	34,024	11.1	88.9	9.8	0.8	0.2	0	0.5	1.6	2.2
White County, Tennessee	26,373	3.8	96.2	2.9	0.8	0	0	0.1	1.9	2.3
Williamson County, Tennessee	205,645	10.5	89.5	4.8	0.5	4.4	0.1	0.9	1.6	4.6
Wilson County, Tennessee	125,616	11.5	88.5	7.4	0.9	1.9	0.2	1.4	1.5	3.7
Bristol city, Virginia	17,340	10.7	89.3	8	0.5	0.7	0	2	1.8	2
Lee County, Virginia	24,911	6.5	93.5	4.3	0.6	0.7	0	1.3	0.8	1.8
Norton city, Virginia	3,978	12.8	87.2	7.7	0.1	3.3	0	1.7	1.7	2.6
Scott County, Virginia	22,378	1.9	98.1	1.1	0.5	0.3	0	0.1	0.7	1.3

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Washington County, Virginia	54,562	3.7	96.3	1.8	0.6	0.6	0.1	0.8	1.2	1.4
Wise County, Virginia	40,074	7.4	92.6	6	0.5	0.6	0.1	0.4	1.2	1.2

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