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Supplement 2, Vol. 1

Final Environmental Statement

Related to the Operation of Watts Bar Nuclear Plant, Unit 2

Supplement 2

Final Report

Office of Nuclear Reactor Regulation

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Final Report

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Abstract

The U.S. Nuclear Regulatory Commission (NRC) prepared this supplemental final environmental statement in response to the Tennessee Valley Authority (TVA) application for a facility operating license. The proposed action requested is for the NRC to issue an operating license for a second light-water nuclear reactor at the Watts Bar Nuclear (WBN) Plant in Rhea County, Tennessee.

TVA received construction permits (CPs) for two units at the WBN site and began construction in 1973. In 1978, the NRC issued a final environmental statement related to the operating license for WBN Units 1 and 2. On March 4, 2009, the NRC received an update to the application from TVA for a facility operating license to possess, use, and operate WBN Unit 2. The NRC published the notice of the receipt of application and the opportunity for hearing in the *Federal Register* on May 1, 2009. NRC regulations in Title 10 of the *Code of Federal Regulations* (10 CFR) 51.92, "Supplement to the Final Environmental Impact Statement," require the NRC staff to prepare a supplement to the final environmental statement if there are substantial changes in the proposed action relevant to environmental concerns or if there are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts. The same regulation permits the NRC staff to prepare a supplement when, in its opinion, preparation of a supplement will further the interests of the National Environmental Policy Act of 1969.

This supplement documents the NRC staff's environmental review related to the operating license for WBN Unit 2. The NRC staff evaluated a full scope of environmental topics, including land and water use, air quality and meteorology, terrestrial and aquatic ecology, radiological and nonradiological impacts on humans and the environment, historic and cultural resources, socioeconomics, and environmental justice. The NRC staff's evaluations are based on (1) the application submitted by TVA, including the environmental report and previous environmental impact statements and historical documents, (2) consultation with other Federal, State, Tribal, and local agencies, (3) the NRC staff's independent review, and (4) the NRC staff's consideration of comments related to the environmental review received during the public scoping process.

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Executive Summary

On March 4, 2009, the Tennessee Valley Authority (TVA) submitted to the U.S. Nuclear Regulatory Commission (NRC) a request to reactivate its application for a license to operate a second light-water nuclear reactor at the Watts Bar Nuclear (WBN) Plant in Rhea County, Tennessee. The NRC published a notice of receipt of the application and the opportunity for hearing in the *Federal Register* on May 1, 2009 (74 FR 20350). The proposed action is NRC issuance of a 40-year facility operating license for WBN Unit 2. WBN Unit 2, a pressurized-water reactor, could produce up to 3,425 megawatts thermal. The reactor-generated heat would be used to produce steam to drive steam turbines, providing 1,160 megawatts electric of net electrical power capacity to the region.

Section 102 of the National Environmental Policy Act of 1969, as amended (NEPA) (42 U.S.C. 4321), directs that an environmental impact statement (EIS) be prepared for major Federal actions that significantly affect the quality of the human environment. In 1978, the NRC issued a final environmental statement related to the operating license for WBN Units 1 and 2 (NUREG-0498, "Final Environmental Statement Related to Operation of Watts Bar Nuclear Plant Units Nos. 1 and 2," December 1978, 1978 FES-OL) for operating Units 1 and 2 at the WBN site (the final environmental statement [FES] is an EIS equivalent). Because TVA did not operate WBN Unit 2 as scheduled, the NRC's regulations in Title 10 of the *Code of Federal Regulations* (10 CFR) 51.92, "Supplement to the Final Environmental Impact Statement," require the NRC staff to prepare a supplement to the 1978 FES-OL. The purpose of this supplement is to determine if there are substantial changes in the proposed action relevant to environmental concerns or if significant new circumstances or information exist related to environmental concerns that bear on the proposed action or its impacts.

Upon acceptance of the TVA application, the NRC began the environmental review process described in 10 CFR Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions," by publishing a notice of intent in the *Federal Register* to prepare a supplemental final environmental statement (SFES) and conduct scoping. On October 6, 2009, the NRC held two scoping meetings in Sweetwater, Tennessee, to obtain public input on the scope of the environmental review. To gather information and become familiar with the WBN site and its environs, the NRC and its contractor, Pacific Northwest National Laboratory, visited the WBN site and environs in Rhea County, Tennessee, October 6–8, 2009.

During the site visit, the NRC team met with TVA staff, public officials, and the public. The NRC reviewed the comments received during the scoping process and contacted Federal, State, Tribal, regional, and local agencies to solicit comments. This SFES includes (1) the results of the NRC staff's analyses, which consider and weigh the environmental effects of the NRC's proposed action, issuance of a facility operating license for WBN Unit 2, (2) mitigation measures for reducing or avoiding adverse effects, and (3) the NRC staff's recommendation on the proposed action.

The NRC's standard of significance for impacts was established using the Council on Environmental Quality terminology for "significant" as defined in 40 CFR 1508.27. In addition, NRC guidance states that "Information in the GEIS [Generic Environmental Impact Statement] for license renewal, for example, the impact categorization approach (i.e., SMALL, MODERATE, and LARGE), may also be used in the preparation of NEPA documents prepared in conjunction with other types of applications such as ESPs [early site permits] and COLs [combined licenses] when it is appropriate to do so." The NRC staff used the impact categorization approach in this SFES. Impact categories include:

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

The NRC staff considered potential mitigation measures for each resource category only if adverse impacts were identified.

In preparing this SFES for WBN Unit 2, the NRC staff reviewed the TVA "Final Supplemental Environmental Impact Statement for Completion and Operation of Watts Bar Nuclear Plant Unit 2," dated February 15, 2008, which TVA submitted to the NRC as the environmental report portion of its application. The NRC staff also consulted with other Federal, State, Tribal, regional, and local agencies and followed the guidance set forth in NUREG-1555, "Standard Review Plans for Environmental Reviews of Nuclear Power Plants," dated October 1999. In addition, the NRC staff considered public comments related to the environmental review received during the scoping process. Appendix D to this SFES includes these scoping comments and the NRC staff's responses to them.

The draft SFES was published in October 2011. The U.S. Environmental Protection Agency Notice of Filing in the *Federal Register* (76 FR 70130) indicated a 75-day comment period, commencing on November 10, 2011, to allow members of the public to comment on the results of the NRC staff's review. This was amended in the *Federal Register* on November 18, 2011 to a 45-day comment period (76 FR 71560). The NRC issued a Notice of Availability (76 FR 70169) of the draft SFES in the *Federal Register* that provided a 45-day comment period and announced the date and location of the public meetings. On December 8, 2011, two public meetings were held in Sweetwater, Tennessee. At the meetings, the NRC staff described the results of the NRC environmental review, answered questions related to the review, and provided members of the public with information to assist them in formulating their comments. Based on comments received at the public meetings, the comment period was extended by the NRC to January 24, 2012 (76 FR 80409). When the comment period ended on January 24, 2012, the NRC staff considered and addressed all the comments received. All comments received on the draft SFES are included in Appendix E.

In this SFES, the NRC staff concludes that impacts from the operation of WBN Unit 2 associated with water use, terrestrial resources, aquatic ecology, design-basis accidents, socioeconomics, the radiological and nonradiological environments, decommissioning, air quality, and land use are generally consistent with those reached in the 1978 FES-OL and Supplement No. 1 to the "Final Environmental Statement Related to the Operation of Watts Bar Nuclear Plant, Units 1 and 2," dated April 1995 (1995 SFES-OL-1). In some cases, the impacts were less than those identified in the 1978 FES-OL.

Groundwater quality, public services, noise, socioeconomic transportation, cultural and historical resources, environmental justice, greenhouse gas emissions, severe accidents, severe accident mitigation alternatives, and cumulative impacts were not addressed in the 1978 FES-OL but are addressed in this SFES. The NRC staff concludes that impacts associated with the operation of WBN Unit 2 on groundwater quality, public services, noise, socioeconomic transportation, cultural and historical resources, greenhouse gas emissions, and severe accidents would be SMALL. In addition, the NRC staff concludes that the operation of WBN Unit 2 would not result in a disproportionately high and adverse human health or environmental effect on any of the low-income communities near the WBN site.

The NRC staff also considered cumulative impacts from past, present, and reasonably foreseeable future actions. The NRC staff concludes that, although some of the cumulative impacts are LARGE as the result of other activities that affected the environment, the incremental impact from operation of WBN Unit 2 would in all cases be minor.

The NRC staff's recommendation to the Commission related to the environmental aspects of the proposed action is that the operating license for WBN Unit 2 be issued as proposed. This recommendation is based on (1) the application, including the February 15, 2008 final EIS submitted by TVA as the ER, and responses to staff requests for additional information submitted by TVA; (2) the NRC staff's review conducted for the 1978 FES-OL; (3) consultation with Federal, State, Tribal, and local agencies; (4) the NRC staff's own independent review of information available since the preparation and publication of the 1978 FES-OL; and (5) the assessments summarized in this SFES, including consideration of public comments received during scoping and on the draft SFES.

The NRC's final safety evaluation report, anticipated to be published in 2014, will address the NRC staff's evaluation of the site safety and emergency preparedness aspects of the proposed action.

Abbreviations/Acronyms

χ/Q	atmospheric dispersion value
°C	degree(s) Celsius
°F	degree(s) Fahrenheit
ac	acre(s)
ACRS	Advisory Committee on Reactor Safeguards
A.D.	Anno Domini
ADAMS	Agencywide Documents Access and Management System (NRC)
ADEM	Alabama Department of Environmental Management
ADTV	average daily traffic volume
AEC	U.S. Atomic Energy Commission
ALARA	as low as is reasonably achievable
AOC	averted offsite costs
AOE	averted occupational exposure
AOSC	averted onsite costs
APE	area of potential effect or averted public exposure
AQCR	Air Quality Control Region
ATWS	anticipated transient without scram
B.C.	Before Christ
BLS	Bureau of Labor Statistics
BMP	best management practice
Bq	becquerel
Btu	British thermal unit(s)
Btu/hr	British thermal unit(s) per hour
CAFTA	Computer Aided Fault Tree Analysis
CCP	centrifugal charging pump
CCS	component cooling water system
CCW	condenser circulating water or condenser cooling water
CDC	Centers for Disease Control
CDF	core damage frequency

CDWE	condensate demineralizer waste evaporator
CEQ	Council on Environmental Quality
CET	containment event trees
CFR	*Code of Federal Regulations*
cfs	cubic (foot) feet per second
Ci	curies
cm	centimeter(s)
CO_2	carbon dioxide
CORMIX	Cornell Mixing Zone Expert System
CPI	Consumer Price Index
CPPR	construction permit power reactor
CTBD	cooling-tower blowdown
CWA	Clean Water Act
CWS	Circulating Water System
dBA	decibels on the A-weighted scale
DBA	design basis accident
DC	design certification
D.C.	District of Columbia
DOE	U.S. Department of Energy
DSM	demand-side management
EAB	exclusion area boundary
ECCS	emergency core cooling system
EDG	emergency diesel generator
EIS	environmental impact statement
ELF	extremely low frequency
EMF	electromagnetic field
EO	Executive Order
EPA	U.S. Environmental Protection Agency
EPACT	1992 National Energy Policy Act
EPRI	Electric Power Research Institute
ER	environmental report
ERCW	essential raw cooling water
ESFAS	emergency safety features actuation system

ESRP	Environmental Standard Review Plan
FCC	Federal Communications Commission
FERC	Federal Energy Regulatory Commission
FES	final environmental statement
FES-CP	final environmental statement related to the construction permit for WBN Units 1 and 2
FES-OL	final environmental statement related to the operating license for WBN Units 1 and 2
FHA	fuel handling accident
FIVE	fire-induced vulnerability evaluation
FONSI	finding of no significant environmental impact
FR	*Federal Register*
FSAR	Final Safety Analysis Report
ft	foot (feet)
ft^3	cubic foot (feet)
FWS	U.S. Fish and Wildlife Service
gal	gallon(s)
GAO	U.S. General Accounting Office
GC	gaseous centrifuge
GCRP	U.S. Global Change Research Program
GD	gaseous diffusion
GEIS	Generic Environmental Impact Statement
GEIS-DECOM	Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities Regarding the Decommissioning of Nuclear Power Reactors
GHG	greenhouse gas
gpd	gallon(s) per day
gpm	gallon(s) per minute
GWPP	Ground Water Protection Program
Gy	gray(s)
ha	hectare(s)
HCLPF	high confidence of low probability of failure
HFO	high winds, floods, and other
HLW	high-level waste

HPFP	high pressure fire protection
HPI	high pressure injection
hr	hour(s)
HRA	human reliability analysis
HVAC	heating, ventilation, and air conditioning
Hz	hertz
I	Interstate
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IMP	internal monitoring point
in.	inch(es)
in.^{2}	square inch(es)
IPE	Individual Plant Examination
IPEEE	Individual Plant Examination of External Events
IPS	intake pumping station
IRP	Integrated Resource Plan
ISFSI	independent spent fuel storage installation
ISLOCA	interfacing system loss-of-coolant accidents
kg	kilogram(s)
km	kilometer(s)
km^2	square kilometer(s)
kV	kilovolt(s)
L/d	liter(s) per day
L/s	liter(s) per second
L/yr	liter(s) per year
lb	pound(s)
LCV	level control valves
LERF	large early release frequency
LLW	low-level waste
LM	log mile(s)
LOCA	loss-of-cooling accident
LOOP	loss of offsite power

LPZ	Low Population Zone
LVWTP	Low Volume Waste Treatment Pond
LWR	light water reactor
m	meter(s)
m^3/s	cubic meter(s) per second
MACR	maximum averted cost risk
MACCS2	MELCOR Accident Consequence Code System
MCR	main control room
MEI	maximally exposed individual
MGD	million gallons per day
mg/L	milligram(s) per liter
mGy	milligray(s)
mGy/yr	milligray(s) per year
MHz	megahertz
mi	mile(s)
mi^2	square mile(s)
MIT	Massachusetts Institute of Technology
MMACR	modified maximum averted cost risk
mo	month(s)
mrad	millirad(s)
mrad/d	millirad(s) per day
mrem	millirem(s)
mrem/yr	millirem(s) per year
msl	mean sea level
mSv	millisievert(s)
mSv/yr	millisievert(s) per year
MT	metric ton(s)
MW	megawatt(s)
MW(e)	megawatt(s) electric
MW(t)	megawatt(s) thermal
NCRP	National Council on Radiation Protection and Measurements
NEI	Nuclear Energy Institute
NEPA	National Environmental Policy Act of 1969, as amended

NERC	North American Electric Reliability Corporation
NESC	National Electrical Safety Code
NHPA	National Historic Preservation Act of 1966, as amended
NPDES	National Pollutant Discharge Elimination System
NPF	nuclear power facility
NRC	U.S. Nuclear Regulatory Commission
NSSS	Nuclear Steam Supply System
O&M	operation and maintenance
ODCM	Offsite Dose Calculation Manual
OL	Operating License
OSHA	Occupational Safety and Health Administration
PCB	polychlorinated biphenyl
pCi/L	picocurie(s) per liter
PDS	plant damage state
PNNL	Pacific Northwest National Laboratory
PORV	power-operated relief valves
PPA	purchased power arrangement
ppm	parts per million
PRA	probabilistic risk assessment
PWR	pressurized-water reactor
RAI	Request for Additional Information
RCP	reactor coolant pump
RCS	reactor coolant system
RCRA	Resource Conversation and Recovery Act
RCW	raw cooling water
rem	roentgen equivalent man
REMP	radiological environmental monitoring program
RLE	review level earthquake
ROI	region of influence
ROS	Reservoir Operations Study
RPS	reactor protection system
RRS	Reliability Review Subcommittee

RRW	risk-reduction worth
RWST	refueling water storage tank
Ryr	reactor-year
s/m^2	second(s) per square meter
SACE	Southern Alliance for Clean Energy
SAMA	severe accident mitigation alternative
SAMDA	severe accident mitigation design alternative
SBO	station blackout
SCCW	Supplemental Condenser Cooling Water
SEIS	supplemental environmental impact statement
SERC	Southeastern Electric Reliability Corporation
SFES	supplemental final environmental statement
SFES-OL-1	NRC 1995 Supplement No. 1 to the Final Environmental Statement related to the operating license
SFES-OL-2	NRC 2011 Supplement No. 2 to the Final Environmental Statement related to the operating license
SGTR	steam generator tube rupture
SHPO	State Historic Preservation Officer
SPCC plan	Spill, Prevention, Control, and Countermeasure Plan
SRP	Standard Review Plan
Sv	sievert(s)
TACIR	Tennessee Advisory Committee on Intergovernmental Relations
TDEC	Tennessee Department of Environment and Conservation
TDOH	Tennessee Department of Health
TDOT	Tennessee Department of Transportation
TDS	total dissolved solids
TN	Tennessee State Route
TOSHA	Tennessee Occupational Safety and Health Administration
tpy CO_2e	tons per year of carbon dioxide equivalent
TRM	Tennessee River Mile
TRO	Total Residual Oxident
TVA	Tennessee Valley Authority
TWRA	Tennessee Wildlife Resource Agency

USGS	U.S. Geological Survey
V	volt(s)
WCD	Waste Confidence Decision
WBN	Watts Bar Nuclear
WNA	World Nuclear Association
WOG	Westinghouse Owners Group
yd^3	cubic yard(s)
YHP	Yard Holding Pond
yr	year(s)

1.0 Introduction

The Watts Bar Nuclear (WBN) plant site is located in southeastern Tennessee and is owned by Tennessee Valley Authority (TVA). The site contains two Westinghouse-designed pressurized-water reactors (PWRs). In early 1996, the U.S. Nuclear Regulatory Commission (NRC) issued an operating license for WBN Unit 1. TVA has not yet completed WBN Unit 2. The proposed action is for the NRC to issue a facility operating license for Unit 2 at the WBN site.

WBN Units 1 and 2 possess a unique licensing history, which is shown in the following timeline:

- 1972 – TVA published the final environmental statement (FES) for WBN Units 1 and 2 (TVA 1972).
- 1973 – Atomic Energy Commission (predecessor to the NRC) issued construction permit power reactor (CPPR) numbers CPPR-91 and CPPR-92 for WBN Units 1 and 2.
- 1978 – NRC published the FES related to the operating license for WBN Units 1 and 2 (1978 FES-OL) (NRC 1978).
- 1995 – NRC published Supplement No. 1, the supplemental FES (SFES) related to the operation of WBN Units 1 and 2 (1995 SFES-OL-1) (NRC 1995).
- 1996 – NRC issued a full power nuclear power facility (NPF) operating license (NPF-90) for WBN Unit 1.
- 1998 – TVA published the final environmental assessment related to the WBN supplemental condenser cooling water project (TVA 1998).
- 2006 – TVA informed the NRC of its intent to study the feasibility of completing WBN Unit 2, with the goal of producing power from the reactor in 2013 (TVA 2006).
- 2007 – TVA notified the Director of the Office of Nuclear Reactor Regulation on August 3, 2007, of its intention to complete construction activities at WBN Unit 2 (TVA 2007).
- 2007 – The NRC Commission, in the Staff Requirements Memorandum SECY-07-0096, directed the NRC staff to use the current licensing basis for WBN Unit 1 as the reference for reviewing and licensing WBN Unit 2 (NRC 2007).
- 2008 – TVA transmitted its final supplemental environmental impact statement for the completion and operation of WBN Unit 2 (TVA) to the NRC (TVA 2008).
- 2009 – TVA submitted an update to the application for a facility operating license from NRC to possess, use, and operate WBN Unit 2 (TVA 2009a).
- 2009 – NRC published a notice of the receipt of application and the opportunity for hearing in the *Federal Register* (FR) on May 1, 2009 (74 FR 20350).

- 2011 – NRC published the draft of this SFES (Supplement No. 2) related to the operation of WBN Unit 2 (draft SFES-OL-2) (NRC 2011).
- 2012 – TVA requested extension of Watts Bar Nuclear Plant, Unit 2, construction permit CPPR-92 (TVA 2012a).

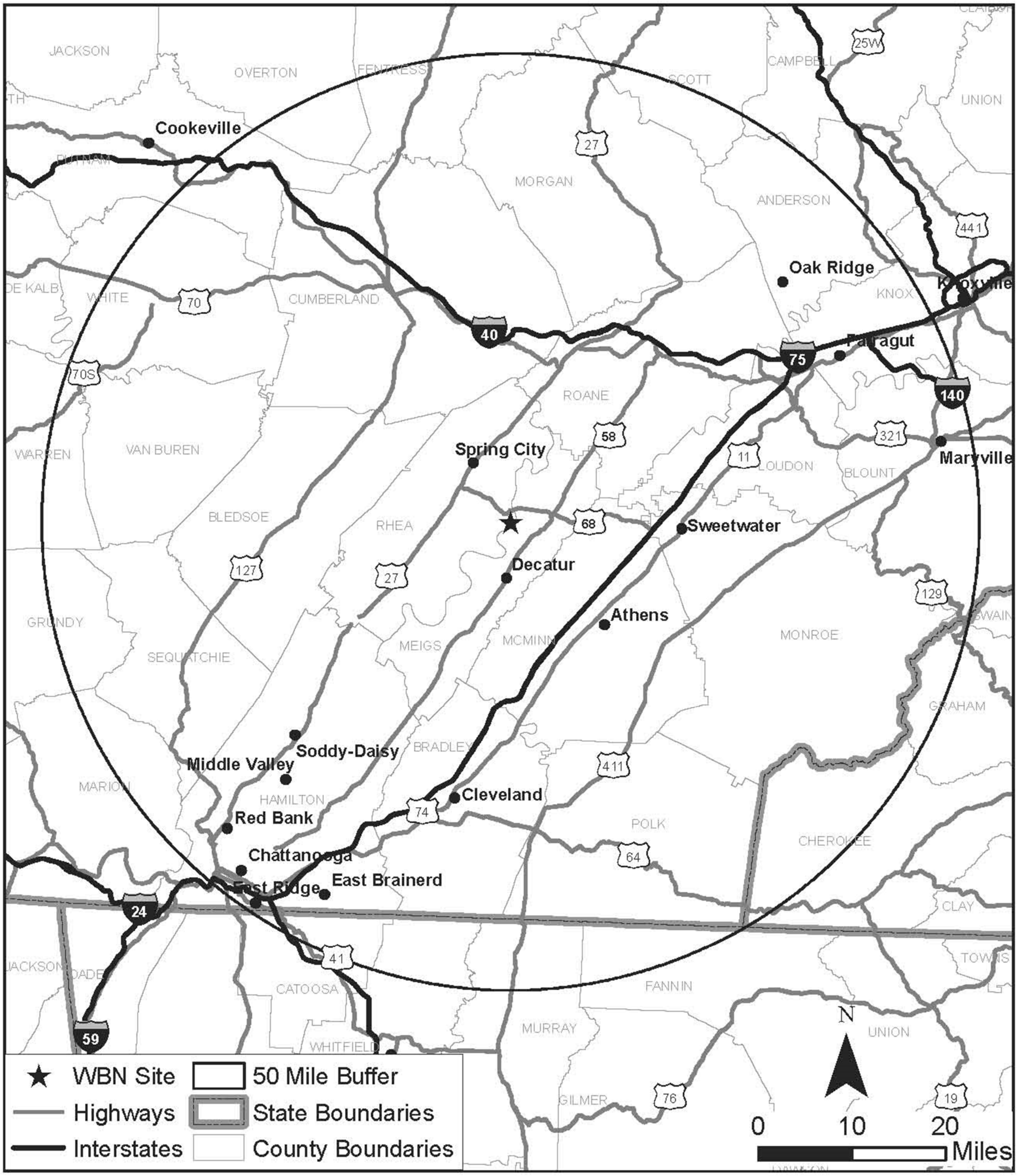
This document supplements NRC's 1978 FES-OL (NRC 1978) and updates the 1995 SFES-OL-1 (NRC 1995). This SFES documents the environmental review of WBN Unit 2 operation (SFES-OL-2). It focuses on changes to impacts associated with operation of WBN Unit 2 as a result of changes in the environment, plant design, and proposed methods of plant operation since 1978. It covers matters that have changed since the 1978 FES-OL or were introduced subsequent to publication of the 1995 SFES-OL-1. New sections have been added in this SFES to address issues not previously considered.

1.1 Background

The WBN plant, which includes Units 1 and 2, is located approximately 80 km (50 mi) northeast of Chattanooga, Tennessee (Figure 1-1). The WBN site occupies approximately 427 ha (1,055 ac) on Federal property controlled by TVA. The TVA reservation comprises 690 ha (1,700 ac) on the western shore of Chickamauga Reservoir of the Tennessee River at Tennessee River Mile (TRM) 528, as measured from the mouth of the river. The reservation includes the WBN site, the Watts Bar Dam and Hydro-Electric Plant, the site of the recently demolished Watts Bar Fossil Plant (TVA 2012), the TVA Central Maintenance Facility, and the Watts Bar Resort Area (TVA 2008). The WBN site lies approximately 1.6 km (1 mi) south of Watts Bar Dam (TRM 529.9). TVA designed, is building, and proposes to operate WBN Unit 2. The facility, administrative and support facilities, and all associated parking occupy Federal property in the custody of the applicant.

Each of the two identical plants (WBN Units 1 and 2) uses a four-loop PWR nuclear steam supply system furnished by Westinghouse Electric Corporation (NRC 1995). The Unit 2 reactor would operate at 3,425 MW(t). The net electrical output would be 1,160 MW(e), and the gross electrical output would be 1,218 MW(e) for the rated core power (TVA 2009b).

Under Title 10 of the *Code of Federal Regulations* (CFR) 51.92(a), the NRC is required to supplement an FES if the proposed action has not been taken and (1) substantial changes in the proposed action exist that are relevant to environmental concerns, or (2) significant new circumstances or information exist relevant to environmental concerns and bear on the proposed action or its impacts. Under 10 CFR 51.92(c), the NRC may prepare a supplement when, in its opinion, preparing one will further the purposes of the National Environmental Policy Act of 1969, as amended (NEPA).



(To convert miles [mi] to kilometers [km], multiply by 1.6 km/mi)

Figure 1-1. The WBN Site and the 80-km (50-mi) Vicinity

The NRC staff prepared this supplement to the 1978 FES-OL to further NEPA purposes. This supplement updates 1995 SFES-OL-1 (NRC 1995) and discusses new information related to the need for power and alternative sources of energy. As part of its assessment of the TVA application, the NRC staff reviewed the 1972 FES-CP, the 1978 FES-OL, the 1995 SFES-OL-1, and the applicant's submittals. The NRC staff also conducted a multidisciplinary environmental site visit and met with TVA and appropriate Federal and State regulatory and resource agencies at and in the vicinity of the WBN site.

1.2 NRC Operating License Application Review

The purpose of the NRC's environmental review of the TVA application is to determine if a second nuclear power plant of the proposed design can be operated at the WBN site without unacceptable adverse impacts on the environment. NRC regulations 10 CFR 51.95(a) and 10 CFR 51.95(b) direct staff reviews of supplemental environmental impact statements (SEISs) at the initial operating license stage. The NRC's *Environmental Standard Review Plan* (NRC 2000) presents detailed guidance for conducting the environmental review.

The NRC initiated the environmental review process for acceptance of the TVA application on September 11, 2009, by publishing a Notice of Intent to prepare a supplement to the 1978 FES-OL and conduct scoping in the *Federal Register* (74 FR 46799). This action complies with 10 CFR Part 51. On October 6, 2009, the NRC held two scoping meetings in Sweetwater, Tennessee, to obtain public input on the scope of the environmental review. The NRC also contacted Federal, State, Tribal, regional, and local agencies to solicit comments. Appendix B provides a list of the agencies and organizations contacted. The NRC staff reviewed the comments received during the scoping process. Appendix D includes comments from scoping and their associated responses.

In October 2009, the NRC and its contractor, Pacific Northwest National Laboratory (PNNL), visited the WBN site to gather information and become familiar with the site and its environs. During the site visit, the NRC staff and its contractor met with TVA staff, public officials, and members of the public. This SFES lists documents reviewed during the site visit as references, where appropriate.

The draft SFES was published in October 2011. The U.S. Environmental Protection Agency Notice of Availability in the *Federal Register* (76 FR 70130) indicated a 75-day comment period, commencing on November 10, 2011, to allow members of the public to comment on the results of the NRC staff's review. This was amended in the *Federal Register* on November 18, 2011, to a 45-day comment period (76 FR 71560). The NRC issued a Notice of Availability (76 FR 70169) of the draft SFES in the *Federal Register* on November 10, 2011, that provided a 45-day comment period and announced the date and location of the public meetings. Two public meetings were held in Sweetwater, Tennessee, on December 8, 2011. During these meetings, the NRC staff described the results of the NRC environmental review, answered questions related to the review, and provided members of the public with information to assist them in formulating comments on the SFES. Based on comments received at the public meeting, the comment period was extended by the NRC to January 24, 2012 (76 FR 80409). When the comment period ended on January 24, 2012, the NRC staff considered and addressed all the comments received. Appendix E includes all comments received on the draft SFES.

The NRC's standard of significance for impacts was established using the Council on Environmental Quality terminology for "significant" as defined in 40 CFR 1508.27. In addition, NRC guidance (NRC 2000) states that "Information in the GEIS [Generic Environmental Impact Statement] for license renewal, for example, the impact categorization approach (i.e., SMALL, MODERATE, and LARGE), may also be used in the preparation of NEPA documents prepared in conjunction with other types of applications such as ESPs [early site permits] and COLs [combined licenses] when it is appropriate to do so." The NRC staff used the impact categorization approach in this SFES. Impact categories include:

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

This SFES presents the NRC staff's analysis, which considers and weighs the environmental impacts of the proposed action at the WBN site. The analysis describes environmental impacts associated with operation of a second reactor at the WBN site and the cumulative effects of the proposed action along with other past, present, and reasonably foreseeable future actions. The analysis also considers the no-action alternative to granting the operating license. This SFES provides the NRC's recommendation to the Commission for issuing TVA an operating license for WBN Unit 2.

1.3 Compliance and Consultations

Before operating WBN Unit 2, TVA is required to hold certain Federal, State, and local environmental permits, as well as meet applicable statutory and regulatory requirements. TVA provided a list of environmental approvals and consultations associated with the WBN site as part of the responses to the request for additional information dated April 9, 2010 (TVA 2010). Appendix G provides the list of approvals and consultations associated with WBN Unit 2.

The NRC reviewed this list and contacted the appropriate Federal, State, Tribal, and local agencies to identify any compliance, permit, or environmental issues of concern that could affect the acceptability of the WBN site for operating WBN Unit 2. Appendix C lists this correspondence in chronological order. Appendix F provides a list of the consultation correspondence between the NRC and other agencies.

1.4 Report Contents

Chapter 2 of this SFES describes the proposed site and the environment that would be affected by operating WBN Unit 2. Chapter 3 discusses the power plant layout, structures, and activities related to operating proposed WBN Unit 2. The NRC staff uses Chapters 2 and 3 as the basis for evaluating environmental impacts. Chapter 4 examines site acceptability by updating the 1978 FES-OL analysis of environmental impacts of operating proposed WBN Unit 2. Chapter 5 discusses the environmental monitoring programs at the WBN site. Chapter 6 analyzes environmental impacts of postulated accidents involving radioactive materials. Chapter 7 discusses alternatives to the proposed action. Chapter 8 addresses the need for power. Chapter 9 summarizes the findings of the preceding chapters, provides a benefit-cost evaluation, and presents the NRC staff's recommendation to the Commission.

The appendices to this SFES provide the following additional information:

- Appendix A – Contributors to the Supplement
- Appendix B – Organizations Contacted
- Appendix C – Chronology of NRC Staff Environmental Review Correspondence Related to Tennessee Valley Authority Application for an Operating License for Watts Bar Nuclear Plant Unit 2
- Appendix D – Scoping Comments and Responses
- Appendix E – Draft Supplemental Final Environmental Statement Comments and Responses
- Appendix F – Key Consultation Correspondence Regarding the Watts Bar Nuclear Unit 2 Operating License (including the Biological Assessment submitted to the U.S. Fish and Wildlife Service)
- Appendix G – List of Authorizations, Permits, and Certifications
- Appendix H – Severe Accident Mitigation Design Alternatives
- Appendix I – Supporting Documentation for Radiological Dose Assessment.

1.5 References

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

40 CFR Part 1508. Code of Federal Regulations, Title 40, *Protection of Environment*, *Chapter V – Council on Environmental Quality*, Part 1508, "Terminology and Index."

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76 FR 70130. November 10, 2011. "Environmental Impact Statements; Notice of Availability." *Federal Register*. Environmental Protection Agency, Washington D.C.

76 FR 70169. November 10, 2011. "Draft Supplement 2 to Final Environmental Statement Related to the Operation of Watts Bar Nuclear Plant, Unit 2; Tennessee Valley Authority." *Federal Register.* U.S. Nuclear Regulatory Commission.

76 FR 71560. November 18, 2011. "Environmental Impact Statements; Notice of Availability." *Federal Register*. U.S. Environmental Protection Agency.

76 FR 80409. December 23, 2011. "Draft Supplement 2 to Final Environmental Statement Related to the Operation of Watts Bar Nuclear Plant, Unit 2; Tennessee Valley Authority." *Federal Register*. U.S. Nuclear Regulatory Commission.

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[NRC] U.S. Nuclear Regulatory Commission. 1978. *Final Environmental Statement Related to Operation of Watts Bar Nuclear Plant Units Nos. 1 and 2*. NUREG-0498, Washington, D.C. Accession No. ML082540803.

[NRC] U.S. Nuclear Regulatory Commission. 1995. *Final Environmental Statement Related to the Operation of Watts Bar Nuclear Plant, Units 1 and 2*. NUREG-0498 Supplement No. 1, Washington, D.C. Accession No. ML081430592.

[NRC] U.S. Nuclear Regulatory Commission. 2000. *Environmental Standard Review Plan—Review Plans for Environmental Reviews for Nuclear Power Plants.* NUREG-1555, Washington, D.C.

[NRC] U.S. Nuclear Regulatory Commission. 2007. Memo from Annette L. Vietti-Cook (U.S. Nuclear Regulatory Commission, Secretary) dated July 25, 2007, "Commission Voting Record, Decision item: SECY-07-0096*,* Possible Reactivation of Construction and Licensing Activities for the Watts Bar Nuclear Plant Unit 2." Accession No. ML072080173.

[NRC] U.S. Nuclear Regulatory Commission. 2011. *Draft Supplemental Environmental Impact Statement Related to the Operation of Watts Bar Nuclear Plant, Unit 2.* NUREG-0498 Supplement 2, Washington, D.C. Accession No. ML11298A094, ML11298A095.

[TVA] Tennessee Valley Authority. 1972. *Final Environmental Statement, Watts Bar Nuclear Plant Units 1 and 2*. TVA-OHES-EIS-72-9, Office of Health and Environmental Science, Chattanooga, Tennessee. Accession No. ML073470580.

[TVA] Tennessee Valley Authority. 1998. *Watts Bar Nuclear Plant Supplemental Condenser Cooling Water Project, Environmental Assessment.* Knoxville, Tennessee. Accession No. ML12170A104.

[TVA] Tennessee Valley Authority. 2006. Letter from K.W. Singer (Tennessee Valley Authority, Chief Nuclear Officer and Executive Vice President) to U.S. Nuclear Regulatory Commission dated November 14, 2006, "Watts Bar Nuclear Plant (WBN) – Unit 2 – Feasibility Study for the Completion of Construction Activities." Accession No. ML063200135.

[TVA] Tennessee Valley Authority. 2007. Letter from William R. McCollum (Tennessee Valley Authority, Chief Operating Officer) to U.S. Nuclear Regulatory Agency dated August 3, 2007, "Watts Bar Nuclear Plant (WBN) – Unit 2 – Reactivation of Construction Activities." Accession No. ML072190047.

[TVA] Tennessee Valley Authority. 2008. *Final Supplemental Environmental Impact Statement; Completion and Operation of Watts Bar Nuclear Plant Unit 2, Rhea County, Tennessee*, submitted to NRC as the TVA Environmental Report for an Operating License, Knoxville, Tennessee. Accession No. ML080510469.

[TVA] Tennessee Valley Authority. 2009a. Letter from Masoud Bajestani (Watts Bar Unit 2, Vice President) to U.S. Nuclear Regulatory Commission dated March 4, 2009, "Watts Bar Nuclear Plant (WBN) Unit 2 – Operating License Application Update." Accession No. ML090700378.

[TVA] Tennessee Valley Authority. 2009b. *Watts Bar Nuclear Plant (WBN) - Unit 2 - Final Safety Analysis Report (FSAR)*. Amendment 94, Spring City, Tennessee. Accession Nos. ML092460757, ML092460772.

[TVA] Tennessee Valley Authority. 2010. Letter from Masoud Bajestani (Watts Bar Unit 2, Vice President) to the U.S. Nuclear Regulatory Commission dated April 9, 2010, "Watts Bar Nuclear Plant (WBN) Unit 2 - Response to U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information Regarding Environmental Review (TAC No. MD8203)." Accession No. ML101130393.

[TVA] Tennessee Valley Authority. 2012. Letter from Brenda E. Brickhouse (Tennessee Valley Authority) to U.S. Nuclear Regulatory Commission, dated January 27, 2012, regarding "Docket ID NRC-2008-0369 -Comments on Draft Supplement 2 to Final Environmental Statement (SFES) Related to the Operation of Watts Bar Nuclear Plant, Unit 2, Tennessee Valley Authority (TVA)." Accession No. ML12040A052.

[TVA] Tennessee Valley Authority, 2012a. Letter from Raymond A. Hruby, Jr. (Watts Bar, Unit 2) to U.S. Nuclear Regulatory Commission, dated May 17, 2012, regarding, "Watts Bar Nuclear Plant (WBN) – Unit 2 – Request for Extension of Construction Permit CPPR-92. Accession No. ML12143A346.

2.0 Affected Environment

This chapter describes the affected environment in the vicinity of Watts Bar Nuclear (WBN) Unit 2. Section 2.1 describes the location of the site and land use. Sections 2.2 through 2.8 describe water use and quality, ecology, socioeconomics, historic and cultural resources, radiological environment, nonradiological human health, and meteorology and air quality. Section 2.9 examines related Federal projects and Section 2.10 provides references.

2.1 Land Use

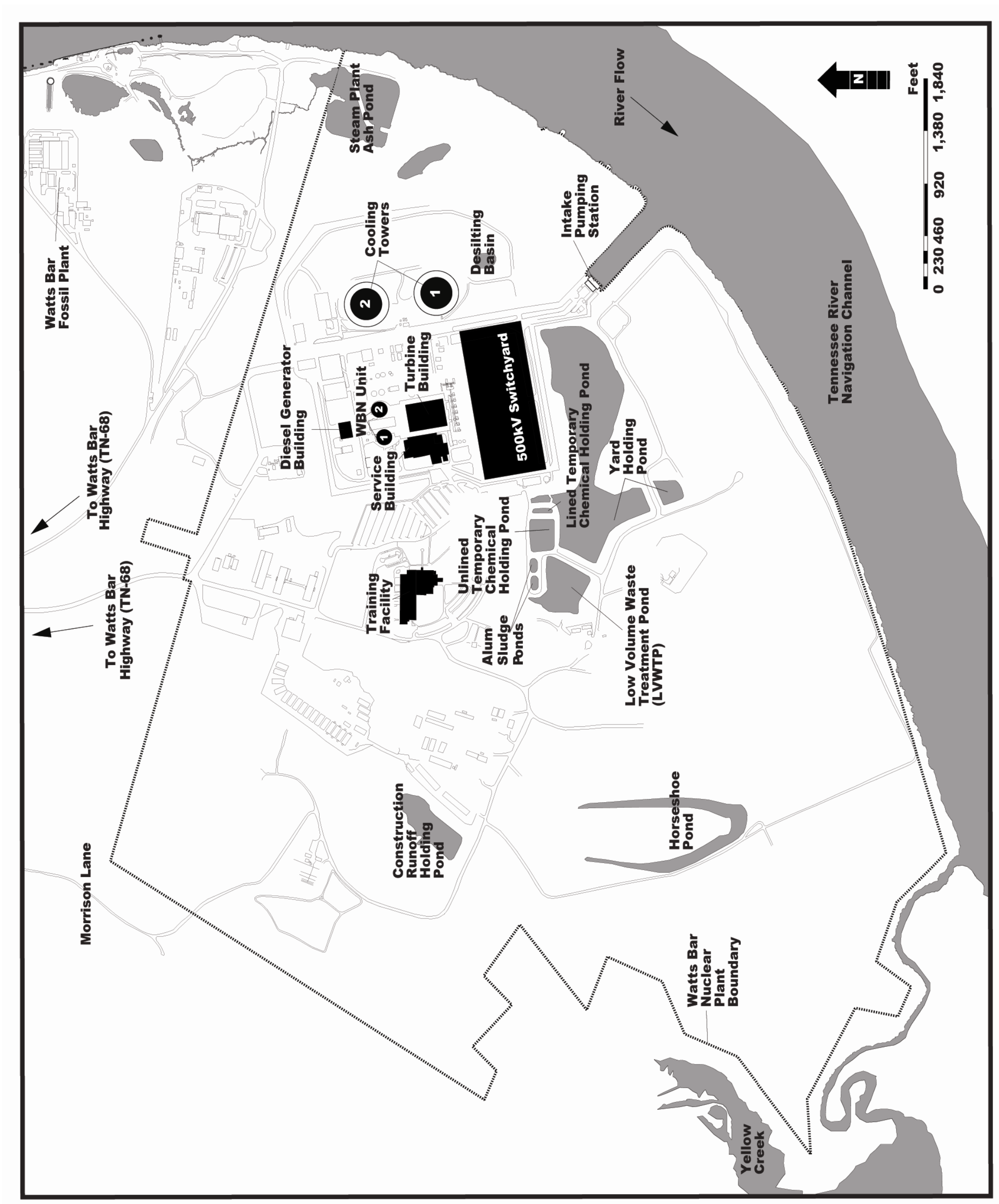
This section describes the WBN site location and land use within and around the WBN site.

2.1.1 Site Location

Figure 2-1 shows the WBN Unit 2 location adjacent to WBN Unit 1, both wholly located within WBN site boundaries. The WBN site lies in rural Rhea County, Tennessee, about 13 km (8 mi) southeast of Spring City, which has a population of 1,981. The nearest population centers with more than 25,000 residents include Chattanooga, 97 km (60 mi) to the southwest (population 167,674) and Knoxville, about 97 km (60 mi) to the northeast (population 178,874) (USCB 2010a). Figure 2-2 shows the WBN Unit 2 site in relation to the counties, cities, and towns located within an 80-km (50-mi) radius of the site. Interstate Highway 75 (I-75) passes within 29 km (18 mi) to the east of the site, and Interstate 40 (I-40) passes within 45 km (28 mi) to the north of the site. Workers and visitors access the site from Tennessee State Route 68 (TN-68), which connects with U.S. Highway 27 (US-27) to the west, and TN-302, TN-58, and I-75 to the east. The WBN site occupies approximately 427 ha (1,055 ac) within the Watts Bar reservation, which is 690 ha (1,700 ac) of land owned by the U.S. Federal Government in the custody of the Tennessee Valley Authority (TVA). The reservation includes the WBN site, the Watts Bar Dam and Hydro-Electric Plant, the Watts Bar Fossil Plant site (the plant was demolished in December 2011 [TVA 2012a]), the TVA Central Maintenance Facility, and the Watts Bar Resort Area (TVA 2008a).

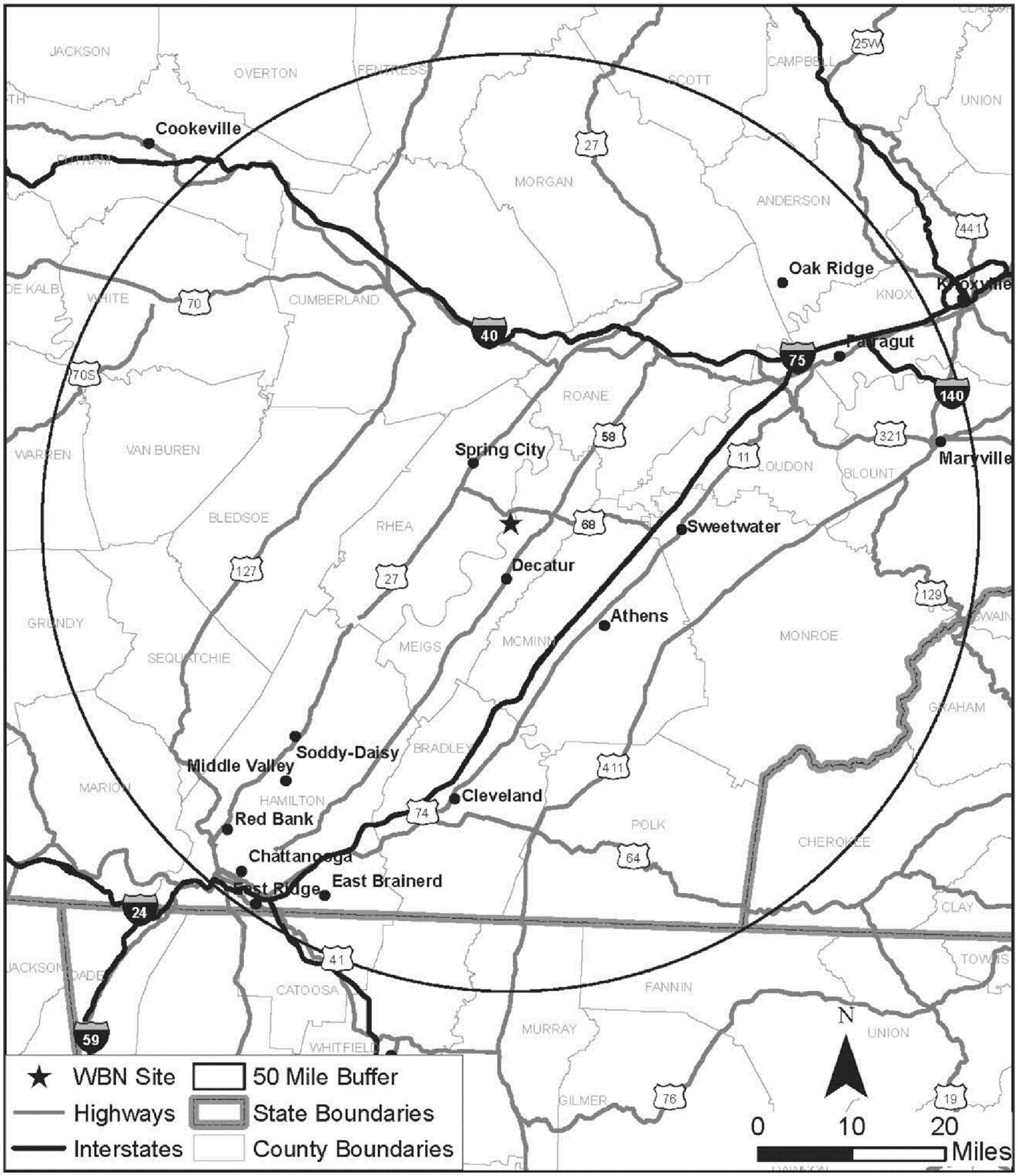
2.1.2 The Site and Vicinity

The WBN site is bounded by Chickamauga Reservoir to the east and south. The WBN site contains structures to support two nuclear units. WBN Unit 1 is currently operating and WBN Unit 2 is partially constructed. Figure 2-1 shows the layout of the WBN site. A rural road, Morrison Lane, and forested land form the western border of the site (see Figure 2-1), while TN-68 (also known as Watts Bar Highway) makes up the northern border. The WBN site lies entirely within an unincorporated area of Rhea County, Tennessee, approximately 13 km (8 mi) southeast of Spring City. The town of Spring City is zoned for commercial and residential land uses; however, unincorporated areas of Rhea County are not zoned for any particular land uses.



(To convert feet [ft] to meters [m], multiply by 0.3048 m/ft)

Figure 2-1. The WBN Site (Based on TVA 2008a)



(To convert miles [mi] to kilometers [km], multiply by 1.6 km/mi)

Figure 2-2. The WBN Site and the 80-km (50-mi) Vicinity

Table 2-1 includes the acreage estimates for land categories within the WBN site. Deciduous and evergreen forest, along with grass, shrub, and brush cover more than 70 percent of the WBN site. The reactor complex, cooling towers, and supporting infrastructure make up about 15 percent.

Table 2-1. Acreage Estimates for Land Categories Within the WBN Site

Land-Use Coverage	Acreage ha (ac)	Percent of Total
Reactor complex, buildings, and supporting infrastructure	64.4 (159.2)	15
Miscellaneous use, disturbed land (includes a 0.2-ha [0.5-ac] cemetery)	26.8 (66.1)	6
Grass, shrub, and brush	155.7 (384.7)	36
Forest (deciduous and evergreen)	147.8 (365.1)	35
Wetlands	15.7 (38.8)	4
Water	16.9 (41.7)	4

Source: TVA 2010a

2.1.3 Transmission Corridors and Offsite Areas

Four 500-kV transmission lines currently support the transmission of power from the WBN Unit 1 reactor on the WBN site (see Figure 3-4). The site also houses two 1.6-km- (1-mi-) long 161-kV lines (Watts Bar Hydro-Watts Bar Nuclear Nos. 1 and 2). The four 500-kV lines include the Bull Run-Sequoyah loop into the WBN site, the Watts Bar-Volunteer line, the Watts Bar-Roane line, and the Watts Bar-Sequoyah line. The Bull Run-Sequoyah loop extends northeast to the Bull Run Substation and loops into the WBN site on its way to the Sequoyah substation approximately 64 km (40 mi) to the southwest of the WBN site. The Watts Bar-Volunteer line runs from the WBN site to the northeast, connecting with the Volunteer substation near Knoxville, Tennessee. The Watts Bar-Roane line runs from the WBN site north to the Roane substation, near Oak Ridge, Tennessee. The Watts Bar-Sequoyah line runs southwest to the Sequoyah substation, providing a second 500-kV line connecting the WBN site substation with the Sequoyah nuclear site substation. TVA acquired approximately 1,281 ha (3,165 ac) of right-of-ways to support the construction of the 500-kV lines from the WBN site. When this land was originally acquired, approximately 25 percent of the land was forested, 25 percent was used for farming and pastures, and the remainder was primarily uncultivated open land (TVA 1972; NRC 1978). TVA currently owns the right-of-ways associated with all 500-kV lines supporting the WBN site and actively maintains these transmission lines and corridors (TVA 1972, 2010a; NRC 1978).

2.1.4 The Region

The WBN site lies on the western shore of Chickamauga Reservoir on the Tennessee River at Tennessee River Mile (TRM) 528 (TVA 2008a). The site is approximately 1.6 km (1 mi) south of the Watts Bar Dam (TRM 529.9) (NRC 1995). The 1972 TVA final environmental statement related to the construction permit for WBN Units 1 and 2 (1972 FES-CP) and other earlier studies described land use in the area around the site. Since that time, housing and commercial development has increased while open space and land used for farming has decreased (TVA 2008a).

TVA owns and manages both the Chickamauga Dam and Reservoir and Watts Bar Dam and Reservoir. TVA also owns and manages several thousand acres of land around the two reservoirs with a combined shoreline totaling just over 2,400 km (1,500 mi) (TVA 2004a). TVA has developed comprehensive plans for the management of the public land around each reservoir (TVA 2009a).

Deciduous and some evergreen and mixed forest cover most of the land surrounding the WBN site. Pasture land and row crops make up the second most common form of land coverage in the region. TVA classifies approximately 1,101 ha (2,720 ac) of the land it manages on the Chickamauga and Watts Bar reservoirs as recreational (TVA 2004a; TDEC 2006).

2.2 Water Use and Quality

This section describes the surface and groundwater resources and hydrologic processes in and around the WBN site including existing water use and water quality in the environment in the vicinity of WBN Unit 2. During proposed Unit 2 operations, Watts Bar and Chickamauga reservoirs on the Tennessee River would provide cooling water. Only Chickamauga Reservoir would receive discharge water.

2.2.1 Hydrology

Hydrological features of the site are described in the Final Safety Analysis Report (FSAR) portion of the application (TVA 2009b) and the 1995 Supplement No. 1 to the final environmental statement related to the operating license (1995 SFES-OL-1) (NRC 1995). Site-specific and regional hydrological features and their characteristics are summarized below.

2.2.1.1 Surface-Water Hydrology

The WBN site is located on the western shore of Chickamauga Reservoir on the Tennessee River at TRM 528 (TVA 2008a) approximately 1.6 km (1 mi) south of Watts Bar Dam (TRM 529.9) (NRC 1995). The Tennessee River system is the fifth largest river system in the United States (Bohac and McCall 2008) and one of the most highly regulated for flood control, navigation, and power generation (TVA 2009b). The Tennessee River watershed above the WBN site drains 44,830 km^2 (17,319 mi^2) of land (TVA 2009b). Dams on the mainstem of the Tennessee River create nine reservoirs. Chickamauga and Watts Bar reservoirs are the two closest to the WBN site and their characteristics are listed in Table 2-2. Fort Loudon Reservoir is upstream of Watts Bar Reservoir, and Nickajack, Guntersville, Wheeler, Wilson, Pickwick, and Kentucky reservoirs are downstream of Chickamauga Reservoir (TVA 2004a).

Table 2-2. Physical Characteristics of Watts Bar and Chickamauga Reservoirs

Reservoir	Drainage Area km^2 (mi^2)	Mean Annual Flow m^3/s (cfs)	Area at Full Pool ha (ac)	Volume at Full Pool 10^6 m^3 (10^6 ft^3)	Mean Depth m (ft)	Residence Time Days
Watts Bar	44,830 (17,310)	778 (27,500)	15,783 (39,000)	1,246 (44,000)	7.9 (26)	17
Chickamauga	53,850 (20,790)	962 (34,000)	14,326 (35,400)	775 (27,400)	5.4 (18)	8

From Table 4.4-02 Reservoir Operations Study May 2004 (TVA 2004a), Section 4.4, page 4.4-8.
Mean depth and residence time are based on average, rather than full pool area and volume.

Since the publication of the U.S. Nuclear Regulatory Commission (NRC) SFES-OL-1 in 1995 (NRC 1995), TVA has altered the operation of reservoirs on the Tennessee River. TVA completed a Reservoir Operations Study (ROS) in 2004 (TVA 2004a) that resulted in modifications of the operation of Watts Bar and Chickamauga reservoirs. Historically, TVA maintained the summer high-water pool at Watts Bar Reservoir at 225.7 m (740.5 ft) above mean sea level (msl) (National Geodetic Vertical Datum 1929) from April through October (TVA 1998). Between November and March, TVA reduced the pool level and maintained it at approximately 224 m (736 ft) above msl. As a result of ROS findings, TVA now maintains the summer high-water level at 226 m (740 ft) above msl between May and October and 224 m (736 ft) above msl from November to April (TVA 2004a).

TVA has instituted similar operational changes at Chickamauga Reservoir. Historically, TVA maintained the summer high-water pool at 208 m (682 ft) above msl from April to June, dropped it to 207 m (680 ft) above msl from July through September, then gradually dropped it to 206 m (676 ft) above msl between October and December. TVA held the water at that elevation through March. As a result of the ROS findings, TVA now maintains the summer pool elevation at 208 m (682 ft) above msl from May to September and lowers it to 206 m (676 ft) above msl from December through April (TVA 2004a).

As Table 2-2 notes, Watts Bar Dam releases water at a mean annual flow of approximately 778 m^3/s (27,500 cfs). The FSAR (TVA 2009b) summarizes information about low flows past the WBN site. The FSAR indicates that, since January 1942, the TVA system of dams and reservoirs, particularly Watts Bar and Chickamauga dams, has regulated low flows at the site. Under normal operating conditions, periods of several hours daily may occur when no water is released from either or both dams. However, TVA has recorded average daily flows of less than 280 m^3/s (10,000 cfs) only 4.8 percent of the time and less than 140 m^3/s (5,000 cfs) only 0.9 percent of the time at the site.

During special operations to control watermilfoil on March 30 and 31, 1968, neither Watts Bar Dam nor Chickamauga Dam released any water. TVA has recorded daily average releases of zero on four other occasions during the last 25 years (TVA 2009b).

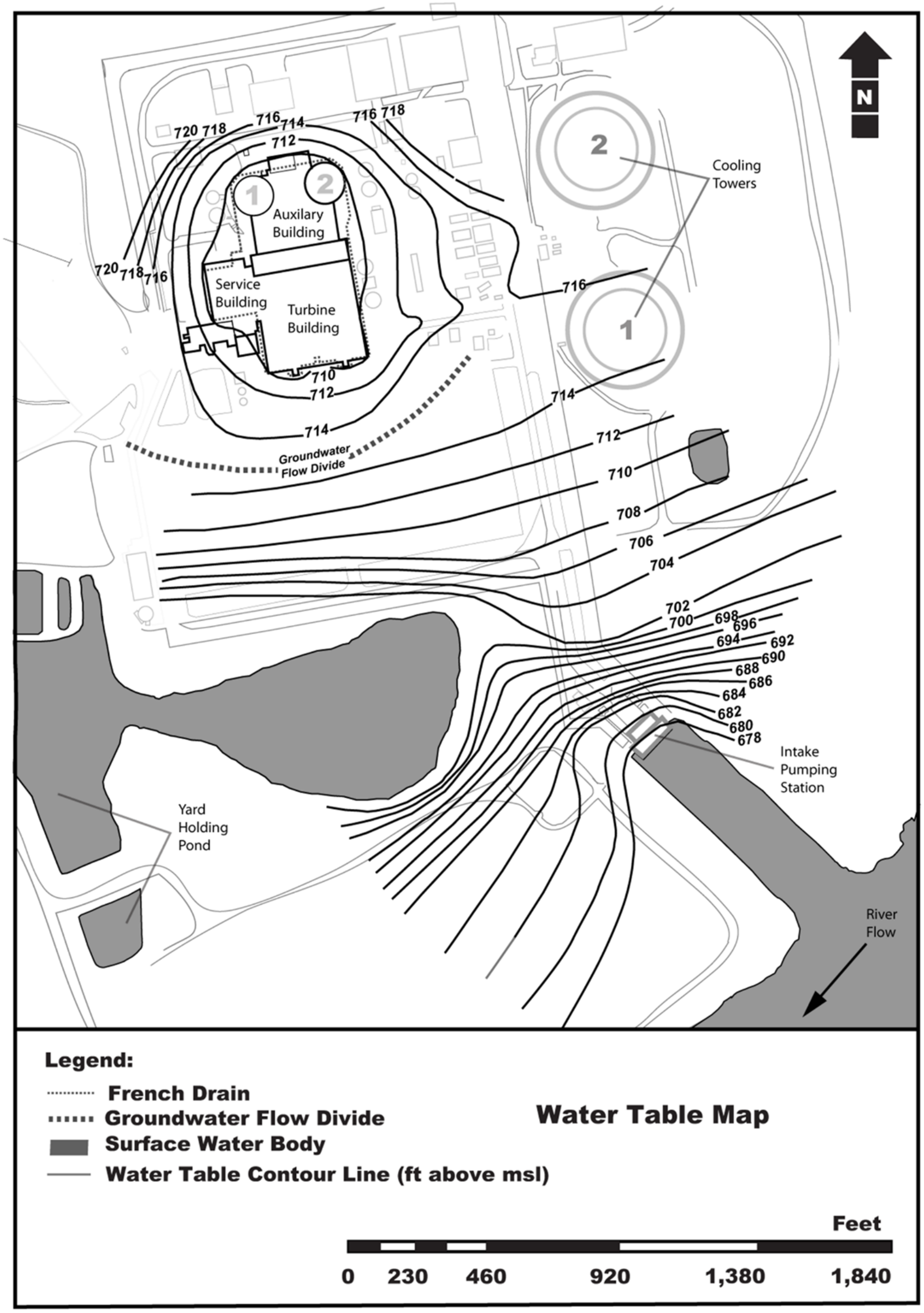
The National Pollutant Discharge Elimination System (NPDES) permit renewal application (TVA 2006a) and the 1995 SFES-OL-1 (NRC 1995) describe surface-water features of the site, including two chemical cleaning holdup ponds (for waste from the turbine generator building), the Yard Holding Pond (YHP), Construction Runoff Holding Pond, Yellow Creek, and an unnamed tributary of Yellow Creek. In addition, TVA (2005a) identified the Horseshoe Pond in the southeastern area of the WBN site. TVA created the chemical holding ponds, the YHP, and the Construction Runoff Holding Pond to support WBN site operations. Yellow Creek and its tributary are natural water bodies resulting from surface-water runoff and/or interaction with Chickamauga Reservoir. Horseshoe Pond predates WBN development and receives surface-water runoff. The 1995 SFES-OL-1 (NRC 1995) also describes a 9,500-m^3 (2.5-million-gal) evaporation/percolation pond. TVA closed the pond and revegetated the area in 1999 (TDEC 1999).

2.2.1.2 Groundwater Hydrology

The Conasauga Shale, which forms the bedrock beneath the site, consists of about 84 percent shale and 16 percent limestone and has poor water-bearing qualities. Poorly sorted, fine-grained terrace deposits and more recent alluvial deposits overlie the shale. The Knox Dolomite, which overlies the Conasauga Shale, elsewhere is a significant aquifer within the region, but is not present at the WBN site and is not used as a source of groundwater within 3.2 km (2 mi) of WBN Unit 2 except for small water supplies (TVA 2009b).

The local hydrogeologic characteristics were significantly altered by the construction of WBN Units 1 and 2. Unconsolidated material was removed in the vicinity of the reactor and turbine buildings and replaced by engineered backfill. Excavations for installation of piping between Units 1 and 2 and the intake and discharge structures created pathways of higher hydraulic conductivity than the surrounding material. A recent groundwater investigation performed for TVA calculated the hydraulic conductivity of this material to be 1.71 m/d (5.6 ft/d) and 2.65 m/d (8.7 ft/d) (TVA 2010b).

TVA developed a water table map for the WBN site in January 1972 that showed the water table conformed rather closely to surface topography before site construction (TVA 2009b). The water table elevation in the vicinity of the reactor locations was approximately 219 m (720 ft) above msl (FSAR Figure 2.4-105). A recent water table map of the site indicates the construction of WBN Units 1 and 2 and operation of Unit 1 has modified the water table (Figure 2-3). Water levels in the vicinity of the power block and turbine building are approximately 216 m (710 ft) above msl as a result of dewatering through a French drain surrounding the building.



(To convert feet [ft] to meters [m], multiply by 0.3048 m/ft)

Figure 2-3. Water Table Map for the Watts Bar Nuclear Plant (TVA 2010b)

Water levels near the YHP approach the level of the pond (approximately 213 m [700 ft] above msl). A groundwater divide exists between these two features with a water table elevation of approximately 218 m (715 ft) above msl. Water levels drop toward the shore of the Tennessee River/Chickamauga Reservoir at an approximate elevation of 206 m (676 ft) above msl (TVA 2010b).

In 1972, the groundwater gradient between the plant site and Chickamauga Reservoir at maximum water table elevation and minimum river stage measured about 13 m (44 ft) in 980 m (3,200 ft) (TVA 2009b). The recent groundwater study performed for TVA indicates the average gradient for the study period (1996 to 2003) was 0.018 resulting in a groundwater travel time of approximately 9 years from the reactor units to the river (TVA 2010b).

2.2.2 Water Use

The following sections describe consumptive and nonconsumptive uses of surface water and groundwater at the WBN site. Consumptive water use reduces the available water supply. For instance, evaporation due to cooling-tower operation results in a transfer of water from the cooling system to the atmosphere, thereby reducing the volume of water in the cooling system. However, nonconsumptive water use does not reduce the available water supply. Water discharged back into the river is not consumed by the plant. For example, water used to rinse impinged fish off the intake screens does not change the water supply because the same volume of water pumped from the reservoir eventually returns to the reservoir.

2.2.2.1 Regional Water Use

Surface Water

The 1995 SFES-OL-1 updated information about downstream water users from the 1978 final environmental statement related to the operating license for WBN Units 1 and 2 (1978 FES-OL) by identifying users of both public and industrial water supplies within 80 km (50 mi) of the plant. TVA updated the information in 2010, indicating that a number of water users have ceased withdrawal and several have changed names (TVA 2010a).

Table 2-3 lists current water users downstream of the plant. There are no water users between the WBN plant and the Watts Bar Dam. Examples of nonconsumptive uses of water in the Tennessee River include power production, transporting materials on the commercial waterway, recreation, and wildlife habitat protection and restoration (TVA 2004a).

TVA and the U.S. Geological Survey have extensively studied water use in the Tennessee Valley (Hutson et al. 2004; Bohac and McCall 2008). TVA uses this information to inform its policies and practices for operating the reservoirs (TVA 2004a). The 2008 TVA report (Bohac and McCall 2008) indicates that consumptive use of water in the Tennessee River system in 2005 totaled 1,640 million L/d (432 MGD) for irrigation, public water supply, and industrial and thermoelectric uses. Consumptive use within the Watts Bar-Chickamauga reservoir area for 2005 totaled 153 million L/d (40.40 MGD) (Bohac and McCall 2008).

Table 2-3. Downstream Water Users Within an 80-km (50-mi) Radius of the WBN Plant and Selected Users Located Further Downstream

Water User	Location
Watts Bar Nuclear Plant	TRM 528.8R[a]
Dayton, Tennessee	TRM 503.8R
Soddy-Daisy Falling Water Utility District	TRM 487.2R, Soddy Creek 4.0
Sequoyah Nuclear Plant	TRM 483.6R
Greater than 80 km (50 mi) downstream	
East Side Utility	TRM 473.0
Chickamauga Dam	TRM 471.0
Invista-DuPont Company	TRM 469.9R
Tennessee-American Water	TRM 465.3L[b]
BUZZI UNICEM USA	TRM 454.2R
Raccoon Mountain Pump Storage	TRM 444.7L
Nickajack Dam	TRM 424.7
South Pittsburgh, Tennessee	TRM 418.0R
Bridgeport, Alabama	TRM 413.6R
Widows Creek Steam Plant	TRM 407.7R
Smurfit Stone Corporation	TRM 405.2R

Source: TVA 2010a
(a) Right bank looking downriver.
(b) Left bank looking downriver.

Groundwater

Groundwater reportedly supplies 1.5 percent of water used within the Tennessee River Valley (Bohac and McCall 2008). TVA does not pump groundwater for use at the site, although approximately 9.8×10^8 L/yr (2.6×10^8 gal/yr) are removed from the surficial aquifer through the French drain that surrounds the power blocks for the two reactor units at the site. Water removed from the French drain is discharged to the YHP (TVA 2010a). The surficial aquifer on the WBN site is hydraulically isolated from surrounding water users by Yellow Creek and Chickamauga Reservoir to the west, south, and east. It is also hydraulically isolated to the north by the relatively impermeable Rome Formation underlying the site (TVA 2009b).

Table 2.4-10 in the FSAR (TVA 2009b) identifies groundwater users within a 3.2-km (2-mi) radius of the WBN site. Results from a 1972 TVA survey provided in this table identified 89 wells, 58 of which had pumps (TVA 2009b). The survey also identified two springs equipped with pumps. TVA estimated total groundwater consumption within the surveyed area to be less than 630 L/s (10,000 gpm) from these wells and springs (TVA 2009b).

TVA identified five water supplies within 32 km (20 mi) of the WBN site currently relying on groundwater (TVA 2009c). Table 2-4 lists the groundwater users, current withdrawal rates, and distance from the WBN site. As discussed above, these users are all farther than 3.2 km (2 mi) from the site.

Table 2-4. Groundwater Users, Current Withdrawal Rates, and Distance from the WBN Site

Groundwater User	2005 Annual Withdrawal million L/d (MGD)	Radial Distance from the WBN Site km (mi)
Watts Bar Utility District	2.6 (0.7)	6.4 (4)
Decatur Water Department	2.6 (0.7)	6.4 (4)
Athens Utility Board	3.8 (1.0)	23.8 (14.8)
Graysville Water Department	0.8 (0.2)	29.8 (18.5)
Laurelbrook School	0.11 (0.03)	32.5 (20.2)

Source: TVA 2009c

2.2.3 Water Quality

2.2.3.1 Surface-Water Quality

The 1978 FES-OL summarizes water quality in the Tennessee River near the WBN site (NRC 1978). The 1978 FES-OL characterized the quality of the water as "generally good." Total dissolved solids ranged from 60 to 180 mg/L (NRC 1978). In response to requests for additional information (RAIs) for this environmental review, TVA provided analyses performed between January 2006 and December 2008. The results fall within the range previously observed (TVA 2009c).

Under the authority of the Clean Water Act, the Tennessee Department of Environment and Conservation (TDEC) identifies streams and lakes in the state whose desired water use is limited in some way due to water quality or that are expected to exceed water quality standards in the next 2 years and need additional pollution controls. The water bodies are identified on a list published by the State that is commonly known as the 303d list. The Hiwassee River embayment of Chickamauga Reservoir is identified as having an impaired use for fish consumption because of mercury. Watts Bar Reservoir is identified as having an impaired use for fish consumption because of polychlorinated biphenyls (PCBs) (TDEC 2010a). Portions of the reservoir are also identified as impaired for fish consumption due to mercury and chlordane. The Emory River Arm of the reservoir is on the 303d list for arsenic, coal ash deposits, and aluminum, as well as mercury, PCBs, and chlordane (TDEC 2010a). The Emory River Arm was the area of the reservoir most affected by the ash spill that occurred at the Kingston Fossil Plant.

Concerns aired during the scoping process for this SFES related to the impact of the ash spill that occurred at the Kingston Fossil Plant upstream of the WBN site (Appendix D). On December 22, 2008, a retaining wall for a coal ash holding pond failed at the Kingston Fossil Plant, a coal-fired electrical generating plant operated by TVA. As a result, more than 4.1 million m^3 (5.4 million yd^3) of coal ash spilled from the holding pond. Ash spilled into the Emory River, a tributary of the Tennessee River upstream of the WBN site. The Emory River flows into the Clinch River, which enters the Tennessee River (Watts Bar Reservoir) at TRM 567. This is 63 km (39 mi) upstream of the WBN site. The TDEC has been monitoring water quality in the Emory River near the site of the spill (TDEC 2010b).

In the early days of monitoring the spill, contaminants that violated Tennessee water-quality criteria for protection of either human health or fish and aquatic life included thallium, arsenic, lead, aluminum, iron, copper, mercury, and cadmium. Recent analyses indicated that concentrations of these metals remain below water-quality standards in the Emory River (TDEC 2010c). Concentrations of contaminants from the Kingston ash spill are expected to be further diminished by the time water reaches the WBN site due to dilution in the Tennessee River.

2.2.3.2 Groundwater Quality

Because groundwater is not used on the WBN site, the main water-quality interest is tritium in groundwater due to past operations at the site. TVA summarized recent information on tritium in groundwater at the WBN site in its environmental report (ER) (TVA 2008a). TVA stated that, in August 2002, it detected tritium in one of the onsite environmental monitoring locations just at the detectable level. As a result, in December 2002, TVA modified its radiological environmental monitoring program (REMP) and installed four new environmental monitoring wells on the site. TVA reports results from the new wells and existing monitoring locations annually to the NRC and the State of Tennessee in its WBN Annual Radiological Environmental Operating Reports.

In addition to the six REMP monitoring wells, TVA has added 19 non-REMP monitoring wells to track the onsite groundwater plume to indicate the presence or increase of radioactivity in the groundwater (TVA 2011a).

TVA reported in the ER that samples taken from groundwater wells from January 2003 through December 2004 showed low levels of tritium in three of the four monitoring locations. In response, TVA made numerous modifications to Unit 1 to stop tritium leakage. In addition, TVA sealed the fuel transfer tube for Unit 2 and coated the fuel transfer canal. TVA completed these modifications by November 2005 (TVA 2008a).

Results from two of the four new wells, sampled in February 2005 and June 2005, showed tritium levels greater than the NRC reporting level of 1,100 becquerels per liter [Bq/L] (30,000 picocuries per liter [pCi/L]). Further inspections of underground radioactive effluent piping revealed no leakage. TVA determined that the increased tritium levels resulted from a previous effluent piping leak at Unit 1, which had been repaired. The highest concentration of tritium detected in 2005 was approximately 20,400 Bq/L (550,000 pCi/L) (TVA 2008a).

Maximum tritium concentrations observed in groundwater samples in 2010 were 106 Bq/L (2,860 pCi/L) (TVA 2011b). Current concentrations in groundwater are well below the NRC reporting level of 1,100 Bq/L (30,000 pCi/L). No other groundwater-quality impacts from past operations at the site have been identified and tritium concentrations in offsite groundwater wells have not been affected by site operations (TVA 2011b).

Additional information about the REMP and groundwater monitoring can be found in Section 2.6 of this document.

2.3 Ecology

Understanding WBN site ecology plays an important role in assessing the impacts of operating and maintaining proposed Unit 2 on the surrounding environment. Sections 2.3.1 and 2.3.2 provide general descriptions of terrestrial, wetland, and aquatic environments on and in the vicinity of the WBN site.

2.3.1 Terrestrial Resources

This section identifies terrestrial ecological resources and describes species composition and other structural and functional attributes of biotic assemblages that could be affected by the operation and maintenance of WBN Unit 2. It also identifies important terrestrial resources, as defined in NRC guidance (NRC 1999, 2000), such as wildlife sanctuaries and natural areas the proposed action might affect.

2.3.1.1 Terrestrial Communities of the Site

The WBN site lies within the Appalachian Valley and Ridge physiographic province, distinguished by the parallel ridges separated by valley floors that extend from New York to Alabama (USGS 2002). Historically, forest occupied about 65 percent of the landscape. Oak-hickory represents the principal forest type in the region, with oak-gum forest also present (TVA 1972, 2008a). Softwood forest such as yellow pine (*Pinus* spp.), hardwood, and Virginia pine also are present (TVA 1972). Sumac shrub communities, old field vegetation, horseweed (*Conyza canadesis*), and fescue (*Festuca* spp.) meadow grow in disturbed areas (TVA 2008a). In the early 1970s, agriculture occupied an additional 10 percent of the regional landscape (TVA 1972). Currently, deciduous forest is the predominant landcover on the WBN site (Table 2-5). Figure 2-4 provides landcover information for the WBN site. About 91 ha (225 ac) of the site are occupied by facilities. About 115 ha (284 ac) of previously disturbed land around the WBN facilities now supports old field vegetation, represented by poorly and minimally maintained grass habitats shown in Figure 2-5.

Table 2-5. Current Landcover Amounts of the WBN Site

Landcover	Area	% of WBN Site
Facilities	91.1 ha (225.3 ac)	22
Deciduous forest	133.5 ha (330.0 ac)	31
Coniferous forest	14.2 ha (35.2 ac)	3
Lawn/landscaping	5.7 ha (14.4 ac)	1
Old field	115.3 ha (284.8 ac)	27
Shrub scrub	34.6 ha (85.5 ac)	8
Wetlands	15.7 ha (38.8 ac)	4
Water	16.9 ha (41.7 ac)	4
Total	427.2 ha (1055.6 ac)	100

Source: TVA 2010a

Numerous wetlands and streams are present on the WBN site, and wetlands occupy almost 16 ha (40 ac) (Figure 2-5). Five minor stream systems of varying size are present. Open water exists in engineered and industrial ponds.

Invasive species, including Japanese stilt grass (*Microstegium vimineum*), Japanese honeysuckle (*Lonicera japonica*), multiflora rose (*Rosa multiflora*), and Russian olive (*Elaeagnus angustifolia*) have become established on the WBN site (TVA 2008a). TVA also observed autumn olive (*Elaeagnus umbellata*) and Chinese privet (*Ligustrum sinense*) on the site, and mentioned that other common invasive plants including kudzu (*Pueraria montana* var. *lobata*), mimosa (*Albizia julibrissin*), princess-tree (*Paulownia tomentosa*), and the tree-of-heaven (*Ailanthus altissima*) may also be present (TVA 2010a). Animal communities are typical of the region and populations appear locally abundant in the expected habitats.

2.3.1.2 Important Species and Habitat

NRC guidance defines important species as rare, economically or recreationally valuable, essential to the maintenance of an important species, playing a critical role in the function of an ecosystem, or serving as biological indicators for environmental change (NRC 1999, 2000). Further, NRC guidance defines rare species as one of the following: listed as threatened or endangered by the U.S. Fish and Wildlife Service (FWS) in Title 50 of the Code of Federal Regulations (CFR) 17.11 or 50 CFR 17.12; proposed for listing as threatened or endangered; published in the *Federal Register* as a candidate for listing; or listed as threatened, endangered, or other species of concern status by the State in which the proposed facility is located (NRC 1999, 2000).

(To convert feet [ft] to meters [m], multiply by 0.3048 m/ft)

Figure 2-4. Landcover Information for the WBN Site (TVA 2010a)

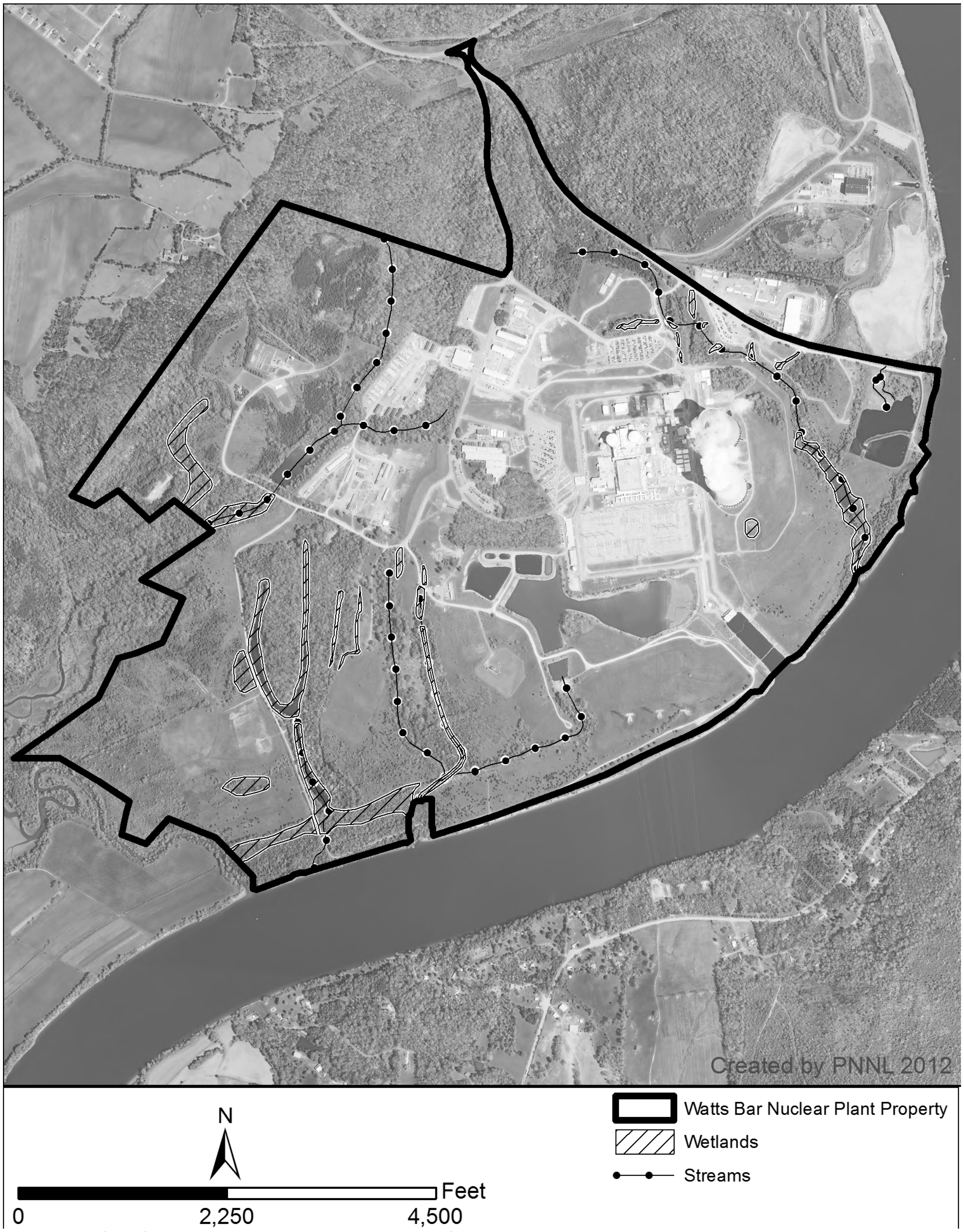


Figure 2-5. Wetlands and Streams Identified by TVA (TVA 2010a)

Terrestrial Species of Ecological Concern

Wildlife

In 1995, TVA counted 33 terrestrial genera (23 plants, 4 mammals, 3 birds, 1 arthropod, and 1 lichen) that were Federally listed as endangered, threatened, or proposed to be listed as endangered or threatened within the Tennessee River Basin (TVA 1995a). However, the Tennessee River Basin includes many species and habitats not present on the WBN site, in the vicinity of the site, or near the transmission corridors. In 1994, the NRC staff identified two Federally listed animal species known to occur on or near the WBN site or within 0.8 km (0.5 mi) of the WBN transmission corridors (NRC 1995). The gray bat (*Myotis grisescens*) is the only one still listed at the time of this publication.

The gray bat species, listed as endangered by the FWS (41 FR 17736) and the State of Tennessee, is limited to limestone karst areas within the southeastern United States (Brady et al. 1982). Most gray bats winter within a few known caves and disperse during seasonal migration to maternal caves for summer. This bat species possesses very specific microclimate requirements and only uses caves that offer these conditions. Summer colonies occupy traditional home ranges that include a maternal cave and several roost caves usually along a water body. In 1982, three Tennessee caves served as major hibernacula for gray bats (Brady et al. 1982). During summer, gray bats are known to roost in two caves within 8 km (5 mi) from the WBN site (NRC 1995). Eves Cave, located approximately 4 km (2.5 mi) south of the site, contained 385 gray bats in 2002. Almost 13 km (8 mi) northeast of the WBN site, Sensabaugh Cave contained 340 gray bats during the same year (Harvey and Britzke 2002). Small numbers (less than 500) of gray bats continue to roost in a cave approximately 5.3 km (3.3 mi) from the project (TVA 2008a). Adult gray bats feed on insects almost exclusively over water bodies (Brady et al. 1982), are known to forage over and along the Tennessee River, and have been known to forage more than 19 km (12 mi) from summer roost caves. Therefore, although no direct observations of gray bats foraging over the Tennessee River immediately adjacent to the WBN site or under transmission lines that service the site have been recorded, the NRC staff concludes gray bats routinely forage at these locations based on habitat preferences and the proximity of known active summer roost caves.

The 1978 FES-OL and subsequent documents discussed the bald eagle (*Haliaeetus leucocephalus*) as a Federally listed species on the WBN site (TVA 1995a; NRC 1978). The FWS delisted this species in 2007 (72 FR 37346) and it is no longer protected under the Endangered Species Act. However, the Bald and Golden Eagle Protection Act does protect the bald eagle (16 USC 668-668c). Bald eagles also occur near the WBN site and TVA has observed them nesting along the Chickamauga and Watts Bar reservoirs with the nearest nest located across the river and less than 1.6 km (1 mi) downstream from the WBN site (TVA 2010a). This nest was reported as active from 2000 to 2002, but was unoccupied during 2007. The FWS considers a bald eagle nest site active for 5 years following the last year of occupation. Two additional nests are located upstream along the Watts Bar Reservoir about 6.4 and 8 km (4 and 5 mi) from the WBN site (TVA 2010a). The FWS has not designated critical habitat in Rhea or Meigs counties for bald eagles.

In addition to the Federally listed gray bat, the State of Tennessee currently lists three wildlife species known to occur in Rhea and Meigs counties as threatened or endangered (Table 2-6) (TDEC 2009a). Bachman's sparrow (*Aimophila aestivalis*) is a bird native to the southeastern United States that prefers open habitats and frequents utility ROWs (Dunning 2006). The Berry Cave salamander (*Gyrinophilus gulolineatus*) is restricted to caves (Amphibia Web 2010) and is not known to occur in Rhea County. The northern pine snake (*Pituophis melanoleucus melanoleucus*) prefers well-drained, sandy, upland pine and pine-oak forests (New Jersey Division of Fish and Wildlife 2009). The osprey (*Pandion haliaetus*), which the State of Tennessee previously listed as endangered, was observed at the WBN site (NRC 1995). However, the State no longer lists osprey as endangered (TDEC 2009a).

Table 2-6. Rare Animal Species Listed by the State of Tennessee Known to Occur on the WBN Site, Within 0.8 km (0.5 mi) of the Transmission Corridor or Within Rhea and Meigs Counties, Tennessee

Common Name	Latin Name	State Status	Federal Status	Location
Bachman's sparrow	*Aimophila aestivalis*	Endangered	None	Transmission corridor
Gray bat	*Myotis grisescens*	Endangered	LE	Watts Bar vicinity and transmission corridor
Berry Cave salamander	*Gyrinophilus gulolineatus*	Threatened	None	Meigs County only
Northern pinesnake	*Pituophis melanoleucus melanoleucus*	Threatened	None	Rhea County only

Source: TDEC 2009a
LE = Listed Endangered

The State of Tennessee also classifies additional species as being *in need of management* (Table 2-7). This status is analogous to *Special Concern* and the State believes these species should be investigated to determine management needs to sustain them. No other Federally or State-listed animal species is known to occur on or immediately adjacent to WBN Units 1 and 2 or within 0.8 km (0.5 mi) of the transmission system that supports the WBN site.

In addition to listed or rare species, recreational species on the WBN site include white-tailed deer (*Odocoileus virginianus*), wild turkey (*Meleagris gallapavo*), eastern cottontail rabbit (*Sylvilagus floridanus*), opossum (*Didelphis virginiana*), raccoon (*Procyon lotor*), and various waterfowl (TWRA 2009). Ecologists consider white-tailed deer to be habitat generalists. White-tailed deer populations benefit from landscape disturbances and thrive in edge habitats—places where two or more distinct habitats meet, such as where the edge of a forest meets a

Table 2-7. Animal Species Listed by the State of Tennessee as Being In Need of Management Known to Occur Within Rhea and Meigs Counties, Tennessee

Common Name	Latin Name	State Status	Federal Status	Location
Barn owl	*Tyto alba*	In need of management	None	Meigs County only
Bald eagle	*Haliaeetus leucocephalus*	In need of management	None	WBN site vicinity and transmission corridor
Least bittern	*Ixobrychus exilis*	In need of management	None	Meigs County only
Allegheny woodrat	*Neotoma magister*	In need of management	None	Rhea County only
Eastern small-footed bat	*Myotis leibii*	In need of management	None	Rhea County only
Meadow jumping mouse	*Zapus hudsonius*	In need of management	None	Rhea County only
Southern bog lemming	*Synaptomys cooperi*	In need of management	None	Rhea County only

Source: TDEC 2009a

clearing (Cadenasso and Pickett 2000). Wild turkeys also prefer a mix of forest and open habitats. The cottontail rabbit thrives in habitats created by fairly recent disturbance, including old field, agricultural edges, and fescue patches (NatureServe 2009a). The opossum is also a habitat generalist and adapts to thrive in many different habitat types (NatureServe 2009b). The raccoon is also highly adaptable, but usually is associated with bottomland forests near streams or rivers (NatureServe 2009c). Waterfowl usually occur in or near wetlands, streams, and rivers.

<u>Plants</u>

No vascular plants listed Federally as threatened or endangered are known to occur on the WBN site, within 8 km (5 mi) of the site, or within Rhea or Meigs counties. However, in 2003, TVA found 20 scattered populations of the large-flowered skullcap (*Scutellaria montana*), a Federally and Tennessee State-threatened species, at two locations in Hamilton County that lie between 0.4 and 0.8 km (0.25 and 0.5 mi) of a transmission line that supports the WBN site (TVA 2010a). This perennial herb is found on rocky, dry slopes, ravines, and stream bottoms under mature deciduous forest (FWS 1991). Although listed as Federally endangered in 1986, subsequent discovery of other populations resulted in the reclassification of this species as threatened by the FWS (67 FR 1662).

The State of Tennessee lists 12 other plants occurring in Rhea or Meigs counties as threatened or endangered (TDEC 2009b). None of these species is known to occur on the WBN site or within 0.8 km (0.5 mi) of the transmission system supporting the site. However, TVA identified six State-threatened or endangered plant species within 8 km (5 mi) of the WBN site (TVA 2008a), four of which are still threatened or endangered. A population of Appalachian bugbane

(*Cimicifuga rubrifolia*) and a population of northern bush-honeysuckle (*Diervilla lonicera*) were last confirmed on a very steep slope along the Chickamauga Reservoir about 4.8 km (3 mi) south of the WBN site in the early 1990s (TVA 2010a). A population of slender blazing-star (*Liatris cylindracea*) occurs on an *Andropogon* spp. (bluegrass) barren about 5.6 km (3.5 mi) east of the WBN site in Meigs County (TVA 2010a). The location of the prairie goldenrod (*Solidago ptarmicoides*) population TVA listed in 2007 is unknown.

In addition to the State-listed species found in Rhea and Meigs counties within 8 km (5 mi) of the WBN site, four State-listed species have been identified in the region that are known to occur in open habitats and could become established within the transmission corridors (NRC 1995) (Table 2-8). The earleaf false-foxglove (*Agalinis auriculata*), tall larkspur (*Delphinium exaltatum*), and prairie goldenrod are State-listed endangered; the false-foxglove and larkspur are also Federal species of concern. The State lists mountain bush-honeysuckle (*Diervilla rivularis*) as threatened, but like the goldenrod, it is not Federally listed. No populations of these four species are known to grow within any of the transmission corridors, and the corridors do not cross any known populations. However, habitat preferences indicate any or all of these species could occur within maintained transmission corridors.

The State of Tennessee also classifies additional plants as being of special concern. None of these occurs on the WBN site, but five occur either within 8 km (5 mi) of the WBN site or within 0.8 km (0.5 mi) of its transmission system. TVA reports that the previously State-threatened spreading false-foxglove (*Aureolaria patula*) occurs within 8 km (5 mi) of the WBN site (TVA 2008a). Three populations of the spreading false-foxglove and one population of American barberry (*Berberis canadensis*) occur along the Lower Little Tennessee River in Loudon County. An individual heavy-fruited sedge (*Carex gravida*) grows within a Meigs County transmission corridor, and a single swamp lousewort (*Pedicularis lanceolata*) population was identified about 0.4 km (0.25 mi) from a transmission line in Roane County (TVA 2010a).

The TVA 1972 FES-CP also discusses a spider lily (*Hymenocallis occidentalis*) as being a Federally listed species (TVA 1972). TVA did not find this plant during field surveys it conducted on the WBN site in 1978 and 1994, and the spider lily is not currently Federally or State-listed (NRC 1995).

Habitats of Importance

The NRC staff deems habitat important if it meets one of four criteria and occurs on lands that may be adversely affected by facility or transmission-line construction, operation, or maintenance. Important habitat criteria include (1) set-aside lands, (2) habitats designated by State/Federal governments to receive protection priority, (3) wetlands/floodplains, and (4) critical habitat designated as such for species Federally listed as threatened or endangered (NRC 2000). The following sections discuss these habitats located in the vicinity of the WBN site.

Table 2-8. Rare Plant Species Listed by the State of Tennessee and Known to Occur Within 8 km (5 mi) of the WBN Site or Within 0.8 km (0.5 mi) of the WBN Transmission System

Common Name	Latin Name	State Status	Federal Status	Location
Earleaf false-foxglove	*Agalinis (Tomanthera) auriculata*	Endangered	Species of Concern	Could occur within transmission corridor
Spreading false-foxglove	*Aureolaria patula*	Special Concern	Not Listed	Transmission corridor, Rhea and Meigs counties, and the WBN site 8-km (5-mi) radius
Large-flowered skullcap	*Scutellaria montana*	Threatened	Threatened	Hamilton County transmission corridor
Heavy-fruited sedge	*Carex gravida*	Special Concern	Not Listed	The WBN site 8-km (5-mi) radius and Meigs County
Appalachian bugbane	*Cimicifuga rubifolia*	Threatened	Not Listed	Transmission corridor and the WBN site 8-km (5-mi) radius
American barberry	*Berberis canadensis*	Special Concern	Not Listed	Loudon County transmission corridor
Tall larkspur	*Delphinium exaltatum*	Endangered	Species of Concern	Could occur within transmission corridor
Northern bush-honeysuckle	*Diervilla lonicera*	Threatened	Not Listed	Transmission corridor, Meigs County, and the WBN site 8-km (5-mi) radius
Mountain bush-honeysuckle	*Diervilla sessilifolia* var. *rivularis*	Threatened	Not Listed	Transmission corridor
Swamp lousewort	*Pedicularis lanceolata*	Special Concern	Not Listed	Roane County transmission corridor
Slender blazing-star	*Liatris cylindracea*	Threatened	Not Listed	Rhea and Meigs counties and the WBN site 8-km (5-mi) radius
Prairie goldenrod	*Solidago ptarmicoides*	Endangered	Not Listed	Transmission corridor, Rhea County, and the WBN site 8-km (5-mi) radius

Set-Aside Lands

The Yuchi Wildlife Refuge at Smith Bend, Tennessee, is about 1.6 km (1 mi) southwest of the WBN site (TWRA 2007). The Tennessee Wildlife Resources Agency (TWRA) manages this 957-ha (2,364-ac) waterfowl refuge, which provides about 400 ha (1,000 ac) of wetlands and upland forest (TWRA 2009). Watts Bar Wildlife Management Area is located 2.7 km (1.7 mi) north of the WBN site and across the Tennessee River in Roane County. This area comprises numerous parcels totaling 1,570 ha (3,880 ac). Hunting of both big and small game is allowed. The TWRA also manages Chickamauga State Wildlife Management Area, a series of parcels totaling about 1,600 ha (4,000 ac). Some parcels lie 10 to 11 km (6 to 7 mi) southwest of the WBN site. The State allows small game, deer, and waterfowl hunting.

State/Federal Priority Protection Habitats

There are no habitats on the WBN site that receive priority protection from the State of Tennessee or the Federal government.

Wetlands/Floodplains

Wetlands are not prevalent within the WBN landscape (as a result of local geology) and only total around 15.8 ha (39 ac) or about 4 percent of the WBN site land area (TVA 2010a). Wetlands on the site are primarily associated with open water, including reservoirs of the Tennessee River (TVA 2004a). Most lie in the western third of the site, are scrub-shrub or emergent, and are found along streams (Figure 2-5). A 0.4-ha (1-ac) forested wetland exists between a road and a rail line outside of the northeast corner of the Unit 2 footprint. This wetland is associated with an unnamed stream and dominated by tag alder (*Alnus serrulata*), sycamore (*Platanus occidentalis*) and black willow (*Salix nigra*). Scattered emergent wetlands are also present along the Tennessee River and within the ash disposal sites and containment ponds in the southwest portion of the site (TVA 2008a). TVA manages water levels within the Tennessee River by operating dams throughout the river system. A policy approved by the TVA Board of Directors dictates surface-water elevations (TVA 2004a). TVA maintains the Watts Bar Reservoir summer high-water pool from May through October at 1.2 m (4 ft) higher than the winter low-water pool. At the Chickamauga Reservoir, the summer high-water pool (May through September) is maintained at 1.8 m (6 ft) higher than the low winter pool (TVA 2004a).

Critical Habitat

The FWS has not designated critical habitat for Federally listed species on the WBN site.

Other Important Habitat Features

TVA documents two additional habitat features deemed important to regional wildlife: rookeries and caves. Rookeries are nesting locations for colonial water birds that are usually located very near a water body. One great blue heron (*Ardea herodias*) rookery is located on the western side of the WBN site adjacent to the Horseshoe Pond wetland area (TVA 2010a). This rookery was active during the mid-1980s, but its current activity status is unknown. TVA has documented three additional great blue heron rookeries within 8 km (5 mi) of the WBN site. All are located on the Watts Bar Reservoir upstream of the site, and nesting activity was noted as recent as 2006 (TVA 2010a).

Caves provide unique habitats and often host important species. As discussed in the gray bat section above, Eves Cave, located about 4 km (2.5 mi) south of the WBN site, is the only known cave within 8 km (5 mi) of the WBN site. Sensabaugh Cave, another cave used by gray bats, is northeast of the site and within 0.8 km (0.5 mi) of a transmission line. Additional caves located within 0.8 km (0.5 mi) of the WBN transmission system include Cooley Cave near the Watts Bar-Volunteer transmission line in Roane County and two unnamed caves within 0.8 km (0.5 mi) of the Sequoyah-Watts Bar transmission line in McMinn County. TVA also disclosed the location of six other named and unnamed caves within 4.8 km (3 mi) of the WBN transmission system.

Wildlife Travel Corridors

Many species of wildlife use both natural and man-made features in the landscape to travel from one environment to another, essentially a corridor. Mammals may use roads, trails, levees, streams, strips of forest, or features such as ridge tops or valleys—depending on their habitat preferences (Frey and Conover 2006; Atwood et al. 2004; Spackman and Hughes 1995). Also, waterfowl may use the Tennessee River as a travel corridor. Beyond these natural travel corridors, no major wildlife travel corridors are known to exist on the WBN site, within 8 km (5 mi) of the site, or within 0.8 km (0.5 mi) of the transmission system.

2.3.1.3 Ongoing Ecological and Biological Studies

There are no ongoing terrestrial ecological or biological studies at the WBN site.

2.3.1.4 Offsite Transmission and Access Corridors

The transmission system that supports the WBN site includes six individual transmission lines totaling 298 km (185 mi) (NRC 1978). The longest, the 142 km (88 mi) Watts Bar-Volunteer line, is a 500-kV line TVA built through woodland, agriculture, and uncultivated open land (NRC 1978). Three other 500-kV lines support the WBN site: the 64-km- (40-mi-) long Watts Bar-Roane line, 64-km- (40-mi-) long Watts Bar-Sequoyah No. 2 line, and the 16-km- (10-mi-) long Bull Run-Sequoyah loop into the WBN site. TVA also uses two additional 1.6-km- (1-mi-) long 161-kV lines (Watts Bar Hydro-Watts Bar Nuclear Nos. 1 and 2). These transmission corridors occupy 1,465 ha (3,621 ac) of land area (NRC 1995).

2.3.2 Aquatic Ecology

The 1972 FES-CP describes the characteristics of the WBN site's aquatic environment and biota based on site-specific data and general knowledge of the Tennessee River tailrace habitats and their associated aquatic biota (TVA 1972). The NRC 1978 FES-OL evaluates supplemental information from preoperational monitoring programs conducted in the years between the two reports (NRC 1978). In April 1995, the NRC updated the 1978 FES-OL to support the operation of Unit 1. The updated information included results of a report detailing preoperational monitoring efforts and results from 1973 to 1985, which was published in 1986 (TVA 1986). The 1995 SFES-OL-1 also discussed and analyzed changes that had occurred either in the aquatic biota or the aquatic habitat within the vicinity of the WBN site (NRC 1995).

The following sections update background information about aquatic ecology since publication of the 1978 FES-OL and expand the discussion of specific areas, such as the Watts Bar Reservoir, to evaluate environmental changes that may occur because of the use of the supplemental condenser cooling water (SCCW) system. The sections also include the results of monitoring studies of the aquatic ecology of the Tennessee River in the vicinity of the WBN site, including freshwater mussels and fish.

2.3.2.1 Aquatic Communities in the Vicinity of the WBN Site

Onsite Ponds and Streams

Aquatic communities in the vicinity of the WBN site include onsite ponds and streams and the Tennessee River. Previous information related to the aquatic ecology of onsite ponds and streams is still valid. TVA does not plan to disturb forested wetland areas (TVA 2008a).

TVA retains the ability to use the emergency overflow of the plant YHP (Outfall 102, which discharges to a local stream channel at TRM 527.2). However, historically, the WBN plant has released water from Outfall 102 only a few times since Unit 1 started operating. Outfall 102 was used during maintenance operations for Outfall 101 and once during an ice storm (TVA 2008a; PNNL 2009).

Tennessee River

The Tennessee River drains an area of approximately 105,000 km^2 (40,540 mi^2) in portions of Virginia, North Carolina, Tennessee, Georgia, Alabama, Mississippi, and Kentucky. A series of impoundments TVA constructed from the late 1930s to the 1960s altered the character of the Tennessee River (Etnier and Starnes 1993). TVA impounded Chickamauga Reservoir, where the WBN site is located, in 1940 and Watts Bar Reservoir, immediately above the site, in 1942 (NRC 1995). Although impoundment has changed much of the environment from riverine to lacustrine (lake-like), some riverine qualities still exist in the upper reaches of some reservoirs where water flows through a dam from one reservoir to another.

The WBN site is located in an area of the Chickamauga Reservoir approximately 1.6 km (1 mi) downstream of Watts Bar Dam where the inflow from the dam creates an environment with a faster river flow than occurs farther downstream. Even so, the impoundments have altered the dynamics of river flow even at this location. For example, spring floods that once occurred along the river no longer occur, and the expansive rocky or gravel shoal areas that once abounded in the Tennessee River no longer exist (Etnier and Starnes 1993). In addition, changes in water depth, temperature, reductions in the amount of dissolved oxygen, and increased sedimentation are all factors that accompany the placement of dams. These changes have affected or are continuing to affect the organisms in the river and result in detectable changes to the aquatic ecosystem when compared to pre-impoundment.

The assemblage of organisms living in the river changed in response to the impoundments. According to Parmalee and Bogan (1998), a total of 11 species of the unionid mussel genus *Epioblasma,* which inhabited the shoal and riffle areas in the Tennessee River and its tributaries, are now extinct. Parmalee and Bogan attribute this to either the direct or indirect result of impoundment. As Neves and Angermier (1990) reported, obligatory river species typically do not survive in reservoirs. Further, they reported that, even though fish sampling on the Tennessee River was not extensive in the years before construction of the dams began (late 1930s), enough surveys were conducted to allow the documentation of the adverse effect that impoundment had on native fish species. For example, fish surveys conducted before and after the impoundment of Melton Hill Reservoir (as reported in 1968) showed a shift in the fauna. Those species requiring shoal and riffle habitats were no longer present in the post-impoundment surveys. The Melton Hill Reservoir is located upstream of Watts Bar Dam on the Clinch River in East Tennessee.

The impoundments created good reservoir fisheries for sport and commercial fishermen. This, in turn, changed the character of the aquatic biota. According to Etnier and Starnes (1993), resource managers and others, whether purposely or accidentally, have introduced other species (including nuisance species) into the system. Nuisance species are those non-native species whose introduction causes, or is likely to cause, economic or environmental harm. These introduced species include Eurasian watermilfoil (*Myriophyllum spicatum*), spiny leaf naiad (*Najas minor*), hydrilla (*Hydrilla verticillata),* zebra mussels (*Dreissena polymorpha*), Asiatic clams (*Corbicula fluminea*), and a variety of fish species. Further discussion of these species and their potential effect on the native aquatic biota is detailed later in this section.

Aquatic biota, particularly those in the Watts Bar Reservoir, also may have been affected by chemical contamination from a coal ash fly spill at the Kingston Fossil Plant located on the Emory River (TDEC 2010a). Other chemical contaminants in the Watts Bar Reservoir include PCBs, metals, mercury, organic compounds, and radionuclides from other facilities including the U.S. Department of Energy's Oak Ridge National Laboratory located on Clinch River upstream of Watts Bar Reservoir (ATSDR 1996; TDEC 2010a). Section 4.14.6 contains a discussion of the cumulative impacts of the operation of other facilities on the aquatic ecosystem.

A description of the aquatic organisms in the Watts Bar Reservoir forebay (the deep water above or upstream of the dam) and the Chickamauga Reservoir inflow that could potentially be affected by operations of WBN Unit 2, follows. Figure 2-6 illustrates a typical food web for this location.

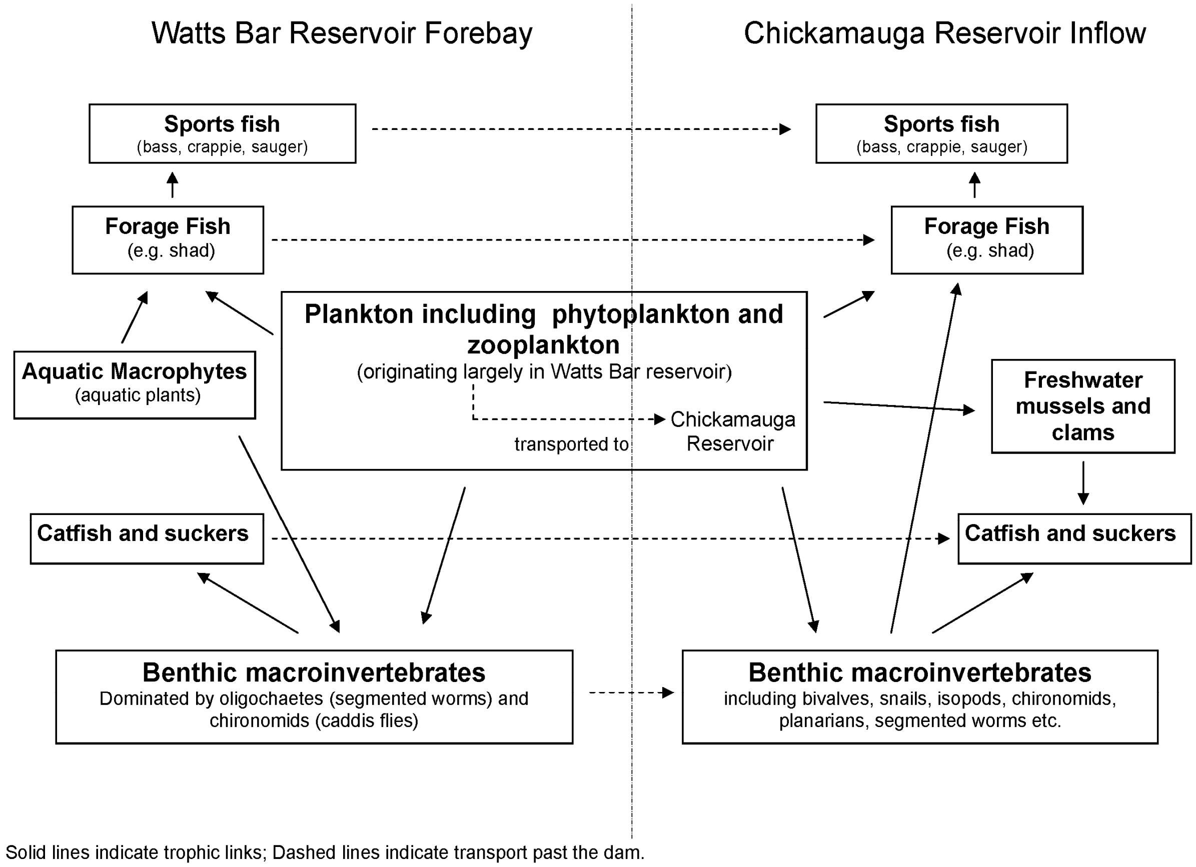


Figure 2-6. Foodweb for Watts Bar Reservoir Forebay and Chickamauga Reservoir Inflow

Zooplankton and Phytoplankton

Plankton are small plants or animals that float, drift, or weakly swim in the water column of any body of water. There are two main categories of plankton: phytoplankton and zooplankton. Plankton, also known as “microscopic algae,” contain chlorophyll and require sunlight to live and grow. Zooplankton, are small microscopic animals, mainly invertebrates (animals that are lacking a true vertebrate or backbone). In a balanced ecosystem, phytoplankton and zooplankton form the basis of the food chains and play key ecosystem roles in the distribution, transfer, and recycling of nutrients and minerals.

TVA conducted phytoplankton and zooplankton sampling quarterly at seven stations from February 1973 through November 1977 (NRC 1978; TVA 1986). One station was located in the Watts Bar Reservoir forebay, the other six stations were located between TRM 496.5 and 529.5. After publication of the 1978 FES-OL, TVA conducted further phytoplankton and zooplankton sampling from May 1982 through November 1985 as indicated in the 1995 SFES-OL-1 and as reported by TVA (1986). As reported in the 1995 SFES-OL-1, sampling results indicated that the well-mixed, relatively fast-flowing riverine portion of the Chickamauga Reservoir that occurs near the WBN site prevented phytoplankton from obtaining enough light to photosynthesize and did not provide adequate residence time for phytoplankton to grow and reproduce. Thus, TVA determined that if operational impacts on the phytoplankton community occur, they would not be apparent. The results also indicated that the highest densities of zooplankton typically occurred in the Watts Bar Reservoir forebay and substantially decreased in the swiftly flowing section of the Chickamauga Reservoir near the WBN site and several miles downstream (TVA 1986). Because the Watts Bar Dam still influences the flow of water in the Tennessee River past the WBN site, these observations are still valid today.

Periphyton

Periphyton are of a complex community of organisms that grow on underwater surfaces. They can include algae, bacteria, fungi, and other organisms. Periphyton plays an important ecological role as a food source for invertebrates, frog larvae (commonly called “tadpoles”), and some types of fish. TVA described periphyton sampling in its preoperational monitoring reports, as discussed in the 1995 SFES-OL-1 (NRC 1995). In general, the sampling results indicated that the periphyton community structure appeared to be more similar in the three stations closest to the WBN site and Watts Bar Dam (TRMs 529.5, 528.0, and 527.4) than in the lower stations (TRMs 496.5, 506.6, and 518). Overall, the communities among the stations comprised similar genera, but they differed in abundance (TVA 1986). TVA has not conducted additional periphyton studies at the WBN site since Unit 1 began operating.

Aquatic Macrophytes

Aquatic macrophytes are vascular aquatic plants (plants with true stems, roots, and leaves), mosses, and in some cases large algae. TWRA (2008) reported that introduced or non-native species of aquatic macrophytes make up the most abundant aquatic plant species, which include exotic or non-native species such as Eurasian watermilfoil, spiny leaf naiad, and hydrilla. In addition, alligatorweed (*Alternanthera philoxeroides*), a vascular plant that root in bottom sediments, and Asian Spiderwort (*Murdannia keisak*) have been found in Chickamauga Reservoir. Invasive aquatic plants provide benefits such as food and cover for waterfowl, fish, and smaller organisms, and they reduce wave action, filter sediments suspended in the water, add oxygen to the water, and help protect shorelines from erosion. The plants also benefit the sportfishing industry by making it easier for recreational and professional anglers to catch fish, which in turn attracts more anglers. However, the plants conflict with activities such as swimming, skiing, bank fishing, and boating, and they can clog intake screens, decrease native plant diversity, and create mosquito habitat. Two additional invasive aquatic plants that have moved into the Tennessee River system but have not been reported to affect recreation are the Brazilian elodea (*Egeria densa*) and the curly-leaf pondweed (*Potamogeton crispus*) (TWRA 2008).

As NRC discusses in its 1995 SFES-OL-1 (NRC 1995), macrophytes were rare in the region of the Chickamauga Reservoir near the WBN site. Macrophytes are still rare and have never reached nuisance levels in this area (TVA 2008a) because the relatively shallow overbank habitat that is suitable for macrophyte growth is not present. Because the WBN site is located near the tailwater area of the reservoir where water velocity is higher, aquatic plants have difficulty establishing dense growths, even during years of peak coverage in the rest of the reservoir (NRC 1995). Peak aquatic plant coverage occurs in Chickamauga Reservoir in shallow, overbank lacustrine (lake-like) habitat far downstream of the WBN site.

<u>Benthic Macroinvertebrates Including Freshwater Mussels</u>

Benthic macroinvertebrates are animals that live all or part of their life on or near the bottom of streams or reservoirs. Invertebrates, as defined previously, are animals that do not have a true backbone. Macroinvertebrates are animals that are large enough to see with the human eye. Macroinvertebrates include animals such as flatworms, roundworms, leeches, crustaceans, aquatic insects, snails, clams, and mussels. Benthic macroinvertebrates are an important food source for other aquatic organisms, including fish. Researchers use studies of benthic macroinvertebrate abundance and distribution to detect major environmental changes because these animals do not migrate rapidly and generally do not make major changes in location.

TVA performed preoperational studies before the start of WBN Unit 1 and operational studies after the start of WBN Unit 1. TVA conducted two types of studies during these two time periods. In one type of study, TVA sampled all types of benthic macroinvertebrates (referred to in this document as “general benthic macroinvertebrate studies”). In the second type of study, TVA specifically sampled unionid mussels (referred to in this document as “mussel surveys”). The following paragraphs and Section 5.5.2 describe these studies in further detail.

Before the start of operations, TVA conducted general benthic macroinvertebrate studies from 1973 to 1976 and from 1982 to 1985. These preoperational studies included monitoring the growth of benthic macroinvertebrates in Chickamauga Reservoir in the vicinity of the WBN site with artificial substrates and monitoring the density of benthic macroinvertebrates with Hess samplers (TVA 1986). After the start of operations for WBN Unit 1, TVA performed additional general benthic macroinvertebrate studies using a Hess sampler (1996 to 1997) and either a Ponar or Peterson grab (1999 to current) (Baxter et al. 2010; Simmons 2011). Study sites during the 1999 to current sampling periods were present in both Chickamauga and Watts Bar reservoirs.

A comparison of the total number of benthic macroinvertebrate taxa collected in the inflow of the Chickamauga Reservoir during preoperational and operational studies showed an increase from 59 recorded during preoperational monitoring to 104 during operational monitoring. Densities of benthic macroinvertebrates also increased considerably at all five stations after WBN Unit 1 began operating. TVA (Baxter et al. 2010) indicated that the connection with the plant operation is not clear and that most likely the density in organisms increased as a result of an aeration system installed in the reservoir upstream of Watts Bar Dam in early summer 1996 to reduce stratification in the vicinity of the dam. This in turn increased the dissolved oxygen levels in the water released through the dam. During preoperational monitoring in Chickamauga Reservoir, three taxa—Asiatic clams; a trichopteran (caddis fly), *Cyrnellus fraternus;* and oligochaeta (segmented worms)—composed approximately 85 percent of the total community (Baxter et al. 2010). During operational monitoring, four taxa—Asiatic clams; a planarian, *Dugesia tigrina*; an amphipod, *Gammarus minus*; and oligochaeta—composed 87.5 percent of the total community (Baxter et al. 2010). Based on a comparison of species composition, occurrence, and densities between the preoperational and operational monitoring periods, TVA (Baxter et al. 2010) concluded that the WBN site had no effect on the benthic macroinvertebrate community in Chickamauga Reservoir immediately below the dam during the first 2 years of operation.

TVA conducted studies between 1999 and 2007 collecting benthic macroinvertebrates annually during autumn in the forebay of the Watts Bar Dam (TRM 533.3) and in the inflow of the Chickamauga Reservoir (TRM 518) as part of its annual monitoring program (Baxter and Simmons 2008). Sampling has continued in recent years, although starting in 2008, the lower sampling location changed to TRM 527.4 (Simmons and Baxter 2009) . Table 2-9 provides a comparison of the data obtained from the two sampling locations during the most recent sampling years (2008 to 2010). The data indicate a greater number of species at the downstream sampling location. Oligochaetes (segmented worms) and chironomids (non-biting midges) dominated the sampling area above the dam, which is expected because it is a slower, deeper aquatic habitat compared to the more turbulent and faster moving habitat near the WBN site. Flatworms, amphipods, caddis fly larvae, and Asiatic and finger clams were present in higher densities in the inflow to the Chickamauga Reservoir (Simmons and Baxter 2009; Simmons et al. 2010; Simmons 2011).

TVA also conducted surveys specific to unionid mussels both before operation and after startup of WBN Unit 1 in the upper Chickamauga Reservoir. Preoperational sampling of the freshwater mussel beds near the WBN Unit 2 site occurred from 1975 to 1976 (brailing, random scuba dives), in 1978, and from 1983 to 1994 (timed scuba dives) (TVA 1986). Sampling of the mussel beds after the start of operations of WBN Unit 1 took place in 1996, 1997 (Baxter et al. 2010), and 2010 (Third Rock Consultants 2010). TVA surveyed the mussel population near the WBN site on 16 occasions from 1983 through 2010.

Table 2-9. Average Mean Density per Square Meter of Benthic Taxa Collected at Upstream and Downstream Sites near the WBN Site

Taxa	2008 Downstream TRM 527.4 (Chickamauga Reservoir)	2009 Downstream TRM 527.4 (Chickamauga Reservoir)	2010 Downstream TRM 527.4 (Chickamauga Reservoir)	2008 Upstream TRM 533.3 (Watts Bar Reservoir)	2009 Upstream TRM 533.3 (Watts Bar Reservoir)	2010 Upstream TRM 533.3 (Watts Bar Reservoir)
Turbellaria						
Planariidae (flatworms)	47	15	15	--	--	--
Oligocheata						
Oligochaetes (segmented worms)	15	5	5	250	--	28
Hirudinea (leeches)	23	--	3	--	55	--
Crustacea						
Amphipoda	3	40	8	--	--	--
Isopoda	20	--	7	--	--	--
Insecta						
Ephemeroptera (mayflies)	2	--	5	--	--	--
Trichoptera (caddis flies)	--	--	13	--	--	3
Odonata (dragon/damselflies)	--	--	3	--	--	--
Diptera Chironomidae (midges)	7	--	47	70	73	190
Gastropoda (snails)	10	15	7	--	8	--
Bivalvia						
Unionoidae (mussels)	--	13	--	--	--	--
Corbiculidae (≤10mm [0.4 in.])	35	428	78	--	7	--
Corbiculidae (≥10mm [0.4 in.])	--	158	72	--	2	--
Sphaeriidae (fingernail clams)	2	8	17	--	--	2
Dressenidae (zebra mussels)	23	7	--	--	15	--
Density of organisms per m^2 (11 ft^2)	187	690	280	320	160	223
Total areas sampled (m^2 [11 ft^2])	0.6	0.6	0.6	0.6	0.6	0.6

Source: Simmons and Baxter 2009; Simmons et al. 2010; Simmons 2011

As NRC stated in the 1995 SFES-OL-1 (NRC 1995), the Tennessee River is home to both introduced and native mussel and clam species. Approximately 130 of nearly 300 species of freshwater mussels in the United States live, or are known to have lived, in waters within Tennessee (Parmalee and Bogan 1998). However, stressors such as farming, strip mining, industry, power dam construction, and commercial exploitation have greatly reduced species distribution and abundance (Parmalee and Bogan 1998).

Mussels spend their entire juvenile and adult lives buried either partially or completely in the substrate. Although mussels are able to change their position and location, they rarely move more than a few hundred yards during their lifetime unless dislodged. Individuals from some species of freshwater mussels live for more than 100 years (Parmalee and Bogan 1998). Freshwater mussels filter organic particles and microorganisms, such as protozoans, diatoms, and bacteria) from the water. Native freshwater mussels have a unique reproductive cycle. Sperm released into the water carry into the female mussel’s body via tubes in the gills, where they fertilize the eggs. The fertilized eggs develop into small larvae, called glochidia, which release into the water. If the glochidia do not encounter a passing fish and attach to its gills, then they fall to the bottom and die a short time later. The glochidia remain on the fish around

1 to 6 weeks and then fall off and begin their growth into adulthood. Each mussel species has specific species of fish that serve as a host fish for the glochidia (Parmalee and Bogan 1998). The survival of freshwater mussel species depends not only on the environmental conditions for the mussel, but on the survival and health of the host fish populations. Some species of freshwater mussel sexually mature at 4 to 6 years of age (Jirka and Neves 1992), although age of sexual maturity is 8 to 10 years of age for other species of freshwater mussels (Downing et al. 1993).

The numbers of native mussels have been declining since the early 1940s when TVA filled the Chickamauga and Watts Bar reservoirs. As noted in the 1995 SFES-OL-1 (NRC 1995), ecologists believe a total of 64 freshwater mussel species occurred near the WBN site prior to impoundment of the river, based on studies of shell midden material and evaluations conducted before the impoundments were built (TVA 1986). Parmalee et al. (1982) studied aboriginal shell middens in the Chickamauga Reservoir (TRM 495-528). The five most abundant species during the Middle Woodland (1 AD) to Late Woodland Mississippian times (approximately 600 AD to 1600 AD) included the currently endangered dromedary pearly mussel (*Dromus dromas*), spike mussel (*Elliptio dilatatus*), mucket (*Actiononaias ligamentina*), elephant ear (*Elliptio crassidens*), and rough pigtoe (*Pleurobema plenum*). Together these species composed about 66 percent of the community surveys at 16 prehistoric aboriginal sites along the Chickamauga Reservoir. In the 1995 SFES-OL-1, the NRC (1995) stated that the mussel species in the Watts Bar tailwater have been in decline since impoundment of the Chickamauga and Watts Bar reservoirs. Further, most specimens found in surveys conducted prior to the 1995 FES-OL-1 were adults 30 or more years old and in poor condition (i.e., emaciated soft parts and extreme shell erosion) (NRC 1995). Watters (2000) points to impoundments, dredging, snagging, and channelization as having long-term detrimental effects on freshwater mussels. The impoundments result in silt accumulation, loss of shallow water habitat, stagnation, accumulation of pollutants, and nutrient-poor water.

As a result of the loss of diversity in mussel species, the State of Tennessee created a freshwater mussel sanctuary in the Chickamauga Reservoir in the vicinity of the WBN site. As NRC stated in its 1995 SFES-OL-1 (NRC 1995), the State extended the freshwater mussel sanctuary, which originally was 4.8 km (3 mi), from TRM 529.9 to 526.9, to 16 km (10 river mi) in which harvesting mussels is illegal (from TRM 529.9 to 520.0). Figure 2-7 shows the extent of the freshwater mussel sanctuary, as well as the approximate locations of the mussel beds and the locations of TVA mussel sampling stations.

TVA has monitored three known concentrations of mussels (mussel beds) within this sanctuary since 1983. The beds are all located on submerged gravel and cobble bars in water 2.7 to 6.4 m (9 to 21 ft) deep (TVA 2010b). The farthest downstream is located at TRM 520 to 521 on the left descending bank of the river. This bed is 10 km (6 mi) downstream of the plant and on the opposite side of the river. A second bed is roughly from TRM 526 to 527 on the right descending bank, and the third from TRM 528 to 529 on the left descending bank (Baxter et al. 2010; Third Rock Consultants 2010).

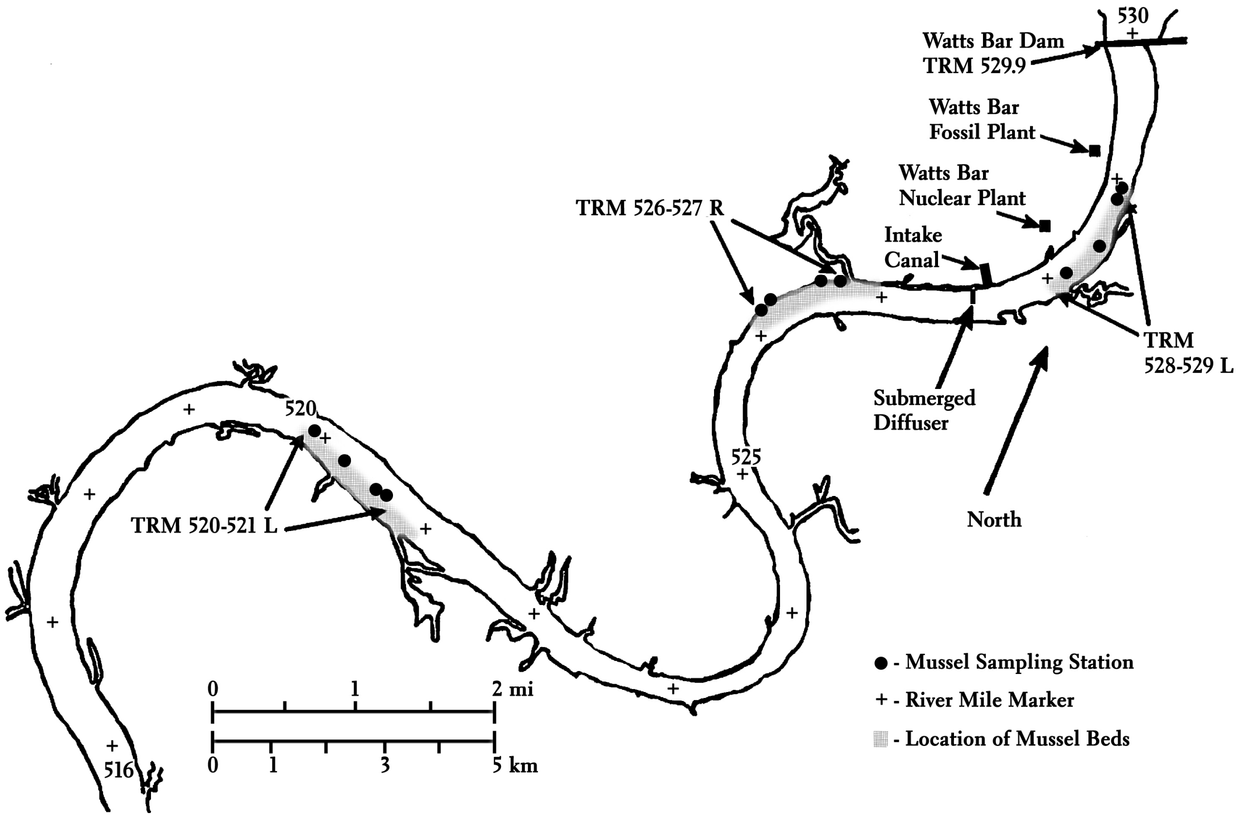


Figure 2-7. Mussel Beds (in gray) and Monitoring Stations (after Baxter et al. 2010)

Although mussel abundance was sampled in 10 different years (16 occasions) from 1983 to 2010, the data in Table 2-10 show the species identified in the years 1983 (September 13-14 survey), 1992, 1997, and 2010, as representative years, with the mussel surveys in 1983 and 1992 occurring prior to operation of WBN Unit 1 and the mussel surveys from 1997 and 2010 occurring after the start of WBN Unit 1 operation. Table 2-10 breaks out the data so that the differences between the mussel beds can also be observed (Baxter et al. 2010, Third Rock Consultants 2010). This provides information related to the potential changes in mussel population size since operation of WBN Unit 1. The mussels in the two downstream beds (see Figure 2-7) are located downstream of the discharge diffuser (the submerged diffuser, which is Outfall 101) and the intake pumping system intake. The upstream bed (TRM 528.2-528.9) is located slightly downstream of the SCCW discharge (Outfall 112), but on the opposite shore.

Table 2-10. Results of 15 Native Mussel Surveys During 1983 (September 13-24 survey), 1992, 1997, and 2010 in the Vicinity of the WBN Site

Native Mussel Species	Common Name	TRM 520.0-520.8				TRM 526.0-526.8				TRM 528.2-528.9				Total			
		1983	1992	1997	2010	1983	1992	1997	2010	1983	1992	1997	2010	1983	1992	1997	2010
Elliptio crassidens	Elephant ear	414	110	123	247	132	42	109	172	208	272	257	115	754	424	489	534
Pleurobema cordatum	Ohio pigtoe	90	26	28	17	109	27	18	73	65	29	55	35	264	82	101	125
Cyclonaias tuberculata	Purple wartyback	45	44	31	49	18	12	3	21	25	12	13	13	88	68	47	83
Quadrula pustuloso	Pimpleback	32	14	9	16	45	16	6	51	22	18	9	7	99	48	24	74
Potamilus alatus	Pink heelsplitter	6	6	2	13	7	5	6	15	1	5	4	3	14	16	12	31
Ellipsaria lineolata	Butterfly	15	8	5	6	8	3	1	20	1	3	2	1	24	14	8	27
Amblema plicata	Threeridge	1	2	0	0	15	6	4	1	2	5	1	1	18	13	5	2
Obliquaria reflexa	Threehorn wartyback	1	1	1	1	12	4	2	5	1	1	0	4	14	6	3	10
Leptodea fragilis	Fragile papershell	0	0	0	2	1	0	2	1	0	0	0	2	1	0	2	5
Quadrula metanevra	Monkeyface	8	2	0	2	4	3	1	1	2	3	1	0	14	8	2	3
Anodonta grandis	Giant floater	0	1	0	0	14	4	1	0	4	0	0	1	18	5	1	1
Lampsilis ovate	Pocketbook	2	0	0	0	0	0	0	0	1	0	1	0	3	0	1	0
Ligumia recta	Black sandshell	3	2	0	0	1	0	0	0	2	1	1	0	6	3	1	0
Tritigonia verrucosa	Pistolgrip	0	2	0	0	5	7	1	0	1	0	0	0	6	9	1	0
Megalonaias nervosa	Washboard	0	1	0	0	2	3	0	1	0	0	0	0	2	4	0	1
Lampsilis abrupta	Pink mucket	0	0	0	0	1	2	0	1	2	4	0	0	3	6	0	1

Table 2-10. (contd)

Native Mussel Species	Common Name	TRM 520.0-520.8				TRM 526.0-526.8				TRM 528.2-528.9				Total			
		1983	1992	1997	2010	1983	1992	1997	2010	1983	1992	1997	2010	1983	1992	1997	2010
Actinonaias ligamentina	Mucket	1	1	0	0	1	0	0	0	1	0	0	0	3	1	0	0
Plethobasus cyphyus	Sheepnose	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	1
Pleurobema oviforme	Tennessee clubshell	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elliptio dilatata	Spike	3	0	0	0	0	0	0	1	1	0	0	1	4	0	0	2
Fusconaia subrotunda	Longsolid	1	0	0	1	0	0	0	0	1	0	0	0	2	0	0	1
Utterbackia imbecillis	Paper pondshell	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Cyprogenia stegaria	Fanshell	1	0	0	0	0	0	0	0	1	0	0	0	2	0	0	0
Dromus dromas	Dromedary pearly mussel	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Pleurobema plenum	Rough pigtoe	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Grand total		**625**	**220**	**199**	**354**	**375**	**135**	**154**	**365**	**341**	**353**	**344**	**183**	**1341**	**708**	**697**	**902**

From TVA 2010b; Baxter et al. 2010; and Third Rock Consultants 2010.

Table 2-11 shows the number of individual mussels and the number of species that were identified in all three beds in each of the preoperational (1983 to 1994), operational (1996 and 1997), and recent (2010) surveys (TVA 1986, Baxter et al. 2010, and Third Rock Consultants 2010). Between 1983 and 1988, the number of individuals and species remained fairly constant (991 to 1,610 individuals; 18 to 22 species). In 1992, the number of individuals and species started decreasing. The largest drop in the number of species and abundance of individuals occurred in 1992, several years before the start of operations of WBN Unit 1, which occurred in 1996. The decline in the number of individuals appears to have stabilized for some species and the overall number of individuals found in the two downstream beds in 2010 has increased from the numbers observed since 1992. However, the total number of individuals reported from the upper bed (Third Rock Consultants 2010) has decreased to or below 50 percent of the number observed in any previous year. Considering the total number of mussels from all three beds, the abundance of the elephant ear, Ohio pigtoe (*Pleurobema cordatum*), purple wartyback (*Cyclonaias tuberculata*), pimpleback (*Quadrula pustuloso*), pink heelsplitter (*Potamilus alatus*), butterfly (*Ellipsaria lineolata*), monkeyface (*Quadrula metanevra*), threehorn wartyback (*Obliquaria reflexa*), and fragile papershell (*Leptodea fragilis*) mussel populations increased since 1997. The number of purple wartyback, pink heelsplitter, and butterfly mussels observed in 2010 is approaching or has exceeded the number observed during sampling in the 1980s (Third Rock Consultants 2010).

Table 2-11. Mussel Abundance and Numbers of Species Present in the Vicinity of the Watts Bar Nuclear Site from 1983 to 2010

Year	Number of Individuals	Number of Species	Federally Threatened and Endangered Species/Individuals	Plant Status
1983 (September)	1,341	22	4/7	preoperational
1983 (November)	1,422	21	3/9	preoperational
1984 (July)	1,270	20	2/8	preoperational
1984 (November)	1,368	19	2/3	preoperational
1985 (July/August)	1,063	20	3/3	preoperational
1985 (October)	1,427	20	1/7	preoperational
1986 (July)	1,075	18	1/6	preoperational
1986 (October)	1,180	20	1/2	preoperational
1988 (July)	1,610	22	1/12	preoperational
1990 (July)	991	22	1/4	preoperational
1992 (Summer)	708	16	1/6	preoperational
1994 (Summer)	880	17	1/2	preoperational
1996 (July)	846	17	1/4	during WBN Unit 1 operations
1997 (July)	697	14	0/0	during WBN Unit 1 operations
2010 (September)	902	17	1/1	during WBN Unit 1 operations

Source: TVA 1986; TVA 2010b; Baxter et al. 2010; Third Rock Consultants 2010

The 2010 surveys found that 60 individuals from 7 species were less than 10 years old (Third Rock Consultants 2010). This information is indicative that mussels have reproduced in the last decade, during the time that WBN Unit 1 was operating. These species included the purple wartyback, elephant ear, fragile papershell, threehorn wartyback, pink heelsplitter, pimpleback, and paper pondshell (*Utterbackia imbecillis*) (Third Rock Consultants 2010). These data lead to a different interpretation than in the 1995 FES-OL-1 (NRC 1995). The 1995 FES-OL-1 (based on information in TVA 1986) states that "…no young or juvenile mussels have been found during sampling since monitoring began in 1983. Although the reason for the mussels' lack of recruitment is not known, it is reasonable to assume that impoundment of the river and the resulting modifications to the riverine system are largely responsible." It now appears that this statement is no longer valid and that some species of mussels are reproducing, the young are surviving, and are likely also reproducing. However, the number of juvenile mussels under the age of 10 years was lower in the upper bed (9) than in either of the lower beds (31 for the middle bed and 20 for the lowest bed).

Possible causes of the decline in mussel population and species diversity include competition, predation, and changes to the mussels' environment. Because mussels are long-lived, events that occurred in previous decades, such as impoundment of the river, pollution, silting or changes in fish host species, may continue to have a negative effect on the population structure (Neves et al. 1997). Other changes may have resulted in a positive effect on the mussel populations. This includes the minimum flow requirements that TVA instituted for the Watts Bar Dam or the installation of an aerator in the Watts Bar Reservoir in 1996 to increase dissolved oxygen concentrations behind the dam and in the inflow to the Chickamauga Reservoir.

An additional survey was conducted at TRM 529.2 in 1997 in the vicinity of the SCCW discharge (TVA 1998). While not considered a mussel bed, some mussels, such as those that were near the SCCW discharge, are located between beds (TVA 2010c). As a result, mussels were relatively scarce in this area and appeared somewhat evenly distributed (TVA 1998). The freshwater mussels that were in an area of 46 by 46 m (150 by 150 ft) at the outlet to the SCCW system (23 m [75 ft] upstream and downstream of the centerline of Outfall 113) were relocated before the startup of the SCCW (Harper and Smith 1999). TVA moved these mussels to the mussel bed located almost directly across the river in an effort to prevent any adverse effects to these mussels from operation of the SCCW system discharge (TVA 2010c). One specimen of the pink mucket (*Lampsilis abrupta*), an endangered species, was identified. In addition, TVA found live representatives of 13 native mussels. The elephant ear, again the most abundant species, made up 57 percent of the total number of individuals. Three other species (pink heelsplitter, pimpleback, and Ohio pigtoe) each accounted for at least 5 percent of the total (TVA 1998).

In 2002, TVA established four experimental plots of freshwater mussels in a boulder field that was reported to be located between TRM 528.3 and 528.8 (TVA 2010b), approximately 1.6 km (1 mi) from the Watts Bar Dam. TVA randomly selected mussels for the experimental plots from the downstream mussel beds (TVA 2010c). TVA undertook this action as a result of the conditional site approval for the SCCW system outfall. The TDEC specified that TVA should provide measures to enhance the available habitat for the mussel population by submitting a habitat enhancement proposal (TVA 1998). The experimental effort was designed to determine if mussel habitat enhancement through relocation to an artificial boulder field would provide a refuge from high flow events resulting from dam discharges (Third Rock Consultants 2010). The result of that proposal was the placement of mussels in a boulder field approximately 3.7 to 4.3 m (12 to 14 ft) deep and approximately 50 m (164 ft) from the right (descending) shore (TVA 2010b). This location is along the right (descending) margin of the navigation channel between the loading facility for the now demolished Watts Bar Fossil Plant and the WBN intake channel. In 2010, TVA attempted to find the plots in the boulder field. Only two historic sampling stations were located. Divers looked for mussels using two types of survey techniques. Five live mussels were found during a 20-minute sampling study throughout the boulder field. The mussels included one purple wartyback, one pimpleback, one pink heelsplitter, and two threehorn wartybacks (Third Rock Consultants 2010). Other researchers have tried relocation of mussel species with mixed success (Parmalee and Bogan 1998; Cope and Waller 1995).

A large population of invasive, non-native, Asiatic clams and an increasing population of the zebra mussel also inhabit the section of the Tennessee River near and downstream of the WBN site. The Asiatic clam is in almost every river and reservoir in Tennessee. The Asiatic clam competes with native bivalve species for food and habitat. Asiatic clams are known to cause biofouling in power plant intakes and industrial water systems, which can result in a large economic impact. Ecologists first found zebra mussels in 1995 at TRM 528.0 (adjacent to the intake channel) (Baxter et al. 2010). Zebra mussels also cause biofouling problems. In addition, they can have large negative effects on the ecosystems, including reductions in the biomass of phytoplankton and zooplankton, which can adversely affect planktivorous and larval fish (TWRA 2008). They also negatively affect freshwater mussels and are likely the cause of freshwater mussel extirpation from Lake St. Clair (Schloesser et al. 2006). The mussel survey conducted in 2010 noted but did not record the presence of Asiatic clams. Researchers did not observe zebra mussels during the 2010 survey (Third Rock Consultants 2010).

Fish

The fish populations in the Tennessee River have changed considerably as a result of human-initiated activities (e.g., impoundment of the river and introduction of invasive non-native species). Etnier et al. (1979) and Neves and Angermeier (1990) both indicate that the Tennessee River was poorly studied prior to impoundment, especially for small fish. In 1977 and 1978, Etnier et al. (1979) examined samples of over 49,000 fish specimens collected by TVA field crews during 1937 to 1943, prior to impoundment of the river. Based on an analysis of the specimens that were collected, and a comparison with more recent observations, Etnier et al. (1979) stated that “many changes have occurred in the Tennessee River fish fauna coincident with main channel impoundments,” including the disappearance of species in response to drastic alteration of the Tennessee River system. Fish extirpated from the Tennessee River system include the lake sturgeon (*Acipenser fulvescens*), the shovelnose sturgeon (*Scaphirhynchus platorynchus*), and the silvery minnow (*Hybognathus nuchalis*) (Etnier et al. 1979).

This section characterizes fish species that may be affected by operation of WBN Unit 2 based on sampling studies that were conducted near the site during the past 35 years. Impingement and entrainment studies also provide information on the fish species that are present. Impingement and entrainment studies are discussed further in Chapter 4.

Sampling of fish populations in Chickamauga and Watts Bar reservoirs, especially near the WBN site, has occurred fairly consistently over the past 40 years. TVA began sampling fish in Chickamauga Reservoir using rotenone in 1947 and in the cove nearest to the site (TRM 524.6) in 1976 (Simmons 2010a). TVA continued sampling until 1993 on an annual basis. TVA restarted the sampling on a biennial schedule from 1995 to 1999. TVA also conducted electrofish sampling in the Chickamauga Reservoir (Simmons 2010a) during years 1977 to 1979, 1982 to 1985, 1990 to 1997 and 1999 to 2010. TVA conducted sampling with experimental gill nets and hoop nets between TRM 524.2 to 524.9 and from TRM 527.4 and 528.4 during 1977 to 1979 and 1982 to 1985 for preoperational monitoring (TVA 1986). TVA has also conducted studies in Watts Bar Reservoir including gillnetting and electrofishing in the Watts Bar Reservoir forebay above the dam since 1999 (Simmons 2011).

Aquatic habitats above and below the dam are considerably different. Above the dam, the water is deeper and the water flow is slower. The dam also influences other habitat characteristics (e.g., temperature and dissolved oxygen levels). Fish living above Watts Bar Dam could be affected by the movement of water into the SCCW intake, but would not be affected by the discharge from WBN Unit 2 (see Chapter 4 for further discussion). Fish below Watts Bar Dam could be affected by the operation of the Intake Pumping Station located below the dam and the thermal and chemical discharges from both the SCCW discharge and the diffuser. Because of the short distance between the dam and the WBN site and the turbulent water in the inflow below the dam, no upstream control site data are available to compare conditions above and below the WBN site. Further, although TVA samples with gill nets above the dam, the velocity of water in the inflow below the dam does not allow gillnetting (Simmons and Baxter 2009). For these reasons, a direct comparison of fish species above and below the WBN site is not meaningful, although an examination of the historical changes in the fish populations can provide information about the potential changes in species and population size through time. Because WBN Unit 1 is already operating, examination of the data can provide insight into the effect that operation of WBN Unit 2 might have on the fish species in the Watts Bar and Chickamauga reservoirs (see Chapter 4). Section 5.5.2 contains the detailed information on the sampling techniques and locations of sampling studies.

Table 2-12 presents the electrofishing results for the years 1999 to 2010 (Simmons and Baxter 2009) at locations in the Chickamauga Reservoir near the WBN site (see Section 5.5.2 for a discussion of the sampling studies during these years). This is new information that was not available in the 1978 FES-OL or the 1995 SFES-OL-1. TVA identified over 40 species (including the hybrid sunfish) from 10 different families. Table 2-13 shows the results of electrofishing and gillnetting upstream of the WBN site (in Watts Bar Reservoir) for the same period (Simmons and Baxter 2009; Simmons 2011). The results yielded over 40 species (including the hybrid sunfish, hybrid shad, or hybrid bass) from 11 families. The bluegill (*Lepomis macrochirus*), and gizzard shad (*Dorosoma cepedianum*) tended to be consistently numerically dominant in the fish community below the dam. In some years, the threadfin shad (*Dorosoma petenense*) and redear sunfish (*Lepomis microlophus*) were also one of the numerically dominant fish below the dam. Bluegill and gizzard shad were numerically dominant in the fish community above the dam.

Table 2-14 provides a summary of the percent composition of the electrofishing catch from preoperational (1977 to 1985 and 1990 to 1995) and operational periods for WBN Unit 1 (1996 to 1997 and 1999 to 2010) for sampling sites below the Watts Bar Dam (Baxter et al. 2010; Simmons and Baxter 2009; Simmons 2011). It also includes an indication of the presence of species found in the cove rotenone studies from 1976 to 1997 at TRM 524.6 (Simmons 2010a). The 1996 to 2010 data constitute new information not available in the 1978 FES-OL or the 1995 SFES-OL-1. Section 5.5.2 describes the sampling studies and provides the location of the studies. The sampling results show over 50 species from 14 families for the 1976 to 1989 preoperational monitoring period; over 40 species from 11 families for the 1990 to 1995 preoperational monitoring period; over 40 species from 12 families during the operational monitoring period (1996 to 1997); and over 40 species from 10 families during the reservoir monitoring studies below the dam (1999 to 2010). These counts also include the hybrid fish. These results are fairly consistent when considering that there were differences in sampling technique and duration of sampling that likely affected the species counts. For example, during the period from 1977 to 1985, electrofishing sampling occurred monthly (Baxter et al. 2010). In 1990, TVA began sampling annually, in the fall (Simmons and Baxter 2009).

Table 2-14, as taken from Baxter et al. (2010), does not include historical counts of threadfin and gizzard shad between 1977 and 1997. However, TVA (1986) provided this data and indicated that between 1977 and 1985, gizzard shad and threadfin shad made up 55 and 7 percent, respectively, of the total individuals sampled by electrofishing. The species that comprised the largest percentage of the population were gizzard shad (55 percent), emerald shiner (22 percent), threadfin shad (7.2 percent), bluegill (3.8 percent), and redear sunfish (2.7 percent).

Table 2-12. Electrofishing in Chickamauga Reservoir Near the Watts Bar Nuclear Site for Years 1999 to 2010

Species Collected			Percentage Composition of Fish Caught During Electrofishing in Chickamauga Reservoir near the WBN Site (TRM 529)											
Family	**Scientific Name**	**Common Name**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Atherinopsidae	*Labidesthes sicculus*	Brook silverside	0	0	3.4	1.6	0.19	0.53	0.10	1.6	0	0.14	0.90	0
	Menidia beryllina	Inland silverside	0	0	0	0	0	0	0	3.2	0	3.2	53	1.0
Catostomidae	*Hypentelium nigricans*	Northern hog sucker	0.72	0.11	0	0.08	0	0	0.10	0	0.13	0.07	0	0
	Ictiobus bubalus	Smallmouth buffalo	0	0	0	0	0	0.07	0	0	0	0.07	0.04	0.09
	Minytrema melanops	Spotted sucker	1.6	0.54	1.1	0.62	0.39	0.27	0.80	0.32	0.65	0.07	0.09	0.37
	Moxostoma carinatum	River redhorse	0	0	0.18	0	0	0	0	0	0	0	0	0.09
	Moxostoma duquesnii	Black redhorse	0.90	0	0.18	0.16	0.58	0	0.20	0.65	0.26	0.21	0.22	1.7
	Moxostoma erythrurum	Golden redhorse	1.3	0.43	1.4	0.54	0.58	0.13	0.80	1.3	1.2	0.49	0.13	1.0
	Moxostoma macrolepidotum	Shorthead redhorse	0.18	0	0	0	0	0	0	0	0	0	0	0
Centrarchidae	*Ambloplites rupestris*	Rock bass	0	0	0	0	0	0	0	0.11	0.13	0	0	0.46
	Hybrid *Lepomis* sp.	Hybrid sunfish	0.18	0.22	0.18	0	0.19	0.07	0	0	0	0	0.04	0.18
	Hybrid *Micropterus* sp.	Hybrid Bass	0	0	0	0	0	0	0	0	0	0	0.09	0.18
	Lepomis auritus	Redbreast sunfish	1.1	1.7	2.7	1.5	0.68	1.3	2.9	2.1	2.8	1.8	0.81	1.7
	Lepomis cyanellus	Green sunfish	0.90	0.43	2.0	0.31	0.29	0.33	3.0	0.32	0.39	1.8	0.49	2.9
	Lepomis gulosus	Warmouth	0	0.98	0.18	0.39	0.10	0	0	0	0.78	0.85	0.49	0.73
	Lepomis macrochirus	Bluegill	9.3	39	30	19	34	5.9	18	27	52	63	21	53
	Lepomis megalotis	Longear sunfish	0	0.98	0.36	0.62	0.29	2.1	4.6	2.7	1.2	1.3	0.54	1.5
	Lepomis microlophus	Redear sunfish	11	15	25	17	5.9	4.3	8.5	9.0	7.0	6.6	3.5	6.9
	Micropterus dolomieu	Smallmouth bass	0.54	2.1	0.36	1.2	0.97	1.7	2.5	1.1	0.52	0.14	0.67	1.6
	Micropterus punctulatus	Spotted bass	2.0	3.8	2.8	2.4	2.3	3.3	5.6	3.5	3.9	0.92	1.6	2.8
	Micropterus salmoides	Largemouth bass	1.4	5.1	3.0	3.0	2.9	4.3	3.0	1.7	2.2	1.1	2.7	2.3
	Pomoxis annularis	White crappie	0	0	0.18	0	0.10	0.40	0	0	0	0	0.04	0.09
	Pomoxis nigromaculatus	Black crappie	0.72	4.7	0	1.4	1.3	1.5	2.6	0.54	0.52	0.35	0.40	0.27
Clupeidae	*Alosa chrysochloris*	Skipjack herring	0	0	0	0	0	0	0	0	0	0	0	0.09
	Alosa pseudoharengus	Alewife	0	0	0	0	0	0	0	0	0	0	0	0.09
	Dorosoma cepedianum	Gizzard shad	8.3	9.9	7.8	11	17	50	31	29	14	13	5.9	9.3
	Dorosoma petenense	Threadfin shad	47	2.9	0	29	26	13	5.6	0.11	0.13	0	1.4	0

Table 2-12. (contd)

Species Collected			Percentage Composition of Fish Caught During Electrofishing In Chickamauga Reservoir near the WBN Site (TRM 529)											
Family	**Scientific Name**	**Common Name**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Cyprinidae	*Campostoma oligolepis*	Largescale stoneroller	0	0	0	0	0	0.07	0	0	0	0.07	0	0.09
	Cyprinella spiloptera	Spotfin shiner	1.6	2.5	5.5	2.2	1.1	0.73	0.40	4.8	3.5	1.2	1.5	1.3
	Cyprinella whipplei	Steelcolor shiner	0	0	0	0	0.39	0	0	0	0.13	0	0.18	0
	Cyprinus carpio	Common carp	0.72	4.1	0.36	0.54	0.58	0.40	0.60	0.11	0.13	0	0.09	0.46
	Luxilus chrysocephalus	Striped shiner	0	0	0	0	0	0	0.20	0	0	0	0	0
	Notemigonus crysoleucas	Golden shiner	1.1	0.11	0.53	0.23	0.29	0.07	0.30	0	0.13	0.57	0.63	0
	Notropis atherinoides	Emerald shiner	1.1	0.43	5.9	0.16	0.29	0.60	4.4	2.1	0.78	0.35	0.04	0
	Pimephales notatus	Bluntnose minnow	0.36	0	0.18	0	0.19	0.07	0	0	0	0	0.27	0.82
	Pimephales vigilax	Bullhead minnow	0	0	0	0.47	0	0	0	0	0	0.07	0	0.09
Ictaluridae	*Ictalurus furcatus*	Blue catfish	0	0.11	2.0	0	0	0	0.20	0.11	0	0.14	0	1.4
	Ictalurus punctatus	Channel catfish	0.72	0.33	2.0	1.7	0.48	0.60	1.5	2.2	1.6	1.1	1.6	2.8
	Pylodictis olivaris	Flathead catfish	1.1	0.54	1.4	0.47	0.48	0.60	1.7	0.76	3.6	0.71	0.22	2.1
Lepisosteidae	*Lepisosteus oculatus*	Spotted gar	0	0	0.18	0	0	0.07	0	0.22	0	0.49	0.04	0
	Lepisosteus osseus	Longnose gar	0.36	0	0	0	0.29	1.2	0.10	0.22	0.13	0	0.31	0.82
Moronidae	*Morone chrysops*	White bass	0.54	0.65	0.18	0.70	0.19	2.1	0	0	0	0	0.04	0.64
	Morone mississippiensis	Yellow bass	1.1	3.7	0.18	2.7	1.6	1.7	1.3	0.86	0.90	0.07	0.99	0.27
	Morone saxatilis	Striped bass	0	0.11	0	0.08	0	0	0	0	0.13	0	0	0
Percidae	*Perca flavescens*	Yellow perch	0	0	0	0.16	0	0.07	0.40	0	0	0	0	0.09
	Percina caprodes	Logperch	3.4	0	0.53	0	0.10	1.2	0.40	2.4	0.65	0.28	0	0.09
	Sander canadensis	Sauger	0.18	0	0	0	0	0	0	0	0	0	0.04	0
	Sander vitreus	Walleye	0	0	0	0	0.10	0	0	0	0	0	0	0
Sciaenidae	*Aplodinotus grunniens*	Freshwater drum	0.54	0.11	1.1	0.47	0.29	1.1	0.30	2.1	0.39	0	0.22	0.64

Adapted from Simmons and Baxter 2009; Simmons 2011

Table 2-13. Electrofishing and Gillnetting Upstream of the Watts Bar Dam for Years 1999 to 2010

			Percentage Composition of Fish Caught During Gillnetting and Electrofishing Upstream of the Watts Bar Dam (in Watts Bar Reservoir at TRM 531.0)											
Family	**Scientific Name**	**Common Name**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Atherinopsidae	*Labidesthes sicculus*	Brook silverside	0	2.3	1.62	0.61	6.6	3.1	3.9	0.21	0	0.13	0.44	2.8
	Menidia beryllina	Inland silverside	0	0	0	0	0	0	0.97	3.3	0.84	0	29	3.4
Catostomidae	*Hypentelium nigricans*	Northern hog sucker	0	0	0	0.15	0	0	0	0	0	0	0.06	0.09
	Ictiobus bubalus	Smallmouth buffalo	1.0	0.38	0.35	1.2	1.1	0.87	0.22	0.49	1.1	0.60	0.13	0.19
	Ictiobus cyprinellus	Bigmouth buffalo	0	0.10	0	0	0	0	0	0	0	0	0	0
	Ictiobus niger	Black buffalo	0	0.10	0	0.15	0.09	0.17	0.45	0.07	0.36	0	0	0
	Minytrema melanops	Spotted sucker	0.33	1.5	2.2	2.0	1.9	2.3	1.6	1.1	0.96	0.33	0.82	0.28
	Moxostoma duquesnii	Black redhorse	0	0.10	0	0	0	0	0	0	0	0	0	0.09
	Moxostoma ecarinatum	River redhorse	0	0	0	0	0	0	0	0	0	0	0.06	0
	Moxostoma erythrurum	Golden redhorse	0.17	0	0.12	0	0	0	0	0	0	0	0	0
Centrarchidae	*Hybrid Lepomis* sp.	Hybrid sunfish	0	0	0	0.46	0.09	0.61	0.15	0	0.24	0.07	0	0.47
	Lepomis auritus	Redbreast sunfish	1.2	3.4	4.2	2.1	1.7	4.9	1.9	5.8	0.96	2.5	1.5	4.5
	Lepomis cyanellus	Green sunfish	0.33	2.0	0.92	1.1	1.5	0.95	2.6	1.7	0.60	0.53	1.9	3.9
	Lepomis gulosus	Warmouth	0	0.29	0.12	0.61	0	0.43	0.60	0.21	0.24	0.07	0.19	0.28
	Lepomis macrochirus	Bluegill	7.8	32	31	39	40	32	40	34	34	63	30	46
	Lepomis megalotis	Longear sunfish	0.17	0	0	0	0.19	0	0.37	0.42	0.12	0.53	0	0.09
	Lepomis microlophus	Redear sunfish	3.0	4.21	6.5	5.5	4.7	3.7	2.6	3.8	3.7	2.3	2.7	5.0
	Micropterus dolomieu	Smallmouth bass	0.83	1.6	0.81	1.2	1.2	2.3	0.97	0.76	0.48	0.47	0.95	0.75
	Micropterus punctulatus	Spotted bass	0.17	1.5	0.35	2.0	1.5	1.0	0.15	0.21	0.48	0.20	0	0
	Micropterus salmoides	Largemouth bass	2.3	2.7	2.0	3.5	2.0	2.3	1.6	2.4	5.5	2.1	3.6	3.5
	Pomoxis annularis	White crappie	0.66	1.9	0	0.30	0.09	0.26	0.30	0.35	0.48	0.07	0.19	0.09
	Pomoxis nigromaculatus	Black crappie	0	0.86	4.2	4.0	1.2	1.1	4.0	2.2	5.3	0.47	1.7	0.57
Clupeidae	*Alosa chrysochloris*	Skipjack herring	2.2	0.48	0.23	0	0.19	2.9	0.67	0.14	0.48	0	0	0
	Dorosoma cepedianum	Gizzard shad	47	18	13	13	18	32	15	27	27	15	5.6	10
	Dorosoma petenense	Threadfin shad	2.8	0.10	0.35	0.15	0.57	0.09	0.37	0.42	0.72	0.13	4.2	0
	Hybrid Dorosoma	Hybrid shad	0	0	0	0	0	0	0	0	1.7	0.13	0.06	0.09

Table 2-13. (contd)

Family	Scientific Name	Common Name	Percentage Composition of Fish Caught During Gillnetting and Electrofishing Upstream of the Watts Bar Dam (in Watts Bar Reservoir at TRM 531.0)											
			1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Cyprinidae	*Cyprinella spiloptera*	Spotfin shiner	1.0	6.3	11	0.91	4.7	1.4	7.6	6.0	1.9	5.3	6.4	2.5
	Cyprinella whipplei	Steelcolor shiner	0	0.10	3.6	0	0	0	0	0	0	0	0.06	0.94
	Cyprinus carpio	Common carp	3.2	1.91	1.2	1.5	1.1	0.69	0.75	0.90	0.10	0.40	0.38	0.47
	Luxilus chrysocephalus	Striped shiner	0	0.10	0	0	0	0	0	0	0	0	0	0
	Notemigonus crysoleucas	Golden shiner	0	0.48	0	0	0.57	0	0.07	0	0	0	0	0
	Notropis atherinoides	Emerald shiner	1.0	0	0	0	0	0.95	0.15	0	0	0	0	0
	Pimephales notatus	Bluntnose minnow	0	0.86	0.35	0.30	0.19	0	0.07	1.5	0.12	0	1.2	1.9
	Pimephales vigilax	Bullhead minnow	0	0	0	0	0	0	0	0	0.12	0.40	0	0
Ictaluridae	*Ictalurus furcatus*	Blue catfish	6.1	0.77	0.58	1.7	0.28	0.26	0.30	0.14	0.36	0.60	0.82	0.47
	Ictalurus punctatus	Channel catfish	1.8	0.96	1.3	0.91	0.95	0.87	0.90	0.35	0.72	0.40	0.63	1.4
	Pylodictis olivaris	Flathead catfish	1.5	2.0	1.3	4.3	2.0	0.69	2.1	1.0	2.5	0.93	0.95	1.8
Lepisosteidae	*Lepisosteus oculatus*	Spotted gar	0	0	0.23	0.15	0.19	0	0.37	0.14	0	0.13	0.06	0.28
	Lepisosteus osseus	Longnose gar	0.17	0	0	0.46	0	0.09	0	0	0	0	0	0
Moronidae	*Hybrid morone (chrysops x sax)*	Hybrid striped x white bass	0	0.29	0.12	0.46	0	0	0	0	0	0	0.06	0.09
	Morone chrysops	White bass	1.7	0.19	0.81	2.9	0.76	1.6	1.3	2.2	0.48	0.47	0.25	0.75
	Morone mississippiensis	Yellow bass	7.5	10	8.2	6.4	5.1	0.52	5.7	1.8	5.5	1.7	4.7	3.3
	Morone saxatilis	Striped bass	0.5	0.38	0.46	0.76	0.66	0.26	0.22	0.14	1.1	0.47	0.38	0.09
Percidae	*Perca flavescens*	Yellow perch	0	0	0.58	0	0	0.43	0.07	0.21	0	0	0	0.28
	Percina caprodes	Logperch	0	0	0.46	0	0.19	0	0.22	0.49	0	0.20	0.25	0.47
	Sander canadensis	Sauger	0.33	0.38	0	0	0.09	0.09	0	0	0	0	0.44	0.09
Polyodontidae	*Polyodon spathula*	Paddlefish	0	0	0	0	0	0	0	0	0	0.07	0	0
Sciaenidae	*Aplodinotus grunniens*	Freshwater drum	4.8	2.2	2.0	2.1	0.57	1.0	1.1	0.49	0.96	0.33	0.70	1.7

Adapted from Simmons and Baxter 2009; Simmons 2011

Table 2-14. Comparison by Species of Percent Composition from Preoperational (1976 to 1989 and 1990 to 1995) and Operational (1996 to 1997 and 1999 to 2010) Monitoring Periods Downstream of Watts Bar Dam in the Vicinity of the WBN Site

Family	Scientific Name	Common Name	1976–1989 Preoperational[a,b]	1990–1995 Preoperational[a,b]	1996–1997 Operational[a,b]	1999–2010 Operational (range for all years)[c]
Anguillidae	*Anguilla rostrata*	American eel	0.0[d]	-	-	-
Atherinopsidae	*Labidesthes sicculus*	Brook silverside	5.4/R[b]	1.1/R[b]	--	0–3.4
	Menidia beryllina	Inland silverside	-	-	-	0–53
Catostomidae	*Carpiodes carpio*	River carpsucker	0.0/R[b]	R[b]	--	--
	Hypentelium nigricans	Northern hog sucker	0.1	0.1	0.1	0–0.72
	Ictiobus bubalus	Smallmouth buffalo	0.0/R[b]	0.1/R[b]	R[b]	0–0.09
	Minytrema melanops	Spotted sucker	1.2/R[b]	1.3/R[b]	2.0/R[b]	0.07–1.6
	Mosostoma carinatum	River redhorse	0.0	--	0.1	0–0.18
	Moxostoma duquesnii	Black redhorse	R[b]	0.2	0.3	0 – 1.7
	Moxostoma erythrurum	Golden redhorse	0.5/R[b]	0.5/R[b]	1.2	0.13–1.4
	Moxostoma macrolepidotum	Shorthead redhorse	--	--	--	0–0.18
Centrarchidae	*Ambloplites rupestris*	Rock bass	0.0[d]	--	--	0–0.46
	Hybrid *Lepomis* sp.	Hybrid sunfish	--	0.0[d]	0.2	0–0.22
	Hybrid *Micropterus* sp.	Hybrid bass	--	--	--	0.09–0.18
	Lepomis auritus	Redbreast sunfish	0.9/R[b]	1.3 /R[b]	0.4	0.68–2.9
	Lepomis cyanellus	Green sunfish	0.0/R[b]	0.4/R[b]	0.3/R[b]	0.29–3.0
	Lepomis gulosus	Warmouth	0.1/R[b]	0.7/R[b]	0.2/R[b]	0–0.98
	Lepomis humilis	Orangespotted sunfish	R[b]			
	Lepomis macrochirus	Bluegill	10.0/R[b]	32.4/R[b]	45.1/R[b]	5.9–63
	Lepomis megalotis	Longear sunfish	0.2/R[b]	0.1/R[b]	0.3/R[b]	0–4.6
	Lepomis microlophus	Redear sunfish	7.2/R[b]	13.4/R[b]	12.5/R[b]	3.5–25
	Micropterus dolomieu	Smallmouth bass	0.3	1.8/R[b]	3.5	0.14–2.5
	Micropterus punctulatus	Spotted bass	1.0/R[b]	3.1/R[b]	3.2	1.9– 5.6
	Micropterus salmoides	Largemouth bass	3.4/R[b]	7.8/R[b]	6.9/R[b]	1.1–5.1

Table 2-14. (contd)

Family	Scientific Name	Common Name	1976–1989 Preoperational (a,b)	1990–1995 Preoperational (a,b)	1996–1997 Operational (a,b)	1999–2010 Operational (range for all years)(c)
	Pomoxis annularis	White crappie	0.8/R(b)	0.2/R(b)	0.4/R(b)	0–0.40
	Pomoxis nigromaculatus	Black crappie	0.0/R(b)	0.8/R(b)	1.8/R(b)	0–4.7
Clupeidae	*Alosa chrysochloris*	Skipjack herring	1.5/R(b)	0.7/R(b)	-/R(b)	0–0.09
	Alosa pseudoharengus	Alewife	--	--	--	0–0.09
	Dorosoma cepedianum	Gizzard shad	(e)/R(b)	(e)/R(b)	(e)/R(b)	5.9–50
	Dorosoma petenense	Threadfin shad	(e)/R(b)	(e)/R(b)	(e)/R(b)	0–47
Cyprinidae	*Campostoma oligolepis*	Largescale stoneroller	R(b)	--	--	0–0.07
	Carpoides cyprinus	Quillback	R(b)	--	--	--
	Cyprinella spiloptera	Spotfin shiner	0.1/R(b)	1.8/R(b)	0.4	0.4–5.5
	Cyprinella whipplei	Steelcolor shiner	--	2.5	--	0–0.39
	Cyprinus carpio	Common carp	1.2/R(b)	1.0/R(b)	3.8	0.09–4.1
	Ictobius cyprinellus	Bigmouth buffalo	R(b)	--	--	--
	Ictobius niger	Black buffalo	R(b)	--	R(b)	--
	Luxilus chrysocephalus	Striped shiner	R(b)	0.0/R(b)	--	0–0.20
	Macrhybopsis storeriana	Silver chub	0.0(d)	--	--	--
	Notemigonus crysoleucas	Golden shiner	0.2/R(b)	0.4/R(b)	0.1/R(b)	0–1.1
	Notropis atherinoides	Emerald shiner	58.6/R(b)	17.1/R(b)	1.5/R(b)	0.04–5.9
	Notropis buchanani	Ghost shiner	R(b)	--	--	--
	Notropis volucellus	Mimic shiner	R(b)	--	--	--
	Opsopoeodus emiliae	Pugnose minnow	R(b)	--	--	--
	Pimephales notatus	Bluntnose minnow	R(b)	0.1/R(b)	0.1	0–0.82
	Pimephales vigilax	Bullhead minnow	0.0(d) /R(b)	0.1/R(b)	R(b)	0–0.47
Hiodontidae	*Hiodon tergisus*	Mooneye	0.2	--	0.1	--
Ictaluridae	*Ameiurus melas*	Black bullhead	R(b)	R(b)	--	--
	Ameiurus natalis	Yellow bullhead	R(b)	R(b)	--	--
	Ameiurus nebulosus	Brown bullhead	R(b)	R(b)	R(b)	--

Table 2-14. (contd)

Family	Scientific Name	Common Name	1976–1989 Preoperational (a,b)	1990–1995 Preoperational (a,b)	1996–1997 Operational (a,b)	1999–2010 Operational (range for all years)(c)
	Ictalurus furcatus	Blue catfish	0.0/R(b)	0.1	--	0–2.0
	Ictalurus punctatus	Channel catfish	0.0/R(b)	1.6/R(b)	0.6/R(b)	0.33–2.8
	Pylodictis olivaris	Flathead catfish	0.0/R(b)	0.6/R(b)	0.9	0.22–3.6
Lepisosteidae	*Lepisosteus oculatus*	Spotted gar	0.01/R(b)	R(b)	R(b)	0–0.49
	Lepisosteus osseus	Longnose gar	0.5/R(b)	0/R(b)	0.1/R(b)	0–1.2
Moronidae	*Morone chrysops*	White bass	1.3/R(b)	1.7/R(b)	1.8/R(b)	0–2.1
	Morone mississippiensis	Yellow bass	4.1/R(b)	4.3/R(b)	8.5/R(b)	0.07–3.7
	Morone saxatilis	Striped bass	0.1	0.2	0.2	0–0.13
Percidae	*Perca flavescens*	Yellow perch	0.4	0.4	0.6	0–0.40
	Percina caprodes	Logperch	0.1/R(b)	1.5	1.3	0–3.4
	Sander canadensis	Sauger	0.1	0.1	0.4	0–0.18
	Sander vitreus	Walleye	0.0(d)	--	--	0–0.10
Poeciliidae	*Gambusia affinis*	Western mosquitofish	R(b)	R(b)	R(b)	--
Polyodontidae	*Polyodon spathula*	Paddlefish	R(b)	--	--	--
Pteromyzontidae	*Ichthyomyzon castaneus*	Chestnut lamprey	--	--	0.1	--
Sciaenidae	*Aplodinotus grunniens*	Freshwater drum	0.2/R(b)	0.6/R(b)	1.0/R(b)	0.11–2.1
Number of Species			59	46	43	49
Number of Families			14	11	12	10

(a) Baxter et al. 2010. Electrofishing results are from 1977 to 1985, 1990 to 1995, and 1996 to 1997.
(b) "R" indicates this species was present during rotenone sampling in a cove at TRM 524.6 between 1976 and 1989, 1990 to 1995, and 1996-1997 (Simmons 2010a).
(c) Simmons and Baxter 2009; Simmons 2011.
(d) A "0" means "present" but less than 0.01 percent.
(e) Threadfin and gizzard shad are not included in percent composition but are included in species and family counts.

As with the mussel community, the fish community appears to be changing in response to historical changes in land use, river regulation, and other human activities. Table 2-14 shows the largest drop in species abundance occurred between the surveys taken from 1975 to 1989 (over 50 species identified) and those from 1990 to 1995 (over 40 species identified).

Table 2-13 and Table 2-14 show declines in the number of individuals for some species. For example, over the past 35 years (Table 2-14) emerald shiners (*Notropis aterinoides*) declined substantially in numerical importance—most obviously downstream of the Watts Bar Dam in the period from 1976 to 1997. The emerald shiner composed 58.6 percent of the community (not counting threadfin or gizzard shad) from 1976 to 1989, 17.1 percent from 1990 to 1995, and only 1.5 percent from 1996 to 1997. During sampling from 1999 to 2010, the emerald shiner composed 0.04 to 5.9 percent of the community (or 0.05 to 6.85 percent when threadfin and gizzard shad are not considered). No other species appears to have declined as dramatically. Because the decline began before WBN Unit 1 started operating, operation of WBN Unit 1 is not likely the reason for the decline. Further, Crowder (1980) documented cases of dramatic reductions in emerald shiner populations in other locations. In several cases, competition with another fish species (alewife [*Alosa pseudoharengus*]) contributed to the decline. Alewife have not been found near the Watts Bar plant, but other cluepids (gizzard shad) are prolific in the reservoir. In another study, Short et al. (1998) identified a decline in water quality as the impetus for reduced emerald shiner populations.

Table 2-14 indicates that bluegill increased in numerical importance through the preoperational period and the first 2 years following startup of WBN Unit 1. In 1976 to 1989, bluegill composed 10 percent of the population downstream of Watts Bar Dam. The percentage of bluegill increased to 32.4 percent in the samples from 1990 to 1995. After startup of the facility, 1996 to 1997, bluegill composed 45.1 percent of the fish population in the Chickamauga Reservoir near the WBN site. In the period from 1999 to 2010, the numerical importance of the bluegill has varied from a low of 5.9 percent of the population in 2004 to a high of 63 percent in 2008 (see Table 2-12) below the dam (or 16 to 72 percent when threadfin and gizzard shad are not included in the sample). Bluegill also shows high numerical importance in Watts Bar Reservoir (Table 2-13).

Inland silverside (*Menidia beryllina*) have recently increased in numerical importance (Table 2-12 and Table 2-14). Inland silverside is an invasive species. They were not collected in Chickamauga Reservoir until 2004. Simmons (2011) observed that inland silverside have only recently occurred in large densities in the mainstem Tennessee River. In 2009, inland silverside made up 53 percent of the fish sampled in Chickamauga Reservoir (Table 2-14) and 29 percent of the fish sampled in Watts Bar Reservoir (Table 2-13). However, in 2010, these percentages dropped to 1 and 3.4 percent, respectively. Another source of information regarding the fish populations in the vicinity of the WBN site comes from the ichthyoplankton (fish eggs and larvae) surveys conducted by TVA (see Section 5.5.2 for a detailed description of the sampling studies and locations). Just as for fish, ichthyoplankton surveys were conducted below the dam in Chickamauga Reservoir (in the vicinity of the WBN site) and above the dam in Watts Bar Reservoir. Discussions of the two locations appear separately in the following paragraphs. The ichthyoplankton surveys were used to obtain estimates of the fraction of ichthyoplankton entrained by the facility. Entrainment is result of the operation of the facility as discussed in Section 4.3.2.2.

TVA conducted three sets of ichthyoplankton studies in Chickamauga Reservoir in the vicinity of the WBN site. TVA conducted the first set of studies between 1976 and 1979 and between 1982 and 1985 prior to operation of WBN Unit 1 (TVA 1986). TVA conducted a second set of studies in 1996 and 1997 after Unit 1 began operating (Baxter et al. 2010) to obtain an estimate of entrainment from WBN Unit 1. TVA conducted the third, and most recent, sampling study from March 2010 through March 2011 (TVA 2012b) in the same sampling locations and using the same procedures as in 1996 and 1997. Sampling frequency, locations, and methods are described in more detail in Sections 4.3.2.2 and 5.5.2. The second and third studies are new information not reported in the 1978 FES-OL or the 1995 SFES-OL-1.

After conducting its first set of preoperational studies between 1976 and 1979 and between 1982 and 1985, TVA (1986) reported that overall egg densities were low in the ichthyoplankton samples from the reservoir transects, indicating that the short distance between the dam and the WBN site may not be an area of high productivity. The total number of eggs collected annually varied from 31 in 1985 to 1,312 in 1983. During the preoperational surveys, 13 percent (1983) to greater than 90 percent (1976, 1979, and 1982) were freshwater drum (*Aplodinotus grunniens*). The remainder of the eggs were unidentifiable with the exception of two mooneye (*Hiodon* spp.) eggs—one in 1978 and another in 1985 (TVA 1986).

During the second set of studies, conducted in 1996 and 1997 after the start of operations for WBN Unit 1, the total number of fish eggs collected in the reservoir transects ranged from 1,605 (1997) to 2,929 (1996) (Baxter et al. 2010). During these years it was reported that over 99 percent of the eggs were “mutilated and unidentifiable” (Baxter et al. 2010). The small percentage of identifiable eggs were mostly freshwater drum eggs (Baxter et al. 2010). Freshwater drum eggs numerically dominate samples obtained in other areas of the reservoir, such as near the Sequoyah Nuclear Plant (Baxter and Buchanan 2006). Egg densities in 1996 and 1997 near the WBN site were 340 eggs per 1,000 m^3 of water and 160 eggs per 1,000 m^3 of water respectively (TVA 2012b). Average seasonal density of eggs in the reservoir near Sequoyah Nuclear Plant (TRM 484.5) was close to 664 eggs per 1,000 m^3 of water in 2004 (Baxter and Buchanan 2006).

TVA conducted the third set of studies in Chickamauga Reservoir on a weekly basis from March through August 2010 and then monthly from September 2010 through March 2011 (TVA 2012b). The total number of fish eggs collected along the reservoir transects was 3,575. TVA identified over 98 percent as freshwater drum eggs and the remainder as moronidae such as bass (1.2 percent); clupeids, such as shad (0.4 percent); or percids, such as logperch and yellow perch (0.1 percent). Egg densities were lower in 2010, reported to be 134 eggs per

1,000 m^3 of water. Because this set of sampling studies obtained a larger number of intact eggs, the data provides a better understanding of the types of fish eggs near the WBN site.

TVA also collected fish larvae in the three studies. During the first set of studies, the preoperational surveys (TVA 1986) that started in 1976, the number of fish larvae collected ranged from 2,565 (1979) to 34,086 (1977). The density of larvae in the reservoir ranged from 146 larvae per 1,000 m^3 of water (1979) to 2,119 larvae per 1,000 m^3 of water (1984). The numerically dominant larvae were generally unspecifiable clupeids (likely threadfin shad and gizzard shad) followed by lesser numbers of centrarchids (bluegill or other sunfish) and freshwater drum. Depending on the year, between 48 and 95 percent of the larvae sampled were clupeid larvae.

During the second set of studies, conducted in 1996 and 1997 after the start of operations for WBN Unit 1 (Baxter et al. 2010), clupeid larvae (largely threadfin shad and gizzard shad) represented 82 and 86 percent of the individuals in the larval fish community, respectively, followed by bass (*Morone* spp.) in 1997, freshwater drum in 1996, and centrarchids (*Lepomis* spp.) in both years. The overall density of larval fish was 525 larvae per 1,000 m^3 of water in 1996 and 908 larvae per 1,000 m^3 of water in 1997 when averaged for both intake and channel samples. These densities are within the range of the densities reported from 1976 through 1985 (Baxter et al. 2010). TVA researchers considered larval size to determine whether the larvae originated in Watts Bar Reservoir or in the tailwater of the dam. They determined that *Sander* spp. (walleye and sauger), yellow perch (*Perca flavescens*), clupeids (gizzard and threadfin shad), crappie (*Pomoxis* spp.), and freshwater drum likely were spawned above the dam. TVA (Baxter et al. 2010) found centrarchid (sunfish) larvae in greater numbers near the shoreline and in intake canal samples, indicating these two areas serve as spawning and nursery areas for sunfish.

During the larval ichthyoplankton sampling from 2010 to 2011 (TVA 2012b), TVA collected 5,885 larval fish for a density of 305 larvae per 1,000 m^3 of water for the Chickamauga Reservoir transects and 352 larvae per 1,000 m^3 of water for the intake channel. The density was lower than that observed in the 1996 and 1997 studies (TVA 2012b), although within the variation observed during preoperational studies (TVA 1986). Members of the clupeid family again dominated the sample (71.2 percent), followed by centrarchids (14.8 percent), *Morone* spp. (10.9 percent), and freshwater drums (2.0 percent) (TVA 2012b).

TVA also conducted three studies related to ichthyoplankton density in the forebay of the Watts Bar Reservoir near the Watts Bar Dam. TVA (1976) conducted the first study in 1975 when the SCCW system was used as the intake for the now demolished Watts Bar Fossil Plant. The second was conducted in the spring of 2000, after the start of operation of the SCCW system (Baxter et al. 2001). The third study occurred from March 2010 through March 2011 (TVA 2012b). The second and third studies contain new information not reported in the 1978 FES-OL or the 1995 SFES-OL-1. Section 5.5.2 describes the sampling studies and provides their locations.

The first sampling study (TVA 1976) occurred between March 24 and July 28, 1975, at five transects in the Watts Bar Reservoir. In addition, TVA obtained pumped samples in three of the six intake screen wells. TVA personnel conducted sampling biweekly. Egg collections consisted mostly of unidentified fish eggs in the intake samples and freshwater drum eggs in the reservoir samples. TVA identified fish larvae from 10 families. Unspecified clupeids dominated larvae collections (95 percent for intake samples, 97 percent for reservoir samples) throughout the sampling season. Of the non-clupeid larvae, only *Lepomis* species had more than 1 percent of the abundance (1.2 percent).

TVA personnel conducted the second study (Baxter et al. 2001) during spring 2000 to look at the spatio-temporal concentrations of ichthyoplankton near the WBN SCCW intake. They sampled weekly, from April through June 2000, along the same transect and with equipment similar to that used in the 1975 study. However, no fish eggs occurred in the samples, even though previous sampling studies used the same type of sampling gear and techniques. The samples of larval fish in spring 2000 included five taxa (Baxter et al. 2001). Clupeid larvae composed 69 percent of the larval fish sampled in 2000, which is less numerous than in 1975. Larvae from the genus *Lepomis* (includes bluegill) composed 19 percent and were more abundant in the samples. *Morone* spp. (bass) and *Pomoxis* spp. (crappie) larvae densities were 6 percent and 4 percent, respectively, which was similar to the data obtained in 1975.

The third study (TVA 2012b) also provides insight into the ichthyoplankton residing in the forebay of the Watts Bar Reservoir, as sampled between March 2010 and March 2011. This study reported that clupeid larvae (includes threadfin and gizzard shad) numerically dominated the samples in the reservoir above the Watts Bar Dam (81.7 percent), followed by centrarchids (13.4 percent total, which was predominantly bluegill and crappie) and freshwater drum (1.9 percent). Small numbers of eggs were found at the reservoir transect (nine eggs total) and they were all identified as freshwater drum.

<u>Commercially, Recreationally, and Biologically Important Fish Species</u>. The operation of WBN Unit 2 may directly or indirectly affect commercially, recreationally, and biologically important species. This section describes these species and provides information about their life histories.

TVA and the TWRA allow commercial fishing on Chickamauga Reservoir. The boundary established for commercial fishing is the full pool elevation of 14,000 ha (34,500 ac) (TWRA 2012). However, commercial fishing in the section of Chickamauga Reservoir near the site is practically nonexistent because current velocities make netting virtually impossible (TVA 1998). Although commercial fishing is allowed in Watts Bar Reservoir, very little actually occurs (Black 2010).

The most recent report on commercial fishing indicates small numbers of paddlefish (*Polydoton spathula*) harvested in the Chickamauga Reservoir. Only one paddlefish report occurred in

Watts Bar Reservoir in 2007 and none was reported in 2008 or 2009. Commercial fishing summaries for 2007 to 2009 for roe harvest from Chickamauga Reservoir and from Watts Bar Reservoir are given in Table 2-15. Table 2-16 summarizes non-roe harvest in the two reservoirs for 2008 and 2009. Paddlefish were not observed in the samples collected in the vicinity of the WBN site after 1985 as shown in Table 2-14. The majority of fish caught for commercial use include catfish (blue, channel, and flathead [*Ictalurus* spp. and *Pylodicitis olivaris*]), buffalo (*Ictiobus* spp.), and carp (bighead, silver, and common [*Hypophthalmichthys* sp. and *Cyprinus carpio]).* However, freshwater drum (*Alpodinotus grunniens*) and gar (*Lepisosteus* sp.) are also taken, as well as a small number of snapping turtles (*Chelydra serpentina*) (Black 2010).

Chickamauga and Watts Bar reservoirs are popular locations for recreational fishing. In 2008, they ranked fourth (Watts Bar) and fifth (Chickamauga) in a list of 16 lakes in terms of angling effort (number of hours spent angling) during the annual creel survey conducted by TWRA. They ranked third (Chickamauga) and fourth (Watts Bar) for number of fish caught (Black 2009). Important recreational species for both reservoirs are shown in Table 2-17 for 2007 and 2008. The most frequently caught species include bluegill, redear sunfish, black and white crappie (*Pomoxis nigromaculatus* and *Pomoxis annularis*), black bass (largemouth bass, spotted bass, and smallmouth bass [*Micropterus* spp.])*,* catfish (blue and channel), white bass (*Morone chrysops*), yellow bass (*Morone mississippiensis*), and sauger (*Sander canadensis*) (Black 2008, 2009).

Table 2-15. Commercial Harvest Rates for Paddlefish from Chickamauga and Watts Bar Reservoirs in 2007, 2008, and 2009

	Chickamauga Reservoir			Watts Bar Reservoir		
Paddlefish	**2007**	**2008**	**2009**	**2007**	**2008**	**2009**
Number	35	166	74	1	0	0
Roe (eggs) (lb)[(a)]	119.1	208.63	90.79	6.22	0	0
Flesh (lb)[(a)]	136	1,339	208.36	0	0	0

Source: Black 2010
(a) To convert lb to kg multiply by 0.45 kg/lb.

Table 2-16. Commercial Harvest Rates for Non-Roe Fish and Turtles from Chickamauga and Watts Bar Reservoirs in 2008 and 2009

		Chickamauga Reservoir Total Weight (lb)[(a)]		Watts Bar Reservoir Total Weight (lb)[(a)]	
Species	**Common Name**	**2008**	**2009**	**2008**	**2009**
Hypophthalmichthys molitrix and *H. nobilis*	Bighead or silver carp[(b)]	331	63	--	--
Ictalurus furcatus and I. punctatus	Blue or channel catfish	147,104	244,035	--	--
Ictiobus bubalus	Buffalo fish	14,641	5,525	--	--
Multiple species	Catfish	1,289	13,814	--	--
Cyprinus carpio	Common carp	2,536	3,944	--	-
Pylodictis olivaris	Flathead catfish	2,806	9,132	--	--
Alpodinotus grunniens	Freshwater drum	6,674	7,456	--	--
Lepisosteus sp.	Gar	67	881	--	--
Alosa chrysochloris	Shad (skipjack herring)	317	0	27	--
Chelydra serpentina	Snapping turtles	70	349	--	--
Morone mississippiensis	Yellow bass	10	0	--	--

Source: Black 2010
(a) To convert lb to kg multiply the numbers in the columns by 0.45 kg/lb.
(b) These species were not identified from Table 2-15 as being seen in the vicinity of the Watts Bar site or the Watts Bar Dam.

Table 2-17. Number of Fish Caught in Annual Creel Survey of the Entire Chickamauga and Watts Bar Reservoirs

			Chickamauga		Watts Bar	
	Species	**Common Name**	**2007**	**2008**	**2007**	**2008**
Polyodontidae	*Polyodon spathula*	Paddlefish[(a)]	137	-	-	-
Amiidae	*Amia calva*	Bowfin[(a)]	-	-	1,016	-
Catostomidae	*Ictiobus* sp.	Buffalo	-	-	1,264	-
Centrarchidae	*Lepomis gulosus*	Warmouth	1,192	609	-	-
	Lepomis macrochirus	Bluegill	573,417	490,803	191,921	189,472
	Lepomis microlophus	Redear sunfish	55,673	32,571	184	446
	Micropterus dolomieu	Smallmouth bass	18,821	17,921	40,623	36,797
	Micropterus punctulatus	Spotted bass	72,874	69,585	38,260	58,155
	Micropterus salmoides	Largemouth bass	238,006	223,018	167,471	253,243
	Pomoxis annularis	White crappie	54,654	31,070	76,057	85,065
	Pomoxis nigromaculatus	Black crappie	201,365	114,294	69,540	79,619
	Pomoxis nigromaculatus	Blacknose crappie[(a)]	662	48	3,588	1,380

Table 2-17. (contd)

	Species	Common Name	Chickamauga 2007	Chickamauga 2008	Watts Bar 2007	Watts Bar 2008
Clupeidae	*Alosa chrysochloris*	Skipjack herring	3,812	-	43,463	967
	Alosa pseudoharengus	Alewife[(a)]	185	-	-	-
Cyprinidae	*Carassius auratus*	Goldfish[(a)]	-	-	586	-
	Cyprinus carpio	Carp	92	-	183	-
	Notemigonus crysoleucas	Golden shiner	196	1,340	-	-
Esocidae	*Esox masquinongy x lucius*	Tiger muskie[(a)]	100	-	-	-
Ictaluridae	*Ictalurus furcatus*	Blue catfish	167,105	156,086	82,146	76,800
	Ictalurus punctatus	Channel catfish	54,917	67,755	28,636	51,811
	Pylodictis olivaris	Flathead catfish	10,751	11,100	7,872	8,814
Lepisosteidae	*Lepisosteus osseus*	Longnose gar	-	92	-	-
Moronidae	Hybrid striped bass x white bass	Cherokee bass[(a)]	40	64	1,701	187
	Morone chrysops	White bass	52,626	93,407	153,788	323,471
	Morone mississippiensis	Yellow bass	159,219	142,693	60,404	70,918
	Morone saxatilis	Striped bass	7,789	18,489	35,120	25,938
Percidae	*Aplodinotus grunniens*	Freshwater drum	36,095	65,696	21,438	27,141
	Perca flavescens	Yellow perch	-	-	-	187
	Sander canadensis	Sauger	1,666	22,784	24,131	36,319
	Sander vitreus	Walleye	-	-	242	-

Source: Black 2008, 2009
(a) Although these species are found in the Chickamauga or Watts Bar reservoirs they have not been reported in the vicinity of the WBN plant or in the vicinity of the Watts Bar Dam.

The following paragraphs present life-history information relevant to the potential of the WBN Unit 2 facility to affect specific commercially and recreationally important fish. These include sunfish, buffalo, catfish, carp, black bass, white and yellow bass, crappie, freshwater drum and sauger. Shad is included because it is one of the main groups of forage fish in the Chickamauga and Watts Bar reservoirs.

- Sunfish (*Lepomis* spp.). Sunfish species found in the vicinity of WBN Unit 2 include the bluegill and the redear sunfish. Bluegill are both a forage fish and a game fish. The young are prolific and provide prey for bass. Bluegill frequent shallow water with vegetative cover, submerged wood, or rocks. They spawn from late spring into summer. Like other sunfish, male bluegill and redear sunfish construct nests in shallow water on varied substrates (although they prefer gravel) and guard the eggs until hatching occurs. Young sunfish frequent weed beds or other heavy cover. Redear sunfish feed on benthic organisms such as mollusks, snails, and aquatic insect larvae (including midges and burrowing mayflies). Bluegill eat a varied diet, including midge larvae and microcrustaceans (Etnier and Starnes 1993). Etnier and Starnes (1993) report that bluegill select larger prey items when they are abundant but become less selective feeders as the abundance of their favorite prey decreases. The population of bluegill can affect the largemouth bass population.

- Smallmouth buffalo *(Ictiobus bubalus)*. The species of buffalo caught by commercial fishers is likely the smallmouth buffalo because it is more common in the Tennessee River than other species of buffalo. This fish can reach sizes of 14 to 18 kg (30 to 40 lb) (Etnier and Starnes 1993). Smallmouth buffalo eating habits seem to vary between populations, but they feed largely on benthic invertebrates such as bivalves or on copepods, cladocerans, and aquatic insects (Etnier and Starnes 1993; Mettee et al. 1996). Etnier and Starnes (1993) report that buffalo prefer to spawn on submerged vegetation, although Mettee et al. (1996) found active spawning occurring in the rapids below Lake Tuscaloosa Dam. Spawning occurs in early to mid-spring in the Tennessee region. Spawning is random, although the eggs are adhesive and range in number from 18,000 to 500,000 per female per year (Etnier and Starnes 1993).
- Catfish (Family Ictaluridae). Catfish that occur in the Chickamauga Reservoir include the blue catfish (*Ictalurus furcatus*), channel catfish (*I. punctatus*), and flathead catfish (*Pylodictis olivaris*). Catfish are both recreationally and commercially important species. Members of the family Ictaluridae spawn in summer and deposit their eggs in depressions or nests they construct in natural cavities and crevices in rivers. Male catfish display territorial behavior after spawning and aggressively defend their eggs. Catfish are opportunistic feeders and eat aquatic insect larvae, crayfish, mollusks, and small fish (live and dead) (Etnier and Starnes 1993; Mettee et al. 1996).
- Carp (*Cyprinius carpio*). Carp are a non-native fish introduced into North America from Eurasia. These fish tend to frequent deep water (up to 6 m [20 ft] deep). They are omnivores that feed on the bottom (mostly in mud). Carp eat worms, insect larvae, plankton, vascular plants, and, occasionally, small fish (Mettee et al. 1996; Etnier and Starnes 1993). Carp increase the turbidity of the water as they feed and spawn, which decreases light penetration and primary productivity and covers the eggs of other fish species with silt resulting in detrimental effects on the environment. Spawning occurs in the spring, in flooded fields or along the shore of the reservoir, and the eggs are small and adhesive. Female carp may produce over 2,000,000 eggs in a given season and may release 600,000 or more in a given spawning period (Etnier and Starnes 1993). Carp are a long-lived fish species (20 years) and reach sizes of 23 to 36 kg (50 to 80 lb) (Etnier and Starnes 1993).
- Black bass (*Micropterus* spp.). Black bass include largemouth bass (*Micropterus salmoides*), smallmouth bass (*M. dolmieu*), and spotted bass (*M. punctulatus*). Largemouth bass and spotted bass inhabit sluggish portions of streams and larger lakes and reservoirs. In reservoirs, smallmouth bass prefer steep rocky slopes along the submerged river and creek channels. Smallmouth and spotted bass spawn in April or early May, and largemouth bass spawn from late April to June. Black bass construct nests in coarse gravel at depths less than 1 m (3.3 ft) near the margins of streams or lakes (smallmouth bass) or in other types of gravel or firm substrates (spotted bass and largemouth bass) along the shallow margins of lakes. For all three species, the males guard the nests until the fry have hatched

and dispersed. For smallmouth bass, hatching requires about 4 to 6 days; fry swim up from the nest 5 to 6 days later. The fecundity of females varies with the size of the fish but they may produce from 2,000 to 145,000 eggs. Young bass feed on zooplankton, insects, and small fish, and are cannibalistic (Etnier and Starnes 1993). Smallmouth and spotted bass feed primarily on small fish, crayfish, and aquatic insects. Largemouth bass prey on bluegill, redear sunfish, shad, minnows, crayfish, and amphibians (Mettee et al.1996).

- White bass (*Morone chrysops*) and yellow bass (*M. mississippiensis*). White and yellow bass are important game fish in the Chickamauga and Watts Bar reservoirs. Yellow bass school and avoid flowing water habitats more so than the white bass (Etnier and Starnes 1993). Spawning occurs in midwater for both species, although the yellow bass migrate into large streams or tributaries to spawn. Spawning runs for white bass occur in mid-February, while spawning for yellow bass occurs in April and May. The eggs of both species drift to the bottom and are adhesive. White bass larvae hatch in two days, and yellow bass eggs in four to six days. Rather than being passively transported downstream with the river flow, the larvae of white bass in the Tennessee River appear to use areas of low-velocity as a refuge or stay near the bottom of the river. Juveniles eat small invertebrates such as cladocerans, copepods, and midge larvae. Adults are aggressive predators and feed on threadfin and gizzard shad (Mettee et al. 1996), as well as silverside and occasionally young sunfish (Etnier and Starnes 1993). In some populations, adult yellow bass continue to feed heavily on aquatic insects (Etnier and Starnes 1993).
- Black crappie (*Pomoxis nigromaculatus*) and white crappie (*P. annularis*). Both the black and white crappie are popular sport and food fishes. The white crappie inhabits sluggish streams and lakes and is tolerant of turbidity. The black crappie prefers clear waters and is more abundant in natural lakes, although it does well in less turbid reservoirs. Spawning occurs from April to June. Spawning sites generally are located in shallow protected areas such as coves or deeper overflow pools near vegetation (black crappie), brush, or overhanging banks. Hatching requires 2 to 5 days depending on the water temperatures. Adult males guard the nests until the fry have dispersed. Females contain from 10,000 to 160,000 mature eggs and spawn repeatedly in the nests of several males over the season. Young crappies feed on small invertebrates, including microcrustaceans and small insects, but prey progressively more on fish as they mature. Adults feed heavily on forage fish such as shad. However, they also consume microcrustacea and other plankton (Etnier and Starnes 1993; Mettee et al. 1996).
- Freshwater drum (*Aplodinotus grunniens*). Freshwater drum are common in large rivers and reservoirs and prefer backwaters and areas with slow current. They are an important part of the commercial fishery in the larger rivers and reservoirs of Tennessee. Freshwater drum are broadcast spawners and spawn large numbers of eggs (40,000 to 60,000 per female) in midwater at water temperatures in the range of 18 to 20°C (64 to 68°F) (Etnier and Starnes 1993). Spawning in this stretch of the Tennessee River typically occurs in late spring, although it can also continue into the late summer (TVA 2012b). The eggs are pelagic and

float until they hatch within one to two days (Etnier and Starnes 1993). The larvae are small, about 3.2 mm (0.13 in.) long at hatching, and grow rapidly; they are considered juveniles a few weeks later at 1.5 cm (0.60 in.) long. The larvae feed on other fish larvae (especially shad and younger drum). Individuals are 10 to 12 cm (4 to 5 in.) long by the fall, at which time they begin to feed on zooplankton, small crustaceans (e.g., amphipods), and aquatic insects (Etnier and Starnes 1993).

- Sauger (*Sander canadensis*). Sauger inhabit large, often turbid rivers and have been successful in many reservoirs (Etnier and Starnes 1993). They spawn from April through May, commonly over rubble and gravel in tailwaters (Etnier and Starnes 1993). In an effort to understand the population dynamics of sauger in Chickamauga Reservoir, TVA used standard and experimental gill nets during a set of special studies conducted from 1986 to 1994 in the upper 24 km (14.9 mi) of the reservoir (Simmons 2010a). These studies indicate that Watts Bar Dam blocks sauger from their annual spawning migration up the Tennessee River. In Chickamauga Reservoir, spawning occurs approximately 13 km (8 mi) downstream of Watts Bar Dam (TVA 1998) at Hunter Shoals (Hevel and Hickman 1991). Eggs adhere to rubble and gravel immediately after spawning, but shortly become nonadhesive and currents may widely disperse the eggs. Larger females can produce over 100,000 eggs annually, but most produce 20,000 to 60,000 eggs. Larvae feed on cladocera, copepods, and midge larvae. Juveniles switch to a diet almost exclusively made up of fish, primarily gizzard and threadfin shad, in the Tennessee River Basin (Etnier and Starnes 1993), although they are also known to feed on young walleye (*Sander vitreus*), sauger, white bass, crappie, and yellow perch (Mettee et al. 1996).
- Threadfin shad (*Dorosoma petenense*) and gizzard shad (*D. cepedianum*). Shad are valuable forage fish. The gizzard shad is possibly less likely to be a forage fish because of its rapid growth and larger maximum size (52.1 cm [20.5 in.] total length; 1.59 kg [3.5 lb]). Threadfin shad on the other hand have a maximum total length of 21.6 cm (8.5 in.). Spawning occurs along the shorelines. Both species are prolific spawners. An average size female gizzard shad produces about 300,000 eggs a year. Gizzard shad deposit their eggs in substrate such as boulders, logs, or debris. The eggs adhere to the substrate and hatch in 2 to 3 days. Gizzard shad typically spawn from mid-May to mid-June in Tennessee, although researchers indicate that threadfin shad may spawn well into the summer and possibly fall. The fish synchronize their spawning time and spawn as a group activity. In particular, threadfin shad spawn a few hours after sunrise. Ecologists think the synchronous behavior is important for avoiding predators and rapidly building up populations that may have been depleted during the winter (Etnier and Starnes 1993). Shad feed on plankton (Mettee et al. 1996). Both threadfin shad and gizzard shad are susceptible to large winter die-offs when temperatures drop. The threadfin shad is less cold tolerant than the gizzard shad. Sublethal effects such as feeding cessation can begin at 10°C (50°F). Inactivity occurs at 6 to 7°C (43 to 45°F) and death at 4 to 5°C (39 to 41°F), although death has been reported at temperatures as high as 12°C (54°F) (Etnier and Starnes 1993).

Non-Native Species. The introduction of non-native species has also affected the fish population in the Tennessee River. Discussion of non-native aquatic plant species and mollusks occurred earlier in this section. Non-native aquatic animal species have become residents of the TVA reservoir system. Invasive species are those non-native species whose introduction causes or is likely to cause economic or environmental harm. Non-native and invasive fish species found in parts of the Watts Bar and Chickamauga reservoirs include the common carp (*Cyprinus carpio*), grass carp (*Ctenopharyngodon idella*), bighead carp (*Hypophthalmichthys nobilis*), silver carp (*H. moltrix*), alewife, redbreast sunfish, inland silverside, and yellow perch. Mechanisms of introduction have included recreational boating (silver carp), bait distribution (alewife), and natural forces such as interconnected waterways, pond breaches, and waterfowl (TWRA 2008).

Carp are considered invasive species and they have clearly changed the environment of the Tennessee River aquatic communities. Common carp have been present in the Tennessee River aquatic communities for over 100 years and currently exist in all reservoirs. Common carp have been found in the vicinity of the WBN site. Grass carp have been introduced throughout much of the United States for biological control of nuisance aquatic plants, but were not identified in the sampling studies in the vicinity of the WBN site. TVA reports grass carp primarily in the lower portions of the river system (TVA 2004a). Silver and bighead carp have been found in parts of Chickamauga Reservoir (Black 2010) but were not identified in the sampling studies in the vicinity of the WBN site. Carp are detrimental to the native fauna and decrease the water-quality conditions. They are highly tolerant of poor water-quality conditions, and researchers expect them to continue to spread throughout the Tennessee River system. Carp are an important commercial fish, and the grass carp has a recreational value in some Tennessee River reservoirs such as Guntersville Reservoir.

Alewife are native to the Atlantic coast from Newfoundland to South Carolina. Introduced into Tennessee and other states intentionally as a forage fish, alewife occur in parts of Chickamauga Reservoir and are identified as part of the commercial catch. In other reservoirs, alewife may be the cause of recruitment failure in walleye (TWRA 2008). Alewife were not identified in the sampling studies in the vicinity of the WBN site.

Redbreast sunfish are native to the Atlantic slope drainages and were introduced intentionally for sportfishing. Redbreast sunfish have been found in the vicinity of the WBN site. This species may have caused the decline or extirpation of many native longear sunfish populations through direct competition (Etnier and Starnes 1993). However, longear sunfish still occur in the Chickamauga and Watts Bar reservoirs (TWRA 2008).

Inland silverside are native to coastal and freshwater habitats from Massachusetts to Mexico. In Tennessee, they have invaded the Tennessee River system. The first individuals were collected in the Chickamauga Reservoir in 2004, but were not observed in the electrofishing sampling data adjacent to the WBN site until 2006. They were observed in data for Watts Bar

Reservoir electrofishing in 2005. Inland silverside completely replaced brook silverside in introduced populations in Oklahoma. More time is needed to understand the impact on the brook silverside populations in the Tennessee River, as well as on other species with similar ecological niches (TWRA 2008). Inland silverside have been found in the vicinity of the WBN site.

Yellow perch have been introduced into many states, including Tennessee, from their native range in the middle Mackenzie drainage in Canada through the northern states east of the Rocky Mountains and to the Atlantic Slope drainages south to South Carolina. They were introduced in the late 1800s for food and sportfishing. Yellow perch are known to compete for food resources with trout, but at the same time are valuable forage for walleye (TWRA 2008). Yellow perch have been found in the vicinity of the WBN site.

2.3.2.2 Designated Species and Habitat

In 1995, TVA (1995a) counted 43 aquatic genera (11 fish, 26 mussels, 4 snails, 1 cave dwelling shrimp, and 1 cave dwelling isopod) within the Tennessee River Basin that were Federally listed as endangered, threatened, or proposed to be listed as endangered or threatened. In addition, TVA (1995a) noted that three species of mussel were extirpated. However, the Tennessee River Basin includes many species and habitats not present on the WBN site, or in the mainstem of the Tennessee River in the vicinity of the site. The FES-OL-1 (NRC 1995) identified three Federally listed mussel species known to occur near the WBN site (i.e., dromedary pearly mussel, pink mucket pearly mussel, and rough pigtoe), and the threatened snail darter. This section discusses Federally and State-listed aquatic species that may occur near the WBN site as shown in Table 2-18.

State-Listed Species

This section describes Tennessee State-listed and proposed threatened and endangered aquatic species near the WBN site that are not also Federally listed.

<u>Flame Chub (*Hemitremia flammea*)</u>

The flame chub is a small fish, usually no more than 8.1 cm (3.2 in.) in length (Etnier and Starnes 1993), that inhabits springs and spring runs. It prefers areas with lush aquatic vegetation. The State deems it as “in need of management.” Historical records place the flame chub in tributaries off Watts Bar Reservoir in Rhea County prior to impoundment of the reservoir. However, the only recent (1996 and prior) observations are from Loudon County and those individuals would not be affected by operations of Unit 2 (TVA 2010a). As a result, this SFES will not consider the flame chub further.

Table 2-18. Federally and State-Listed Aquatic Species in Rhea and Meigs Counties, Tennessee

Scientific Name	Common Name	State of Tennessee Status	Federal Status
Mussels			
Cyprogenia stegaria	Eastern fanshell pearly mussel	Endangered	Endangered
Dromus dromas	Dromedary pearly mussel	Endangered	Endangered
Lampsilis abrupta	Pink mucket	Endangered	Endangered
Plethobasus cooperianus	Orange pimpleback	Endangered	Endangered
Pleurobema plenum	Rough pigtoe	Endangered	Endangered
Plethobasus cyphyus	Sheepnose mussel	-	Endangered
Fish			
Chrosomus saylori[(a)]	Laurel dace	Endangered[(b)]	Endangered
Erimonax monachus	Spotfin chub	Threatened	Threatened
Percina macrocephala	Longhead darter	Threatened (Meigs County)	-
Acipenser fulvescens	Lake sturgeon	Endangered (Meigs County)	-
Hemitremia flammea	Flame chub	Deemed in need of management	-
Percina aurantiaca	Tangerine darter	Deemed in need of management	-
Phoxinus tennesseensis	Tennessee dace	Deemed in need of management	-
Percina tanasi	Snail darter	Threatened (Meigs County)	Threatened
Carpiodes velifer	Highfin carpsucker	Deemed in need of management (Meigs County)	-
Amphibians			
Cryptobranchus alleganiensis alleganiensis	Eastern hellbender	Deemed in need of management (Meigs County)	-

Sources: FWS 2012; TDEC 2012a; 77 FR 14914

(a) FWS previously referred to laurel dace as *Phoxinus saylori*, but now refers to them as belonging to the genus *Chrosomus.*

(b) The State of Tennessee still uses the name *Phoxinus saylori* for the laurel dace.

Tangerine Darter (*Percina aurantiaca*)

The tangerine darter, one of the larger Tennessee darters, reaches a length of 17.2 cm (6.75 in.). It inhabits clearer portions of large-to moderate-size headwater tributaries of the Tennessee River and prefers deeper riffles with boulders, large rubble, and bedrock substrate, although it moves to deeper pools in the winter. The tangerine darter's range currently is confined to the Upper Tennessee River, although it may have occurred in the mainstem of the Tennessee River before TVA impounded the river (Etnier and Starnes 1993). Because it is not known to currently exist in the mainstem and the occurrence data for the area surrounding the site did not show it as present (TVA 2010a), the tangerine darter is not discussed further in this SFES.

Tennessee Dace (*Phoxinus tennesseensis*)

The Tennessee dace's range is restricted to small low-gradient woodland tributaries that do not exceed 1.8 m (6 ft) in width in the Upper Tennessee River drainage (Etnier and Starnes 1993). Although the State considers the dace as "in need of management" for Rhea County, it has not been observed in the occurrence data in the vicinity of the site (TVA 2010a) and is not known to exist in the mainstem of the Tennessee River. As a result, it is not discussed further in this SFES.

Highfin Carpsucker (*Carpiodes velifer*)

The State deems the highfin carpsucker, the smallest carpsucker in Tennessee, as "in need of management" for Meigs County (located across the river from the WBN site). Its habitat occurs in areas of gravel substrate in relatively clear medium-to-large rivers. The highfin carpsucker is more susceptible to impoundment and siltation than other carpsuckers. It is currently known in Tennessee to persist in the Nolichucky, French Broad, Clinch, Hiwassee, Sequatchie, and Duck river systems (Etnier and Starnes 1993). The occurrence data indicated that a single individual was observed in 1981 in Sewee Creek at Creek Mile 3.6 (TVA 2010a). Because it is not found in the mainstem of the Tennessee River or in the vicinity of the site, it would not be affected by operation of WBN Unit 2 and is not discussed further in this SFES.

Longhead Darter (*Percina macrocephala)*

The longhead darter is listed as threatened by the State of Tennessee in Meigs County (TDEC 2012a). This darter is usually found in larger upland creeks and in rivers that are small to medium in size and have good water quality. Longhead darter prefer negligible siltation and areas that lack turbidity. In general, this species is found in pools approximately 1 m (3 ft) in depth. It feeds on small crayfish and mayfly nymphs. The longhead darter spawns in the spring at temperatures of about 10°C (50°F) in shallow gravel shoal areas. It is currently known to be present in the Little River in Blount County. However, it is considered to be rare or extirpated in other Tennessee River tributaries (Etnier and Starnes 1993). Sampling studies conducted in the vicinity of the WBN site, as reported earlier in this section, have not observed longhead darters.

Lake Sturgeon (*Acipenser fluvescens*)

The lake sturgeon is listed as endangered by the State of Tennessee in Meigs County (TDEC 2012a). This sturgeon is extremely rare and considered critically imperiled by the State. It is a bottom feeder, preferring crayfish, mollusks, and insect larvae for food. This species prefers to inhabit large rivers or lakes with moderate to rapid currents and gravel and sand substrates. The lake sturgeon does not spawn every year; females spawn every 4 to 9 years and males spawn every 1 to 2 years. Spawning occurs from April to June in shallow graveled areas at water temperatures of 12 to 18°C (54 to 65°F). Lake sturgeon have been eliminated from most of its former range through the upper and middle Mississippi River basin and the Hudson Bay and Great Lakes drainages. In 1941, researchers conducting sampling studies identified six lake sturgeon on the lower Tennessee near Decatur, Alabama. Around 1960, researchers identified another lake sturgeon in Fort Loudon Reservoir (Etnier and Starnes 1993). Simmons (2010b) reported a single lake sturgeon caught during sampling with a gill net in 2003 from TRM 490.5.

Eastern Hellbender (*Cryptobranchus alleganiensis alleganiensis*)

The eastern hellbender, also called the mudpuppy or waterdog, is an aquatic salamander that grows from 30 to 74 cm (12 to 29 in.) long. Members of this species are found distributed from southern New York to northern Georgia and Alabama. They prefer habitats with swift running, fairly shallow, highly oxygenated waters. This species finds flat rocks, logs, or other cover in the vicinity of riffle areas, essential for feeding and breeding (Mayasich et al. 2003). Its habitat is generally medium-to-large clear, fast-flowing streams with rocky bottoms, especially riffle areas and upper pool reaches. The species occurrence data indicate that eastern hellbenders were present in 1981 in Sewee Creek at Creek Mile 3.6 (TVA 2010a). These individuals or their progeny in Sewee Creek would not be affected by potential operations of Unit 2 at the WBN site. No eastern hellbenders have been reported from the inflow zone of Chickamauga Reservoir. As a result, they are not further discussed in this SFES.

Federally Listed Species

The NRC received a letter from the FWS (DOI 2009) indicating that five Federally endangered mussels and two Federally threatened fish exist in the vicinity of the WBN site. The laurel dace (*Chrosomus saylori*) was listed as endangered on September 8, 2011 (76 FR 48722) and the sheepnose mussel was listed as endangered on March 13, 2012 (77 FR 14914). The following sections describe these species.

Eastern Fanshell Pearlymussel (*Cyprogenia stegaria*)

The FWS has listed the Eastern fanshell pearlymussel, also known simply as the fanshell, as endangered since 1990 (55 FR 25591). Generally, this species is distributed in the Tennessee and Cumberland river systems. The fanshell is a big river species, but it also may be found inhabiting shallow, unimpounded upper stretches of the Clinch River as well as unimpounded portions of the Tennessee and Cumberland rivers. Fanshells are usually found on coarse sand and gravel less than 1 m (3 ft) deep. Researchers believe fanshells may be reproducing below Pickwick Landing Dam on the Tennessee River (Parmalee and Bogan 1998). The glochidial (larval form of freshwater mussel) host has been reported to be banded sculpin (*Cyprogenia stegaria*), mottled sculpin (*Cottus bairdi*), greenside darter (*Etheostoma blennioides*), Tennessee snubnose darter (*E.simoterum*), banded darter (*E. zonale*), tangerine darter, blotchside logperch (*Percina burtoni*), logperch (*P. caprodes*), and the Roanoke darter (*P. roanoka*). Many factors have caused the decline of this species, including impoundment, navigation projects, water-quality degradation, and other forms of habitat alteration such as gravel and sand dredging. These habitat modifications either directly affected the species or reduced or eliminated the fish hosts (55 FR 25591). TVA last found the fanshell in 1983 in the mussel bed nearest the WBN site (TRM 528.2 to 528.9) and in 1985 at TRM 520.6 (Baxter et al. 2010). However, the occurrence data (TVA 2010a) show that TVA researchers found the Eastern fanshell pearly mussel as recently as 1994 in the mussel beds from TRM 524 to 525.

Dromedary Pearlymussel (*Dromus dromas*)

The FWS listed the dromedary pearlymussel as endangered in 1976 throughout its entire range in Kentucky, Tennessee, and Virginia. This species was historically widespread in the Cumberland and Tennessee river systems. It inhabits small to medium streams that have low turbidity and high to moderate gradients. The dromedary pearlymussel is found near riffles on sand and gravel substrates with stable rubble. Individuals have also been found in slower waters and up to a depth of 5.5 m (18 ft). Most historic populations apparently were lost when the river sections they inhabited were impounded. The more than 50 impoundments on the Tennessee and Cumberland rivers eliminated the majority of riverine habitat for this species in its historic range. The specific food habits of the dromedary pearlymussel are unknown, but the FWS has identified the fantail darter (*Etheostoma flabellare*) as the host species. Other potential hosts include the banded darter (*E. zonale*), tangerine darter, logperch, gilt darter (*P. evides*), black sculpin (*Cottus baileyi*), greenside darter, snubnose darter (*E. simoterum*), blotchside logperch, channel darter (*P. copelandi*), and the Roanoke darter (FWS 2010a). TVA did not find the dromedary pearlymussel in the bed closest to the WBN site (TRM 528.2 to 528.9) in surveys conducted between 1983 and 1997 or in the survey conducted in 2010 (Baxter et al. 2010; Third Rock Consultants 2010). The most recent observation of a dromedary pearlymussel in the vicinity of the WBN site was in the bed located at TRM 520.0 to 520.8 during the September 1983 survey (Baxter et al. 2010).

Pink Mucket Mussel (*Lampsilis abrupta*)

The FWS designated the pink mucket mussel as endangered in 1976 (41 FR 24062). Historically, this species was recorded from the Mississippi, Ohio, and Cumberland rivers and in the Tennessee River up to the lower Clinch River (Parmalee and Bogan 1998). Currently, it occurs only in the riverine reaches downstream of Wilson Dam in Tennessee and Guntersville Dam in Alabama (Mirarchi et al. 2004) and in the Cumberland River in Smith County, Tennessee (Parmalee and Bogan 1998). However, FWS considers the species as uncommon to rare. Researchers report specimens younger than 10 years of age as rare in the Wilson and Guntersville dam tailwaters. Pink muckets prefer free-flowing reaches of large rivers, typically in silt-free and gravel substrates. Fishes that reportedly serve as hosts for glochidia (the larval form of freshwater mussels) include the smallmouth, spotted, and largemouth bass as well as freshwater drum and possibly sauger (Mirarchi et al. 2004). TVA has found the pink mucket in the vicinity of the WBN site during every mussel survey from 1986 through 1996, although the number of specimens has never amounted to more than 10 (1988) in the surveys from TRM 528.2 to 528.9 (Baxter et al. 2010). A single individual was found at middle site (TRM 526 to 527) in the September 2010 survey (Third Rock Consultants 2010).

Orangefoot Pimpleback (*Plethobasus cooperianus*)

The FWS has listed the orangefoot pimpleback, also known as the Cumberland pigtoe (Mirarchi et al. 2004), as endangered since 1976 (41 FR 24062). It is primarily a big river species found in silt-free areas in a mixture of sand and gravel. The species still survives in the tailwaters of some Tennessee River dams, such as Pickwick Dam. Its glochidial host is unknown (Mirarchi et al. 2004; Parmalee and Bogan 1998). TVA has not found the orangefoot pimpleback near the WBN site during any of the mussel surveys conducted from 1983 to 2010 (Baxter et al. 2010; Third Rock Consultants 2010). The occurrence data provided by the State of Tennessee shows that the closest individual was found near TRM 595 in Watts Bar Reservoir in 1978 (TVA 2010a).

Rough Pigtoe (*Pleurobema plenum*)

The FWS listed the rough pigtoe as endangered in 1976 (41 FR 24062). It is found primarily in large rivers inhabiting a mixture of sand and gravel in areas kept free of silt by moderate to strong current. Researchers have identified extant populations in the Tennessee River tailwaters of Wilson Dam, where they are very rare, and possibly Guntersville Dam (Mirarchi et al. 2004). A fish host for the glochidia is unknown (Parmalee and Bogan 1998). During surveys conducted near the WBN site in 1985, TVA found only one specimen in the mussel bed closest to the site (TRM 528.2 to 528.9). It discovered two additional specimens in the bed at TRM 520.0 to 520.8 in 1983, 1984, and one specimen in 1985 (Baxter et al. 2010). The rough pigtoe mussel was not observed in the samples collected in the vicinity of the WBN site in 2010 (Third Rock Consultants 2010).

Sheepnose Mussel (*Plethobasus cyphyus*)

The FWS listed the sheepnose mussel as endangered in the Federal Register on March 13, 2012 (77 FR 14914). It occurs across the Southeast and the Midwest, but appears extirpated from two-thirds of streams where it had been known to occur. The sauger is the only known host for sheepnose mussel glochidia (FWS 2011; Parmalee and Bogan 1998). Sheepnose mussels live nearly 30 years (77 FR 14914). Parmalee and Bogan (1998) indicated that the most suitable substrate is “a mixture of coarse sand and gravel.” Further, in unimpounded rivers sheepnose mussels can be found in less than 0.6 m (2 ft) of water and in relatively fast currents. In reservoirs, sheepnose mussels can be found at depths of 3.6 to 4.6 m (12 to 15 ft) (Parmalee and Bogan 1998), though they have also been reported at depths exceeding 6 m (20 ft) (77 FR 14914).

Parmalee and Bogan (1998) indicated that the most stable and viable populations of sheepnose mussels in Tennessee were located in the upper Clinch River (Hancock County) and below Pickwick Landing Dam (Harding County) in the Tennessee River. Mirarchi et al. (2004) reported the sheepnose mussel as being extant, but rare, in Tennessee River locations downstream of Wilson and Guntersville Dams in Alabama. In the fall of 1983, two specimens were found at TRM 526.0. One additional specimen was found near this same location in the summer of 1992 and another at approximately TRM 526.3 in the summer of 1994 (Baxter et al. 2010). In September 2010, TVA found a specimen, judged to be approximately 20 years old, during sampling in the middle bed (TRM 526 to 527) (Third Rock Consultants 2010).

Laurel Dace (*Chrosomus saylori*)

The FWS listed the laurel dace as endangered on September 8, 2011 (76 FR 48722). The FWS previously referred to laurel dace as *Phoxinus saylori*, but now refers to them as belonging to the genus *Chrosomus,* due to recent taxonomic changes. Laurel dace belong to the family Cyprinidae (minnows). They are small fish, with the maximum standard length (distance from the tip of the snout or upper jaw to the base of the caudal fin) observed of 5.1 cm (2 in.). Laurel dace inhabit first and second order streams (headwater streams) and are most often collected from pools or slow flowing sections of the stream—often where the stream runs from undercut banks or beneath slab boulders. The substrate of these streams is often cobble, rubble, and boulders, and the maximum water temperature is 26°C (78°F). Laurel dace primarily eat larvae of flies, stoneflies, and caddisflies. Laurel dace are observed to live as long as 3 years, based on reports of finding as many as three year classes in some collections (76 FR 48722).

The laurel dace are known from only three independent systems on the Walden Ridge section of the Cumberland Plateau: Soddy Creek, Sale Creek, and Piney River (76 FR 48722). The USFWS has designated 42.2 river kilometers (26 river miles) as critical habitat for the laurel dace (77 FR 63604). The Piney River critical habitat unit is the closest to the WBN Unit 2 site. The distance between the closest approach of the Piney River critical habitat units and the WBN site is approximately 13 km (8 mi). The NRC staff does not expect that cooling tower drift or any other activities related to operation of the facility will have any effect on laurel dace or on the listed critical habitat. Laurel dace have not been observed in the mainstem of the Tennessee River and, based on the habitat, it is not likely that they would inhabit the river. Therefore, the laurel dace are not discussed further in this SFES.

Spotfin Chub (*Erimonax monachus*)

The FWS listed the spotfin chub, a fish, as threatened in 1977. The State of Tennessee considers it to be a State-endangered species. The FWS initiated a 5-year status review of the spotfin chub in July 2009 (74 FR 31972). The spotfin chub formerly appeared in 12 tributary systems in five states, but is extant in only four systems. Experimental populations (nonessential) were established in the Lower French Broad, Lower Holston, and Tellico rivers (Tennessee), and in Shoal Creek (Tennessee and Alabama) (FWS 2010b). Adults are typically associated with swift currents and boulder substrates. Juveniles are encountered in moderate currents with small gravel substrates (Etnier and Starnes 1993). Because spotfin chub are not known to occur in the Tennessee River, the species is not considered further in this SFES.

Snail Darter (*Percina tanasi)*

Both the FWS and State of Tennessee list snail darters as threatened. The FWS originally thought snail darters inhabited the mainstem of the Tennessee River and possibly ranged from the Holston, French Broad, Lower Clinch, and Hiwassee rivers downstream in the Tennessee drainage to northern Alabama (FWS 1992). However, impoundments have fragmented much of its range (Etnier and Starnes 1993). Researchers observed a population of snail darters (estimated to be 200 to 400) in South Chickamauga Creek (between Creek Mile 5.6 in Tennessee [Hamilton County] and Creek Mile 19.3 in Georgia [Catoosa County]) in 1980. They also found a few darters in the Tennessee River mainstem just below Chickamauga and Nickajack dams (FWS 1992). A population also was found in the upper Watts Bar Reservoir but it did not appear to be reproducing subsequent to the impoundment of the Tellico Reservoir (Etnier and Starnes 1993). Snail darters inhabited Sewee Creek in Meigs County as recently as 1985 (TVA 2010a). Snail darters inhabit larger creeks where they frequent sand and gravel shoal areas in low turbidity water. They are also known from deeper portions of rivers and reservoirs where current is present (Etnier and Starnes 1993). Because they are not known from the Chickamauga Reservoir and because the habitat in the vicinity of the WBN site is not typical for this species (gravel shoals in low turbidity water), the species is not further considered in this SFES.

Critical Habitat

The FWS and National Oceanic and Atmospheric Administration (NOAA) have not designated any critical habitat in the vicinity of the WBN site for the laurel dace, other than the Piney River critical habitat unit discussed previously (77 FR 63604). Two State-designated natural areas are located in Rhea County approximately 13 km (8 mi) northwest of the WBN site. These include the Piney Falls Natural Area (TDEC 2012b) and Stinging Fork Falls Natural Area (TDEC 2012c). The State of Tennessee has established a freshwater mussel sanctuary in the Chickamauga Reservoir between TRM 520.0 and TRM 529.9, as discussed previously.

2.4 Socioeconomics

This section describes current socioeconomic factors that have the potential to be directly or indirectly affected by operating and decommissioning WBN Unit 2. WBN Unit 2 and the people and communities surrounding it can be described as a dynamic socioeconomic system. The nuclear power plant requires people, goods, and services from local communities to operate the plant; and the communities, in turn, provide the people, goods, and services to run the plant. WBN Unit 2 employees would reside in the community and receive income from the plant in the form of wages, salaries, and benefits, and spend this income on goods and services within the community, thereby creating additional opportunities for employment and income. People and businesses in the community also receive income from the goods and services sold to WBN Unit 2. Payments for these goods and services create additional employment and income opportunities in the community. The measure of a community's ability to support the operational demands of WBN Unit 2 depends on the ability of the community to respond to changing socioeconomic conditions.

The socioeconomics region of influence (ROI) is defined by the areas where WBN Unit 2 employees and their families would reside, drive, spend their income, and use their benefits, thereby affecting the economic conditions of the region. TVA currently employs a permanent workforce of approximately 700 employees (TVA 2010b). Approximately 80 percent of these employees live in Hamilton, Knox, Loudon, Meigs, McMinn, Rhea, and Roane counties, Tennessee (Table 2-19). The NRC staff assumed that WBN Unit 2 employees would reside in the area in a pattern similar to that of the WBN Unit 1 employees. The remaining 20 percent of the workforce is divided among other counties ranging from 1 to 29 employees per county. Given the residential location of WBN Unit 1 employees, the most significant impacts of plant operations are likely to occur in a four-county area that includes the counties closest to the WBN site (Rhea, Meigs, McMinn, and Roane) (Table 2-19). The primary commuting routes to and from the site go through this four-county area. Approximately 30 percent of the WBN Unit 1 employees commute from and reside in Knox and Hamilton counties where the larger cities, Knoxville and Chattanooga, are located. These counties, however, are less likely to be affected by activities at the WBN site due to their relatively large populations and distance from the site. In addition to the permanent workforce TVA employs to operate WBN Unit 1, there are approximately 1,360 construction workers on the WBN site associated with WBN Unit 2 construction activities. The following sections describe the population demography, housing, public services, aesthetics, and economy in the four-county ROI surrounding WBN Unit 2.

Table 2-19. WBN Unit 1 Employee Residence by County

County of Residence	Number of WBN Residents	County Population	WBN Residents as % of Total Population	Civilian Workforce	WBN Residents as % of Civilian Workforce
Blount	14	123,010	0.01	63,591	0.02
Bradley	22	98,963	0.02	47,906	0.05
Hamilton	106	336,463	0.03	165,563	0.06
Knox	88	432,226	0.02	232,390	0.04
Loudon	38	48,556	0.08	23,640	0.16
McMinn	88	52,266	0.17	23,198	0.38
Meigs	40	11,753	0.34	5,171	0.77
Monroe	29	44,519	0.07	18,417	0.16
Rhea	155	31,809	0.49	13,279	1.17
Roane	53	54,181	0.10	27,738	0.19
Other	67				

Source: TVA 2010b; USBLS 2010; USCB 2010b

2.4.1 Demographics

The 1995 SFES-OL-1 discussed changes in the population and the region's socioeconomic characteristics related to the operation of the WBN plant since the 1978 FES-OL. In the four-county ROI (Rhea, Meigs, McMinn, and Roane), population trends over the last four decades have followed a similar pattern. From 1970 to 1980, the region experienced a period of relatively higher growth, with average annual growth rates from 2 to 4 percent. A decade of low growth followed this increase from 1980 to 1990; then a decade of relatively higher growth occurred from 1990 to 2000. Average annual growth rates in the four-county ROI were less than 1 percent from 2000 to 2010. These patterns are similar to overall population trends in the State of Tennessee (USCB 2010b). Table 2-20 provides data on population and growth rates for the four-county ROI and for the State of Tennessee. The Tennessee Advisory Committee on Intergovernmental Relations (TACIR) develops population projections for all Tennessee counties out to the year 2040 (see Table 2-20). The overall population in the four-county ROI is projected to increase at similar rates to the State of Tennessee out to 2020. From 2020 to 2040, the population in Meigs and Rhea counties are projected to increase at a rate greater than neighboring McMinn and Roane counties.

Per capita and median household incomes increased in the ROI in real terms from 1970 to 1990, while the ethnic character of the population remained fairly constant from 1980 to 1990 (NRC 1995). These trends have largely continued since 1990; however, the region around the plant has experienced a slight increase in the percentage of Hispanic populations as part of the overall ethnic mix. Over this same period, the four-county ROI also has experienced a slight decline in the percentage of Black or African Americans (USCB 2010b). The 2000 and 2010 demographic profiles of the four-county ROI population are presented in Table 2-21 and Table 2-22.

Table 2-20. Population Growth in Rhea, Meigs, McMinn, and Roane Counties

	Rhea County		Meigs County		McMinn County		Roane County		State of Tennessee	
Year	Population	% Growth[(a)]	Population	% Growth	Population	% Growth	Population	% Growth	Population	Annual % Growth
1970	17,202	--	5,219	--	35,462	--	38,881	--	3,923,687	--
1980	24,235	40.9	7,431	42.4	41,878	18.1	48,425	24.6	4,591,120	17.0
1990	24,344	0.4	8,033	8.1	42,383	1.2	47,227	-2.5	4,877,185	6.2
2000	28,400	16.7	11,086	38.0	49,015	15.6	51,910	9.9	5,689,283	16.7
2010	31,809	12.0	11,753	6.0	52,266	6.6	54,181	4.4	6,346,105	11.5
2020	34,836	9.5	13,007	1	56,093	7.3	55,740	2.9	6,841,868	7.8
2030	38,715	11.1	14,644	12.6	61,010	8.8	58,351	4.7	7,489,809	9.5
2040	42,763	10.5	16,275	11.1	66,289	8.7	60,787	4.2	8,106,583	8.2

Source: Years 1970-2010 (USCB 2010b); Years 2020-2040 forecasted by TACIR (2011)
-- = No data available
(a) Percent growth rate is calculated as total growth over the previous period.

Table 2-21. Demographic Profile of the Four-County Socioeconomic Region of Influence in 2000

	McMinn	Meigs	Rhea	Roane
Population (2000)	49,015	11,086	28,400	51,910
Race (% of total population, not Hispanic or Latino)				
White	91.9	97.3	94.6	94.8
Black or African American	4.4	1.2	2.0	2.7
American Indian and Alaska Native	0.2	0.2	0.4	0.2
Asian	0.7	0.2	0.3	0.4
Native Hawaiian and Other Pacific Islander	0.0	0.0	0.0	0.0
Some other race	0.0	0.0	0.0	0.0
Two or more races	0.9	0.5	1.0	1.1
Ethnicity				
Hispanic or Latino (of any race)	884	63	474	359
% of total population	1.8	0.6	1.7	0.7
Minority Population (including Hispanic or Latino ethnicity)				
Total minority population	3,985	298	1,520	2,711
% minority	8.1	2.7	5.4	5.2

Source: USCB 2000

Table 2-22. Demographic Profile of the Four-County Socioeconomic Region of Influence in 2010

	McMinn	Meigs	Rhea	Roane
Population (2010)	52,266	11,753	31,809	54,181
Race (% of total population, not Hispanic or Latino)				
White	90.4	95.8	92.1	93.7
Black or African American	3.9	1.0	1.9	2.6
American Indian and Alaska Native	0.3	0.5	0.4	0.3
Asian	0.7	0.2	0.4	0.5
Native Hawaiian and Other Pacific Islander	0.0	0.0	0.0	0.0
Some other race	0.1	0.0	0.1	0.0
Two or more races	1.7	1.0	1.3	1.5
Ethnicity				
Hispanic or Latino (of any race)	1,482	176	1,187	710
% of total population	2.8	1.5	3.7	1.3
Minority Population (including Hispanic or Latino ethnicity)				
Total minority population	4,993	492	2,506	3,429
% minority	9.6	4.2	7.9	6.3

Source: USCB 2011a, b, c, d

2.4.2 Community Characteristics

WBN site activities could potentially affect socioeconomic resources in the region such as housing, public services, infrastructure, and recreational resources. In terms of these socioeconomic resources, the WBN site activities currently have an impact on Rhea, Meigs, and possibly McMinn and Roane counties due to their proximity to the site, workforce residential patterns, commuting patterns, and relatively low population levels. The following sections characterize the regional community around the WBN site, and while the focus is on Rhea and Meigs counties, information on other nearby counties is provided as appropriate.

2.4.2.1 Housing

Any one of the ROI counties (see Table 2-20) provides a reasonable commuting distance from the WBN site. Table 2-23 presents housing data for these four counties. Census data show significant levels of available housing stock in the region around the WBN site, although not all vacant housing would be appropriate for in-migrants drawn by operation of WBN Unit 2.

Table 2-23. Selected County Housing Statistics for 2010

	McMinn County	Meigs County	Rhea County	Roane County
Total housing units	23,341	5,628	14,365	25,716
Occupied units	20,865	4,686	12,276	22,376
Owner occupied	15,225	3,717	8,714	16,829
Renter occupied	5,640	969	3,562	5,547
Vacant units	2,476	942	2,089	3,340
Median value of owner-occupied house	$105,600	$107,000	$102,600	$118,900

Sources: USCB 2010b; 2011a, b, c, d

2.4.2.2 Public Services

The Watts Bar Utility District in Roane County handles the WBN site's potable water needs and the Spring City Sewage plant handles the wastewater needs. The Watts Bar Utility District water system currently operates at 50 percent permitted capacity on average, and the Spring City Sewage system operates at 55 percent capacity (see Table 2-24 and Table 2-25). Additional information regarding water supply and wastewater systems in Rhea and Meigs counties is presented in Table 2-24 and Table 2-25. All regional water and wastewater systems are currently operating below capacity (TVA 2010a).

Table 2-24. Major Public Water Supply Systems in Rhea and Meigs Counties

Water System	Service Area	Daily Capacity million L/d (MGD)	Average Daily Use million L/d (MGD)	% of Capacity
Dayton Water Department	Rhea County	15.26 (4.03)	10.03 (2.65)	66
Grandview Utility Department	Rhea County	NA	0.34 (0.09)	NA
Graysville Water Department	Rhea County	1.64 (0.43)	0.60 (0.16)	37
North Utility District of Rhea County	Rhea County	NA	0.75 (0.20)	NA
Spring City Water System	Rhea County	5.68 (1.50)	1.93 (0.51)	34
Watts Bar Utility District	Rhea County	6.81 (1.80)	3.37 (0.89)	50
Decatur Water Department	Meigs County	3.82 (1.01)	2.34 (0.62)	61

Source: STDD 2011; TVA 2010a
NA = Not available

Table 2-25. Major Public Wastewater Systems in Rhea and Meigs Counties

Wastewater System	Service Area	Daily Capacity million L/d (MGD)	Average Daily Use million L/d (MGD)	Operating Capacity Average Daily Use % of Capacity
Copperhill	Rhea County	2.65 (0.70)	1.14 (0.301)	43
Spring City Sewage	Rhea County	4.16 (1.10)	2.27 (0.60)	55
Dayton Wastewater Treatment Plant	Rhea County	10.11 (2.67)	6.81 (1.80)	67
South Pittsburg	Meigs County	5.3 (1.4)	2.65 (0.70)	50
Decatur Operating	Meigs County	1.29 (0.34)	1.16 (0.306)	90

Source: STDD 2011; TVA 2010a
NA = Not available

2.4.2.3 Education

The WBN site is located in the Rhea County School District and just across the river from the Meigs County School District. Eleven public schools provide elementary and secondary education to approximately 7,100 students in Rhea and Meigs counties. Two public school districts serve Rhea County: the Rhea County School District and the Dayton School System. The Rhea County District accommodates approximately 4,300 students (NCES 2012a). The high school, one middle school, and four elementary schools currently operate at capacity, and modular buildings have been located at two schools. The Dayton system operates one school, the Dayton City Elementary School, which currently operates at capacity (nearly 800 students) (Rhea County Schools 2009).

Meigs County serves approximately 1,900 students in four schools (NCES 2012b). All schools in the Meigs County School System currently operate at or near capacity. The school system has just completed a high school addition and plans are in place for additions at an elementary school, which would include either two or four additional classrooms (TDOE 2005). In addition to Meigs and Rhea counties, McMinn and Roane County School Districts could serve school-aged children associated with the WBN workforce. McMinn County School District has 16 schools with approximately 8,300 students enrolled, and Roane County School District has 18 schools with approximately 7,400 students enrolled (NCES 2012c, d).

2.4.2.4 Transportation

Figure 2-1 shows the location of the WBN site in relation to the counties, cities, and towns within an 80-km (50-mi) radius of the site. I-75 passes within 29 km (18 mi) to the east of the site, and I-40 passes within 45 km (28 mi) to the north of the site (see Figure 2-1). Workers and visitors access the site from TN-68, which connects with US-27 to the west and TN-302, TN-58, and I-75 to the east. TN-68, TN-302, and TN-58 are all two-lane highways in good condition.

U.S. Highway 27 is a four-lane highway. Although the Tennessee Department of Transportation has not developed a Level of Use grading system on these road networks, it does maintain average daily traffic volume (ADTV) statistics. On TN-68, the highway that provides access to the site, the ADTV in 2008 was about 4,000 near the site. The Tennessee Department of Transportation considers this level of traffic to be well below the capacity for a two-lane highway in this part of the county (TDOT 2008, 2009). Access to the WBN site is from a three-way intersection with a turning lane off TN-68.

2.4.2.5 Aesthetics and Recreation

The area around the WBN site consists of wooded rolling hills. The WBN site is visible from the Chickamauga and Watts Bar reservoirs and from the eastern shoreline of Chickamauga Reservoir, including a public boat ramp directly across the Chickamauga Reservoir from the site. It is also visible from the Watts Bar Dam and certain other locations off TN-68. The forested land and terrain provide barriers to viewing the containment, turbine buildings, and support structures from most nearby areas.

A number of recreational facilities and resources exist in the area, including the Chickamauga and Watts Bar reservoirs. More than 50 developed recreational facilities are located in the area, including 15 overnight campgrounds on Chickamauga Reservoir, and more than 30 developed recreational facilities on the Watts Bar Reservoir (TVA 2004a).

2.4.2.6 Economy

Table 2-26 and Table 2-27 provide comparative economic statistics for the four-county ROI. Table 2-26 presents information on the annual average unemployment rates, median incomes, and percentage of individuals below the poverty line for 2010. Table 2-27 contains county employment by proprietorship and industry (2009) for the four-county ROI.

Table 2-26. Civilian Labor Force, Percent Unemployment, Median Household Income, and Individual Poverty in Region around the WBN Site, 2010

	Labor Force[(a)]	Unemployment Rate (%)	Median Household Income ($)	Below Poverty (%)
McMinn County	23,198	12.4	37,146	17.3
Meigs County	5,171	12.7	33,305	25.2
Rhea County	13,279	12.6	36,761	19.1
Roane County	27,738	8.0	42,698	13.4
Tennessee	3,056,704	9.7	43,314	16.5

Sources: USCB 2011a, b, c, d; USBLS 2010
(a) Labor Force and Unemployment Rates estimated from annual averages for the year 2010.

Table 2-27. County Full-Time and Part-Time Employment by Type and by Industry, 2009

Industry	McMinn County	Meigs County	Rhea County	Roane County
Total employment	24,430	6,074	14,059	22,061
Wage and salary employment	16,972	1,856	10,903	19,728
Proprietors employment	7,458	4,218	3,156	2,333
Nonfarm proprietor employment	6,379	3,893	2,756	1,816
Farm proprietor employment	1,079	325	400	517
By Industry				
Farm employment	1,244	335	421	546
Construction	1,694	(D)	1,142	(D)
Manufacturing	4,452	725	3,485	1,242
Transportation and public utilities	(D)	(D)	(D)	(D)
Retail trade	2,967	473	1,371	2,065
Finance, insurance, and real estate	1,127	(D)	345	354
Services	4,271	731	2,155	6,172
Government and government enterprises	2,436	513	2,728	3,901

Source: USBEA 2009
D = USBEA did not disclose this information, however, estimates were included in the totals

The U.S. Bureau of Labor Statistics reported that the average annual 2010 unemployment rates in the relatively more rural counties of McMinn, Meigs, and Rhea were higher than the state average, while unemployment rates in nearby Roane County were slightly below the state average. In 2010, the highest estimated rates of poverty were reported in Meigs and Rhea counties; these counties had the lowest median income as well.

Table 2-27 contains county employment by proprietorship and industry (2009) for the four-county ROI. Although these counties are relatively rural, agriculture does not serve as a primary employment source in the region. Rather, the U.S. Bureau of Economic Analysis lists manufacturing and retail as major employment sectors in McMinn and Rhea counties, construction and the service industries as primary employers in Meigs County, and services and government as primary employers in Roane County.

2.4.2.7 Tax Revenues

Property and sales taxes generate funding for most county and city government operations in Tennessee. Cities levy a separate property tax and collect returns on sales taxes generated by business within their corporate limits (Rhea County 2009). Under Section 13 of the TVA Act,[(a)]

(a) Section 13 of the TVA Act, 16 USC 831.

TVA makes tax-equivalent payments to the State of Tennessee. The amount of the tax-equivalent payments is determined by the book value of the TVA property in the State and the value of TVA power sales in the State. In turn, the State of Tennessee redistributes 48.5 percent of the increase in payments to local governments. Payments to counties are based on relative population (30 percent of the total), total acreage in the county (30 percent), and TVA-owned acreage in the county (10 percent). The State pays the remaining 30 percent to cities, based on population. In 2006, the State-distributed TVA generated tax-equivalent payments of $724,050 to Rhea County and $484,465 to Meigs County (TVA 2008a).

The State of Tennessee sets aside 3 percent of the TVA total annual tax-equivalent payments for distribution to counties that TVA designates as “impacted” by construction of facilities used to produce electric power. The State uses these impact payments to assist counties with the temporary increase in local population during the construction period. The counties of Rhea, Meigs, McMinn, Roane, and Monroe, as well as the cities within these counties, all receive impact payments related to the construction of WBN Unit 2. The State distributes impact payment allotments to county and city locations based upon expected population impacts. The payments will continue, at a decreasing rate, for 3 years after construction is complete. In fiscal year 2009, Rhea and Meigs counties each received impact payments from TVA of approximately $680,000, McMinn and Roane counties each received approximately $170,000, and Monroe County received $136,000. These payments are in addition to the TVA tax-equivalent funds distributed by the State to local governments (TVA 2009c).

2.4.3 Environmental Justice

Executive Order (EO) 12898 (59 FR 7629), as amended by 60 FR 6381, requires Federal agencies to identify and address, as appropriate, disproportionately high and adverse human health and environmental impacts on minority and low-income populations. In 2004, the Commission issued a Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions (69 FR 52040) that states “The Commission is committed to the general goals set forth in EO 12898, and strives to meet those goals as part of its NEPA review process.”

The Council on Environmental Quality (CEQ) provides the following information in *Environmental Justice Guidance Under the National Environmental Policy Act* (CEQ 1997):

> **Disproportionately High and Adverse Human Health Effects**. Adverse health effects are measured in risks and rates that could result in latent cancer fatalities, as well as other fatal or nonfatal adverse impacts on human health. Adverse health effects may include bodily impairment, infirmity, illness, or death. Disproportionately high and adverse human health effects occur when the risk or rate of exposure to an environmental hazard for a minority or low-income population is significant (as

employed by the National Environmental Policy Act [NEPA]) and appreciably exceeds the risk or exposure rate for the general population or for another appropriate comparison group (CEQ 1997).

Disproportionately High and Adverse Environmental Effects. A disproportionately high environmental impact that is significant (as defined by NEPA) refers to an impact or risk of an impact on the natural or physical environment in a minority or low-income community that appreciably exceeds the environmental impact on the larger community. Such effects may include ecological, cultural, human health, economic, or social impacts. An adverse environmental impact is an impact that is determined to be both harmful and significant (as employed by NEPA). In assessing cultural and aesthetic environmental impacts, impacts that uniquely affect geographically dislocated or dispersed minority or low-income populations or American Indian Tribes are considered (CEQ 1997).

The environmental justice analysis assesses the potential for disproportionately high and adverse human health or environmental effects on minority and low-income populations that could result from the operation of WBN Unit 2. In assessing the impacts, the NRC used the following CEQ (CEQ 1997) definitions of minority individuals and populations and low-income population:

- Minority. Individual(s) who are members of the following population groups: American Indian or Alaskan Native; Asian or Pacific Islander; Black, not of Hispanic origin; or Hispanic.
- Minority populations. Minority populations are identified when (1) the minority population of an affected area exceeds 50 percent, or (2) the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis.
- Low-income populations. Low-income populations in an affected area are identified with the annual statistical poverty thresholds from the Census Bureau's Current Population Reports, Series P-60, on Income and Poverty.

2.4.3.1 Minority Populations

The WBN site is located in Rhea County where about 8 percent of the population identified themselves as minorities, with Hispanic or Latino being the largest minority group (3.7 percent) followed by Black or African American (2 percent) (USCB 2010b).

Within the 80-km (50-mi) region of the site, approximately 15 percent of the population identified themselves as minority. Approximately 238 census block groups wholly or partly within the 80-km (50-mi) radius of the WBN site were determined to have a minority population of 15 percent of the total population (see Figure 2-8). Of these 238 block groups, 71 had aggregate minority population percentages that exceed the regional (within 80-km [50-mi] radius of the WBN site) average by 20 percentage points or more, and 52 census block groups had aggregate minority population percentages that exceed 50 percent. These block groups are located near the town centers of Maryville (Blount County), Oak Ridge (Anderson County), Cleveland (Bradley County), and the City of Chattanooga (Hamilton County). Some more rural concentrations are located in Whitfield County, Georgia. No block groups with high-density minority populations were found in Rhea or Meigs county (USCB 2010c).

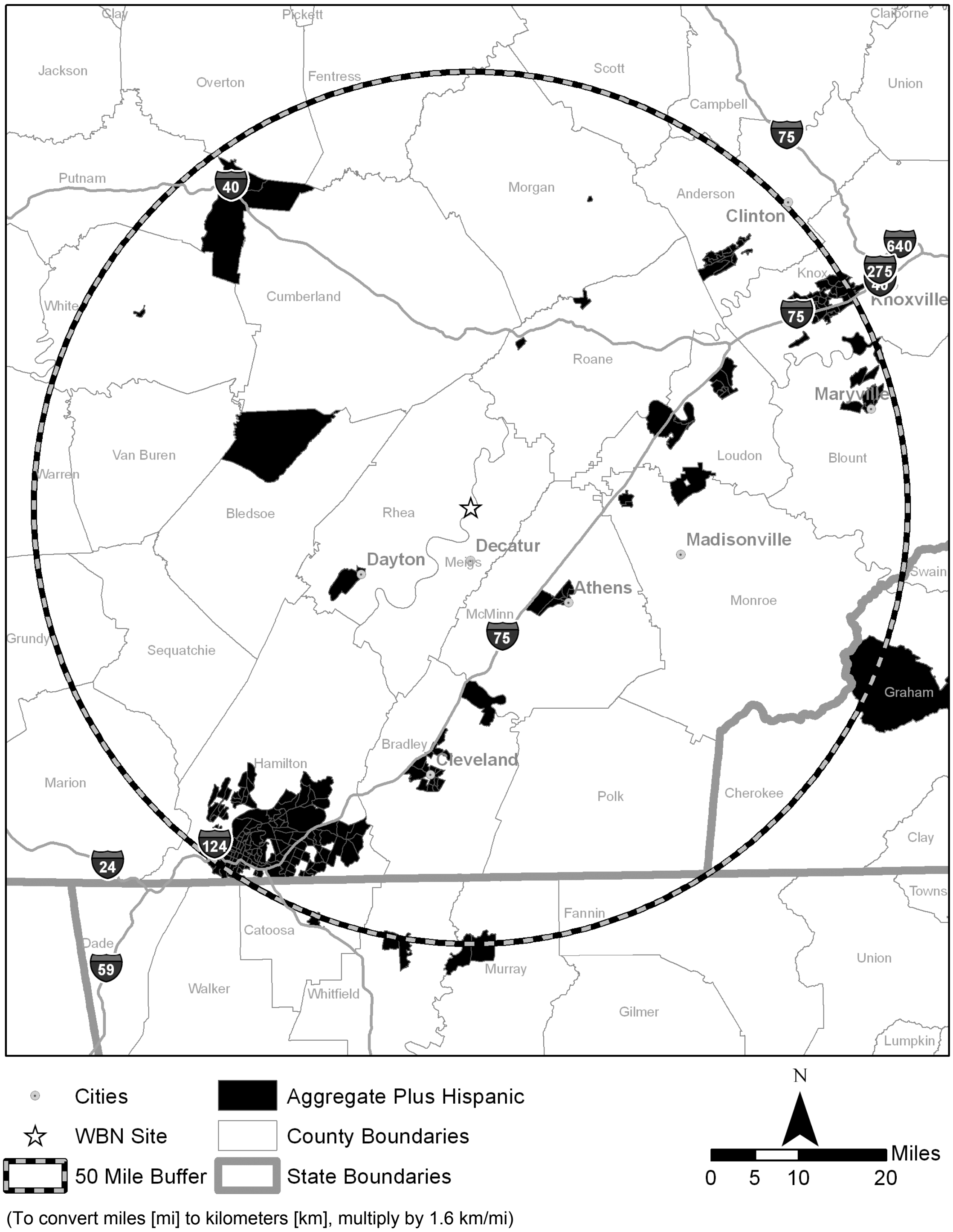
2.4.3.2 Low-Income Populations

According to 2010 census data, approximately 15.5 percent of the population residing within 80 km (50 mi) of the WBN site was identified as low-income (defined as living at or below the Federal poverty threshold[(a)]). There were 336 census block groups within the 80-km (50-mi) region of the WBN site (see Figure 2-9) with low-income populations of 15.5 percent or more (USCB 2011e).

According to census data estimates, the median household income for Tennessee in 2010 was $43,314, with 16 percent of the state population living in households below the Federal poverty threshold in 2010 (USCB 2011a). Rhea County had a lower median household income average ($36,761) and a higher percentage (19) of individuals living below the poverty level when compared to the state.

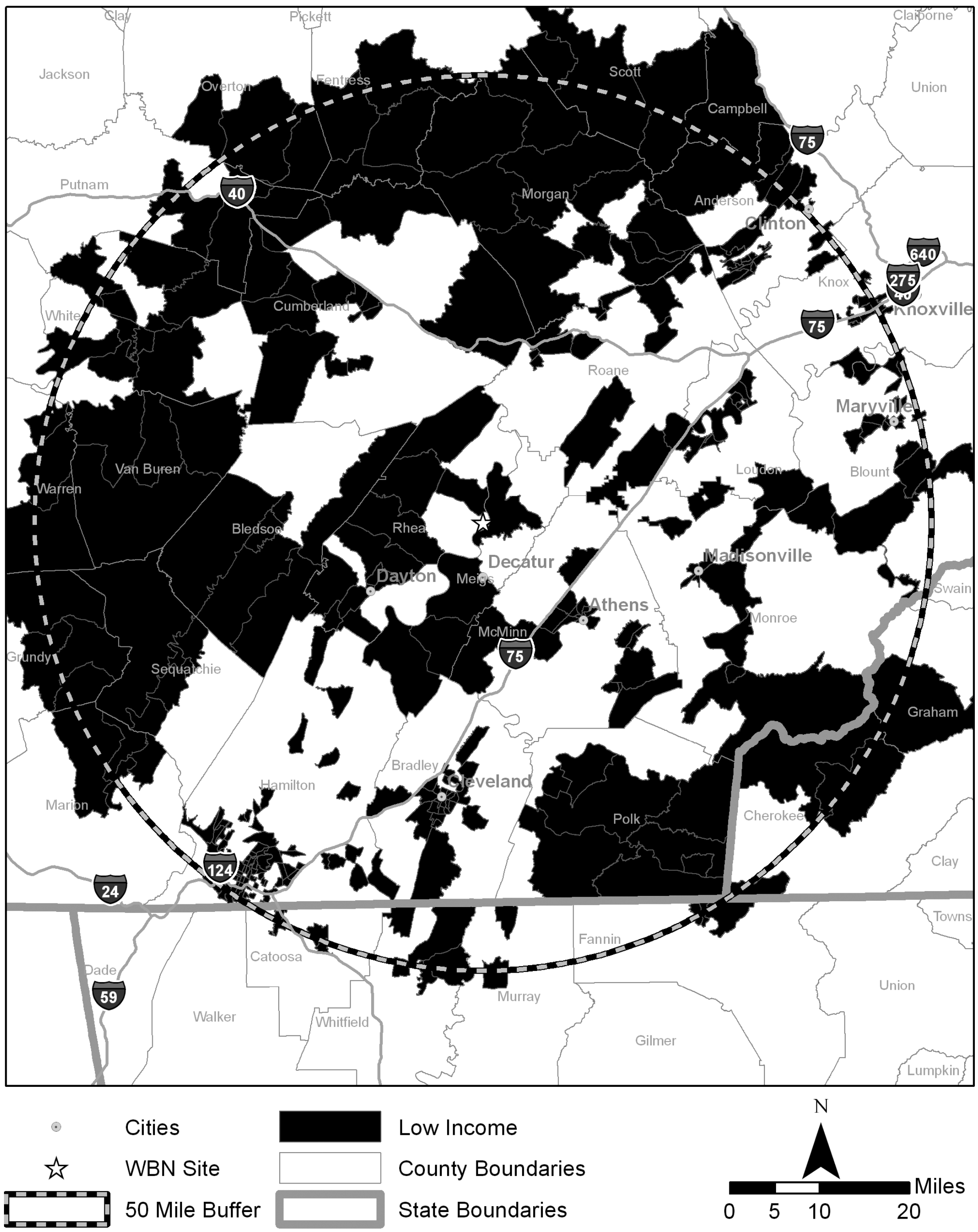
Census block groups were considered high-density low-income block groups if the percentage of the population living below the Federal poverty threshold exceeds the regional (i.e., 80-km [50-mi] radius around the WBN site) average (15.5 percent) by 20 percent or more or if 50 percent or more of the households in the block group are identified as low-income. Based on 2011 data from the American Community Survey, 57 block groups exceeded the 80-km (50-mi) average (15.5 percent) by 20 percent or more, while only 16 block groups had low-income populations of 50 percent or more (USCB 2011e). These block groups are distributed throughout the 80-km (50-mi) radius in relatively rural areas of Scott, Cumberland, Grundy, Roane, Sequatchie, and White counties. In addition, some low-income concentrations are found near the town centers of Dayton (Rhea County), Oak Ridge (Anderson County), Cookeville (Putnam County), Athens (McMinn County), Cleveland (Bradley County), and the City of Chattanooga (Hamilton County). No high-density low-income block groups were found in Meigs County (USCB 2011e).

(a) The USCB weighted average Federal Poverty threshold for a family of four was $17,603 (annual) in the year 2000 and $22,341 in 2010 (USCB 2012, “Poverty Thresholds” available at: http://www.census.gov/hhes/www/poverty/data/threshld/index.html).



(To convert miles [mi] to kilometers [km], multiply by 1.6 km/mi)

Figure 2-8. Minority Block Groups (15 percent or more of population) in 2010 Within an 80-km (50-mi) Radius of WBN Unit 2 (USCB 2010c)



(To convert miles [mi] to kilometers [km], multiply by 1.6 km/mi)

Figure 2-9. Low-Income Block Groups (15.5 percent or more of population) in 2010 Within an 80-km (50-mi) Radius of WBN Unit 2 (USCB 2011e)

2.5 Historic and Cultural Resources

In accordance with 36 CFR 800.8(c), the NRC uses the NEPA process to comply with the obligations of Section 106 of the National Historic Preservation Act of 1966, as amended (NHPA). The NRC identified the Area of Potential Effect (APE) for this operating licensing action to be the area at the power plant site and the immediate environs that may be affected by operating WBN Unit 2. All new TVA construction is restricted to the previously built portion of the WBN property.

2.5.1 Cultural Background

The area in and around the WBN site carries a rich cultural history and a substantial record of significant cultural resources. The site is located in Rhea County, Tennessee, south of Watts Bar Reservoir on the Tennessee River. For at least 12,000 years, humans have occupied the Tennessee River and the Little Tennessee River Valley. This part of east Tennessee has a cultural sequence that extends back to about 12,000 BC. The record indicates prehistoric occupation of the area was as follows: Paleo-Indian (12,000 to 8000 BC), Archaic (8000 to 1200 BC), Woodland (1200 BC to 1000 AD), and Mississippian (1000 to 1500 AD) (TVA 2009a).

Beginning in the 1700s, Cherokee Indians occupied the area (TVA 2009a). The Overhill Cherokee, one group of this Tribe, settled along the Little Tennessee, Tellico, and Hiwassee rivers, where Chickamauga and Tellico lakes are now located (Garrow et al. 1992). The Chickamauga and Creek Indians also occupied these lands (TVA 1972).

Spanish explorers (Hernando deSoto's expedition of 1540 and the Juan Pardo expeditions of 1566 and 1568) were the first Europeans to explore the area (Garrow et al. 1992). During the centuries following the Spanish explorations, French and British traders entered the Tennessee Valley and Watts Bar area to trade with the Cherokees and other Tribes but did not establish settlements (Johnson and Dennings 1984).

Euro-Americans began to settle east Tennessee in the 1760s when pioneers from the British colonies of Pennsylvania, Virginia, and North Carolina moved into the area (Johnson and Dennings 1984).

Pioneers staked claims for farmsteads and created small port towns along the Tennessee River. Settlers established many ferry crossings (Garrow et al. 1992). In 1791, after Congress established the "Territory of the United States South of the River Ohio," the territorial governor signed a treaty with the Cherokee Nation that expanded Euro-American settlement in the Watts Bar area and cut a road through Cherokee lands (Johnson and Dennings 1984).

Historians believe the Cherokee Nation ceded lands along the Tennessee River on which the WBN site is located to the United States via treaties in the late 1700s and early 1800s (Garrow et al. 1992).

2.5.2 Historic and Cultural Resources at the WBN Site

The NRC used the following information to identify historic and cultural resources at the WBN site:

- The NRC final environmental statement related to the operation of WBN Units 1 and 2 (NUREG-0498, Supplement No. 1 [NRC 1995] and NUREG-0498 [NRC 1978]).
- The TVA ER (TVA 2008a).
- The TVA supplemental ER for operation of the WBN plant (TVA 1995b).
- *Final Environmental Impact Statement: Watts Bar Reservoir Land Management Plan for Loudon, Meigs, Rhea, and Roane Counties* (TVA 2009a).
- NRC Environmental Trip—environmental records review on October 6 and 7, 2009, at the WBN plant.
- NRC meeting on October 8, 2009, with the Tennessee State Historic Preservation Office/Officer (SHPO) to discuss the proposed action and any concerns related to historic and cultural resources.
- Scoping process and consultation letters (see Appendices C and F for a complete list).
- RAI Responses from TVA that include several cultural resource management reports.

TVA has an extensive cultural resources management program and employs several archaeologists, a historian, and a historic architect to manage and protect historic and cultural resources on TVA lands or land affected by TVA actions (TVA 2009d). To identify historic and cultural resources within the APE, TVA conducted a desktop review of all previous environmental reviews and existing archaeological data on the plant property to determine if the completion of Unit 2 would result in effects to historic properties (TVA 2006b).

TVA identified one archaeological site (40RH6) in the APE for this operating licensing action. Researchers have studied this site since the 1970s construction of WBN Units 1 and 2. The site consists of a mound complex that the University of Tennessee in Knoxville partially excavated in 1971. Researchers conducted the excavations to mitigate construction activities of Units 1 and 2 (Calabrese 1976). TVA is not certain whether intact portions of 40RH6 currently exist in this location; therefore, its preference is to avoid ground-disturbing activity in this area (TVA 2006b).

TVA did not identify any historic structures in the APE for this operating licensing action. The Watts Bar Fossil Plant that was located adjacent to the APE was demolished in December 2011 and TVA prepared an environmental assessment (EA) that documents TVA compliance with Section 106 and the impacts to archaeological and historic resources from the demolition activities (TVA 2011c). At one time, the Watts Bar Fossil Plant was considered eligible for listing in the National Register of Historic Places (NRHP) (PNNL 2009). TVA conducted studies in 2011 to identify, evaluate, and assess adverse effects of the demolition of the Watts Bar Fossil Plant on historic resources and archaeological resources. TVA concluded that the overall integrity of the plant had been compromised due to a variety of activities such as the introduction of modern office and storage buildings and modern alterations or deterioration of extant structures over time (TVA 2011c). TVA "determined that the Watts Bar Fossil Plant Powerhouse is the only contributing resource to the NRHP-eligibility of the Watts Bar Fossil Plant" (TVA 2011c). The Tennessee SHPO concurred with the TVA finding and recommendations that the demolition of the Watts Bar Fossil Plant would not directly or indirectly affect archaeological resources, however, the demolition activity would adversely affect the Watts Bar Fossil Plant Powerhouse, which is a historic property eligible for listing in the NRHP (TVA 2011c). The Tennessee SHPO concurred with the TVA findings and recommendations regarding the architectural assessment of the Watts Bar Fossil Plant and amended its 2007 Memorandum of Agreement for resolution of the adverse effect (TVA 2011c).

2.5.3 Consultation

In September 2009, the NRC initiated consultations on the proposed action by writing to the Advisory Council on Historic Preservation and the SHPO. Also in September 2009, the NRC initiated consultation with 18 Federally recognized Tribes (see Appendices C, D, and E for a complete list). In its letters, the NRC provided information about the proposed action and indicated the NHPA review would be integrated with the NEPA process, according to 36 CFR 800.8. The NRC invited participation in the identification and possible decisions concerning historic properties and also invited participation in the scoping process.

On September 22, 2009, the NRC received a letter from the Tennessee Historical Commission stating that the WBN Unit 2 project as currently proposed may affect properties eligible for listing in the National Register of Historic Places (THC 2009). As part of the NRC staff's independent environmental assessment, NRC staff met with the Tennessee Historical Commission on October 8, 2009, to discuss the proposed action, the known issues, and the path forward for completing the Section 106 process for the NRC. TVA completed the Section 106 process and consultation with the Tennessee Historical Commission for WBN Unit 2 in 2007. The Tennessee Historical Commission responded with a letter to TVA, dated March 30, 2007, as evidence of compliance with Section 106 for licensing WBN Unit 2. The Tennessee Historical Commission concurred that no National Register of Historic Places listed or eligible properties would be affected by this undertaking (TVA 2008a). On March 5, 2010, the NRC received a letter from the Tennessee Historical Commission stating that “there are no National Register of Historic Places listed or eligible properties affected by this undertaking,” thus completing the NRC Section 106 consultation process with the Tennessee Historical Commission for the WBN Unit 2 operating license action (THC 2009).

On September 29, 2009, the NRC received a letter from the Eastern Band of Cherokee Indians stating that the project’s location is within the aboriginal territory of the Cherokee People (Eastern Band of Cherokee Indians 2009). Potential cultural resources important to the Cherokee People may be threatened due to adverse effects from this undertaking. The Eastern Band of Cherokee Indians informed the NRC that the Tribe would like to act as a consulting party for this Section 106 undertaking as mandated under 36 CFR Part 800. The NRC staff followed up with the Eastern Band of Cherokee Indians via email and phone and did not receive additional comments from the Tribe. On November 21, 2011, the NRC received a letter from the Choctaw Nation of Oklahoma that the WBN Unit 2 project is out of the Choctaw Nation of Oklahoma’s area of interest (Choctaw Nation of Oklahoma 2011). On January 19, 2012, the NRC received a letter from the Chickasaw Nation stating that the Chickasaw Nation concurs with the NRC’s finding of no adverse effect to historic properties (Chickasaw Nation 2012). The staff did not identify any additional cultural resource information through the process of seeking comments on the draft SFES or through public meetings held on December 8, 2011. The consultation process is complete.

2.6 Radiological Environment

Between December 1976 and December 1995, TVA conducted a preoperational REMP around the WBN site to establish a baseline from which to observe fluctuations of radioactivity in the environment after WBN Unit 1 began operating (TVA 2003a). TVA has continued to conduct an operational environmental monitoring program to assess the radiological impacts on workers, the public, and the environment since WBN Unit 1 received its operating license in 1996.

The REMP measures radiation and radioactive materials from all sources and includes the following pathways: direct radiation, atmospheric, aquatic and terrestrial environments, and groundwater and surface water. TVA documents the results of this monitoring program in its *Annual Radiological Environmental Operating Report*. The report documents the results of monitoring the environment for radiation and radioactive material resulting from WBN Unit 1 (TVA 2003a, 2004b, 2005b, 2006c, 2007a, 2008b, 2009e, 2010d, 2011b). The NRC staff reviewed historical REMP data from these reports for a 9-year period (2002 through 2010) (TVA 2003b, 2004c, 2005c, 2006d, 2007b, 2008c, 2009f, 2010e, 2011a). A 9-year period was chosen because it provides a representative data set that covers a broad range of activities over the years. For example, years where there are refueling outages, or years where there are no refueling outage years and only routine operation, or years where there may be significant maintenance activities. The year 2002 was included because it was the year the tritium leak occurred at WBN Unit 1, and additional monitoring of tritium was performed after that time.

These data show exposures or concentrations in air, water, and vegetation at locations near the plant perimeter (i.e., indicator stations) and at distances greater than 16 km (10 mi) (i.e., background control locations) are comparable. During the 9-year period from 2002 to 2010, the average annual direct radiation exposure at the indicator and control locations ranged from 0.44 mSv (44 mrem) to 0.66 mSv (66 mrem), and from 0.37 mSv (37 mrem) to 0.61 mSv (61 mrem), respectively for the WBN site (TVA 2003a, b, 2004b, c, 2005b, c, 2006c, d, 2007a, 2007b, 2008b, c, 2009e, f, 2010d, e, 2011a, b). The indicator and control location results are similarly comparable for drinking water, vegetation, and fish.

In its *Annual Radioactive Effluent Release Report*, TVA calculated maximum doses to a member of the public. For the 9 years reviewed (TVA 2003b, 2004c, 2005c, 2006d, 2007b, 2008c, 2009f, 2010e, 2011a), the maximum annual dose to a member of the public was less than 0.374 mSv (3.74 mrem) from operating WBN Unit 1. These data show that doses to the maximally exposed individual (i.e., a hypothetical member of the public outside of the site boundary who could potentially be exposed to all radioactive sources) around the WBN site were below the limits specified in Federal environmental radiation standards, 10 CFR Part 20 (1 mSv/yr [100 mrem/yr] total effective dose equivalent to members of the public); 10 CFR Part 50, Appendix I (0.05 mSv/yr [5 mrem/yr] to the whole body from noble gases and 0.03 mSv/yr [3 mrem/yr] to the whole body from liquid effluents); and 40 CFR Part 190 (0.25 mSv/yr [25 mrem/yr] to the whole body, 0.75 mSv/yr [75 mrem/yr] to the thyroid, and 0.25 mSv/yr [25 mrem/yr] to other organs).

In the 2010 *Annual Radioactive Effluent Release Report* (TVA 2011a), TVA reported that there are six onsite groundwater monitoring wells that are part of the REMP and an additional 19 wells that are not part of the REMP. The wells are sampled semi-annually for tritium, and have been showing a downward trend for tritium following the leak that was identified in the 2002. TVA implemented a Ground Water Protection Program (GWPP) for the WBN site. TVA developed the program to implement requirements in Nuclear Energy Institute (NEI) 07-07, including early detection, reporting, and mitigation of impacts associated with potential subsurface and or groundwater contamination (NEI 2007). The program also addresses, as appropriate, guidance in Electric Power Research Institute (EPRI) Report 1015118 (EPRI 2007). This report provides guidance for practical methods for locating monitoring wells and establishing a groundwater protection program. The TVA GWPP assigns the Site Chemistry Manager to coordinate and implement the program. In addition, the Site Radiation Protection Manager provides radiation protection support, including controls for work activities and documentation of spills or leaks of licensed radioactive material (TVA 2008d).

2.7 Nonradiological Human Health

This section describes aspects of the environment at the WBN site and within the vicinity of the site associated with nonradiological human health impacts. The section provides the basis for evaluation of impacts on human health from operation of the WBN Unit 2, which has the potential to affect the public and workers at the WBN site from operation of the cooling system, noise generated by operations, and electromagnetic fields (EMFs) generated by transmission systems.

2.7.1 Etiological Agents

Activities at the WBN site could compromise public and occupational health by increasing water temperature and encourage growth of disease-causing thermophilic microorganisms (etiological agents). Thermal discharges at the WBN site into the cooling-tower basins and then into the Tennessee River have the potential to increase the growth of thermophilic microorganisms. The segment of the Tennessee River near the WBN site is listed by Tennessee Department of Environmental Conservation as Category 5, which means that one or more uses of the water body do not meet the water-quality criteria (e.g., the sediments are contaminated with PCBs) (TDEC 2010a). There is no indication that bacteria or nutrients impair the Tennessee River near the WBN site. The types of organisms of concern from water exposures for public and occupational health include enteric pathogens (such as *Salmonella* spp. and *Pseudomonas aeruginosa*), thermophilic fungi, bacteria (such as *Legionella* spp.), and free-living amoeba (such as *Naegleria fowleri* and *Acanthamoeba* spp.). These microorganisms could result in potentially serious human health concerns, particularly at high exposure levels.

Etiological agents generally occur at temperatures of 25 to 80°C (77 to 176°F) with an optimal growth temperature range of 50 to 66°C (122 to 150°F) and a minimum temperature tolerance of 20°C (68°F) (Joklik and Willett 1976). However, thermal preferences and tolerances vary across groups of microorganisms. Pathogenic thermophilic microbiological organisms that are of concern during nuclear power reactor operation typically have optimal growing temperatures of approximately 37.2°C (99°F) (Joklik and Smith 1972).

The microorganisms of concern are known to cause infections in people accessing water bodies such as the Tennessee River. *Pseudomonas aeruginosa* is an opportunistic pathogen that causes serious and sometimes fatal infections in immuno-compromised individuals by producing and releasing toxins. The bacterium has an optimal growth temperature of 37.2°C (99°F) (McCoy 1980). *Legionella* spp. can cause a type of pneumonia known as Legionnaires' disease, and the elderly, cigarette smokers, persons with chronic lung or immuno-compromising disease, and persons receiving immuno-suppressive drugs are most susceptible to the disease. *Legionella* spp. grow best at 32 to 40.6°C (90 to 105°F) (CDC 2008a). *Salmonella* spp. are a group of bacteria that can cause fevers, abdominal cramps, and diarrhea. *Salmonella* spp. can occasionally establish localized infection (e.g., septic arthritis) or progress to sepsis. All ages can be affected, but groups at greatest risk for infection include infants, the elderly, and persons with compromised immune systems. *Salmonella* spp. occur at temperatures between 10 and 49°C (50 and 120°F) (Aserkoff et al. 1970; CDC 2008b), with optimal growth occurring at 35 to 37.2°C (95 to 99°F) (Lake et al. 2002). There are more than 40 species of the free-living amoeba, *Naegleria*, but only *N. fowleri* is pathogenic and the causative agent of human primary amoebic meningoencephalitis. Infection usually occurs after water containing the amoeba enters the nose and subsequently the brain through the olfactory nerve. All ages are susceptible to the infection, but groups at greatest risk are children that play in the water in southern-tier states. *Naegleria* spp. are ubiquitous in freshwater and can be enhanced in thermally altered water bodies at temperatures up to 45°C (113°F) (Yoder et al. 2009). The NPDES temperature limits for WBN outfalls to the Tennessee River are at or below 95°F, which is below the optimal growth temperatures for the above-mentioned organisms, and TVA has stated they would comply with those requirements (see Table 4-1) (TVA 2010a). Although the thermal discharge will change the temperature of the receiving waters, the change in temperature especially after mixing would still be within the organisms' range of tolerance. Since the organisms are ubiquitous in the aquatic environment, it is unlikely the minor change in temperature would increase the populations by a significant amount. A review of outbreaks of human water-borne diseases in Tennessee indicates that the incidence of most of these diseases is not common. The Centers for Disease Control (CDC) reported that outbreaks of legionellosis, salmonellosis, or shigellosis that occurred in Tennessee from 1996 to 2006 were within the range of national trends in terms of cases per 100,000 population or total cases per year. The CDC associated these outbreaks with pools, spas, or lakes (CDC 1997, 1998a, 1999, 2001, 2002a, 2003, 2004a, 2005, 2006a, 2007, and 2008c). The CDC reported no cases in the state of the disease caused by *Naegleria fowleri*, primary amoebic meningoencephalitis, which is a brain infection that leads to destruction of brain tissue and is fatal (CDC 1998b, 2000, 2002b, 2004b, 2006b, 2008d; Yoder et al. 2009).

2.7.2 Noise

Sources of noise at the WBN site are those associated with operation of WBN Unit 1, including transformers and other electrical equipment, circulating water pumps, cooling tower, and the public address system. In addition, high-voltage transmission lines emit a corona discharge noise. This section discusses these noise sources.

The 1995 SFES-OL-1 (NRC 1995) evaluated noise. The NRC used information on operational sound levels from published values on noise from larger cooling towers and a TVA sound survey data on noise emissions from 500-kV transformers. The 1995 SFES-OL-1 placed the nearest residents to the plant at 900 m (3,000 ft) to 1,800 m (6,000 ft) from the WBN site boundary. It estimated noise from the transformers and cooling towers combined with background noise ranged from 53 to 63 decibels on the A-weighted scale (dBA; this scale simulates human hearing sensitivity). Intermittent noise emissions from air-blast circuit breakers breaking under an electrical load or steam venting ranged from 84 to 103 dBA at the residential locations.

As illustrated in Table 2-28, noise strongly attenuates with distance. A decrease of 10 dBA in noise level is generally perceived as cutting the loudness in half. At a distance of 15 m (50 ft) from the source, these peak noise levels would generally decrease to the 80- to 95-dBA range and at distance of 122 m (400 ft), the peak noise levels would generally be in the 60- to 80-dBA range. For context, the sound intensity of a quiet office is 50 dBA, normal conversation is 60 dBA, busy traffic is 70 dBA, and a noisy office with machines or an average factory is 80 dBA (Tipler 1982).

Table 2-28. Construction Noise Sources and Attenuation with Distance

Source	Noise Level (dBA) (peak)	Noise Level (dBA) Distance from Source			
		50 ft	100 ft	200 ft	400 ft
Heavy trucks	95	84–89	78–83	72–77	66–71
Dump trucks	108	88	82	76	70
Concrete mixer	105	85	79	73	67
Jackhammer	108	88	82	76	70
Scraper	93	80–89	74–82	68–77	60–71
Dozer	107	87–102	81–96	75–90	69–84
Generator	96	76	70	64	58
Crane	104	75–88	69–82	63–76	55–70
Loader	104	73–86	67–80	61–74	55–68
Grader	108	88–91	82–85	76–79	70–73
Dragline	105	85	79	73	67
Pile driver	105	95	89	83	77
Forklift	100	95	89	83	77

Source: Golden et al. 1980
To convert ft to m, multiply by 0.3048 m/ft.

Regulations governing noise associated with the activities at the WBN site are generally limited to worker health. Federal regulations governing construction noise are found in 29 CFR Part 1910, *Occupational Health and Safety Standards*, and 40 CFR Part 204, *Noise Emission Standards for Construction Equipment*. The regulations in 29 CFR Part 1910 deal with noise exposure in the construction environment, and the regulations in 40 CFR Part 204 generally govern the noise levels of compressors. The Tennessee Occupational Safety and Health Administration (TOSHA) has a Special Emphasis Program for occupational noise exposure and hearing conservation. TOSHA requires employers to provide hearing protection for workers when noise exposure exceeds 85 dBA over 8 hours (TDLWD 2010).

Transmission lines and substations can produce noise from corona discharge (the electrical breakdown of air into charged particles). This noise, referred to as corona noise, occurs when air ionizes near irregularities (such as nicks, scrapes, dirt, and insects) on the conductors. Corona noise consists of broadband noise, characterized as a crackling noise, and pure tones, characterized as a humming noise. The weather also affects corona noise. During dry weather, the noise level off the corridor is low and often indistinguishable from background noise. In wet conditions, water drops collecting on conductors can cause louder corona discharges (NRC 1996; TVA 2008a).

2.7.3 Electromagnetic Fields

Transmission lines generate both electric and magnetic fields, referred to collectively as EMFs. Acute and chronic exposure to EMFs from power transmission systems, including switching stations (or substations) onsite and transmission lines connecting the plant to the regional electrical distribution grid, can compromise public and occupational health. Transmission lines operate at a frequency of 60 Hz (60 cycles per second), which is considered to be extremely low frequency (ELF). In comparison, television transmitters have frequencies of 55 to 890 MHz and microwaves have frequencies of 1,000 MHz and greater (NRC 1996).

Electric shock resulting from direct access to energized conductors or from induced charges in metallic structures is an example of an acute effect from EMF associated with transmission lines (NRC 1996). Objects close to the electric field of a transmission line can carry an induced current. The current can flow from the line through the object into the ground. Capacitive charges can occur in objects that are in the electric field of a line, storing the electric charge, but isolated from the ground. A person standing on the ground can receive an electric shock from coming into contact with such an object because of the sudden discharge of the capacitive charge through the person's body to the ground. The National Electrical Safety Code has criteria for the design and construction of transmission systems to control and minimize acute affects from electric shock in transmission systems.

Research on the potential for chronic effects of EMFs from energized transmission lines was reviewed and addressed by the NRC in NUREG-1437 (NRC 1996). At that time, research results were not conclusive. The National Institute of Environmental Health Sciences (NIEHS) directs related research through the U.S. Department of Energy. An NIEHS report (NIEHS 1999) contains the following conclusion:

> The NIEHS concludes that ELF-EMF exposure cannot be recognized as entirely safe because of weak scientific evidence that exposure may pose a leukemia hazard. In our opinion, this finding is insufficient to warrant aggressive regulatory concern. However, because virtually everyone in the United States uses electricity and therefore is routinely exposed to ELF-EMF, passive regulatory action is warranted such as a continued emphasis on educating both the public

> and the regulated community on means aimed at reducing exposures. The NIEHS does not believe that other cancers or non-cancer health outcomes provide sufficient evidence of a risk to currently warrant concern.

The NRC staff reviewed available scientific literature on chronic effects to human health from ELF-EMF published since the NIEHS report and found that several other organizations reached the same conclusions (AGNIR 2006; WHO 2007a). Additional work under the auspices of the World Health Organization (WHO) updated the assessments of a number of scientific groups reflecting the potential for transmission-line EMF to cause adverse health impacts in humans. The monograph summarized the potential for ELF-EMF to cause disease such as cancers in children and adults, depression, suicide, reproductive dysfunction, developmental disorders, immunological modifications, and neurological disease. The results of the review by WHO (2007b) found that the extent of scientific evidence linking these diseases to EMF exposure is not conclusive.

2.8 Meteorology and Air Quality

Previous environmental reviews discuss the meteorology and air quality of the WBN site (TVA 1972, 1993; NRC 1978, 1995). The TVA ER (TVA 2008a) updates the discussion through 2005. This section summarizes the previous discussions and presents the NRC's assessment of the climatology and air quality of the WBN site.

2.8.1 Climate

The WBN site is located in the Tennessee Valley between the Appalachian Mountains and Great Smoky Mountains to the east and Cumberland Plateau to the west. The orientation of the valley in this area is generally northeast-southwest. Currently, the area has a moderate climate with cool winters (daily maximum temperatures in January averaging near 10°C [50°F]) and warm summers (daily maximum temperatures in July averaging near 32°C [90°F]). Precipitation averages about 130 cm (50 in.) per year, with 13 to 25 cm (5 to 10 in.) of snow. Prevailing winds tend to be aligned with the valley.

Projected changes in the climate for the region during the life of the WBN Unit 2 include an increase in average temperature of 1.1 to 1.7°C (2 to 3°F) and possibly a small change in precipitation (GCRP 2009). Changes in median annual runoff in the region are predicted to be less than ±2 percent.

2.8.2 Severe Weather

The Appalachian Mountains and the Cumberland Plateau tend to protect the region from severe weather approaching from the east or northwest. Winter storms occasionally bring snow, but the accumulation of snow from individual storms is generally only a few inches and generally remains on the ground for only a few days. Thunderstorms may occur during any month, but are most frequent from April through September. Tornadoes occur infrequently. Based on regional tornado statistics from 1950 through 2008, and the approach described in NUREG/CR-4461, Rev. 2 (Ramsdell and Rishel 2007), the NRC estimates the probability of a tornado striking the WBN site is about 5×10^{-4} per year. This is about a factor of three higher than estimated in the FSAR (TVA 2009b). The difference in estimates, which is largely due to differences in tornado strike models used to obtain the estimates, is less significant than it might appear because WBN Unit 2 has been designed to withstand direct tornado strikes.

2.8.3 Local Meteorological Conditions

TVA has made meteorological measurements at the WBN site since 1971. Data from the site have been reviewed, summarized, and evaluated in prior environmental reviews of the site (TVA 1972; NRC 1978, 1995). In the 1995 SFES-OL-1, the NRC staff evaluated the onsite meteorological measurements through 1993 and concluded there were no significant changes in local meteorological conditions from those described in the 1978 FES-OL.

TVA provided NRC with Watts Bar meteorological data for the years 2004 through 2008 (TVA 2009g). These data form the basis of the NRC staff evaluation of current local meteorological conditions. In addition, the NRC staff reviewed climatological records for Chattanooga and Knoxville for indications of potential regional changes in climate. The NRC staff did not identify any significant local changes in climate.

In its ER (TVA 2008a), TVA notes only a slight decrease in wind speeds. This change and its implications are described by Wastrack et al. (2008). The NRC staff reviewed the recent Watts Bar wind data and the TVA analysis and also compared the recent meteorological data with earlier Watts Bar wind data. The NRC staff concludes that while there may appear to be a trend in the data, it is likely the variations in wind speed are associated with normal climatic variations.

The recent wind direction data show small decreases in frequencies of direction with easterly components and small increases in wind with southwesterly components. However, no change was as large as 3 percent. Similarly, there are small changes in the frequencies of various stability classes. Notably, there are small decreases in the frequency of unstable meteorological conditions and small increases in the neutral and slightly stable classes. The frequencies of the most stable classes are essentially unchanged from those described in the earlier FESs. The NRC staff does not consider the changes in either wind direction or atmospheric stability to be significant.

In summary, the NRC staff reviewed descriptions of local meteorological conditions at the WBN site contained in its earlier FESs related to the site and compared recent data for the site provided by TVA with those descriptions. The NRC staff concludes that the recent data from the WBN meteorological system indicate that current meteorological conditions are consistent with the meteorological conditions described in the 1978 FES-OL and the 1995 SFES-OL-1.

2.8.4 Atmospheric Dispersion

Atmospheric dispersion for WBN Unit 2 was estimated using onsite wind and stability data. These dispersion estimates are needed to evaluate the consequences of potential releases from the site during normal operations and in the event of an accident.

TVA derived initial dispersion estimates for use in evaluation of design basis accidents (DBAs) from Regulatory Guide 1.4 (NRC 1974). They based later DBA dispersion estimates on measurements from the WBN meteorological system. Section 2.3 of the FSAR (TVA 2009b) presents conservative dispersion estimates for use in safety DBA evaluations. More realistic dispersion estimates are used in environmental reviews. The NRC staff estimated realistic (50 percentile) dispersion estimates using meteorological data for 2004 through 2008 provided by TVA (TVA 2009g) following the procedures outlined in Regulatory Guides 1.111 and 1.145 (NRC 1977, 1983). Table 2-29 presents realistic dispersion estimates for environmental review of DBA.

Table 2-29. Atmospheric Dispersion Factors for Proposed Unit 2 Design Basis Accident Calculations

Time period	Boundary	χ/Q (s/m^3)
0 to 2 hours	Exclusion Area Boundary	5.78×10^{-5}
0 to 8 hours[(a)]	Low Population Zone	7.15×10^{-6}
8 to 24 hours[(a)]	Low Population Zone	6.16×10^{-6}
1 to 4 days[(a)]	Low Population Zone	4.46×10^{-6}
4 to 30 days[(a)]	Low Population Zone	2.81×10^{-6}

(a) Times are relative to beginning of the release to the environment.

The NRC staff based its evaluation of the radiological impacts of WBN Unit 2 normal plant operations on its analysis of the same meteorological data using the XOQDOQ computer program (Sagendorf et al. 1982). This program implements the guidance set forth in Regulatory Guide 1.111 (NRC 1977). The results of the NRC staff calculations are presented in Table 2-30 for the points of the maximum normalized annual air concentration and surface deposition on the exclusion area boundary and the outer boundary of the low population zone. The table also includes the location of, and maximum normalized annual air concentration and surface deposition for, milk animals, gardens, and residences.

Table 2-30. Maximum Annual Average Atmospheric Dispersion and Deposition Factors for Evaluation of Normal Effluents for Receptors of Interest

Receptor	Downwind Sector	Distance km (mi)	No Decay χ/Q (s/m^3)	2.26-Day Decay χ/Q (s/m^3)	8-Day Decay χ/Q (s/m^3)	D/Q (1/m^2)
EAB	ESE	1.1 (0.68)	1.5×10^{-5}	1.5×10^{-5}	1.4×10^{-5}	3.3×10^{-8}[(a)]
LPZ Boundary	E	4.8 (3.0)	2.0×10^{-6}	2.0×10^{-6}	1.6×10^{-6}	2.6×10^{-9}[(b)]
Residence	SE	1.4 (0.85)	7.0×10^{-6}	7.0×10^{-6}	6.2×10^{-6}	9.0×10^{-9}
Milk Animal	SSW	2.3 (1.42)	1.5×10^{-6}	1.5×10^{-6}	1.3×10^{-6}	5.0×10^{-9}
Veg. Garden	NE	3.8 (2.38)	2.2×10^{-6}	2.1×10^{-6}	1.8×10^{-6}	5.0×10^{-9}[(c)]

(a) 1.1 km (0.68 mi) NNE.
(b) 4.8 km (3.0 mi) NNE.
(c) 1.6 km (0.98 mi) S.

2.8.5 Air Quality

The WBN site is located in Rhea County, Tennessee, in the Eastern Tennessee-Southwestern Virginia Air Quality Control Region (40 CFR 81.57). This air quality control region generally includes counties to the north and east of Rhea County, including Knox County (Knoxville). The area to the south of Rhea County, including Hamilton County (Chattanooga), is part of the Chattanooga Interstate Air Quality Control Region (40 CFR 81.42).

The State of Tennessee rates Rhea County air quality as "better than national standards," "unclassifiable/attainment," or "not designated" for all criteria pollutants (40 CFR 81.343). However, the State rates several counties, or portions of counties, near Rhea County as "not in attainment." An area roughly corresponding to the city limits of Chattanooga in Hamilton County does not meet secondary standards for total suspended particulates; Hamilton, Knox, and Loudon counties, and part of Roane County, are in nonattainment of the annual National Ambient Air Quality Standards' $PM_{2.5}$ standard (particles with diameters of 2.5 microns or less); and Knox, Blount, and Loudon counties and part of Roane County are in nonattainment of the 24-hour $PM_{2.5}$ standard.

The Clean Air Act amendments of 1977 designated seven mandatory Federal Class 1 areas in Tennessee, Alabama, Georgia, and Kentucky where visibility has been determined to be an important value. Three of these areas are located within 160 km (100 mi) of the WBN site: Great Smoky Mountains National Park and Joyce Kilmer Wilderness Area, located about 80 km (50 mi) east of the WBN site, and the Cohutta Wilderness Area located about 97 km (60 mi) southeast of the WBN site.

The WBN Unit 2 plant is co-located with the retired Watts Bar coal-fired power plant. Previous environmental reviews have addressed potential interactions between plumes from WBN and the coal-fired plant (e.g., 1995 SFES-OL-1). Concerns with these potential interactions are now moot because the coal-fired plant ceased operation in 1982, and air permits for the plant were terminated in 1997.

2.9 Related Federal Project Activities

The NRC staff reviewed the possibility that other Federal agencies' activities, such as dam construction, might affect its issuing an operating license to TVA. Any such activity could result in cumulative environmental impacts and the possible need for another Federal agency to become a cooperating agency for preparation of this SFES.

TVA, a corporation wholly owned by the U.S. Government, is a Federal agency subject to NEPA requirements. In compliance with NEPA, TVA prepared an environmental impact statement (EIS) to provide the public and TVA decision-makers with an assessment of potential environmental impacts from operating WBN Unit 2 (TVA 2008a). The TVA EIS was submitted to NRC as the ER part of the of the license application, but the NRC SFES was prepared independently by NRC staff (10 CFR 51.10(b)(2)).

On the Federally owned WBN site, TVA also operates the Watts Bar Dam and Hydro-Electric Plant, TVA Central Maintenance Facility, and Watts Bar Resort Area (TVA 2009b). The Watts Bar Fossil Plant was also located there until its demolition in December 2011 (TVA 2011c). The dam is approximately 1.6 km (1 mi) upstream of the plant. TVA constructed Watts Bar Dam for flood control, and it serves as a major artery for barge traffic. Residents and visitors to the area use the reservoir for boating, fishing, swimming, camping, and other outdoor activities (TVA 2009b, NRC 1995). TVA published a draft EIS in September 2012 (TVA 2012c) related to safety modifications including the installation of permanent measures to counteract safety deficiencies related to probable maximum flood events. Proposed safety measures also included removing temporary barriers, installing permanent modifications in the form of a combination of concrete floodwalls, raised earthen embankments or berms and gap closure barriers.

TVA also owns and operates the Sequoyah Power Plant, which is located approximately 50 km (31 mi) south-southwest of WBN (TVA 2009b) on Chickamauga Reservoir. The Sequoyah Units 1 and 2 licenses expire on September 17, 2020 and September 15, 2021, respectively (NRC 2011b). TVA submitted a license renewal application for both units to the NRC on January 15, 2013 (TVA 2013). The application seeks to extend the licenses for both units for an additional 20 years. In a separate action, the U.S. Department of Energy (DOE) and National Nuclear Security Agency, with TVA as a cooperating agency, issued a draft supplemental environmental impact statement that considers the potential use of mixed oxide (plutonium-based) fuel in TVA operated reactors, including Sequoyah (DOE 2012).

TVA owns several recreation areas in the region, including the Hiwassee Waterfowl Refuge, located upriver of Watts Bar Dam. The TWRA leases most of the refuge (TWRA 2006).

Several other Federal wildlife and recreational areas are located within 80 km (50 mi) of the WBN site, including the Cherokee National Forest. This national forest provides a wide range of outdoor activities such as hiking, backpacking, fishing, biking, camping, swimming, boating, horseback riding, picnic areas and playgrounds, and inns and cabins. Other Federally owned and operated areas include the Great Smoky Mountains National Park and Nantahala National Forest.

No other Federally owned areas are located in the immediate vicinity of the WBN site. After reviewing Federal activities in the vicinity of the WBN site, the NRC determined no Federal project activities exist requiring another Federal agency to become a cooperating agency for preparation of this SFES. In summary, no other Federal activities or projects are associated with the permitting of the WBN site.

In addition to reviewing any related Federal activities, the NRC is required under Section 102(2)(C) of NEPA to consult with and obtain comments from any Federal agency with legal jurisdiction or special expertise with respect to any environmental impact involved in the subject matter of an EIS. During the course of preparing this SFES, NRC consulted with TVA and the FWS. Contact correspondence is included in Appendix C.

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3.0 Plant Description

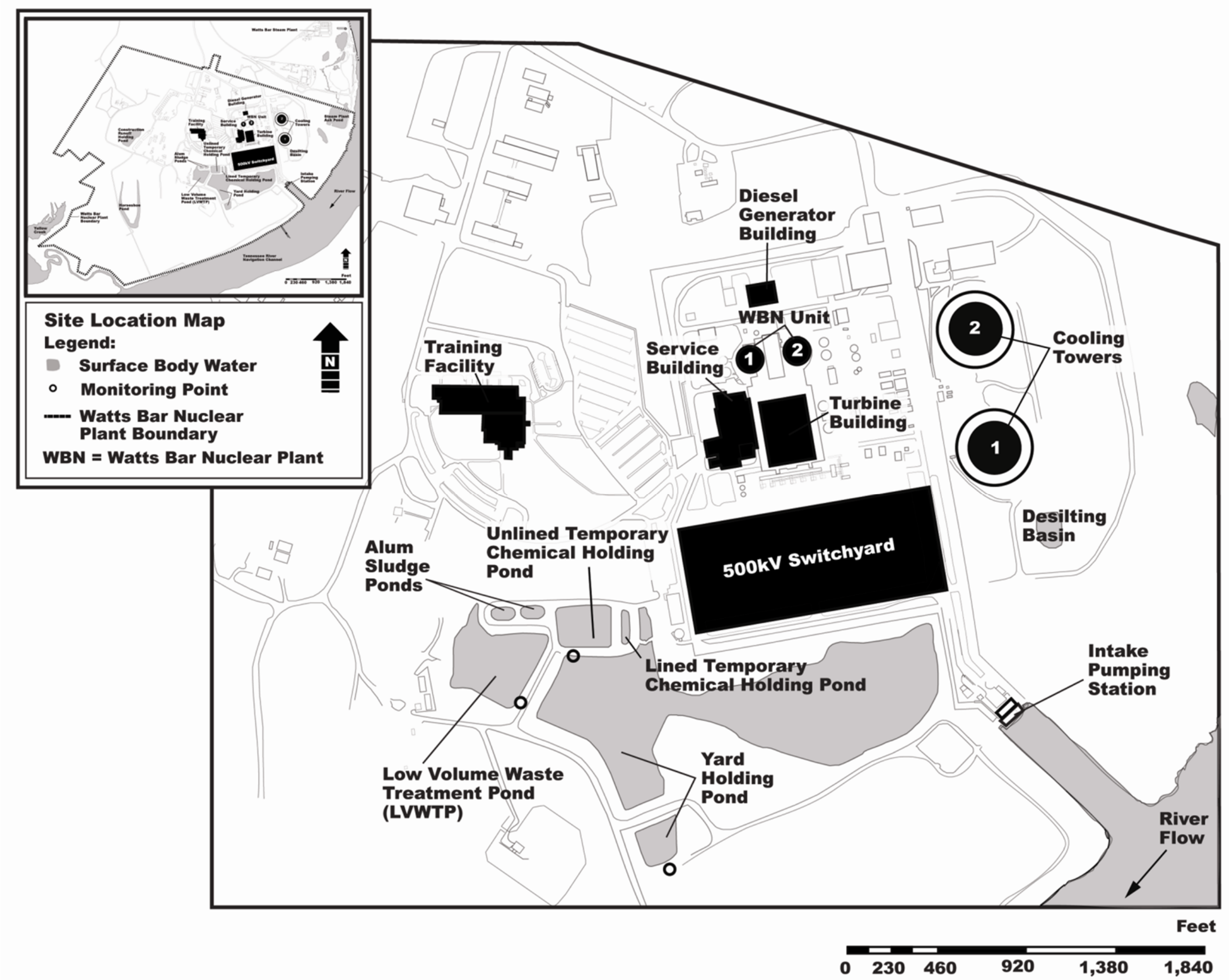
This chapter describes the key physical plant characteristics the U.S. Nuclear Regulatory Commission (NRC) considered in assessing the environmental impacts of the proposed action. The NRC drew on the following documents for the majority of this information: the Tennessee Valley Authority (TVA) environmental report (ER) (TVA 2008), the 1995 supplement to the final environmental statement related to the operating license of Unit 1 (1995 SFES-OL-1) (NRC 1995), the 1978 final environmental statement related to the operating license for Watts Bar Nuclear (WBN) Units 1 and 2 (1978 FES-OL) (NRC 1978), the 1972 final environmental statement related to the construction permit for WBN Units 1 and 2 (1972 FES-CP) (TVA 1972), and the TVA final safety analysis report (FSAR) (TVA 2009a).

While Chapter 2 of this supplemental final environmental statement (SFES) describes the affected environment of the WBN site and its vicinity, this chapter describes the physical aspects of operation of WBN Unit 2. Chapter 4 discusses the environmental impacts of plant operation.

3.1 External Appearance and Plant Layout

TVA originally designed the WBN site as a two-unit pressurized-water reactor (PWR) nuclear plant with a total electrical generating capacity of 2,540 MW(e). Unit 1 began operating in 1996. In addition to the reactors, the WBN site consists of two reactor containment buildings, a diesel generator building, a training facility, a turbine building, a service building, an intake pumping station, a water-treatment plant, two cooling towers, 500-kV and 161-kV switchyards, and associated parking facilities (NRC 1995). Figure 3-1 shows the reactor buildings and associated facility layout (TVA 2008).

TVA terminated construction of Unit 2 in 1985 when the unit was 80 percent complete (TVA 2008). Since that time, TVA has used many Unit 2 components to replace portions of Unit 1 and other TVA facilities. As a result, at the time of the operating license application, Unit 2 was approximately 60 percent complete. With the exception of Unit 2 completion and the addition of training facilities, the remainder of the WBN facilities were developed as planned. WBN Unit 2 would use structures that already exist and most of the work required to complete Unit 2 would be inside of those buildings. The NRC staff reviewed the TVA program for construction refurbishment of WBN Unit 2 and found the plan to contain the appropriate elements and scope, and that upon proper implementation, it would provide reasonable assurance that the equipment would meet design criteria and perform the intended functions (NRC 2010). The implementation of this program will be the subject of follow-on inspections by NRC staff. Completing Unit 2 would result in some additional ground-disturbing activities, but these would be largely restricted to the existing disturbed portion of the property (TVA 2008).



(To convert feet [ft] to meters [m], multiply by 0.3048 m/ft)

Figure 3-1. Site Layout (based on TVA 2008)

3.2 Plant Structures and Operations

This section describes each major WBN plant structure, including the reactor system and structures that would interface with the environment during WBN Unit 2 operation. Understanding the operational aspects of these structures is important in assessing the environmental impacts from WBN Unit 2 operation (Chapter 4).

The reactor system includes the reactor vessel, where nuclear fission takes place to generate heat that converts water to steam. The steam passes through one or more turbines that spin an electrical generator resulting in the flow of electricity. After leaving the generator, the steam is converted back into water in the main condenser that is part of the power plant cooling system (NRC 2002). Additional information on the WBN Unit 2 reactor system and cooling system is provided in the following sections.

3.2.1 Reactor System

For WBN Unit 2, TVA proposes to operate a four-loop PWR Nuclear Steam Supply System (NSSS) using the Westinghouse Electric Corporation design. The NSSS consists of a reactor and four closed-reactor coolant loops connected in parallel to the reactor vessel. Each loop contains a reactor coolant pump, a steam generator, loop piping, and instrumentation. The NSSS also contains an electrically heated pressurizer and auxiliary systems. The reactor design resembles WBN Unit 1, which has operated since 1996. The NSSS for Unit 2 is rated at 3,411 MW(t) and, at this core power, the NSSS would operate at 3,425 MW(t). The additional 14 MW(t) results from the contribution of heat to the primary coolant system from nonreactor sources, primarily reactor coolant pump heat. The net electrical output is 1,160 MW(e), and the gross electrical output is 1,218 MW(e) (TVA 2009a).

3.2.2 Cooling System

To condense the steam into water, the cooling system removes heat from the steam and transfers that heat to the environment. To do this, the cooling system pumps water through thousands of metal tubes in the plant's condenser. Steam exiting the plant's turbine is cooled and condensed into water when it comes in contact with the cooler tubes. The tubes provide a barrier between the steam and the environment so there is no physical contact between the plant's steam and the cooling water. The condenser operates at a vacuum so any leakage in this system will produce an "inflow" of water into the condenser rather than an "outflow" of water to the environment (NRC 2002).

At WBN Unit 2 water is taken from the Tennessee River to cool plant components and to be pumped through the cooling tubes in the condenser. The heated water that exits from the condenser goes to a natural-draft cooling tower where heat is transferred to the atmosphere through evaporation and conductive cooling. The cooled water is cycled back into the condenser to cool additional steam. This type of cooling system is called a closed-cycle cooling system.

The NRC considered normal operating conditions and emergency shutdown conditions as the operational modes for WBN Units 1 and 2 in its assessment of operational impacts on the environment (Chapter 4 of this SFES). The NRC considers these conditions to be those under which maximum water withdrawal, heat dissipation, and effluent discharges occur. Cooldown, refueling, and accidents are considered alternative modes to normal plant operation. During these alternative modes, water intake, cooling-tower evaporation, water discharge, and radioactive releases may change from those observed during normal operating or emergency shutdown conditions. However, the heat fluxes during normal operation at full load are maximal and the following subsections consider flows and effluents during normal operations at full load.

WBN Unit 1 uses a unique system based on a closed-cycle system with natural-draft wet-cooling towers and a supplemental cooling system. WBN Unit 2 would use the same system.

The original cooling system constructed for the WBN units was a closed-cycle system to transfer heat from the main condenser of each unit to the atmosphere through a natural-draft cooling tower associated with that unit. TVA identifies this system as the condenser cooling water (CCW) system in the 2008 ER (TVA 2008). During normal plant operation, the CCW system for each unit would dissipate up to 7.8×10^9 Btu/hr of waste heat (TVA 1972; TVA 2009a). Additional heat is removed from plant components by the essential raw cooling water (ERCW) system and the raw cooling water (RCW) system. Water from both of these systems discharges to the cooling-tower basins for the CCW.

Most excess heat in the cooling water transfers to the atmosphere by evaporative and conductive cooling in the cooling tower. In addition to evaporative losses, a small percentage of water is lost in the form of droplets (drift) from the cooling tower. The water that does not evaporate or drift from the tower is routed back to the cooling-tower basin.

Evaporation of cooling-water-system water from the cooling-tower increases the concentration of dissolved solids in the cooling-water system. In most closed-cycle wet-cooling systems, a portion of the cooling water is removed and replaced with makeup water from the source (for WBN, the Tennessee River), to limit the concentration of dissolved solids in the cooling system and in the discharge to the receiving water body.

Because the WBN cooling towers cannot remove the desired amount of heat from the circulating water during certain times of the year, TVA added the supplemental condenser cooling water (SCCW) system to the cooling system for the WBN reactors (TVA 1998). The SCCW draws water from behind Watts Bar Dam and delivers it, by gravity flow, to the cooling-tower basins to supplement cooling of WBN Unit 1. This cooling system would also be used for Unit 2. The temperature of this water is usually lower than the temperature of the water in the cooling-tower basin and, as a result, lowers the temperature of the water being used to cool the steam in the condensers. Slightly less water enters the cooling-tower basins through the SCCW intake than leaves the cooling-tower basins and is discharged to the Tennessee River through the SCCW discharge structure (TVA 2010a). Figure 3-2 shows the major components of the cooling system.

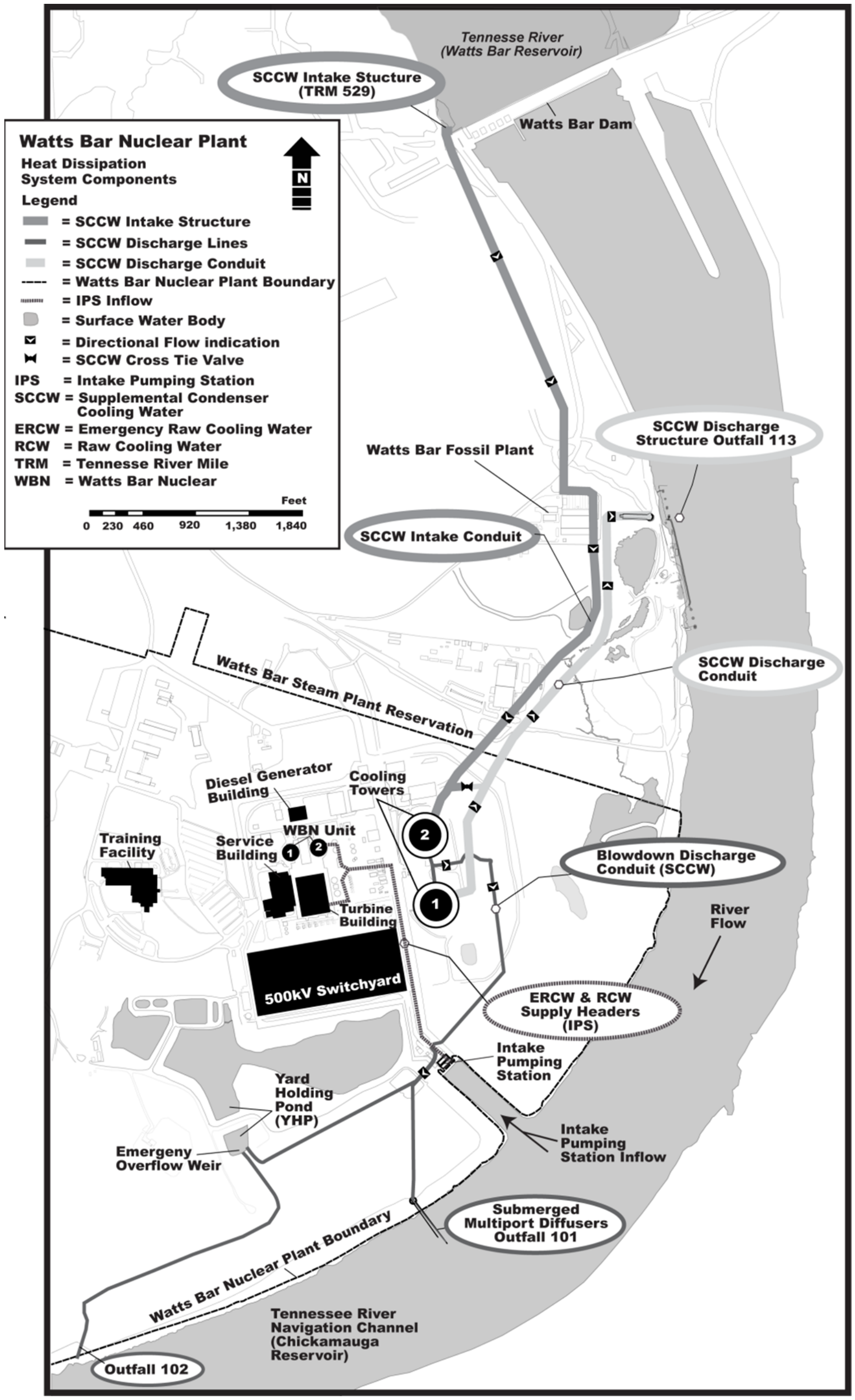
3.2.2.1 Intake Structures

Intake Pumping Station

TVA originally designed the intake pumping station (IPS) to supply water to both WBN Units 1 and 2. Since 1996, it has supplied water to WBN Unit 1. It is located about 3.1 km (1.9 mi) below Watts Bar Dam at Tennessee River Mile (TRM) 528.0. The IPS is located at the end of an intake channel approximately 240 m (800 ft) from the shoreline of the reservoir (TVA 2009a). The IPS has two sump areas, each with two intake openings. The channel leading from the intake opening to the well containing the traveling screen is 1.58 m (5.17 ft) wide at the traveling screens and 5.3 m (17.5 ft) high. Each traveling screen is 1.2 m (4 ft) wide and the height of the water column passing through the screens ranges from 8.8 m (29 ft) in the summer to 7.6 m (25 ft) in the winter due to the fluctuations in the pool elevation for Chickamauga Reservoir. The traveling screens have a fractional open area of 0.503 (50.3 percent open area) (TVA 2011a). The open area through the trash racks at each bay opening in the IPS is approximately 8.84 m^2 (95.1 ft^2), for a total of 35.2 m^2 (380 ft^2) open for the passage of water through the trash racks (TVA 2010a).

The water flows through the trash racks, then through the traveling screens, where it subsequently enters the sump areas within the IPS. Each sump contains four ERCW pumps that pump water into a common header to serve plant components. Typical summertime operation for two units would have two ERCW pumps operating in each sump (TVA 2011a). Once the water passes through the ERCW system and cools the components, it generally discharges to the cooling-tower basins to provide makeup water to offset evaporative losses. The system also can discharge to the Yard Holding Pond (YHP). The two sumps and their associated pumping units provide redundant systems for providing cooling water to both units at the WBN site (TVA 2009a).

The IPS also contains seven RCW pumps. Three RCW pumps are located in one side of the IPS and four are located in the other side. Six of these are sufficient to meet the non-safety-related cooling needs of WBN Units 1 and 2. In general, three pumps in each side of the IPS will be used to meet cooling needs; however, at times, four pumps in one side of the IPS and two in the other side may be used (TVA 2011a), resulting in higher intake velocity in the side of the IPS with four pumps in operation. Water from the RCW system discharges to the outlet flume of the cooling-tower basin for the unit being served. This water also serves as makeup water for the condenser cooling system (TVA 2009a). In addition, the IPS houses high-pressure pumps for the fire-protection system.



(To convert feet [ft] to meters [m], multiply by 0.3048 m/ft)

Figure 3-2. Major Components of the Cooling System for WBN Units 1 and 2 (TVA 2008)

Currently, Unit 1 withdraws between 1.92 m^3/s (68 cfs) of water in winter and 2.06 m^3/s (73 cfs) of water in summer from the Chickamauga Reservoir for normal operations (TVA 2011a). Normal operations for two units would require the withdrawal of between 3.20 m^3/s (113 cfs) of water in winter and 3.79 m^3/s (134 cfs) of water in summer from the reservoir (TVA 2011a). Under normal conditions, while drawing water through all four bays in the IPS and operating four RCW pumps located together in one side of the IPS, the water velocity through the openings in the traveling screens would be 0.21 m/s (0.67 ft/s) in winter and 0.19 m/s (0.62 ft/s) in summer for the portion of the intake structure with four RCW pumps operating (TVA 2011a).

The withdrawal of 3.79 m^3/s (134 cfs) through the IPS would represent 0.5 percent of the mean annual flow of the Tennessee River as measured at Watts Bar Dam (778 m^3/s [27,500 cfs]; see Table 2-2).

Supplemental Condenser Cooling-Water Intake

The intake facility for the SCCW is located above Watts Bar Dam at TRM 529.9. The SCCW has six intake bays, and three are currently used for the operation of WBN Unit 1. No additional bays would be used during the operation of both units. Each intake bay is 2.17 m (7.13 ft) wide at the traveling screens and 9.4 m (31 ft) high at a summer pool elevation of 225.8 m (741 ft) for Watts Bar Reservoir. This results in an opening of 20.5 m^2 (221 ft^2). The traveling screens and their support structures occupy a portion of the opening leaving 8.41 m^2 (90.5 ft^2) open to the passage of water in each bay or a total of 25.2 m^2 (271.5 ft^2) for the passage of water through the screens into the SCCW intake. The open area through the trash racks at each bay opening in the SCCW intake structure is approximately 16.7 m^2 (180 ft^2), for a total of 50.2 m^2 (541 ft^2) (TVA 2012a). Figure 3-2 shows the locations of the IPS and SCCW intakes.

The SCCW system operates by gravity flow, and as such, the flow through the intake structure fluctuates in response to changes in the elevation of the water level in Watts Bar Reservoir. Flow into the SCCW system has not been measured, but is estimated based on the dimensions of system components and calculations based on water levels or plant operations. Losses due to evaporation are also estimated, although discharge from the SCCA is measured (TVA 2012a). TVA estimates the average monthly flow through the SCCW intake for the operation of WBN Units 1 and 2 will be 7.9 m^3/s (278 cfs) of water from the Watts Bar Reservoir (TVA 2012a). This is slightly less than the flow through the SCCW while operating Unit 1 only, however the difference is within the uncertainty in the estimate for flow while operating one or two units.

The normal intake flow rates are higher in the summer months when Watts Bar Reservoir levels are maintained at 225.8 m (740.75 ft). Normal flow rates during summer months with both units operating are expected to be approximately 8.6 m^3/s (303 cfs). Flow through the intake structure can be as high as 8.9 m^3/s (313 cfs) and intake at this rate would result in a water velocity through the open areas in the trash racks in the SCCW of 0.18 m/s (0.58 ft/s) (TVA

2012a). The maximum water velocity through the SCCW intake structure occurs as the water enters the wet well for the traveling screens. This velocity is 0.66 m/s (2.18 ft/s) for the summer pool (TVA 2012b). The water velocity through the openings in the traveling screens at the SCCW would be 0.35 m/s (1.15 ft/s) under these conditions (TVA 2012a).

Table 3-1 lists flow rates for operating two units or a single unit at the WBN site.

Table 3-1. Anticipated Water Use

Service	Normal Two-Unit Operation	Single-Unit Operation
Heat discharged	1.5×10^{10} Btu/hr(a)	7.8×10^{9} Btu/hr(a)
CCW		
Evaporation rate	1.8 m^3/s (62 cfs)(b)	0.82 m^3/s (29 cfs)(a)
Drift rate	5.6 L/s (0.2 cfs)(c)	2.8 L/s (0.1 cfs)(c)
Blowdown rate	1.9 m^3/s (67 cfs)(b)	1.5 m^3/s (53 cfs)(a)
Blowdown rate when diffusers are discharging from cooling towers and YHP	4.81 m^3/s (170 cfs)(d)	3.82 m^3/s (135 cfs)(d)
IPS makeup flow		
Summer	3.79 m^3/s (134 cfs)(e)	2.06 m^3/s (73 cfs)(f)
Winter	3.20 m^3/s (113 cfs)(e)	1.92 m^3/s (68 cfs) (f)
SCCW(b)(g)		
Intake flow rate	6.5 to 8.6 m^3/s (230 to 303 cfs)	6.5 to 8.6 m^3/s (230 to 303 cfs)
Discharge flow rate	6.8 to 7.9 m^3/s (240 to 279 cfs)	6.8 to 7.9 m^3/s (240 to 279 cfs)
YHP overflow weir(d)	0	0

(a) TVA 2010a
(b) TVA 2012a
(c) 1972 FES-CP (TVA 1972).
(d) TVA (2008).
(e) Normal withdrawal is 3.20 m^3/s (113 cfs) of water in winter and 3.79 m^3/s (134 cfs) of water in summer (TVA 2011a); Average annual withdrawal is 3.28 m^3/s (116 cfs) (TVA 2012a)
(f) TVA 2011a.
(g) Flow in the SCCW system is variable, dependent on parameters such as reservoir elevation and cooling tower basin surface elevation (TVA 2012a).

3.2.2.2 Cooling Towers

The WBN cooling-water system uses natural-draft cooling towers to dissipate waste heat from the plant. Two cooling towers, one dedicated to each unit, would serve the WBN site. Each tower is 108 m (354 ft) in diameter and 146 m (478 ft) high (TVA 1972).

3.2.2.3 Temporary Blowdown Storage

TVA uses the unlined YHP (Figure 3-1), which is approximately 8.9 ha (22 ac) in size (TVA 2005a) for temporary storage of cooling-tower blowdown when the flow from the hydroturbines at Watts Bar Dam drops below 99 m^3/s (3,500 cfs). When hydroturbine operation resumes with releases of at least 99 m^3/s (3,500 cfs), valves on the discharge line allow the YHP to discharge into Chickamauga Reservoir through the diffusers (TVA 2008).

3.2.2.4 Discharge Structures

Outfall 101 – Discharge Diffusers

TVA plans to discharge cooling water from the main cooling-water system for WBN Units 1 and 2 to Chickamauga Reservoir through a diffuser system located approximately 3.2 km (2 mi) below Watts Bar Dam at TRM 527.9 (TVA 2008). The National Pollutant Discharge Elimination System (NPDES) permit for the WBN site identifies the diffuser discharge as Outfall 101 (TVA 2011b). Harper (1997) describes this diffuser system as consisting of two pipes branching from a central conduit at the right bank of Chickamauga Reservoir and extending perpendicular to the river flow of the Tennessee River. Each pipe is controlled by a butterfly valve located a short distance from the junction with the central conduit.

The downstream leg of the diffuser consists of 49 m (160 ft) of 1.37-m (4.5-ft)-diameter corrugated steel diffuser pipe at the end of approximately 91 m (297 ft) of corrugated steel approach pipe of the same diameter. The diffuser pipe is half buried in the river bottom and has two 2.54-cm (1-in.)-diameter ports per corrugation. The centroid of the ports is angled up at 45 degrees from horizontal in a downstream direction (Harper 1997).

The upstream leg of the diffuser system consists of 24 m (80 ft) of 1.07-m (3.5-ft)-diameter corrugated steel diffuser pipe at the end of approximately 136 m (447 ft) of corrugated steel approach pipe of the same diameter. The upstream diffuser pipe section is half buried in the river bottom and extends its entire length beyond the dead end of the downstream diffuser pipe section. The port diameter, spacing, and orientation of the upstream leg are the same as those of the downstream leg (Harper 1997). Figure 3 from the TVA analysis of the SCCW thermal plume (Ungate and Howerton 1977) illustrates the diffuser configuration. TVA does not plan to make any upgrades or changes to the diffusers in preparation for operating Unit 2 (TVA 2010b).

TVA maintains operational procedures for this system to ensure the plant effluent is adequately diluted. The 2008 TVA ER explains the process as follows:

> To provide adequate dilution of the plant effluent, discharge from the diffusers is permitted only when the release from Watts Bar Dam is at least 3,500 cubic feet per second (cfs). To ensure this happens, an interlock is provided between the dam and WBN that automatically closes the diffusers when the flow from the hydroturbines at Watts Bar Dam drops below 3,500 cfs. To provide temporary storage of water during these events, the blowdown discharge conduit also is connected to a yard holding pond. When the flow from Watts Bar Dam drops below 3,500 cfs, thereby closing the diffuser valves, the blowdown is automatically routed to the yard holding pond. When hydro operations resume

> with releases of at least 3,500 cfs, the interlock is 'released' and the diffuser valves can be opened. When this occurs, the discharge from the diffusers would contain blowdown from the cooling towers and blowdown from the yard holding pond. To protect the site from the consequences of exceeding the capacity of the yard holding pond, an emergency overflow weir is provided for the pond, which delivers the water to a local stream channel that empties into the Tennessee River at TRM 527.2. The operation of Watts Bar Dam and the WBN blowdown system are very carefully coordinated to avoid unexpected overflows from the yard holding pond (TVA 2008).

A flow of 3,500 cfs is approximately 99 m^3/s.

Outfall 113 SCCW Discharge

The SCCW system discharges water through a discharge structure originally constructed for the Watts Bar Fossil Plant (also called the Watts Bar Steam Plant). The NPDES permit for the WBN site identifies the SCCW discharge as Outfall 113 (TVA 2011b). Water leaving the cooling-tower basins is piped to the discharge structure approximately 1.8 km (1.1 mi) upstream of the IPS. TVA describes the discharge structure as an "open discharge canal, an overflow weir drop structure, and a below water discharge tunnel" (TVA 1998). The discharge tunnel is described as "a rectangular culvert 7 feet wide by 10 feet high at the discharge point" (TVA 1998). The elevation of the culvert outlet is 205.7 m (675 ft). To reduce the impact of the discharge on the river bottom, TVA installed a concrete incline to direct flow toward the river surface as it leaves the outfall (TVA 1998; PNNL 2009).

TVA designed and constructed the SCCW system so it could operate the cooling system for WBN Units 1 and 2 with or without the SCCW. If the temperature of the discharge water exceeds allowable release limits, TVA can shut down the SCCW system. TVA also included a crosstie and control valve in the system that allows part of the flow from the SCCW intake to bypass the cooling-tower basins and mix with the effluent in the discharge pipeline. When there is a possibility of exceeding the NPDES river temperature limit, TVA opens a bypass valve to allow cooler water in the intake pipeline to mix with water in the discharge line, cooling the effluent before it discharges to the reservoir (TVA 2008). The bypass is generally needed during winter months when the water temperature in the Tennessee River is cooler, and a possibility exists of exceeding the in-stream temperature rate-of-change limit in the NPDES permit. TVA opens the crosstie around November 1, and it remains open until the end of April (PNNL 2009).

Outfall 102 YHP Emergency Overflow

The YHP has an emergency overflow weir at 215.3 m (706.5 ft) of elevation designed to prevent the capacity of the pond from being exceeded. If water goes above the height of the weir, it flows into a local stream channel that empties into Chickamauga Reservoir at TRM 527.2

(TVA 2008). The NPDES permit for the WBN site identifies this discharge as Outfall 102 (TVA 2011b).

3.2.3 Landscape and Stormwater Drainage

Landscaping and the stormwater drainage system affect both the recharge to the subsurface and the rate and location that precipitation drains into adjacent creeks and streams. Impervious areas eliminate recharge to aquifers beneath the site, while pervious areas maintained free of vegetation experience considerably higher recharge rates than adjacent areas with local vegetation. The stormwater drainage system, including site grading, ditches, and swales provides a safety function by ensuring a locally intense precipitation event would not flood safety-related structures.

Figure 3-3 shows drainage for the WBN site. The surface-water drainage system directs water away from safety structures and into ditches and drainways, which ultimately feed into drainage ditches and creeks.

3.2.4 Other Plant Systems

Diesel Generators

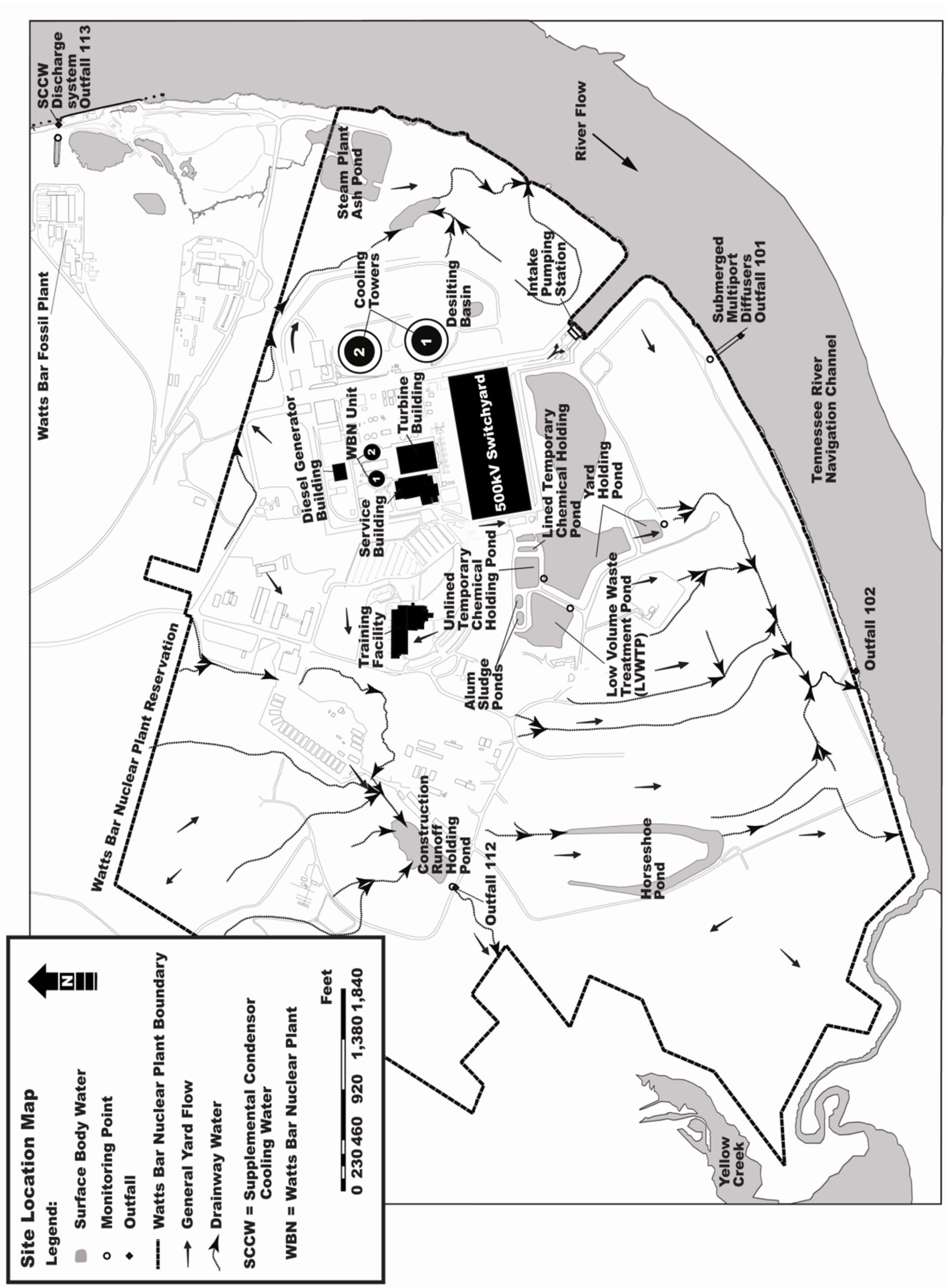
TVA installed five diesel generators on the WBN site. Missile and fire barrier-type shelter walls separate four diesel generators and their associated support equipment from each other. A separate building houses the fifth diesel generator (TVA 2009a).

Roads

The workforce and a portion of the materials needed for plant operations will enter and exit the site via roads. TVA expects to transport solid waste and radwaste from the WBN site via roadways. The nearest land transportation route, Tennessee State Route 68, is located about 1.6 km (1 mi) north of the site (TVA 2009a).

Wells

No water supply wells are located on the WBN site. The 1995 SFES-OL-1 notes that the Watts Bar Utility District supplies groundwater to the WBN site potable water system. The Watts Bar Utility District uses groundwater wells located about 6.4 km (4 mi) (TVA 2009b) northwest of the site to provide potable water to its customers and the WBN site. The utility currently has the capacity to deliver approximately 6.8 million L/d (1.8 million gal/d) of water to customers (TVA 2010c). TVA expects the site will use 91,000 L/d (24,000 gal/d) during normal operations of both units and that peak demand during the completion of Unit 2 and an outage at Unit 1 will be 300,000 L/d (80,000 gal/d) (TVA 2010c).



(To convert feet [ft] to meters [m], multiply by 0.3048 m/ft)

Figure 3-3. Site Drainage for the WBN Site (based on TVA 2005a)

Railroad

A main line of the Cincinnati, New Orleans, and Texas Pacific Railway (Norfolk Southern Corporation) is located approximately 11 km (7 mi) west of the site. A TVA railroad spur track connects with this main line and extends to the site of the recently demolished Watts Bar Fossil Plant (TVA 2012c) and WBN Unit 1. The spur is not currently in use and would need to be repaired prior to use (TVA 2009a).

Barge Facility

Barges delivered replacement steam generators for WBN Unit 1 to the WBN site (TVA 2005b). TVA unloaded these units at a docking area north of the coal-unloading facility for the fossil plant that was located north of WBN Units 1 and 2. This is an example of the kind of delivery that could be made to the site in the future to support operation of WBN Unit 2.

Tennessee River Navigation Channel

The WBN site is located on a 2.7-m (9-ft)-deep navigable channel on the Chickamauga Reservoir, a major barge route regularly maintained to allow commercial traffic. TVA biennially inspects the river channel for silt formation in the forebay of the IPS channel. The results of this inspection are used to determine if dredging is required and if there should be an increase in monitoring. Based on the results of a review TVA completed in October 2008, no dredging is required or planned (TVA 2010c).

Onsite Ponds

The WBN site currently maintains five onsite ponds. The YHP is described in Section 3.2.2.3. The Low Volume Waste Treatment Pond (LVWTP) provides storage for discharge from the turbine building station sump (TVA 2008). TVA uses two temporary chemical holding ponds to contain and treat chemicals from the turbine building. The smaller pond is lined and holds 3,800 m^3 (1 million gal). The larger pond is unlined and holds almost 19,000 m^3 (5 million gal). Both ponds discharge into the YHP via Outfall 107 (NRC 1995). TVA monitors this discharge in accordance with the plant's NPDES permit (TVA 2008). The construction runoff holding pond has remained in service and until recently was used to collect discharge water from an onsite sewage-treatment plant; the heating, ventilation, and air conditioning cooling-water system at the WBN Training Center; fire-protection wastewater; and site stormwater runoff. With the closure and demolition of the sewage-treatment plant, TVA rerouted other wastewater systems, and the construction runoff holding pond now receives only surface-water runoff (TVA 2008). TVA historically monitored the discharge of the construction runoff holding pond at Outfall 112. Monitoring this outfall is no longer required (TVA 2011b).

TVA no longer uses a 9,500-m^3 (2.5-milllion gal) evaporation/percolation pond used for treating and disposing spent preoperational cleaning wastes from WBN Units 1 and 2. The State of Tennessee closed the pond in 1999 (TVA 2009c).

Power Transmission Structures

In its WBN Unit 2 application, TVA proposes to operate WBN Unit 2 with a rated net electrical output capacity of 1,160 MW(e). The WBN site connects to the regional power grid via existing 500-kV transmission lines as illustrated in Figure 3-4. In addition to the four 500-kV lines, TVA uses two 161-kV lines at WBN. TVA originally constructed the existing transmission corridors and lines to support operating Units 1 and 2 on the WBN site. TVA does not plan to change or add transmission lines to complete and operate WBN Unit 2.

The WBN site connects to an existing network that supplies large load centers. WBN Units 1 and 2 tie into the 500-kV transmission system via a 500-kV switchyard and 500-kV transmission lines. The WBN site also ties into the grid with a temporary site power system originally set up to support WBN Unit 1 and 2 construction. WBN Unit 1 currently uses this system to supply power for non-safety-related functions, including the wastewater-treatment plant, offices and storage buildings, and as the power supply during outages. The distribution system consists of the substation in the old Watts Bar Fossil Plant switchyard and a 13-kV line that goes to the Corridor Substation (commonly known as the "Corridor Sub"), located on the north side of the WBN site. The Corridor Substation includes two substations: the Corridor Substation and a Construction Power Substation (TVA 2008).

TVA does not need new transmission lines for the proposed WBN Unit 2. The WBN site is the only TVA nuclear power station that did not convert the temporary site power distribution system to a permanent system when it began operating. This 13-kV system is old, and many parts need upgrading or replacement. If this system is upgraded, it could require additional land disturbance and could affect terrestrial resources of the site. However, TVA has not made a decision regarding upgrading of the 13-kV system and does not consider the potential upgrades essential or required to support WBN Unit 2 operation (TVA 2008).

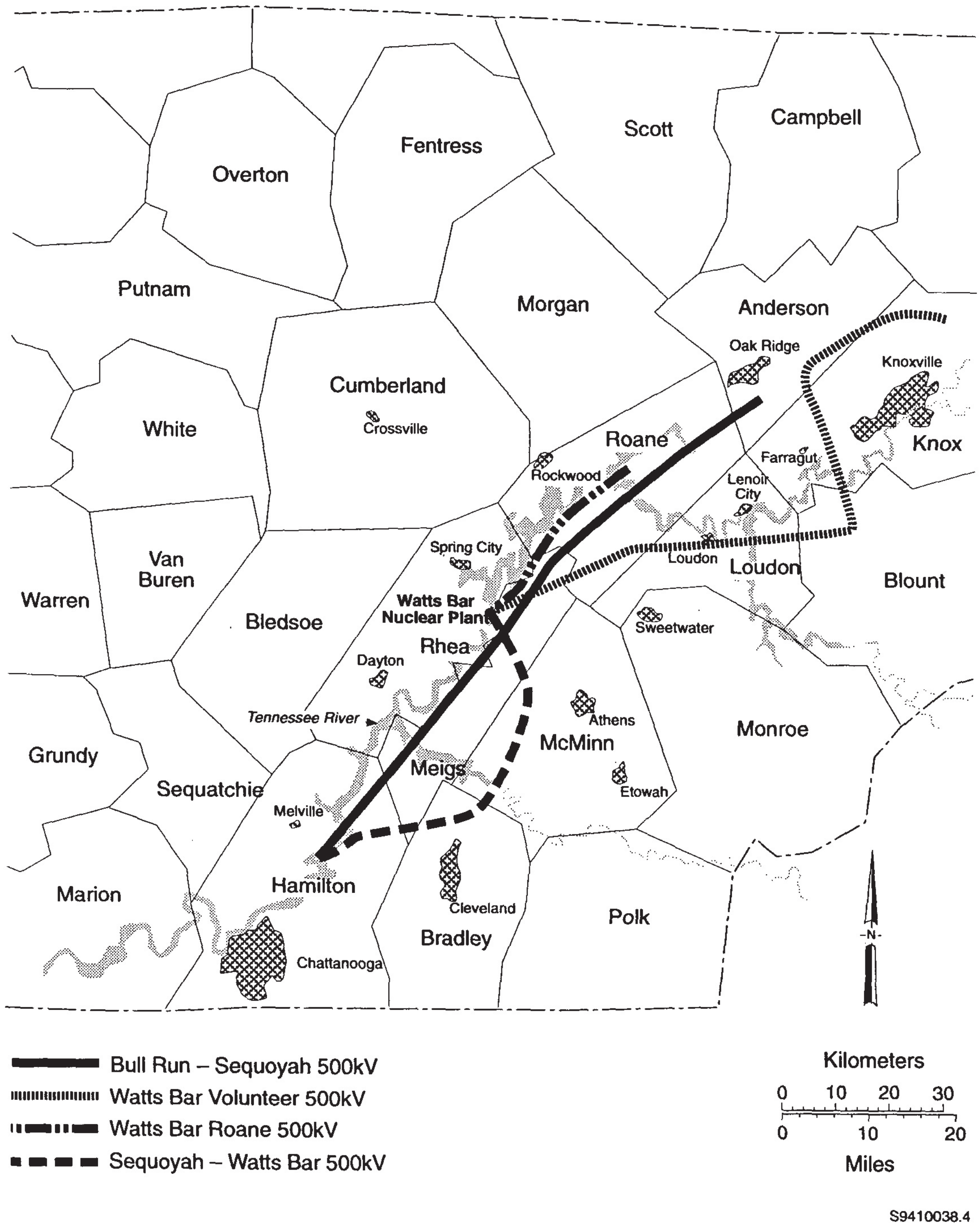


Figure 3-4. WBN Transmission Line Connections (NRC 1995)

3.3 Waste Management and Effluents

The following sections describe the radioactive and nonradioactive waste-management systems (Sections 3.3.1 and 3.3.2). Section 3.4 summarizes the values of resource parameters likely to be experienced during operations.

3.3.1 Radioactive Waste-Management System

Based on the regulations in Title 10 of the Code of Federal Regulations (CFR) 51.95, this SFES only addresses matters that differ from the 1978 FES-OL and 1995 SFES-OL-1 or reflect significant new information. The TVA ER (TVA 2008) describes only minor changes in waste-management systems for WBN Unit 2 from what was outlined in the 1995 SFES-OL-1.

The NRC staff reviewed the information in the 1978 FES-OL and the 1995 SFES-OL-1 (NRC 1978, 1995) for WBN Units 1 and 2 and Chapter 11 of the Watts Bar FSAR (TVA 2009a) to understand operations of the WBN radioactive waste-management systems.

WBN Units 1 and 2 share radioactive waste-management systems. TVA stated that changes in the radioactive waste-management systems for WBN Unit 2 are based on operating experience both from WBN Unit 1 and the Sequoyah Nuclear Plant (TVA 2008). The following paragraphs describe these changes in the liquid waste, gaseous waste, and solid-waste-management systems.

Since NRC published information on WBN's liquid waste-management system in its 1995 SFES-OL-1, TVA provided no new information about the liquid waste-management system. In the 1995 SFES-OL-1, the staff determined that radioactive releases from the liquid waste management systems would be within the limits of 10 CFR Part 20 and 10 CFR Part 50, Appendix I. Therefore, this SFES will not further address liquid waste management.

TVA does not plan to change the gaseous waste processing system. As with liquid waste, WBN Unit 2 shares a gaseous waste system with Unit 1. Because TVA did not identify any new information on gaseous waste systems since the 1995 SFES-OL-1, this SFES will not address this subject further.

WBN Units 1 and 2 share solid radioactive waste management processing. TVA has changed the process since publication of the 1995 SFES-OL-1. TVA deactivated the condensate demineralizers waste evaporator; concentrates are no longer generated and do not need to be disposed. TVA ships all dry active waste to a processor in Oak Ridge, Tennessee, for compaction. The waste processor then sends the compacted waste and the wet active waste to Clive, Utah, for disposal.

Until a licensed facility is available to replace the Barnwell, South Carolina, radwaste facility, TVA will send Class B and C waste to its Sequoyah Nuclear Plant for temporary storage

(TVA 2008). All radioactive waste shipments are made in compliance with the transportation requirements in 10 CFR Part 20, 10 CFR Part 71, and U.S. Department of Transportation regulations.

3.3.2 Nonradioactive Waste Systems

3.3.2.1 Effluents Containing Chemicals or Biocides

TVA will control water chemistry for various plant water uses by adding biocides, algaecides, corrosion inhibitors, pH buffering chemicals, scale inhibitors, and dispersants. The NPDES permit requires that TVA follow the Tennessee Department of Environment and Conservation (TDEC)-approved Biocide/Corrosion Treatment Plan (B/CTP) (TVA 2011b). WBN's current B/CTP was approved in 2009 (TVA 2011b) based on the list of chemicals included in the NPDES permit modification request submitted by TVA in April 2009 (TVA 2010c). Chemicals and the quantities identified in the 2009 permit modification request are shown in Table 3-2 (TVA 2009d).

Table 3-2. Raw Water Chemical Additives at Watts Bar Nuclear Plant

Product	Purpose	Frequency of Discharge	Active Ingredients	Discharge Concentration[(a)] (ppm active ingredients)
Depositrol PY5200 (replaces Nalco 73200)[(b)]	Dispersant to facilitate iron corrosion inhibition	Continuous	copolymer	< 0.2
Inhibitor AZ8100 (replaces Nalco 1336)[(b)]	Copper corrosion inhibition	Periodic	sodium tolyltriazole	< 0.25
Sprectrus BD 1500 (replaces Nalco 73551)[(b)]	Surfactant to facilitate oxidizing biocides	Periodic	nonionic surfactant	< 2.0
Towerbrom 60m (replaces Towerbrom 960)[(b)]	Oxidizing biocide (chlorination)	Periodic	sodium bromide and sodium dichloroisocyanurate	0.10 chlorine (total residual)
Spectrus OX 1200 (replaces Nalco 901 G)[(b)]	Oxidizing biocide (chlorination)	Continuous	bromo-chloro, dimethyl hydantoin	0.10 chlorine (total residual)
Spectrus DT 1404 (replaces Nalco CA-35)[(b)]	Dechlorination	Periodic[(c)]	sodium bisulfite	< 10
Spectrus CT1300[(d)] (replaces H150M)[(b)] or	Nonoxidizing biocide (mollusk control)	Periodic	alkyl dimethyl benzyl ammonium chloride	< 0.001 active ingredient in stream after mixing < 0.05 measured in effluent

Table 3-2. (contd)

Product	Purpose	Frequency of Discharge	Active Ingredients	Discharge Concentration[a] (ppm active ingredients)
Spectrus NX1104[d] (replaces Spectrus NX104)[b]	Nonoxidizing biocide (mollusk control)	Periodic	dimethylbenzylammonium chloride and dodecylguanidine hydrochloride	< 0.001 total active ingredient in stream after mixing < 0.031 quaternary ammonium compound measured in effluent
Bentonite clay[b]	Detoxification of nonoxidizing biocides	Periodic[c]	sodium silicate (bentonite clay)	< 10
Liquid bleach[b]	Oxidizing biocide (chlorination)	Continuous	sodium hypochlorite	0.10 chlorine (total residual)
H150M[e]	Nonoxidizing biocide	Minimum of 4 times per year	25 percent dimethyl benzyl ammonium chloride and 25 percent dimethyl ethylbenzyl ammonium chloride.	< 0.05 ppm
Flogard MS6209[f] (replaces MSW-109)[b]	Iron corrosion inhibitor	Continuous when river temperature is above 15.6°C (60°F).	zinc chloride, orthophosphate	< 0.2 total zinc < 0.2 total phosphorus

Source: From table in TVA (2009d)
(a) The maximum discharge concentration is indicated except where noted. Concentrations are achieved through a combination of dilution and dechlorination with sodium bisulfite or detoxification with bentonite clay.
(b) Denotes chemicals previously approved by the division (TDEC, Division of Water Pollution Control).
(c) Dechlorination and detoxification chemicals are applied as needed to ensure the discharge limitations identified in this table are met.
(d) Nonoxidizing biocide treatments are not applied at the same time as oxidizing biocide treatments.
(e) Active ingredient information from TVA 2008.
(f) SCCW and river flow conditions have a significant impact on these discharge concentrations.

TVA discharges water containing chemical and biocidal additives for the condenser cooling system and the SCCW system to the Chickamauga Reservoir through Outfalls 101 and 113, respectively. Chemical and biocidal additives and waste streams from various other water-treatment processes and drains are returned to the YHP where they are subjected to dilution, aeration, vaporization, and chemical reactions. The plant then discharges the YHP water to Chickamauga Reservoir through Outfall 101 or 102, subject to the limitations of the WBN site's existing NPDES permit (TVA 2011b).

The NPDES permit (TDEC 2011; TVA 2011b) provides additional detail about the chemicals that may be in water discharged through the outfalls. In addition to the chemicals added as biocide and for corrosion treatment, other chemical additives are used in a variety of plant processes. These chemicals may occur in trace quantities at Outfall 101 or Outfall 102. The potential discharge of these chemicals is through the cooling-tower blowdown line to Outfall 101 and Outfall 102 so Outfall 113 would not receive these discharges. The summary of potential chemicals discharged by NPDES outfall number is shown in Table 3-3.

Table 3-3. Potential Chemical Discharge to NPDES Outfalls at WBN

No.	Outfall Description	Chemical
101	Diffuser Discharge	ammonium hydroxide, ammonium chloride, alpha cellulose, asbestos after 5-micron filter, boric acid, sodium tetraborate, bromine, chlorine, copolymer dispersant, ethylene oxide, propylene oxide copolymer, ethylene glycol, hydrazine, laboratory chemical wastes, lithium, molybdate, monoethanolamine, molluscicide, oil and grease, phosphates, phosphate cleaning agents, paint compounds, sodium bisulfite, sodium hypochlorite, sodium hydroxide, surfactant, tolyltriazole, x-ray film processing rinse water, zinc chloride orthophosphate, zinc sulfate, phosphino-carboxylic acid copolymer, diethylenetriaminepenta-methylene phosphonic acid, sodium salt, sodium chloride, ethylenediamine tetracetic acid
102	YHP Overflow Weir	alternate discharge path for Outfall 101
103	Low Volume Waste Treatment Pond	ammonium hydroxide, ammonium chloride, boric acid, sodium tetraborate, bromine, chlorine copolymer dispersant, ethylene glycol, hydrazine, laboratory chemical wastes, lithium, molybdate, monoethanolamine, molluscicide, oil and grease, phosphates, phosphate cleaning agents, paint compounds, sodium hydroxide, surfactant, tolyltriazole, x-ray film processing rinse water, zinc sulfate
107	Lined Pond and Unlined Pond	metals – mainly iron and copper, acids and caustics, ammonium hydroxide, ammonium chloride, asbestos after 5-micron filter, boric acid, sodium tetraborate, bromine, chlorine, copolymer dispersant, hydrazine, laboratory chemical wastes, molybdate, molluscicide, oil and grease, phosphates, phosphate cleaning agents, sodium, sodium hydroxide, surfactant, tolyltriazole, zinc sulfate
113	SCCW Discharge	some contact with chemicals listed for Outfall 101, alpha cellulose, bromine, chlorine, copolymer, molluscicide, zinc chloride orthophosphate

Source: TDEC 2011

3.3.2.2 Sanitary System Effluents

For WBN Unit 2, TVA plans to discharge wastewater from the potable water supply system to the sanitary drainage system, which discharges offsite to the Spring City Wastewater Treatment Facility (PNNL 2009). TVA discharges to the treatment plant averaged 128,700 L/d (34,000 gal/d) between November 2008 and November 2009. TVA has an agreement with the Spring City Wastewater Treatment Plant to treat up to 380,000 L/d (100,000 gal/d) of water (TVA 2009b).

3.3.2.3 Other Effluents

The WBN site's nonradioactive gaseous emissions result primarily from its diesel generators and the combustion turbine generator. The emissions are subject to air quality permits that the Council on Environmental Quality issues. The U.S. Environmental Protection Agency oversees the site's nonradioactive, hazardous waste management through its Resource Conservation and Recovery Act.

3.4 Summary of Resource Parameters During Operation

Table 3-4 lists the significant resource commitments TVA needs to operate WBN Units 1 and 2. The values in this table and the affected environment described in Chapter 2 provide the basis for the NRC's operational impact assessment in Chapter 4. The 2008 TVA ER and subsequent RAI responses present these values, and the NRC staff confirms the values are not unreasonable.

Table 3-4. Resource Parameters Associated with Operation of WBN Units 1 and 2

Item	WBN Unit 1 Current Operations	Anticipated WBN Units 1 and 2	WBN Unit 2 Added Increment
Workforce			
Maximum Workforce	--	4,000	--
Average Workforce	700	900	200
Circulating Water System			
Heat Discharged	7.8×10^9 Btu/hr	1.5×10^{10} Btu/hr	7.7×10^9 Btu/hr
Waste Heat to Atmosphere	6.9×10^9 Btu/hr	1.4×10^{10} Btu/hr	7.1×10^9 Btu/hr
Waste Heat via Liquid Discharges to Outfall 101	1.5×10^8 Btu/hr	1.7×10^8 Btu/hr	2×10^7 Btu/hr
Cooling-Tower Height	146 m (478 ft)		
IPS Makeup Flow Rate			
Summer	2.06 m^3/s (73 cfs)	3.79 m^3/s (134 cfs)	1.73 m^3/s (61 cfs)
Winter	1.92 m^3/s (68 cfs)	3.20 m^3/s (113 cfs)	1.28 m^3/s (45 cfs)

Table 3-4. (contd)

Item	WBN Unit 1 Current Operations	Anticipated WBN Units 1 and 2	WBN Unit 2 Added Increment
Consumptive Use			
Evaporation Rate	0.82 m^3/s (29 cfs)	1.8 m^3/s (62 cfs)	0.93 m^3/s (33 cfs)
Drift Rate	2.8 L/s (45 gpm)	5.7 L/s (90 gpm)	2.8 L/s (45 gpm)
Blowdown Flow Rate			
Normal	1.5 m^3/s (53 cfs)	1.9 m^3/s (67 cfs)	0.4 m^3/s (14 cfs)
Maximum When Discharging from YHP and Cooling-Tower Basins	3.82 m^3/s (135 cfs)	4.81 m^3/s (170 cfs)	0.99 m^3/s (35 cfs)
Maximum Allowable Blowdown Temperature	35°C (95°F)	35°C (95°F)	No change
SCCW System			
Waste Heat via Liquid Discharges	7.5 × 10^8 Btu/hr	8.6 × 10^8 Btu/hr	1.1 × 10^8 Btu/hr
Normal Monthly Intake Flow Rate	6.5 to 8.6 m^3/s (230 to 303 cfs	6.5 to 8.6 m^3/s (230 to 303 cfs	Intake flow rate will decline slightly because elevation of water surface in Unit 2 cooling tower will be higher when both plants are in operation; however the difference is within the uncertainty in the estimates for one or two units in operation.
Normal Monthly Discharge Flow Rate	6.8 to 7.9 m^3/s (240 to 279 cfs)	6.8 to 7.9 m^3/s (240 to 279 cfs)	No significant change
Maximum Allowable Temperature of Discharge	35°C (95°F) also 33.5°C (92.3°F) in receiving stream bottom	35°C (95°F) also 33.5°C (92.3°F) in receiving stream bottom	No change
Maximum Allowable Water Temperature Change	3°C (5.4°F) relative to an upstream control point	3°C (5.4°F) relative to an upstream control point	No change
Sanitary Waste Discharge			
Average	49,000 L/d (13,000 gpd) Unit 1 staff 130,000 L/d (34,000 gpd) Unit 1	68,000 L/d (18,000 gpd)	19,000 L/d (5,000 gpd)

Table 3-4. (contd)

Item	WBN Unit 1 Current Operations	Anticipated WBN Units 1 and 2	WBN Unit 2 Added Increment
	staff plus Unit 2 construction		
Maximum	380,000 L/d (100,000 gpd)	380,000 L/d (100,000 gpd)	No change
Mean Annual Flow Past Watts Bar Dam	779 m^3/s (27,500 cfs)	779 m^3/s (27,500 cfs)	No change

3.5 References

10 CFR Part 20. Code of Federal Regulations, Title 10, *Energy*, Part 20, "Standards for Protection Against Radiation."

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

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

10 CFR Part 71. Code of Federal Regulations, Title 10, *Energy*, Part 71, "Packaging and Transportation of Radioactive Material."

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[TVA] Tennessee Valley Authority. 2008. *Final Supplemental Environmental Impact Statement; Completion and Operation of Watts Bar Nuclear Plant Unit 2, Rhea County, Tennessee* submitted to NRC as the TVA Environmental Report for an Operating License, Knoxville, Tennessee. Accession No. ML080510469.

[TVA] Tennessee Valley Authority. 2009a. *Watts Bar Nuclear Plant (WBN) – Unit 2 – Final Safety Analysis Report (FSAR).* Amendment 94. Spring City, Tennessee. Accession No. ML092460757.

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4.0 Environmental Impacts of Station Operation

This chapter addresses the environmental consequences associated with operating Watts Bar Nuclear (WBN) Unit 2. Sections 4.1 through 4.8 address potential operational impacts on land use, water use, terrestrial and aquatic ecology, socioeconomics, historic and cultural resources, radiological environment, nonradiological human health, and meteorology and air quality. Sections 4.9 through 4.12 discuss potential impacts related to nonradioactive and radioactive waste, uranium fuel cycle, decommissioning, and transportation of radioactive materials. Section 4.13 addresses measures and controls to limit adverse impacts during operation. Potential cumulative impacts from operation of WBN Unit 2 are discussed in Section 4.14. Section 4.15 provides references.

4.1 Land-Use Impacts

Sections 4.1.1 and 4.1.2 provide information regarding land-use impacts associated with operating WBN Unit 2. Section 4.1.1 discusses land-use impacts at, and within the vicinity of, the WBN site. Section 4.1.2 discusses land-use impacts with respect to offsite transmission-line corridors.

4.1.1 The Site and Vicinity

The 1972 final environmental statement related to the construction permit for WBN Units 1 and 2 (1972 FES-CP), the 1978 final environmental statement related to the operating license for WBN Units 1 and 2 (1978 FES-OL), and the 1995 supplement to the final environmental statement related to the operating license (1995 SFES-OL-1) noted that anticipated land use during operation of WBN Units 1 and 2 would not differ from prior land use, either at the plant or along transmission lines. Because the Tennessee Valley Authority (TVA) built the plant and the transmission lines as planned and no changes to transmission lines or routings are expected as a result of operating WBN Unit 2, the U.S. Nuclear Regulatory Commission (NRC) staff identified no additional impacts on land use that were not identified in the previous analyses (TVA 1972; NRC 1978, 1995).

Because land has already been disturbed onsite and no additional land disturbance would be required, the NRC staff identified no additional onsite land-use impacts from operating WBN Unit 2 beyond those experienced from the operation of WBN Unit 1 and identified in the 1972 FES (TVA 1972).

4.1.2 Transmission Corridors and Offsite Areas

The WBN site uses approximately 813 ha (2,008 ac) of offsite land for transmission lines. These lines were built as planned. The 1972 FES-CP, 1978 FES-OL, and 1995 SFES-OL-1 (TVA 1972; NRC 1978, 1995) evaluated the impacts of transmission lines.

The 1978 FES-OL and 1995 SFES-OL-1 noted that anticipated land use during operation of WBN plant (Units 1 and 2) would not differ from prior land use at the plant or along transmission lines. TVA built the plant and the transmission lines as planned, and the NRC staff expects no land-use impacts beyond those identified in previous analyses. Some indirect offsite land-use impacts could occur due to development of land for housing and retail to serve the 200 additional operations workers moving into the region (TVA 2010a). However, as discussed in Section 2.1.2, the counties surrounding the WBN site have no restrictive zoning or growth measures. Because TVA has previously disturbed the land for transmission lines, and will not disturb additional land, the NRC staff expects no additional offsite land-use impacts from operating WBN Unit 2 beyond those experienced with the operation of WBN Unit 2 and identified in the 1978 FES-OL and the 1995 SFES-OL-1 (NRC 1978, 1995).

4.2 Water-Related Impacts

Managing water resources requires understanding and balancing various, often conflicting, objectives. At the WBN site, these objectives include navigation, recreation, visual aesthetics, reservoir ecology, and a variety of beneficial consumptive uses of water.

Water-use and water-quality impacts involved with operating a nuclear plant are similar to the impacts associated with any large thermoelectric power generation facility. Accordingly, the TVA maintains the same water-related permits and certifications as any other large industrial facility. These include:

- National Pollutant Discharge Elimination System (NPDES) Discharge Permit. TDEC issues this permit to limit liquid pollutants the plant discharges to surface water. This permit covers the requirements of the CWA Sections 316(a), 316(b) and 402(p). Tennessee issued NPDES Permit TN0020168 on June 30, 2011, effective August 1, 2011, to June 29, 2016 (TDEC 2011). This permit modification includes discharges associated with both WBN Unit 1 and Unit 2. The state made additional minor modifications to this permit on November 28, 2011 (TVA 2011a).
- Clean Water Act (CWA) Section 401 Certification. The Tennessee Department of Environment and Conservation (TDEC) issues this certification to ensure operating the plant does not conflict with State water-quality management programs. The NPDES permit issued on June 30, 2011 states that it constitutes the State’s certification under Section 401 of the Clean Water Act for the purpose of obtaining any federal license for activities resulting in the discharges covered under the NPDES permit.

4.2.1 Hydrological Alterations and Plant Water Supply

The Watts Bar Utility District would provide WBN plant with potable water from groundwater wells located offsite. TVA would meet all other water needs using Tennessee River water, most of which the plant would use directly for cooling. TVA hydrological impacts related to operating WBN Unit 2 are limited to intake of Tennessee River water from Chickamauga Reservoir through the intake pumping station (IPS); intake from Watts Bar Reservoir through the supplemental condenser cooling water (SCCW) system; discharge of blowdown water to Chickamauga Reservoir, SCCW system water, and associated waste streams; altered surface hydrology (from buildings, paved surfaces, stormwater collection trenches, and basins); and associated groundwater impacts.

4.2.2 Water-Use Impacts

The following sections describe water-use impacts on surface water and groundwater.

4.2.2.1 Surface-Water-Use Impacts

Consumptive surface-water use through evaporation would increase from 0.8 m^3/s (29 cfs) during the operation of Unit 1 alone to 1.8 m^3/s (62 cfs) during the operation of both units, for an increase of 0.93 m^3/s (33 cfs) associated with the operation of WBN Unit 2. As noted in Table 2-2, the mean annual flow TVA releases from Watts Bar Dam is 778 m^3/s (27,500 cfs). The maximum annual consumption rate for WBN Unit 2 represents just 0.1 percent of the mean annual flow rate of the Tennessee River at Watts Bar Dam. Based on the NRC staff's independent analysis, the NRC staff concludes that because of the small volume of water consumed relative to the Tennessee River flow, the impact on surface-water use of operating WBN Unit 2 is SMALL.

4.2.2.2 Surface-Water-Quality Impacts

The water discharged from WBN Unit 2 primarily would include blowdown from the condenser cooling system cooling-tower basins (through Outfall 101) and discharge from the SCCW system (through Outfall 113). Operating WBN Unit 2 would also increase discharges of heating, ventilation, and air conditioning (HVAC) cooling water, stormwater, fire-protection wastewater and discharges from the Yard Holding Pond (YHP) (through Outfalls 101 and 102). Discharges to the Tennessee River from WBN Units 1 and 2 are permitted under NPDES Permit TN0020168. The State of Tennessee issued the permit on June 30, 2011, effective August 1, 2011, to June 30, 2016 (TDEC 2011; TVA 2011a).

The condenser cooling system discharge includes chemicals in the intake waters the reactor unit concentrates as a result of evaporation, metals from plant component corrosion, and biocides and chemicals TVA uses to prevent plant fouling and corrosion. Constituents discharged through the SCCW are virtually the same as those from the condenser cooling system because both systems discharge water from the cooling-tower basins.

The YHP currently receives waste streams from a variety of sources onsite from operating WBN Unit 1, including stormwater runoff, turbine building sump water, alum sludge supernate, reverse osmosis reject water, discharge from the French drain around the power blocks, and water purification plant water. Operating WBN Unit 2 would increase the volume of water the plant discharges to the YHP, but the waste stream constituents would not change. Constituents that end up in the YHP before discharge include biocides, chemicals, organics, radionuclides, and dissolved solids. Chemicals that could be discharged to the pond are listed in Tables 3-2 and 3-3. In the pond, they are subject to dilution, aeration, vaporization, and chemical reactions before being discharged to Chickamauga Reservoir through the diffusers (Outfall 101) and/or Outfall 102.

TVA must meet the requirements of the current NPDES permit with respect to discharging constituents. TVA (2008a) confirms its compliance with State water-quality criteria by routine semi-annual Whole Effluent Toxicity testing at Outfall 101, Outfall 112, and Outfall 113. TVA submits the results of environmental monitoring to the NRC each year (e.g., TVA 2011b). Based on TVA conformance to NPDES permit requirements and the outcome of its routine outfall water-quality monitoring, the NRC staff concludes that the impact of chemical discharges to surface water due to operating Unit 2 would be minimal.

Thermal Impacts of Discharge

The temperature standards in the existing TVA NPDES permit for the WBN site are based on TVA studies of the temperature impacts of operating WBN Unit 1 and resources to be protected in the Chickamauga Reservoir near the diffuser outfall (Outfall 101) (TVA 2008a). TVA conducted these studies in response to a requirement included in the 1993 NPDES permit for the site. The TVA report, *Discharge Temperature Limit Evaluation for Watts Bar Nuclear Plant* (Lee et al. 1993) summarizes the studies. TVA performed the studies to evaluate the thermal effects of operating hydro, fossil, and nuclear plants on and near the WBN site under a range of operating scenarios (Lee et al. 1993). The study assessed the temperature variations in the Tennessee River resulting from releases of cooling water to the river under a range of thermal discharge and river flow conditions. The goal of the assessment was to identify operating limits for these facilities that would not violate the State of Tennessee water-quality standards. The State of Tennessee established those standards to protect aquatic biota (TDEC 2011).

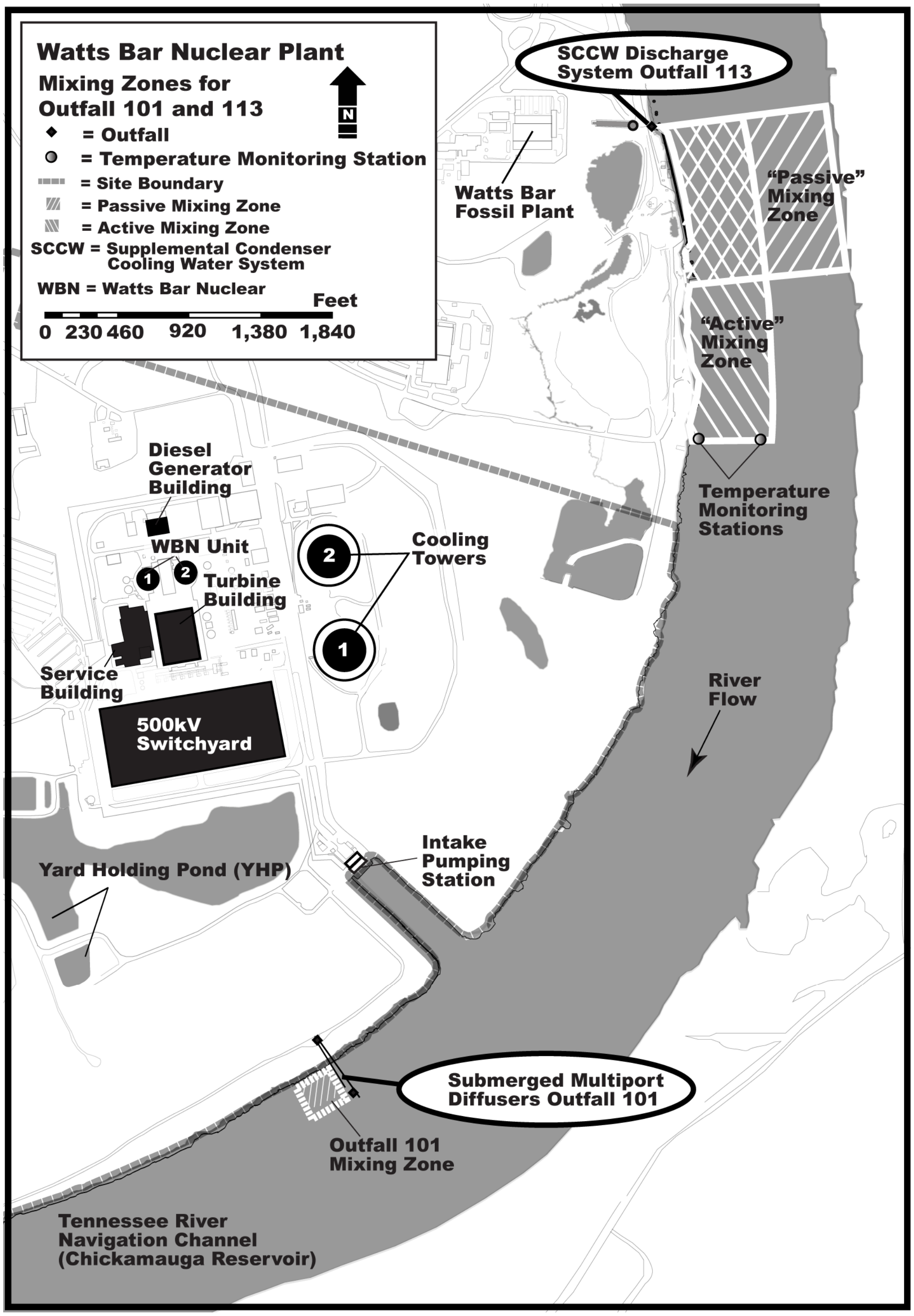
The report recommended a daily average discharge temperature limit of 35°C (95°F) for Outfall 101 and that the mixing zone dimensions for the discharge diffusers provide sufficient space for fish movement past the outfall (Lee et al. 1993).

TVA (2008a) states that:

> The studies and recommendations included the operation of one or both nuclear units at WBN. The recommendations were adopted by the permitting authority, as specified in the current NPDES permit, effective November 2004. The temperature for outfall 101 is measured by a continuous monitor in the blowdown conduit before the water enters the river. The current NPDES permit also specifies a discharge temperature limit of 35°C (95°F) for Outfall 102. Since discharge by the emergency overflow is infrequent, the temperature limit for Outfall 102 applies as a daily grab sample rather than a daily average value of continuous measurements. The TVA modeling studies demonstrated that outside of the recommended mixing zone, these discharge limits will ensure compliance with the State of Tennessee water quality standards for the protection of aquatic wildlife. These standards are as follows:
>
> *The receiving water shall not exceed (1) a maximum water temperature change of 3°C (5.4°F) relative to an upstream control point, (2) a maximum temperature of 30.5°C (86.9°F), except when upstream (ambient) temperatures approach or exceed this value, and (3) a maximum rate of change of 2°C (3.6°F) per hour outside of a mixing zone.*

The current NPDES permit (TDEC 2011; TVA 2011a) specifies these thermal limits for the operation of both WBN units. The mixing zone for Outfall 101 extends 70 m (240 ft) downstream of the diffuser (TDEC 2011; TVA 2011a).

These temperature standards also apply to Outfall 113 for two different mixing zones depending on flow conditions in the Tennessee River. The NPDES permit for Outfall 113 establishes an active mixing zone and applies the temperature standards when Watts Bar Dam turbines are operating and water is flowing past the SCCW outfall. This mixing zone extends 609 m (2,000 ft) downstream of the SCCW outfall, and TVA verifies temperature standards are being met by monitoring temperature at the downstream edge of the mixing zone. The NPDES permit for Outfall 113 also establishes a passive mixing zone for conditions when no water is flowing past the outfall. This zone extends to the full width of the river and 300 m (1,000 ft) downstream of the outfall (TDEC 2011; TVA 2011a). The dimensions of the mixing zones have not changed with the addition of WBN Unit 2 to the permit (TDEC 2011; TVA 2011a). Figure 4-1 illustrates the two mixing zones.



(To convert feet [ft] to meters [m], multiply by 0.3048 m/ft)

Figure 4-1. Mixing Zones for Outfall 101 and Outfall 113 (based on TVA 2008a)

TVA (2009a) describes its monitoring at Outfall 113 as follows: "Outfall 113 also contains a temperature limit of 33.5°C (92.3°F) in the receiving stream bottom at the SCCW outlet…In contrast to Outfall 101 and Outfall 102, the standards for Outfall 113 are enforced by a combination of continuous in-stream temperature measurements, field tests, and routine model predictions" (see Table 4-1). Additional information on thermal monitoring of the WBN outfalls is presented in Section 5.1.

Table 4-1. NPDES Temperature Limits for WBN Outfalls to the Tennessee River from TVA

Outfall	Effluent Parameter	Daily Report	Limit
101	Effluent Temperature	Daily Avg	35.0°C (95°F)
102	Effluent Temperature	Grab	35.0°C (95°F)
113	In-Stream Temperature[(a)]	Max Hourly Avg	30.5°C (86.9°F)
	In-Stream Temperature Rise[(b)]	Max Hourly Avg	3.0°C (5.4°F)
	In-Stream Temperature Rate-of-Change[(a)]	Max Hourly Avg	±2°C/hr (±3.6°F/hr)
	In-Stream Temperature Receiving Stream Bottom[(c)]	Max Hourly Avg	33.5°C (92.3°F)

Source: TVA 2011a; TDEC 2011
(a) Downstream edge of mixing zone.
(b) Upstream ambient to downstream edge of mixing zone.
(c) Mussel relocation zone at SCCW outlet.

The NPDES permit conditions that have been in effect for the operation of WBN Unit 1 will continue to apply for WBN outfalls when operating WBN Unit 2 (TDEC 2011; TVA 2011a). As discussed in Section 3.2.2, the plant can release water from Outfall 101 only when the river flow from Watts Bar Hydro (the turbines installed in Watts Bar Dam) is at or above 99 m^3/s (3,500 cfs). Outfall 113 releases do not require a minimum flow in the river, except in events where a planned, sudden change in thermal loading from the SCCW system occurs.

The NRC staff reviewed the procedures TVA follows to manage the operation of the cooling system to stay within the temperature limits of the NPDES permit. Plant operations stay within the NPDES limits by

- calling on TVA to increase the volume of water released through Watts Bar Dam
- diverting blowdown to the YHP
- using the SCCW to supplement cooling
- cooling the discharge from the SCCW by opening the crosstie between the inflow pipe and the discharge pipe
- taking the SCCW out of service.

TVA continuously monitors the Outfall 101 temperature. If it reaches 35°C (95°F), a signal in the control room alerts operators of the condition, and they divert discharge to the YHP. These conditions have been reached in the late afternoon on hot summer days. However, given that the NPDES limit is a daily average limit, implementing this procedure has resulted in the daily average temperature for Outfall 101 never reaching 35°C (95°F) (TVA 2010b). TVA has indicated the average monthly discharge from the diffuser will be virtually unchanged with the operation of WBN Unit 2 (e.g., from 1.25 to 1.3 m^3/s [44 to 46 cfs] for January). TVA has also predicted the temperature rise at the end the mixing zone would be virtually unchanged at between 0.06 and 0.11°C (0.1 and 0.2°F) (TVA 2012a).

The NRC staff independently conducted a thermal plume analysis to estimate the thermal plume's extent across the reservoir. Flow in the Tennessee River must exceed 99 m^3/s (3,500 cfs) before the diffuser is operated. The NRC staff used this flow to estimate the blowdown thermal plume dimensions for winter and summer conditions. TVA provided the temperature information used as input for the analysis (TVA 2012a). The month with the lowest river temperature (February) and the month with the highest river and blowdown temperature (August) were selected for the analysis. The month with the lowest river temperature will likely have the largest plume size because the difference between river temperature and blowdown temperature would be the greatest. The month with the highest river temperature and highest blowdown temperature will likely have the highest temperature for the mixed water plume. For this analysis, the NRC staff used a river temperature of 7.4°C (45.4°F) for February and a river temperature of 25.6°C (79°F) for August. To make the estimates conservative, the analysis used the maximum effluent discharge flow rate (blowdown plus other liquid effluents) reported by TVA, the maximum blowdown discharge temperature allowed by the NPDES permit (35°C [95°F]), minimum flow under which releases from the diffuser are allowed, low ambient water temperatures in February, and high ambient water temperatures in August.

The NRC staff based its thermal plume analysis on the estimation of the completely mixed water temperature within a prescribed fraction of the cross section of the Tennessee River at the diffuser location. The assumption that the water in the plume is well-mixed results in a larger estimated plume within the 3°C (5.4°F) isotherm because this simple model does not account for the higher temperature at the core of the plume. The higher temperatures that occur near the discharge point and in the center of the plume result in more heat being stored in the core of the plume and a plume of smaller areal extent. The calculations are not designed to distinguish these plume features; estimated plume temperatures in the context of this discussion refer solely to the well-mixed, or average temperature within the plume. The analysis assumes that the blowdown significantly affects a portion of the cross section of the Tennessee River. That is, a portion of the ambient flow (based on specification of the fraction of affected width and depth) completely mixes with the blowdown discharge. The analysis also assumes the plume is mixed over one-half of the river depth, meaning that the upper half of the water column would contain the thermal plume because of the buoyancy of the warmer water. A range of plume widths was examined (10 percent, 25 percent, and 50 percent of the channel width). A fraction of the ambient flow is assumed to be entrained into the blowdown discharge flow, which, when mixed, adjusts to the combined water temperature above the ambient water temperature and below the blowdown discharge temperature. The NRC staff computed the difference between the estimated plume water temperature and the ambient water temperature as well as the overall plume temperature for these conditions. The results are summarized in Table 4-2 and Table 4-3.

Table 4-2. Estimated Spring and Summer Blowdown Plume Temperatures with Assumed Plume Thickness Equal to 50 Percent of Water Depth

	Plume Temperature °C (°F)	
Plume Width	**February, 99 m^3/s (3,500 cfs)**	**August, 99 m^3/s (3,500 cfs)**
10% of Channel Width	16 (60)	28.9 (84)
25% of Channel Width	11.1 (52)	27.2 (81)
50% of Channel Width	9.4 (49)	26.7 (80)

Table 4-3. Estimated Blowdown Plume Temperature Rise Above Ambient Water for Spring and Summer with Assumed Plume Thickness Equal to 50 Percent of Water Depth

	Plume Temperature Above Ambient °C (°F)	
	February 7.4°C Ambient (45.4°F)	**August 25.6°C Ambient (78°F)**
Plume Width	**Normal Operation**	**Normal Operation**
10% of Channel Width	7.8 (14)	2.6 (4.9)
25% of Channel Width	3.9 (7)	1.3 (2.4)
50% of Channel Width	2.2 (4)	0.7 (1.3)

During February conditions, the difference between the plume water temperature and ambient water temperature exceeds 3°C (5.4°F) only if the plume width is restricted to less than 25 percent of the river width. Under more plausible conditions for February (blowdown temperature of 18.3°C [65°F]), the plume width would have to be restricted to approximately 10 percent of the river width to exceed 3°C (5.4°F). During August conditions, the difference between the plume water temperature and ambient water temperature does not exceed 3°C (5.4°F) even if the plume width is restricted to less than 10 percent of the river width.

Using the Cornell Mixing Zone Expert System (CORMIX) modeling software (Doneker and Jirka 2007), TVA calculated that the thermal discharge from Outfall 113 with both plants operating would meet all State of Tennessee requirements (TVA 2008a).

The NRC staff examined the applicant’s CORMIX plume model analysis and the model setup files provided by the applicant. The applicant made model runs using CORMIX version 3.1 for a number of cases covering a range of conditions to interpolate the results for the hydrothermal discharge conditions (TVA 2010b). The NRC staff selected representative conservative cases covering winter and summer conditions to run as confirmatory analysis using CORMIX version 6.0. The selected cases fall into four categories:

- winter condition with low river flow (28.01 m^3/s [989 cfs])
- winter condition with approximate minimum operational flow (113.0 m^3/s [3,990 cfs])
- summer extreme condition with low river flow (28.01 m^3/s [989 cfs])
- summer extreme condition with approximate minimum operational flow (113.0 m^3/s [3,990 cfs]).

The NRC staff simulated multiple scenarios for each category, constructing each scenario with a combination of different river depths and discharge temperate conditions. Simulations performed by the NRC staff using CORMIX 6.0 tended to produce smaller plume sizes for winter conditions than the model runs performed by TVA using the older version of CORMIX (Version 3.1). For most cases, the 3.0°C (5.4°F) isothermal line plume size did not exceed the allowable mixing zone size. However, for some extreme winter cases, the temperature increase at the downstream boundary of the mixing zone exceeded the NPDES permit limits. These cases represent conditions where the TVA procedure for operating the cooling system calls for diverting water from the inlet side of the SCCW system to the outlet pipe through the crosstie to cool the discharge to meet the NPDES limits for the mixing zone, or, if temperature limits cannot be met in this way, shutting down the SCCW system (TVA 2010b). TVA indicates that its normal operating practice is to open the crosstie from late November through March to prevent these conditions from occurring (PNNL 2009). A review of summer and winter thermal monitoring data indicates that TVA has historically adjusted the operation of the SCCW system to stay within the temperature limits set in the NPDES permit (e.g., McCall and Hopping 2007; Proctor and Hopping 2007). Implementation of the TVA procedures (TVA 2010b) would result in compliance with temperature limits in the future and impacts on surface-water quality would be negligible.

Physical Impacts of Discharge

As described in Section 3.2.2.4, a diffuser system located approximately 3.2 km (2 mi) below Watts Bar Dam would discharge cooling water from the WBN Unit 2 main cooling water system to Chickamauga Reservoir. The diffuser system consists of two pipes extending into Chickamauga Reservoir perpendicular to the flow through the reservoir. The diffuser ports direct the discharge upward away from the reservoir bottom at 45 degrees and in a downstream direction. As a result, the NRC staff concludes that discharge of cooling-tower blowdown through the diffuser would not result in significant scour of the reservoir bottom.

To reduce the impact of the discharge from the SCCW system on the river bottom, TVA installed a concrete incline to direct flow toward the river surface as it leaves the outfall (PNNL 2009; TVA 1998). Temperature monitoring data (Hopping 2004) indicate the concrete incline is successful in directing the flow upward, and as a result, the NRC staff concludes that the discharge through the SCCW outfall would not result in significant disturbance of reservoir bottom sediments.

TVA has used Outfall 102, which discharges emergency overflow from the YHP, very infrequently. Outfall 102 discharges into a local stream channel that empties into Chickamauga Reservoir. Because of the infrequency of the use of this outfall, the NRC staff concludes that the discharge would not result in a significant impact on bottom sediments.

Surface-Water Quality Summary

Based on the independent analysis of additional information since the 1978 FES-OL, including the temperature of, physical effects of, and chemical constituents in plant discharges to Chickamauga Reservoir, the NRC staff concludes the impacts of WBN Unit 2 discharges on surface-water quality would be SMALL.

4.2.2.3 Groundwater-Use Impacts

TVA does not plan to use groundwater from the WBN site to operate Unit 2. However, the modifications TVA made to the land surface while constructing WBN Units 1 and 2 have altered the local hydrology. TVA removes groundwater through a French drain surrounding the power blocks for both units on the site. A sump collects groundwater entering the French drain and the water is pumped to the YHP (see Section 2.2.1.2). This process removes approximately 9.8×10^8 L (2.6×10^8 gal) of groundwater per year (32 L/s [500 gpm]) (TVA 2010c). Because of this removal, the water table is depressed near the power block (TVA 2010a) (see Figure 2-3). The French drain and sump have been used while operating WBN Unit 1 and their use while operating WBN Unit 2 would likely not create any additional impact on site groundwater.

TVA routes surface water away from the plant through ditches shown in the site drainage plan (Figure 3-3). This routing, the plant's large number of impervious surfaces, and the use of surface-water retention basins by TVA have affected groundwater infiltration areas on the WBN site. Most of these changes in surface-water routing and infiltration characteristics occurred during site construction (before 1988). TVA has used the surface-water retention basins to operate WBN Unit 1 since 1996. Additional impact on site groundwater from the operation of WBN Unit 2 would be unlikely. The deeper aquifers are isolated from the surficial aquifer and, therefore, would not be affected.

The Watts Bar Utility District provides potable water for the WBN site. The utility withdraws water from wells approximately 4.0 km (2.5 mi) from the site. TVA expects the site would use 91,000 L/d (24,000 gpd) during normal operations of both units and that peak demand during the completion of Unit 2 and an outage at Unit 1 would be 303,000 L/d (80,000 gpd) (TVA 2010a). Watts Bar Utility District currently withdraws 2,730 m^3 (720,000 gal) of groundwater per day to meet customer needs. The groundwater withdrawn to support WBN during normal operation would be less than 3 percent of current withdrawals by the utility and approximately 10 percent of current withdrawals during peak staffing. The volume of water the Watts Bar Utility District would withdraw to support operating WBN is small relative to current withdrawals and groundwater withdrawal and surface alterations affecting groundwater onsite have existed for some time. Based on the independent analysis of additional information since the 1978 FES-OL, the NRC staff concludes that the impact on groundwater from operating WBN Unit 2 would be SMALL.

4.2.2.4 Groundwater-Quality Impacts

The 1978 FES-OL did not address groundwater-quality impacts, and TVA would not use groundwater for the operation of WBN Unit 2. No changes to the removal of groundwater through the French drain and sump surrounding the power block and turbine building are planned by TVA, so this continued dewatering would not change groundwater quality.

In support of the Nuclear Energy Institute Ground Water Protection Initiative, TVA developed a Ground Water Protection Program (GWPP) to monitor the onsite plant environment for indication of leaks from plant systems and buried piping carrying radioactive liquids. This program includes a groundwater monitoring program to detect and track tritium in groundwater. TVA would respond and attend to any spills through its ongoing radiological environmental monitoring program (REMP).

TVA also performs monitoring and notification for routine and accidental nonradioactive liquid releases to groundwater required by the NPDES permit and the Spill Prevention, Control, and Countermeasure Plan (SPCC plan) (TVA 2009a). These programs to monitor and respond to radioactive and nonradioactive spills reduce the likelihood spilled materials would reach groundwater. The monitoring programs would detect any spilled material reaching groundwater and TVA would take appropriate cleanup actions.

Factors limiting the impacts of operations on groundwater quality in the area are the TVA GWPP, REMP, and SPCC plan mentioned above and the relative isolation of the WBN site from local groundwater supply wells. Based on these factors, the NRC staff concludes that groundwater-quality impacts of WBN Unit 2 operations would be SMALL.

4.3 Ecology

4.3.1 Terrestrial Impacts

This section describes potential impacts on ecological resources from operating WBN Unit 2. One activity that may affect terrestrial and wetland resources is operation of the WBN Unit 2 cooling system. The cooling system includes a 146-m (478-ft) high natural-draft cooling tower.

Heat would transfer to the atmosphere in the forms of water vapor and drift. Vapor plumes and drift may affect crops, ornamental vegetation, and native plants by depositing minerals on the plants. The WBN site uses the Tennessee River as the source of its cooling water. River water contains dissolved solids, and, through the process of evaporation, the concentration of dissolved solids in the condenser cooling water (CCW) system increases. The CCW system releases a small percentage of its water into the atmosphere as fine droplets containing elevated levels of total dissolved solids (TDS).

Operation and maintenance of the transmission system may also affect terrestrial and wetland resources. As indicated in Section 4.1.1, there are no changes in the transmission line corridors or routings as a result of operation of WBN Unit 2. TVA currently performs periodic vegetation removal within transmission-line corridors for safety and operational reasons. Vegetation may be cleared chemically (e.g., herbicides), mechanically (e.g., mowing, sawing), or by pulling by hand (TVA 2010d). Tall structures, including the cooling tower and transmission lines crossing over waterways, may contribute to bird collision mortality.

4.3.1.1 Terrestrial Communities of the Site, Including Important Species and Habitat

Flora

During operation of the cooling system, cooling-tower drift deposits TDS on nearby vegetation. Depending on the source of makeup water, the TDS concentration in the drift may contain high levels of salts that can cause damage under certain conditions and for certain species. Drift containing high levels of TDS can stress or damage vegetation directly (by depositing the concentrated solids onto foliage) or indirectly (by accumulating in soils). General guidelines for predicting the effects of drift deposition on plants suggest many species have thresholds for visible leaf damage in the range of 120 to 240 kg/ha/yr (9 to 18 lb/ac/mo) during the growing season (NRC 1996). To limit the concentration of TDS within drift below two cycles of concentration, TVA would remove a portion of the blowdown water from the Tennessee River and replace it with makeup water, also from the Tennessee River. TVA estimates the maximum deposition rate for the WBN Units 1 and 2 cooling-tower plumes to be 10 kg/ha/yr (0.75 lb/ac/mo) (TVA 1972). Because this maximum deposition for WBN Units 1 and 2 would be far below the level that could cause leaf damage in many common species, the impacts would be negligible. Although most of the important plant species listed in Table 2-8 may occur close enough to the WBN Unit 2 cooling tower for TDS deposition to affect them, the TVA and the NRC staff do not expect deposition rates of 10 kg/ha/yr (1 lb/ac/mo) to noticeably affect these plant species. Internal modifications by TVA to the Unit 1 cooling tower, which also would be made to the Unit 2 tower (TVA 2008a), would not change the NRC staff's original calculations of TDS deposition effects discussed in the1972 FES-CP. The modifications would not noticeably affect any vegetation, including important species, in the area.

Increased localized fog, precipitation, and icing may affect local flora. TVA stated that naturally heavy fog occurs in the Watts Bar area about 35 days per year, most frequently in late fall and winter (TVA 1972). TVA expects the average visible plume height of 150 to 300 m (500 to 1,000 ft) above the 146-m (478-ft) tall tower will rarely intercept the ground. The visible portions of the plume may occasionally intercept the ground on Walden Ridge 8 to 11 km (5 to 7 mi) northwest of the site, and some local fogging may occur there (TVA 1972). During naturally foggy periods, stable air near the ground would prevent mixing of the plume and cooling-tower moisture from increasing fog density, frequency, or aerial extent (TVA 1972). The potential for icing near the WBN site exists for about 60 to 70 days from November through March and would likely occur within 8 km (5 mi) of the plant in a southerly direction, although it could also occur at Walden Ridge. Consistent with the 1972 FES-CP findings, the NRC staff does not expect localized fogging or icing to occur often enough or over a large enough area to noticeably affect terrestrial resources on the WBN site or in the vicinity, including Walden Ridge. Although most important plant species listed in Table 2-8 may occur close enough to the Unit 2 cooling tower for increased fogging or icing to affect them, the NRC staff expects that the limited temporal and spatial extent of fogging or icing from the WBN Unit 2 cooling tower would not noticeably affect important plant species, including those that may occur on Walden Ridge. TVA proposed modifications to the WBN Unit 2 cooling tower, which are the same as those made to the Unit 1 cooling tower, would not change this conclusion. Therefore, the NRC staff concludes environmental impacts associated with fogging and icing would be minimal.

<u>Species of Ecological Concern</u>

This section discusses potential impacts on plants species identified as being of ecological concern at the State and/or Federal level. During the NRC staff's site audit, TVA confirmed it conducts a sensitive area review (TVA 2010d) to identify habitats for rare flora and fauna when and wherever routine transmission line maintenance is conducted. None of the important plant species listed in Chapter 2 are known to occur within the WBN transmission corridors; however, many are found in the vicinity of the transmission corridors. The 1995 SFES-OL-1 (NRC 1995) identifies earleaf false-foxglove (*Agalinis auriculata*), tall larkspur (*Delphinium exaltatum*), and prairie goldenrod (*Solidago ptarmicoides*) as species of ecological concern. The 1995 SFES-OL-1 also indicates these are species known to occur in open habitats in the region. These species, as well as other ecologically important plants known to occur in open habitats in the region, could become established within transmission corridors. These plants are mainly herbaceous or low-growing and would not become a safety issue requiring specific maintenance activities if they would become established within a transmission corridor. The yellow jessamine (*Gelsemium sempervirens*), an important plant that occurs in open habitats, is a climbing vine. This plant, if established, could become entangled on transmission structures and require removal. Open habitats maintained through maintenance activities may benefit these plant species and provide potential habitat that would otherwise be unavailable in a forested landscape. However, the potential benefit of early-successional habitat plants is counterbalanced with the fact that plants that occur within mid- to late-successional habitats, including various forest types, could not benefit from transmission corridors reverting back naturally without routine vegetation removal. The plants that occur in mid-to-late successional habitats include the spreading rockcress (*Arabis patens*), spreading false-foxglove (*Aureolaria patula*), northern bush-honeysuckle (*Diervilla lonicera*), goldenseal (*Hytrastis canadensis*), and the Alabama snow-wreath (*Neviusia alabamensis*). Transmission-line maintenance could affect ecologically sensitive areas such as rock outcrops and wetlands. However, the sensitive area review process identifies ecologically sensitive areas, and TVA then uses best management practices (BMPs) to limit effects to the extent possible (TVA 2010d). Therefore, current maintenance activities conducted for the operation of Unit 1 minimally affect important wetland plants and those that occur in rocky habitats. Future maintenance conducted during the operation of Unit 2 would also minimally affect these habitats.

Fauna

The potential exists for wildlife to collide with tall structures, including the WBN Unit 2 cooling tower. The cooling tower reaches 146 m (478 ft) high, and is 108 m (354 ft) in diameter. TVA has not noted any unusual occurrences of bird collision mortality for either cooling tower during WBN Unit 1 operations (NRC 1995). The NRC staff estimates the threat of avian collision as a biologically significant source of mortality to be very low because only a small fraction of birds die from colliding with nuclear power plant structures (NRC 1996). Most collisions occur at night (FCC 2004). Adequate lighting and noise created during plant operation would preclude most collision events from happening. Researchers note that thriving bird populations, including important wildlife such as the wild turkey (*Meleagris gallapavo*), bald eagle (*Haliaeetus leucocephalus*), least bittern (*Ixobrychus exilis*), barn owl (*Tyto alba*), and various waterfowl can withstand small losses without threatening their existence (EPRI 1993).

Also, most waterfowl TVA has observed in the WBN site vicinity are associated with the Tennessee River. Flight paths of waterfowl associated with the river would fly along the river, avoiding collision with WBN facilities. The NRC staff does not expect wild turkeys to collide with the cooling tower often enough to effect local populations. Bald eagles forage near the Tennessee River and may perch or roost on the WBN site. Even with a substantial plume, the NRC staff does not expect eagles to collide with the Unit 2 cooling tower. The plant has not recorded any such collision with either of the cooling towers. Least bitterns reside exclusively along the river, and the NRC staff does not expect them to collide with the Unit 2 cooling tower during operation of WBN Unit 2. Barn owls forage on the wing at night, but adequate lighting should preclude the possibility that they will collide with the cooling tower. Researchers know little about the eastern small-footed bat (*Myotis leibii*). It appears the species prefers foraging within forest or over open water (Johnson et al. 2009) and may use buildings to roost (Best and Jennings 1997). As with the other wildlife species, noise from cooling-tower operation and adequate lighting would likely prevent these bats from colliding with the cooling tower.

As with collision mortality related to operating a cooling tower, the transmission lines and towers present obstacles to resident or migratory bats and birds. The Federal Communications Commission (FCC) reports that utility structures can kill thousands of birds in a single event (FCC 2004). The FCC has found as many as 59 bird species electrocuted by power transmission infrastructure (APLIC 2006), and more than 100 individual birds under a single telecommunication tower in a single night (FCC 2004).

The Electric Power Research Institute (EPRI) (1993) notes that factors appearing to influence the rate of avian impacts with structures are diverse and related to bird behavior, structure attributes, and weather. Structure height, location, configuration, and lighting also appear to play a role in avian mortality. Weather such as low cloud ceilings, advancing fronts, and fog also contribute to this phenomenon. Larger birds such as waterfowl are more prone to collide with transmission lines, especially when they cross wetland areas used by large concentrations of birds (EPRI 1993). Transmission lines supporting WBN Unit 2 cross waterways in eight different locations (Table 4-4): four cross the Tennessee River, two cross backwaters of the Tennessee River, and two cross the Hiwassee River. These transmission lines currently support WBN Unit 1. TVA would not install any new transmission towers or lines to support WBN Unit 2. While TVA does not conduct studies of avian mortality, no noticeable events of avian mortality associated with the existing transmission system have been recorded by TVA.

Table 4-4. Watts Bar Nuclear Unit 2 Transmission Corridor Water Crossings

Line	Water Body	Approximate Water Crossing Location
Sequoyah-Watts Bar	Tennessee River	0.35 TRM downstream from the WBN plant
Watts Bar-Roane	Tennessee River (backwater)	8.5 TRM upstream of Watts Bar Dam
Watts Bar-Roane	Tennessee River (backwater)	9.2 TRM upstream of Watts Bar Dam
Watts Bar-Roane	Tennessee River	4.8 km (3 mi) south-southwest of Kingston, Tennessee
Bull Run-Sequoyah	Tennessee River	8 km (5 mi) south-southeast of Kingston, Tennessee
Bull Run-Sequoyah	Tennessee River	At the Sequoyah Plant
Bull Run-Sequoyah	Hiwassee River	5 TRM upstream of confluence with Tennessee River
Sequoyah-Watts Bar	Hiwassee River	12.5 TRM upstream of confluence with Tennessee River

TRM = Tennessee River Mile

A study of non-hunting mortality of wild waterfowl concluded that transmission wire collision was less than 0.1 percent of reported mortality (Stout and Cornwell 1976). This level of mortality would not measurably reduce local bird populations. The NRC staff does not expect operating transmission lines in support of WBN Unit 2 to affect measurably the waterfowl that use the Tennessee or Hiwassee rivers. Neither does it expect operating the WBN Unit 2 cooling tower to contribute to conditions such as low cloud ceilings or fog to increase the likelihood of collision mortality with transmission lines. The eastern small-footed myotis forages over water and also could suffer from collision mortality. However, the NRC staff found no evidence that bats would be predisposed to transmission-line collision and mortality. For reasons stated above, the NRC staff concludes that impacts from wildlife colliding with structures related to WBN Unit 2 would be negligible.

EPRI (1993) documents electrocution of large birds, particularly eagles, as a source of mortality that could be significant to listed species. Electrocutions do not normally occur on lines whose voltages are greater than 69 kV because the distance between lines is too great to be spanned by birds (EPRI 1993). The voltages of all lines supporting WBN Unit 2 are greater than 69 kV. Therefore, transmission-line electrocution should not noticeably affect bald eagle and other large bird populations.

Routine maintenance within transmission corridors may benefit important wildlife that thrive in open habitats in the region, including the grasshopper sparrow (*Ammadramus savannarum*), barn owl, southern bog lemming (*Synaptomys cooperi*), and the meadow jumping mouse (*Zapus husonius*). Vegetation removal serves to maintain transmission corridors in an early-successional stage, providing potential habitat for these wildlife species. White-tailed deer (*Odocoileus virginianus*), wild turkey, and rabbit (*Sylvilagus* spp.) thrive in fragmented landscapes and would continue to benefit from TVA routinely removing vegetation. As with important plants, natural succession of the transmission corridors would not benefit important wildlife that prefer open or fragmented habitats. TVA uses maps, aerial photographs, and personnel observations or video reconnaissance captured from low-altitude aircraft flyovers to identify potential areas of concern that it then surveys on the ground or assumes to contain sensitive species in advance of routine transmission corridor maintenance activities. TVA uses the Regional Natural Heritage Program database, National Wetland Inventory maps, county soil surveys, and any other available data to identify ecologically sensitive areas and determine which vegetation practices to use. If TVA finds habitat potentially suitable for listed species, it assumes the species are present. Current maintenance does not affect wetland wildlife such as the least bittern and the Allegheny woodrat (*Neotoma magister*) because these species occur in habitats identified as sensitive in the sensitive area review process and would either be avoided or managed to specifically limit adverse impacts (TVA 2010d). Future maintenance would also not affect these species.

Noise

Researchers recognize that noise affects wildlife. Effects range from disturbance to damage. Disturbance includes acute effects such as that producing a flush response, while damage may be a chronic effect such as a measurable decrease in survivorship or reproduction near a major sound source (Kaseloo and Tyson 2004). TVA expects operating WBN Units 1 and 2 to result in maximum chronic noise levels between 53 and 63 dBA, which would result in only slight noise increases at the site boundary (TVA 1972). Chronic traffic noise at this level has been related to a reduction in woodland bird density (Kaseloo and Tyson 2004). Although scientists have not thoroughly defined how chronic noise affects wildlife, the NRC staff does not expect noise from operating the WBN Unit 2 cooling tower to noticeably affect common or important wildlife species at a population level. The NRC staff expects intermittent noise from 84 to 103 dBA at distances between 900 and 1,800 m (3,000 and 5,900 ft) from the cooling tower (NRC 1995), and intermittent noise at this level may produce a startle response and displace individual wildlife of some species (NRC 1995). Displacement of individuals into adjacent habitats usually results in increased competition for resources with individuals already occupying these habitats and ultimately results in a decreased population. However, like chronic noise, the NRC staff does not expect startling or displacement from intermittent operational noises and ultimate population reduction to destabilize local wildlife populations. The NRC staff concludes that operational noise-related impacts to wildlife would be negligible.

Electromagnetic Fields

The NRC reports that electromagnetic fields (EMFs) are unlike other agents that adversely affect the environment. Neither dramatic acute effects nor long-term effects have been demonstrated, and, if they exist, they are subtle (NRC 1996). In the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants,* NUREG-1437 (NRC 1996), the NRC staff reviewed biological and physical studies of EMFs, but did not find any consistent evidence linking harmful effects with field exposures. Since 1997, researchers have published more than a dozen studies looking at cancer in animals exposed to EMFs for all or most of their lives (Moulder 2003). These studies found no evidence that EMFs cause any specific types of cancer in rats or mice (Moulder 2003). Therefore, the NRC staff concludes that the incremental EMF impact posed by operating transmission lines to support WBN Unit 2 would be minimal.

Species of Ecological Concern

This section discusses potential impacts on animal species identified as being of ecological concern at the State and/or Federal level. Although healthy wildlife populations are able to sustain collision mortality and remain viable, loss of individuals may be significant enough to jeopardize threatened and endangered species or unlisted species in decline. The endangered gray bat (*Myotis grisescens*) is the only Federally listed animal species that is known to occur on or in the immediate vicinity of the WBN site. Because bats forage while flying, gray bats have the potential to die from colliding with WBN Unit 2 structures; however, the NRC staff concludes the potential is very limited because the gray bat forages almost exclusively over open water (Brady et al.1982). In addition, this bat forages within a few meters of the water’s surface, which also limits the potential for collision with transmission lines that cross water bodies in the region. Both lighting and noise on the WBN site would further reduce any collision potential. A biological assessment of potential adverse effects on the gray bat is located in Appendix F.

Wetlands

The Chickamauga Reservoir of the Tennessee River acts as the source of cooling water for WBN Unit 2. Chapter 2 lists many important species associated with the Tennessee River and habitats of importance, including wetlands/floodplains and set-aside parcels located on the immediate river shoreline. Current river management dictates the surface elevation of Watts Bar Reservoir be maintained in summer at a level 1.2 m (4 ft) higher than the winter pool level. Similarly, TVA maintains summer levels of the Chickamauga Reservoir 1.8 m (6 ft) higher than winter levels (TVA 2004).

Section 4.2.2.1 states that the annual consumption rate for WBN Unit 2 represents just 0.1 percent of the mean annual flow of the Tennessee River at Watts Bar Dam. Operation of both Units 1 and 2 would consume 0.2 percent of the mean annual flow of the river due to evaporation through the cooling towers. The NRC staff determined this level of surface-water usage would not measurably affect surface-water elevation, especially considering the magnitude of change within the current water management regime. The NRC staff does not expect additional shoreline exposure to be measurable, wetland function to be altered, or wetland flora and fauna along the Tennessee River shoreline to be affected. Consequently, the NRC staff concludes that the potential effects on terrestrial ecology, including all important species and habitats, from using Tennessee River water to operate a natural-draft cooling tower for WBN Unit 2 would be negligible. Shoreline impacts were not addressed in the 1978 SFES-OL or 1995 SFES-OL-1.

TVA notes that conditioning roads within transmission corridors could pollute local streams with eroded soil, organic debris, heat, and chemicals (TVA 1992). Chemical pollutants and herbicide runoff could directly affect important wetland species, and indirectly degrade habitat through erosion and increased organic matter. Increased temperatures in streams intersected by transmission corridors could also affect the hellbender (*Cryptobranchus alleganiensis*), which thrives in streams and rivers with temperatures less than 20°C (68°F). TVA uses BMPs to limit negative impacts from road maintenance on wildlife and habitats with both short- and long-term strategies. Short-term strategies include using silt fences and traps, barriers, and annual vegetation growth to limit erosion potential during work activities. The long-term strategies of TVA consist of checking dam construction; planting and retaining perennial vegetative cover alongside streams, wetlands, and bare soil areas; retaining trees and shrubs that do not interfere with safety; and limiting erosion into nearby wetlands and streams (TVA 1992). TVA uses good housekeeping practices on the WBN site to limit deposition of organic matter and petroleum products in streams and wetlands. Retaining vegetation along streams and wetlands increases shade and limits excessive heat load (TVA 1992). If TVA continues to use these BMPs, impacts on wetlands, important wetland plants, and important wetland wildlife would be minimal.

During transmission-line maintenance planning, the sensitive area review process accounts for wetlands within and adjacent to transmission corridors. TVA maps and applies a 1.6-km (1-mi) buffer around known wetlands that occur within a transmission corridor and maps potential wetlands by their boundaries. TVA then applies BMPs, such as restricting herbicide application methods or eliminating herbicides altogether, limiting use of heavy machinery, and designating sensitive areas as "hand-clearing only," depending on the sensitivity of the area (TVA 2010d). Therefore, transmission-line maintenance would minimally affect important wetland plants, animals, and function.

4.3.1.2 Terrestrial Resource Summary

Using the natural-draft cooling tower would result in the deposition of TDS on vegetation from cooling-tower drift. However, TVA estimates the amount of TDS deposited would be far below levels known to affect vegetation. TVA expects localized fogging and icing to occur infrequently and at a small scale, and it does not expect any noticeable effect on terrestrial resources.

Cooling-tower collision mortality would not normally affect healthy wildlife populations. TVA has not recorded any notable collision mortality events from operating the WBN Unit 1 tower, and it does not expect any for the WBN Unit 2 tower. The four 500-kV transmission corridors that currently support WBN Unit 1 would also support WBN Unit 2, and although the current eight waterway crossings of these lines would continue to pose a risk to waterfowl, this does not change with the operation of WBN Unit 2. TVA has not recorded any notable collision mortality from operation of these transmission lines. Transmission-line mortality is not normally a significant factor for waterfowl. Healthy bird populations can sustain minor losses without a noticeable effect. Transmission-line engineering virtually eliminates electrocution of wildlife with transmission lines whose voltages are greater than 69 kV because of line spacing. Routine maintenance in the established transmission corridors benefits wildlife that prefer open habitats, but deters those that prefer forested habitats. Operational noise likely would displace individual wildlife and may slightly reduce populations, but not enough to noticeably affect or destabilize wildlife populations. Researchers have not consistently linked EMFs to harmful effects in terrestrial biota.

The NRC staff does not expect that operating WBN Unit 2 would affect wetland resources along the Chickamauga Reservoir. Consumptive water use during operation would equate to less than 1 percent of the water flowing past the WBN site. The NRC staff determined that the surface-water fluctuation resulting from operating Unit 2 would be to be too small to measure, and current management of the Chickamauga Reservoir results in seasonal water fluctuations that far exceed what would result from operating WBN Unit 2. Current road and transmission-line maintenance affects resources through deposition of sediment, organic debris, chemicals, and increased heat loads into streams and wetlands. However, TVA uses BMPs, including temporary and permanent erosion barriers, retention of favorable vegetation retention, and good housekeeping to minimize impacts of road maintenance to the environment.

The TVA sensitive area review process limits adverse impacts on threatened or endangered plants and animals. It identifies habitats for this biota before performing work. TVA uses BMPs such as limits on timing and equipment in sensitive habitats, including where listed species are known or believed to occur. Foraging habits of the gray bat would preclude collision mortality with WBN Unit 2 structures and transmission system components.

Based on information TVA provided and NRC staff's independent review of additional information since the 1978 FES-OL, the NRC staff concludes that the impacts of operating the WBN plant transmission system on terrestrial resources, including Federally and State-listed species, would be SMALL.

4.3.2 Aquatic Impacts

This section describes potential impacts on the currently existing aquatic ecosystems and threatened and endangered species from the operation of intake and discharge systems of WBN Unit 2. The cumulative analysis, considering the effects of other past, present, and reasonably foreseeable future actions, is in Section 4.14.6. The previous section (4.3.1) addresses impacts from transmission-line maintenance on aquatic ecosystems.

The information in this section updates the information provided in the 1978 FES-OL (NRC 1978) by considering changes in the design of WBN Unit 2 (specifically the use of the SCCW system) and including information from more recent surveys and studies of aquatic biota as presented in Chapter 2. The NRC staff's analysis of the potential impacts on the aquatic biota of the Tennessee River from operating WBN Unit 2 are based on the NRC staff's observations at the site, discussions and information provided by the State of Tennessee, peer-reviewed articles or other documents obtained directly by the NRC staff, and analysis of studies conducted by TVA between 1973 and 2011 as discussed in Section 2.3.2.1 and listed in Table 5-1. The NRC staff considered the consumption of river water, the impingement and entrainment of aquatic organisms in the cooling-water systems (SCCW and condenser circulating water [CCW]), as well as thermal, chemical, and physical discharges from both the SCCW and the CCW systems.

4.3.2.1 Water Withdrawal and Consumption

As discussed in Section 3.2.2, the normal makeup water flow rate through the IPS from Chickamauga Reservoir for a single unit is 2.06 m^3/s (73 cfs) in the summer and 1.92 m^3/s (68 cfs) in the winter. This would increase to 3.79 m^3/s (134 cfs) in the summer and 3.20 m^3/s (113 cfs) in the winter for the operation of both units simultaneously. The combined operation of both units would represent 0.5 percent of the mean flow of the Tennessee River at Watts Bar Dam, which is 778 m^3/s (27,500 cfs).

The average intake flow rate through the SCCW intake from above the Watts Bar Dam in the Watts Bar Reservoir is estimated to be 7.9 m^3/s (278 cfs) for both units. This is slightly less than the flow through the SCCW while operating Unit 1 only; however, the difference is within the uncertainty in the estimate for flow while operating one or two units (see Section 3.2.2.1). The average intake flow rate through the SCCW intake is one percent of the mean flow of the Tennessee River at Watts Bar Dam.

Combined withdrawals for both units and both intakes is 1.5 percent of the mean flow of the Tennessee River at Watts Bar Dam. Much of this water returns to the river in the discharge. As discussed in Section 4.2.2.1, the maximum annual plant consumption rate for WBN Unit 2 represents 0.1 percent (for both units it represents approximately 0.2 percent) of the mean flow of the Tennessee River at Watts Bar Dam. The NRC staff concludes that the total withdrawal and the consumptive withdrawal would not destabilize or noticeably alter the aquatic biota in Watts Bar Reservoir, Chickamauga Reservoir, and downstream.

4.3.2.2 Entrainment and Impingement

Entrainment, as defined by the U.S. Environmental Protection Agency (EPA) (66 FR 65256) occurs when

> …organisms are drawn through the cooling water intake structure into the cooling system. Organisms that become entrained are normally relatively small benthic, planktonic, and nektonic organisms, including early life stages of fish and shellfish. Many of these small organisms serve as prey for larger organisms that are found higher on the food chain. As entrained organisms pass through a plant's cooling system they are subject to mechanical, thermal, and/or toxic stress. Sources of such stress include physical impacts in the pumps and condenser tubing, pressure changes caused by diversion of the cooling water into the plant or by the hydraulic effects of the condensers, sheer stress, thermal shock in the condenser and discharge tunnel, and chemical toxemia induced by antifouling agents such as chlorine. The mortality rate of entrained organisms varies by species and can be high under normal operating conditions. (footnotes omitted)

EPA indicated that "entrainment is related to flow" and that "[L]larger withdrawals of water may result in commensurately greater levels of entrainment" (69 FR 41576). For this analysis, the NRC staff assumes 100 percent mortality as a result of entrainment.

Impingement, according to EPA (66 FR 65256),

> …takes place when organisms are trapped against intake screens by the force of the water passing through the cooling water intake structure. Impingement can result in starvation and exhaustion (organisms are trapped against an intake screen or other barrier at the entrance to the cooling water intake structure),

> asphyxiation (organisms are pressed against an intake screen or other barrier at the entrance to the cooling water intake structure by velocity forces that prevent proper gill movement, or organisms are removed from the water for prolonged periods of time), and descaling (fish lose scales when removed from an intake screen by a wash system) and other physical harms.

The impingement rate depends on flow, intake velocity, and swimming speed, among other things. Death from impingement ("impingement mortality") can occur immediately or subsequently as an individual succumbs to physical damage upon its return to the waterbody.

As discussed in Section 3.2.2.1, WBN Unit 2 would use two different intakes. The intake for the SCCW system, which TVA originally used for its Watts Bar Fossil Plant, is located above Watts Bar Dam on the Watts Bar Reservoir. WBN Unit 2 would also use the IPS, which pulls water into the CCW system. The IPS and associated cooling intake canal are located in Chickamauga Reservoir at Tennessee River Mile (TRM) 528.0, about 3.1 km (1.9 mi) below the dam. Both intakes are already in use by WBN Unit 1.

Sections 316(a) and 316(b) of the CWA require "that the location, design, construction, and capacity of the cooling water intake structures reflect the best technology available for minimizing adverse environmental impacts" (33 USC 1326). EPA published Section 316(b) implementing regulations for new facilities (Phase I) in 2001 (66 FR 65256) and for existing facilities (Phase II) in 2004 (69 FR 41576). TDEC has issued a revised NPDES permit that incorporates the operations of Unit 2 (TVA 2011a; TDEC 2011). The permit indicates that "[the permit] may be reopened to address new 316(b) compliance requirements upon issuance of a final rule or guidance by EPA."

The NRC does not regulate NPDES permits, and the NRC does not determine whether Phase I or Phase II regulations apply to a specific cooling water intake structure. Compliance with EPA regulations should protect aquatic populations and communities.

SCCW Intake

TVA currently holds an NPDES permit for discharge from the SCCW system for both units (TVA 2011a, TDEC 2011). TVA currently uses the SCCW to operate WBN Unit 1 and plans to continue to use the system for WBN Unit 2. TVA presented the environmental effects of the SCCW in an Environmental Assessment (TVA 1998). The NRC staff did not consider the SCCW system in the 1978 FES-OL (NRC 1978) or the 1995 SFES-OL (NRC 1995) because the system did not begin operating until July 1999 (Baxter et al. 2001). As discussed in Section 3.2.2.1, the average monthly flow through the SCCW intake for the operation of WBN Units 1 and 2 will be slightly less than the flow through the SCCW while operating Unit 1 only, although the difference is within the uncertainty in the estimate for flow while operating either one or two units. For this reason, the NRC staff could evaluate the operation of the SCCW intake solely as a cumulative impact from an existing facility for the period of time when WBN Unit 1 is operating. However, occasionally, the SCCW intake may be operated solely for the purpose of running WBN Unit 2 (e.g., during an outage for WBN Unit 1). Although these periods are not expected to be frequent, consistent with the National Environmental Policy Act (NEPA), the NRC staff chose to discuss the impacts of continued operation of the SCCW (entrainment and impingement) in this SFES. The impacts of continued operation of the SCCW are also included in the Section 4.14.6 description of cumulative impacts.

During the summer months when the Watts Bar Reservoir levels are maintained at 225.8 m (740.75 ft), the water velocity through the open areas of the trash racks in the SCCW would be 0.18 m/s (0.58 ft/s). The water velocity through the openings of the traveling screens at the SCCW would be 0.35 m/s (1.15 ft/s) (TVA 2012a), as discussed in Section 3.2.2.1. The maximum velocity through the SCCW intake structure occurs as the water enters the wet well for the traveling screens. This velocity is 0.66 m/s (2.18 ft/s) for the summer pool and 0.50 m/s (1.65 ft/s) for the winter pool (TVA 2012b). For the purpose of comparison, the through-screen velocity and velocity at the entrance to the wet well are above the EPA guideline of 0.15 m/s (0.5 ft/s). Intake velocities at the SCCW system vary because it is a gravity-fed system, so higher pool elevations for Watts Bar Reservoir result in higher intake velocities.

Entrainment at the SCCW

Three studies related to entrainment or ichthyoplankton density in the Watts Bar Reservoir exist for the SCCW system. The first, an entrainment study (TVA 1976), was conducted in 1975 when the SCCW system was used as the intake for the Watts Bar Fossil Plant. The second study looked at ichthyoplankton densities during the spring of 2000 following the start of operation of the SCCW system for WBN Unit 1 (Baxter et al. 2001). The third study (TVA 2012b), conducted between March 7, 2010, and March 25, 2011, used samples taken in front of the SCCW intake structure and at a transect located at TRM 530.2 in the Watts Bar Reservoir. The following paragraphs discuss the results of the studies in chronological order. Section 5.5.2 contains a more detailed description of the studies.

The first study occurred before operation of WBN Unit 1, when the intake was used for the Watts Bar Fossil Plant. During operation of the Watts Bar Fossil Plant the flow of water into the intake ranged from 5.23 m^3/s (185 cfs) to 12.8 m^3/s (452 cfs) (TVA 1976), which is almost twice the flow that will be used for both WBN Units 1 and 2.[(a)] TVA conducted entrainment sampling for the Watts Bar Fossil Plant during ten sampling periods between March 24 and July 28, 1975, at five transects in the reservoir. In addition, TVA obtained pumped samples in three of the six intake screen wells. TVA personnel conducted sampling biweekly. Egg collections consisted mostly of unidentified fish eggs in the intake samples and freshwater drum (*Aplodinotus grunniens*) eggs in the reservoir samples. TVA researchers did not calculate total egg entrainment because eggs occurred erratically in samples. Eggs did not appear in both

(a) TVA (1976) uses 0.45×10^6 m^3/d (1.6×10^7 ft^3/d) to 1.11×10^6 m^3/d (3.9×10^7 ft^3/d). These flow rates have been converted for consistency with other SFES flow rates.

reservoir and intake samples during any sample period. As discussed in Section 2.3.2.1, TVA identified fish larvae from 10 families, but “unspecified clupeids” (such as threadfin shad or gizzard shad) dominated larvae collections (95 percent for intake samples, 97 percent for reservoir samples) throughout the sampling season. Of the non-clupeid larvae, only *Lepomis* species (e.g., bluegill) had more than 1 percent of the abundance (1.2 percent).

TVA (1976) estimated the quantity of water entrained (hydraulic entrainment) by the intake during operation of the Watts Bar Fossil Plant. TVA obtained measurements during 24-hr periods sampled once every 2 weeks. TVA reported that the 10 biweekly samples ranged from 0 to 1.53 percent of the reservoir flow. TVA estimated total larval fish entrainment for the entire study period (127 days) to be 0.24 percent of the transported population with a range from 0.11 to 0.86 percent of the transported population for the 10 sampling periods. Because of the low estimates for entrainment of fish eggs and larvae, TVA concluded that the Watts Bar Fossil Plant did not adversely affect the fisheries resource of Watts Bar Reservoir.

The second study was an ichthyoplankton study (Baxter et al. 2001) in the Watts Bar Reservoir forebay, in the vicinity of the SCCW intake, during operation of WBN Unit 1 in the spring of 2000. The purpose of the study was to determine if entrainment impact conclusions of the 1975 study were still relevant. The results of this study found that clupeid larvae (includes threadfin and gizzard shad) were the dominant species, followed by centrarchid larvae (e.g., *Lepomis*). However, the percentage of the *Lepomis* larvae (19 percent) in 2000 was higher than in 1975, reflecting a general trend discussed previously in Section 2.3.2.1. The report did not provide entrainment rate estimates.

In the final study, TVA (2012b) conducted ichthyoplankton monitoring weekly from March 7 through August 29, 2010, and monthly from September 20, 2010, through March 25, 2011, at a transect located at TRM 530.2 to estimate entrainment from the SCCW intake. TVA collected two samples weekly from a location in front of the SCCW intake and five stations on a transect at TRM 530.2 in Watts Bar Reservoir. Section 5.5.2.7 contains additional information on the sampling and the sampling equipment. Very small numbers of fish eggs, 23 total, were collected at the intake during the entire year of sampling. TVA identified the eggs as sciaenids, presumably freshwater drum (18 individual eggs), and clupeids (5 individual eggs). Sampling on the transect in the reservoir forebay resulted in nine sciaenid eggs. Densities at the SCCW intake ranged from 0 to 13 eggs per 1,000 m^3 of water. Densities in the reservoir ranged from 0 to 11 eggs per 1,000 m^3 of water. TVA estimated an entrainment rate at the SCCW intake of 2.23 percent for fish eggs. This estimate includes two sampling dates with low densities observed in front of the SCCW intake and no eggs obtained in reservoir samples.

During the sampling year, TVA collected a total of 2,498 fish larvae at the intake. Clupeids (89.3 percent) and centrarchids (9.0 percent) numerically dominated the samples. TVA collected a total of 5,056 larvae at the upstream transect, including clupeids (77.9 percent), centrarchids (15.6 percent), and sciaenids (2.5 percent). Densities of larvae at the SCCW intake ranged from zero to 4,125 per 1,000 m^3 of water. The densities peaked on May 2, 2010

(6.53 percent weekly entrainment of larvae transported past the site) and July 11, 2010 (6.15 percent). TVA estimated an annual entrainment rate at the SCCW intake of 1.98 percent for larvae. This estimate includes three sampling dates with low densities in front of the SCCW intake and no eggs in the reservoir samples (TVA 2012b).

The levels of entrainment (based on the percent of the transported population that is entrained) observed in the 2010–2011 study (TVA 2012b), are higher than those observed in the 1975 study during operation of the Watts Bar Fossil Plant (TVA 1976). However, the number of eggs observed in the reservoir transect and the SCCW samples (9 freshwater drum eggs in the reservoir; 18 freshwater drum eggs and 5 clupeid eggs at the intake) is extremely low. The composition of the ichthyoplankton entrained in the SCCW system, primarily clupeid and sciaenid eggs and clupeid and *Lepomis* sp. larvae, remained constant since the 1975 study, although the relative percentages have varied.

The NRC staff concludes that any additional entrainment of aquatic biota from the Watts Bar Reservoir would be minor as a result of operation of WBN Unit 2 because there will be no change in the operation of the SCCW intake during normal operations. Operation of two units will not increase the current water withdrawal rates and the species that are entrained (clupeids, centrarchids and freshwater drum) are very prolific in the reservoir. Based on the NRC staff review, entrainment from the SCCW system during operation of WBN Unit 1 has not noticeably altered the aquatic biota of the Watts Bar Reservoir. The entrainment from the SCCW for the days when WBN Unit 2 is operating, while WBN Unit 1 is shutdown, will also not noticeably alter the aquatic biota of the Watts Bar Reservoir.

<u>Impingement at the SCCW System</u>

TVA conducted three different impingement studies at the location of the SCCW system. TVA conducted the first impingement study in 1974 and 1975 during operations of the Watts Bar Fossil Plant (TVA 1976). The second impingement study occurred after the SCCW system began operating in support of WBN Unit 1 between August 31 and September 28, 1999, and again between March 7 and April 26, 2000 (Baxter et al. 2001). TVA conducted a third fish impingement demonstration of the SCCW intake as part of the 316(b) monitoring program from August 16, 2005, to August 7, 2007 (TVA 2007a). The following paragraphs discuss the results of the studies in chronological order. Section 5.5.2 contains a more detailed description of the impingement studies.

TVA (1976) collected 33 weekly samples between August 8, 1974, and May 29, 1975, during the operation of the Watts Bar Fossil Plant. A total of 2,130 individuals from 19 species were collected during the weekly 24-hour sampling period. Cluepids (shad) constituted 73 percent of the fish collected. Bluegill was the next most abundant followed by freshwater drum and skipjack herring. The estimated annual number of fish impinged during operation of the Watts Bar Fossil Plant was 16,421 fish.

TVA conducted the second impingement study (Baxter et al. 2001) to verify that impingement losses from the SCCW system "remained minimal." Monitoring occurred in two periods, August 31 through September 29, 1999, and March 7 through April 26, 2000. Further details on the sampling are provided in Section 5.5.2. TVA collected 11 impingement samples containing 146 fish from 9 species. Again the majority of fish impinged were gizzard shad and threadfin shad (75 percent) followed by bluegill (17.6 percent). Baxter et al. (2001) predicted that 9,125 fish would be impinged annually by the SCCW system during operation of WBN Unit 1.

TVA (2007a) conducted the third and most recent impingement demonstration as part of the 316(b) monitoring program. The study was conducted in two periods, the first from August 16, 2005, through August 9, 2006 (referred to as 2005–2006) and the second from August 16, 2006, through August 7, 2007 (referred to as 2006–2007). TVA researchers conducted weekly impingement monitoring by rotating the intake screens and washing them on prearranged schedules. See Section 5.5.2 for additional details on the impingement study. Researchers extrapolated impingement data from the weekly 24-hour samples to estimate the total fish impinged by week and fish impingement for the year. Table 4-5 provides the number of fish impinged for each species during the 2005–2007 impingement study. Table 4-6 specifies the average estimated annual number of fish and biomass impinged over the 2-year period. As in the previous impingement studies, threadfin and gizzard shad had the highest impingement rates, followed by bluegill. For the most part, only small numbers of fish were impinged, with the exception of threadfin shad (*Dorosoma petenense*), of which 5,381,439 (annual estimate) were impinged during 2005–2006.

To determine whether the number of threadfin shad impinged would have an effect on the aquatic ecosystem in Watts Bar Reservoir, the NRC staff used a modified weight-of-evidence approach. The term "weight of evidence" has many meanings. NRC (2010) has defined it as "an organized process for evaluating information or data from multiple sources to determine whether there is evidence to suggest that an existing or future environmental action has the potential to result in an adverse impact." The NRC staff used such an approach for the Cooper Nuclear Station license renewal supplemental environmental impact statement (SEIS) (NRC 2010) and other license renewal applications.

The first line of evidence relates to comparison of data across additional years of impingement studies and additional locations. Historically, threadfin shad were consistently impinged at higher rates than other fish in the previous impingement studies of the SCCW system intake (TVA 1976; Baxter et al. 2001). Threadfin shad are also consistently impinged at rates higher than other fish at other Tennessee River plants. Table 4-7 shows the total estimated annual number of fish impinged by species during impingement studies at the TVA Sequoyah Nuclear Plant (2005–2007; TVA 2007b) and the TVA Kingston Fossil Plant (2004–2006; TVA 2007c). The Kingston Fossil Plant, near Kingston, Tennessee, is located on a peninsula at the junction of the Emory and Clinch rivers, approximately 68 river km (42 river mi) upstream from Watts Bar Dam. The Sequoyah Nuclear Plant is located at TRM 484.5 on Chickamauga Reservoir, approximately 71 river km (44 river mi) downstream of the WBN site. This comparison provides an indication that the differences in impingement rates between the three plants are in many cases largely related to the impingement of threadfin shad.

Table 4-5. List of Fish Species by Family, Scientific, and Common Name and Numbers Collected in Impingement Samples During 2005–2007 at the SCCW During Operation of WBN Unit 1

			Total Number of Fish Impinged	
Family	**Scientific Name**	**Common Name**	**Year-One**	**Year-Two**
Atherinidae	*Labidesthes sicculus*	Brook silverside	2	1
Centrarchidae	*Lepomis auritus*	Redbreast sunfish	5	0
	Lepomis gulosus	Warmouth	1	0
	Lepomis macrochirus	Bluegill	229	48
	Lepomis megalotis	Longear sunfish	5	0
	Lepomis microlophus	Redear sunfish	6	0
	Micropterus punctulatus	Spotted bass	2	0
	Micropterus salmoides	Largemouth bass	17	1
	Pomoxis annularis	White crappie	3	2
	Pomoxis nigromaculatus	Black crappie	11	0
Clupeidae	*Alosa chrysochloris*	Skipjack herring	1	1
	Dorosoma cepedianum	Gizzard shad	1,086	2,957
	Dorosoma petenense	Threadfin shad	768,777	27,164
Cyprinidae	*Cyprinella spiloptera*	Spotfin shiner	0	1
	Pimephales notatus	Bluntnose minnow	0	2
	Pimephales vigilax	Bullhead minnow	1	7
Ictaluridae	*Ictalurus furcatus*	Blue catfish	4	0
	Ictalurus punctatus	Channel catfish	12	3
	Pylodictis ofivaris	Flathead catfish	0	1
Moronidae	*Morone chrysops*	White bass	2	1
	Morone mississippiensis	Yellow bass	18	10
	Morone saxatilis	Striped bass	1	0
Percidae	*Perca flavescens*	Yellow perch	2	0
	Percina aurantiaca	Tangerine darter	1	0
	Percina caprodes	Logperch	14	1
Sciaenidae	*Aplodinotus grunniens*	Freshwater drum	18	2
Total number of fish			770,218	30,202
Total number of species			23	16

Source: TVA 2007a

Table 4-6. Estimated Numbers and Biomass of Fish Species Impinged at the SCCW Intake of Watts Bar Nuclear Plant During 2005–2007

	Estimated Number			Estimated Biomass (g)		
Species	**Year-One**	**Year-Two**	**Average**	**Year-One**	**Year-Two**	**Average**
Threadfin shad	5,381,439	190,148	2,785,794	9,810,374	266,280	5,038,327
Gizzard shad	7,602	20,699	14,151	359,296	70,245	214,771
Bluegill	1,603	336	970	40,138	8,953	24,546
Yellow bass	126	70	98	4,445	1,064	2,755
Freshwater drum	126	14	70	10,381	483	5,432
Largemouth bass	119	7	63	43,302	35	21,669
Channel catfish	84	21	53	987	266	627
Logperch	98	7	53	1,491	84	788
Black crappie	77	0	39	23,352	0	11,676
Bullhead minnow	7	49	28	14	70	42
Redear sunfish	42	0	21	8,512	0	4,256
Longear sunfish	35	0	18	4,858	0	2,429
Redbreast sunfish	35	0	18	2,555	0	1,278
White crappie	21	14	18	1,295	35	665
Blue catfish	28	0	14	3,472	0	1,736
Brook silverside	14	7	11	56	21	39
White bass	14	7	11	3,654	1,393	2,524
Bluntnose minnow	0	14	7	0	21	11
Skipjack herring	7	7	7	1,281	2,590	1,936
Spotted bass	14	0	7	84	0	42
Yellow perch	14	0	7	1,183	0	592
Flathead catfish	0	7	4	0	1,344	672
Spotfin shiner	0	7	4	0	21	11
Striped bass	7	0	4	35	0	18
Tangerine darter	7	0	4	98	0	49
Warmouth	7	0	4	1,127	0	564
Total	5,391,526	211,414	2,801,470	10,321,990	352,905	5,337,448

Source: TVA 2007a

Table 4-7. Comparison of Total Estimated Number of Fish Impinged at WBN (SCCW intake), Sequoyah Nuclear Plant, and Kingston Fossil Plant

	Extrapolated Annual Number of Fish Impinged			Extrapolated Annual Number of Fish (not including threadfin shad) Impinged		
Facility	**2004–2005**	**2005–2006**	**2006–2007**	**2004–2005**	**2005–2006**	**2006–2007**
Watts Bar Nuclear Plant	----	5,391,526	211,414	------	10,087	21,266
Sequoyah Nuclear Plant	----	20,223	40,362	------	2,520	2,751
Kingston Fossil Plant	185,577	225,197	----	8,337	11,746	----

Sources: TVA 2007a, b,c
Dashes indicate no sampling.

The second line of evidence is that impingement of threadfin shad in large numbers occurs frequently. A study of 32 southeastern United States power plants found threadfin shad accounted for more than 90 percent of all fish impinged (Loar et al. 1978). EPA (2001) reported similar data in its compilation of impingement data; however, the study was not limited to facilities in the southeast, and the percentage of threadfin shad impinged was not as high, although it was the most frequently impinged species. The EPA found the typical annual impingement rate per facility for all reservoirs and lakes (excluding the Great Lakes) to be 678,000 fish/yr with a range from 203,000 to 1,370,000 depending on the facility. McLean et al. (1985) reported on a reservoir-wide mortality and impingement of threadfin shad that occurred previously during the period October 1976 to April 1977 in Watts Bar Reservoir. In addition, the data show threadfin shad accounted for 95 percent of the fish impinged at the Kingston Fossil Plant in 2004 to 2006 (TVA 2007c), and 91 percent for the Sequoyah Nuclear Plant during 2005 and 2006 (TVA 2007b).

The third line of evidence is the biological response of shad cold water temperatures. Shad are intolerant of cold water temperatures, which often results in high winter mortality, as discussed in Section 2.3.2.1. According to the TVA environmental report (ER) (TVA 2008a), the peak impingement at WBN occurred January through March (over 99 percent of the fish were impinged during these months), which are the colder months of the year. In colder temperatures, shad may become impaired (decreased swimming) or moribund (and may have died regardless of whether they were impinged). However, TVA did not have water temperature data available to determine the temperature conditions in the Watts Bar Reservoir.

The fourth line of evidence relates to the location of the SCCW system intake. The SCCW intake location is unique among thermal power plants in the vicinity of Watts Bar, in that it is located above the Watts Bar Dam and the thermal discharge for the WBN plant is below the dam. Thus, the shad are not able to take refuge in the thermal discharge from the plant, as they may be doing during cold weather in the vicinity of the Sequoyah Nuclear Plant and the Kingston Fossil Plant. McLean et al. (1985) discussed the ability of threadfin shad to survive rapid drops in temperatures "if thermal refuges 3 to 4°C [5.4 to 7.2°F] warmer than ambient were available." Second, the location of the SCCW intake at the dam would mean that any threadfin shad that are unable to swim because of low water temperatures would drift to the face of the dam and then possibly either through the dam or into the SCCW intake. Loar et al. (1978) made similar observations.

The fifth line of evidence relates to estimates of the standing stock of threadfin shad in the Watts Bar Reservoir. The NRC staff requested information from TVA related to an estimate of the standing stock of threadfin shad in the Watts Bar Reservoir in order to compare with the number of fish estimated impinged in the 2005–2006 period. TVA based its estimate of standing stock on 8 years of data from sampling coves in the Watts Bar Reservoir from 1960 to 1980 using rotenone (a chemical previously used for sampling, which kills all the fish in a given cove when given in large enough amounts). TVA (2010a) estimated the threadfin shad population to be greater than 20 million when the total area of Watts Bar Reservoir that is composed of coves and embayments is considered. The population is likely much greater because threadfin shad also inhabit the open water areas of the reservoir. Thus, the estimated fraction of the shad population impinged in 2005–2006 is less than 25 percent of the threadfin shad likely present in Watts Bar Reservoir, and this rate of impingement was observed in only one year.

The final line of evidence is the population size and biomass of fish that prey on shad for the years before and after 2005–2006. Table 4-8 shows the catch rates for black bass (*Micropterus* spp.) using electrofishing for Watts Bar Reservoir in 2006 and 2007 were comparable to those from previous years. In addition, the mean weight of black bass in 2006 was equivalent to the mean weight the previous year, and the mean weight of black bass increased in 2007 and further increased in 2008, indicating the loss of threadfin shad in Watts Bar Reservoir did not noticeably affect their predators (Simmons and Baxter 2009). McLean et al. (1985) reported that prior to the relatively large impingement of threadfin shad in Watts Bar Reservoir during 1976 and 1977, threadfin shad made up 99 percent of the combined diet of sauger (*Sander canadensis*) and skipjack herring (*Alosa chrysochloris*) from November until the shad disappeared in January. By the next autumn, 25 to 100 percent of the diet of the predators was an alternative prey.

Table 4-8. Electrofishing Catch Rates and Population Characteristics of Black Bass Collected During Spring Sport Fish Surveys on Watts Bar Reservoir, 2001–2008

Year	Electrofishing Catch Rate (no/hr)	Mean Weight (lb)	% Harvestable	No. of Bass > 4 lb	No. of Bass > 5 lb	Largest Bass (lb)
2008	71.5	1.6	72.4	33	17	9.5
2007	61.1	1.5	63.2	20	8	6.7
2006	39.4	1.3	71.7	14	7	7.1
2005	72.6	1.3	36.9	15	9	6.2
2004	40.9	1.3	60.2	13	6	6.6
2003	62.0	1.3	65.8	23	8	6.1
2002	57.4	1.1	59.4	9	4	6.6
2001	34.5	0.8	45.2	0	0	2.8

Source: Simmons and Baxter 2009

The NRC staff has determined that the aquatic biota of Watts Bar Reservoir would not be affected further by impingement from the additional operation of the SCCW intake for WBN Unit 2 because during routine operations the intake flow and intake velocity for both units would be unchanged from the current operation of WBN Unit 1, as explained in Section 3.2.2.1. Operation of two units will not increase the water velocity through the SCCW intake. Further, the levels of impingement observed during past studies were minor, except for the threadfin shad, and based on the weight-of-evidence approach even the large number of shad impinged during the 2005–2007 study appears not to have destabilized or noticeably altered the aquatic biota of the Watts Bar Reservoir in the following years. Based on the NRC staff review, impingement during operation of the SCCW intake for WBN Unit 1 has not noticeably altered the aquatic biota of the Watts Bar Reservoir. Impingement from the SCCW for the additional days when WBN Unit 2 is operating (while WBN Unit 1 is shutdown) will also not noticeably alter the aquatic biota of the Watts Bar Reservoir.

CCW System – Intake Pumping Station

As discussed in Section 4.2.2, WBN Unit 2 would withdraw water from the Chickamauga Reservoir through the CCW system intake located at the IPS. WBN Unit 1 has used this intake since it started operation in 1996. TVA holds a valid NPDES permit for discharge from the CCW system that pulls water from the river through the IPS (TVA 2011a). NRC (1978) previously considered the use of the IPS for operation of two units.

Currently, WBN Unit 1 withdraws between 1.92 m^3/s (68 cfs) of water in the winter and 2.06 m^3/s (73 cfs) of water in summer from Chickamauga Reservoir for normal operations as discussed in Section 3.2.2.1. Normal operations for two units would require the withdrawal of between 3.20 m^3/s (113 cfs) of water in winter and 3.79 m^3/s (134 cfs) of water in summer from the reservoir (TVA 2011a). As stated in Section 3.2.2.1, the withdrawal of 3.79 m^3/s (134 cfs) through the IPS would represent approximately 0.5 percent of the mean annual flow of the Tennessee River as measured at Watts Bar Dam.

TVA (2011d) reports for the two unit operation, the average velocities at the entrance to the IPS canal would be 0.055 m/s (0.18 ft/s) for the winter pool level and 0.051 m/s (0.17 ft/s) for the summer pool level. The velocity in the intake channel would be 0.11 m/s (0.37 ft/s) for winter operation and 0.12 m/s (0.4 ft/s) for summer operation. TVA (2011c) predicts that for operation of two units the water velocity through the openings of the traveling screens would be 0.21 m/s (0.67 ft/s) in winter and 0.19 m/s (0.62 ft/s) in the summer with four raw cooling water pumps operating. For the purpose of comparison, this is less than the velocity of water in the reservoir as it flows past the site, which averages 0.7 m/s (2.3 ft/s) under normal winter conditions and 0.3 m/s (1.0 ft/s) in the summer months (TVA 2009a). The flow through the traveling screens is above the EPA guideline for the design through-screen velocity of intake screens for new plants of 0.15 m/s (0.5 ft/s) (40 CFR 125.84(b)(2)). The EPA guidelines are based on a study of fish swimming speeds and endurance that indicated that the species and life stages evaluated could endure a velocity of 0.31 m/s (1.0 ft/s). The EPA indicated that the application of a safety factor of two was appropriate (66 FR 65256).

Entrainment at the IPS

TVA conducted two sets of entrainment studies at the IPS, as part of or in addition to the ichthyoplankton studies discussed in Section 2.3.2.1. TVA conducted the first entrainment study after the start of operations of WBN Unit 1 in 1996–1997 (Baxter et al. 2010). TVA conducted the second entrainment study from March 7, 2010, through March 25, 2011 (TVA 2012b). The entrainment estimates from these two studies will be discussed in the following paragraphs. In addition, the species composition found in the intake channel during the 1996–1997 entrainment study will be compared with the species composition of the intake channel in the ichthyoplankton study conducted in 1984–1985 (Baxter et al. 2010) and in 2010–2011 (TVA 2012b). Section 5.5.2 contains a more detailed description of the studies.

In the first entrainment study (1996 – 1997) for the IPS, TVA (Baxter et al. 2010) calculated the fraction of ichthyoplankton transported past the plant as the estimated average densities of fish eggs and larvae (ichthyoplankton) from a transect located at TRM 528 (just upstream of the intake channel) multiplied by the corresponding 24-hour flow past the plant. TVA also obtained intake channel samples, consisting of four, 1-minute towed samples taken from the trash boom to the mouth of the IPS canal. Section 5.5.2 contains further information on the sampling and the sampling equipment. TVA multiplied an estimate of the mean density of eggs or larvae in the intake samples by the plant-intake water demand to derive an estimate of the number of eggs and larvae entrained for each year of the study. TVA reported an annual entrainment rate of fish eggs and larvae that would otherwise have been transported past the site during 1996 of 0.02 and 0.88 percent, respectively. TVA estimated the percentage entrainment of fish eggs and larvae during 1997 that would otherwise have been transported past the site to be 0.02 and 0.22 percent, respectively (TVA 2012b).

TVA conducted the second entrainment study weekly from March 7 through August 29, 2010, and monthly from September 20, 2010, through March 25, 2011 (TVA 2012b). Four samples were taken within the intake channel (TRM 528.0) and from five stations along a transect located in Chickamauga Reservoir upstream of the intake channel at TRM 528.5 perpendicular to the flow of the river. River flows during the sampling period ranged from a low of 14,770,000 m^3/d (6,037 cfs) on April 18, 2010, to a high of 119,250,000 m^3/d (46,742 cfs) on May 2, 2010. Section 5.5.2 provides further information on the sampling and the sampling equipment. TVA estimated a total annual entrainment rate at the IPS of 0.11 percent for fish eggs and 0.43 percent for larvae.

One purpose of this study was to update and verify historical monitoring conducted in 1996 and 1997 (TVA 2012b). TVA compared the estimated entrainment rates observed in 1996 and 1997 with those from 2010 during approximately the same sampling months (late March/early April to the middle/end of June). The entrainment rates for fish eggs during the early studies, as discussed previously, were 0.02 percent for both 1996 and 1997 and 0.12 percent in 2010. The entrainment rates for larvae in 1996 and 1997 were 0.88 and 0.22 percent, respectively, and 0.4 percent in 2010. Although the rates are higher for fish eggs in 2010 than in previous years, the NRC staff considers the overall entrainment rate for fish eggs of 0.12 percent as low.

TVA (2012b) also identified the fish larvae obtained in the samples from the intake channel during the 1996 and 1997 studies and the 2010–2011 study and compared them to the results of previous sampling from the preoperational (1984 and 1985) studies (Baxter et al. 2010). During preoperational ichthyoplankton studies, the clupeid (threadfin shad and gizzard shad [*Dorosoma cepedianum*]) larvae made up 86 to 98 percent of the larvae in the samples taken in the intake channel, with the centrarchids (sunfish) the next most abundant (0.9 to 12.5 percent) (Table 4-9). During operational studies, the clupeid larvae made up between 66 and 91 percent of the larvae in the intake channel, with sunfish abundance ranging from 7.6 to 21.5 percent. TVA postulated (Baxter et al. 2010; TVA 2012b) that the higher composition of centrarchid or sunfish (*Lepomis*) larvae in the intake channel compared to in the river was a result of resident populations using the intake channel as habitat for spawning and nursery (as discussed in Section 2.3.2.1). This was similar to 1984 and 1985 when researchers observed that the highest percentage of *Lepomis* spp. was near the shoreline and in the intake samples (TVA 1986).

The highest estimated entrainment for fish eggs occurred during the May 17, 2010 (4.1 percent) and August 22, 2010 (6.5 percent) sample periods. The highest estimated entrainment for fish larvae during the 2010–2011 study occurred on June 21, 2010 (8.65 percent) and July 25, 2010 (10.34 percent). These dates occurred during a roughly 14-week period that saw higher densities of centrarchid larvae in the IPS channel than in the reservoir samples. Because centrarchids construct nests in shallow water, as discussed in Section 2.3.2.1, the higher density in the IPS channel is likely due to centrarchids that are using the intake channel shoreline as spawning and nursery habitat. Other authors have reported centrarchids using intake channels as spawning areas (Schreiber et al. 1974; Wang and Reyes 2008).

Based on the low levels of entrainment from the two entrainment studies, the NRC staff concludes that even though the operation of the IPS for WBN Unit 2 will effectively double the hydraulic entrainment rate, the increased entrainment of aquatic biota will not have a noticeable effect and will not destabilize the population of aquatic biota near the WBN site. The species that are entrained are either very prolific in the reservoir, and/or, in the case of the sunfish, likely to be using the intake canal area as a spawning and nursery habitat. Further, the NRC staff does not anticipate that the additional water withdrawal and subsequent entrainment from the additional operation of WBN Unit 2 would be noticeable or destabilizing to the aquatic ecology.

Table 4-9. Percent Composition of Dominant Larval Fish Taxa Collected in the CCW Intake Channel 1984–1985, 1996–1997, and 2010-2011

		Percent Composition of Larval Fish Taxa				
		Preoperational		**Operational**		
Taxon	**Common Name**	**1984(a)**	**1985(a)**	**1996(a)**	**1997(a)**	**2010-2011(b)**
Aplodinotus grunniens	Freshwater drum	0.1	0.2	0.8	0.3	1.2
Centrachidae	Sunfish	0.9	12.5	7.6	8.1	21.5
Clupeidae	Unidentified shad	97.8	86.4	90.5	83.7	57.5
Dorosoma sp.	Threadfin or gizzard shad	0.09	--	0.8	0.2	8.5
Morone (not *saxatilis*)	Bass (not striped)	0.6	0.5	0.1	1.0	7.8
Morone sp.	Bass	0.5	0.5	0.1	5.4	2.1

Source: (a) Baxter et al. 2010; (b) TVA 2012b

Impingement at the IPS

TVA conducted two impingement studies at the IPS. The first began on March 15, 1996, before WBN Unit 1 started producing commercial power (Baxter et al. 2010). TVA conducted an additional impingement study at the IPS between March 26, 2010, and March 17, 2011 (TVA 2011d). Section 5.5.2 contains a more detailed description of the impingement studies after WBN Unit 1 had started operating.

From March 15, 1996, through February 28, 1997, TVA researchers collected weekly screen-washing samples. A total of 36 samples were obtained after leaving the screens stationary for 24 hours to collect the samples, then rotating and backwashing them to remove the impinged fish. An additional 21 samples were collected from March 4 through September 30, 1997. As indicated in Table 4-10, 16 fish representing 8 species were collected during sampling from March 15, 1996 through February 28, 1997. A total of four fish from two species (three freshwater drum and one logperch) were impinged between March 4 and September 30, 1997. The study found the total annual estimated number of fish impinged during 1996-1997 and March to September 1997 to be 162.2 and 40.8, respectively (Baxter et al. 2010). The numbers of fish impinged were so low that the TDEC approved a request by TVA to discontinue sampling as a result of the extremely low numbers of fish impinged (Baxter et al. 2010).

Table 4-10. Actual and Estimated Numbers of Fish Impinged at Watts Bar Nuclear Plant During Sample Periods from March 1996 through March 1997 and During March 2010 through March 2011

	March 1996 – March 1997			March 2010 – March 2011		
Common Name	**Actual Number Impinged**	**Total Annual Estimated Number**	**Composition (%)**	**Actual Number Impinged**	**Total Annual Estimated Number**	**Composition (%)**
Gizzard shad	4	40.6	25	1,172	8,204	60.4
Threadfin shad	2	20.3	12.5	766	5,362	39.5
Freshwater drum	3	30.4	18.8	0	0	0
Channel catfish	1	10.1	6.3	0	0	0
Flathead catfish	1	10.1	6.3	0	0	0
Bluegill	2	20.3	12.5	0	0	0
Redear sunfish	1	10.1	6.3	0	0	0
White crappie	2	20.3	12.5	0	0	0
Inland silverside	0	0	0	1	7	0.1
Total	16	162.2	100	1,939	13,573	100

Source: Baxter et al. 2010; TVA 2011d

TVA conducted additional impingement studies at the IPS between March 26, 2010, and March 17, 2011 (TVA 2011d). TVA researchers collected weekly screen wash samples using the same procedures used in the 1996 to 1997 study. A total of 1,939 fish from 3 species were collected. Gizzard shad (60.4 percent) and threadfin shad (39.5 percent) accounted for almost all of the fish impinged. A single inland silverside, *Menidia beryllina*, was also found in the intake samples. Table 4-10 contains the results of the impingement study. The majority of the individuals were impinged (99.6 percent) between January and the first week of March (TVA 2011d). The increased number of gizzard and threadfin shad in the 2010 to 2011 impingement studies and the timing of the impingement (January through March) may be the result of stress and cold shock. A comparison of water temperature data shows that the daily water temperatures during December 2010 and January, February, and March 2011 averaged 0.78°C (1.4°F), 1.3°C (2.3°F), 0.83°C (1.5°F), and 1.8°C (3.2°F) lower, respectively, than the temperatures for the corresponding months in 1996 and 1997. In addition, the average daily water temperatures decreased 9.7°C (17.5°F) from November 2010 to January 2011 and 6.6°C (11.8°F) from November 1996 to January 1997. As discussed previously, shad are known to become moribund and lethargic when cold-stressed, although the thermal discharges from

WBN Unit 1 might provide a thermal refuge. Some of the impinged shad also may have originated in Watts Bar Reservoir and passed through the dam before becoming impinged on the IPS screens. As discussed previously for entrainment at the SCCW system, shad occur in large numbers in Watts Bar Reservoir. Shad also occur in large numbers in Chickamauga Reservoir and the number of shad impinged in the 2010–2011 study is small compared to the entire population.

The NRC staff concludes that impingement at the IPS, even with the operation of both units, would be too low to be readily detected in the reservoir populations and would not destabilize or noticeably alter the aquatic biota of the Chickamauga Reservoir. The NRC staff bases this decision on the velocity of water through the intake as compared to the velocity of reservoir water past the site, impingement data obtained from two different time periods during the operation of WBN Unit 1, and on the very low numbers of fish impinged, with the exception of shad, which were likely cold-stressed at the time of impingement.

4.3.2.3 Thermal Discharges

Thermal discharges raise the local temperature of the Tennessee River and cause adverse effects. Cessation of the thermal discharge can also cause cold shock when aquatic organisms that are acclimated to warm water experience a sudden decrease in temperature. The effects of the raised temperatures for each of the three thermal outfalls are discussed below, followed by a discussion of the potential for cold shock.

As discussed in Section 3.2.2, river water is pumped through the SCCW intake and the IPS to cool the steam that enters the condenser. Although most of the excess heat in the cooling water transfers to the atmosphere in the cooling tower by evaporation and conductive cooling, the water that does not evaporate or drift from the tower ends up in the cooling-tower basin. A portion of the water in the cooling-tower basin is returned to the river at a higher temperature than when it was originally removed. The water from the SCCW system continually enters and leaves the cooling-tower basins as discussed in Section 3.2.2. A portion is also removed, usually through the discharge diffusers.

Discharge of the excess heat presently occurs during operation of WBN Unit 1 and will increase with the addition of WBN Unit 2. Thermal discharges will continue to occur via the same three outfalls as described in Section 4.2.2.2 for WBN Unit 1. Table 3-4 provides the additional increment added for waste heat discharges to the river for both Outfall 113 (SCCW system shoreline discharge) and Outfall 101 (diffuser discharge) as a result of the additional operation of WBN Unit 2.

TVA has an NPDES permit for operation of both units (TDEC 2011, TVA 2011a). Table 4-1 shows the current NPDES temperature limits for the three outfalls. As Section 4.2.2.2 indicates, the permit also establishes an active mixing zone and defines in-stream monitoring and reporting requirements necessary to comply with effluent limitations.

SCCW System – Outfall 113

A description of Outfall 113 for the SCCW system discharges is given in Section 3.2.2.4. The SCCW system discharges water through a discharge structure originally constructed for the Watts Bar Fossil Plant.

As discussed in Section 5.1, TVA continuously monitors the temperature from the SCCW (Outfall 113) on the stream bottom to ensure it meets the permitted limit of 33.5°C (92.3°F) (TDEC 2011; TVA 2011a).

As discussed in Section 4.2.2.2, the NPDES permit specifies thermal limits for two different mixing zones for Outfall 113, which depends on the flow conditions in the Tennessee River. The active mixing zone applies when the turbines are operating at the Watts Bar Dam. During periods of normal release from Watts Bar Dam, the plume remains near the right descending bank. The passive mixing zone occurs when no water is flowing past the outfall. This zone extends to the full width of the river and 300 m (1,000 ft) downstream of the outfall (TDEC 2011).

TVA used a physical hydrothermal model test of the discharge to determine the passive mixing zone dimensions for the outfall to the SCCW (Outfall 113) as discussed in Section 4.2.2.2. To calibrate the model, TVA conducts two in-stream temperature surveys each year as required by the NPDES permit (TVA 2011a) and discussed in Section 4.2.2.2. TVA has confirmed the model output with actual measurements (McCall and Hopping 2005, McCall and Hopping 2006, McCall and Hopping 2007, Proctor and Hopping 2007). The model and measurements indicate that the plume rises after hitting the concrete pad located at the end of the discharge. The model results also predict the preservation of a zone of passage for fish along the bottom of the river, especially in the area of the navigation channel (Hopping 2004). Further, the model predicts the location of the plume from the SCCW discharge does not prohibit fish from swimming past the plant and that the plume would likely not reach the river’s mussel beds.

As discussed in Section 2.3.2.1, TVA moved freshwater mussels from an area measuring 46 m by 46 m (150 ft by 150 ft) at Outfall 113 to the mussel bed directly across the river, with the goal of preventing any potential adverse impacts on the mussels from operation of the SCCW system. In addition, TVA placed the ramp (mentioned previously) on the invert of the SCCW outfall to deflect the discharge (and accompanying thermal plume) upward, and away from the bottom of the river (Hopping 2004).

The analysis of in-stream data collected by TVA for Outfall 113 showed that the temperature rise in the vicinity of the upper mussel bed, on the opposite shore from the SCCW outfall, was approximately 0.3 to 1°C (0.5 to 2°F) in the summer at the 2 m (7 ft) depth, and approximately 1 to 1.6°C (2 to 3 °F) in the winter at the 2 m (7 ft) depth (McCall and Hopping 2005; McCall and Hopping 2006; McCall and Hopping 2007; Proctor and Hopping 2007; Ruth and Hopping 2010;

Ruth and Hopping 2011a; Ruth and Hopping 2011b; Saint and Hopping 2012a; Saint and Hopping 2012b; Saint and Hopping 2013). The mussels identified by the 2010 survey in this upper bed were in water 4.3 to 6.1 m (14 to 20 ft) deep (Third Rock Consultants 2010). Based on the low potential for thermal stress from the SCCW discharge at 4.3 m (14 ft) or greater, the WBN operations would not likely discernibly affect the health of mussels.

TVA (2011e) has characterized the attributes of the SCCW thermal plume as compared with ichthyoplankton distribution with studies during May and August 2010 when there were no releases from the dam. During these studies, TVA measured ichthyoplankton to describe the temporal and spatial distribution of fish eggs and larvae and their exposure rates to the thermal plume during the time that there are no releases from the dam. The survey in May was designed to coincide with the peak abundance of ichthyoplankton in the vicinity of the site. The August survey was designed to coincide with near maximum ambient water temperatures, even though at this time most of the fish eggs have hatched and the larvae no longer drift in the water column. Details of the study design are given in Section 5.5.

The maximum temperatures that were recorded during the May and August surveys (with no flow from the dam) were between 23.7 and 28.2°C (74.8 and 82.7°F). These temperatures are below the maximum seasonal temperatures established by the Tennessee State Water Quality Criteria (30.5°C [86.9°F]) for the protection of aquatic resources. Based on the ichthyoplankton taxa collected, thermal tolerance data, river temperatures, and exposure times, TVA (2011e) concluded "there is essentially no risk of thermal damage to ichthyoplankton during no-flow conditions" from the dam.

Discharge Diffusers – Outfall 101

TVA will continue to discharge cooling water from the main cooling water system for WBN Units 1 and 2 to Chickamauga Reservoir through a diffuser system located approximately 3.2 km (2 mi) below Watts Bar Dam at TRM 527.9 (TVA 2008a). The additional increment (1.1×10^8 Btu/hr for Outfall 113 and 2×10^7 Btu/hr for Outfall 101) is approximately 14 percent of the current amount of heat discharged.

To provide adequate dilution of the plant effluent, TVA permits the diffusers to discharge water only when Watts Bar Dam releases at least 99 m^3/s (3,500 cfs), as discussed in Section 3.2.2.3. This policy will remain the same when both units are operating. Furthermore, TVA continuously monitors the Outfall 101 temperature. If it reaches 35°C (95°F), a signal in the control room alerts operators of the condition, and they divert discharge to the YHP. As discussed previously in Section 4.2.2.2, these conditions have been reached in the late afternoon on hot summer days, and other actions such as increasing the flow of water from the dam can be used to prevent the diversion of the discharge.

The NRC staff's modeling of the plume, as discussed in Section 4.2.2.2, indicates that the location and design of the diffuser discharge would not impede fish passage up and down the river. Fish and other organisms likely would avoid the warmer water, but mussels and benthic organisms would not be able to avoid the elevated temperatures. Because the diffuser's plume angles upward at 45 degrees above horizontal in the downstream direction and the plume is buoyant because the water is warmer, the plume should not have much of an effect on the mussels and other benthic organisms in the area of or immediately downstream of the diffuser.

Outflow 102 – Emergency Yard Holding Pond

As indicated in Section 4.2.2.2, discharge from the emergency overflow (Outfall 102) is infrequent. The current NPDES permit also specifies a discharge temperature limit of 35°C (95°F) for Outfall 102.

Cold Shock

Thermal discharges also may affect aquatic biota by cold shock. Cold shock occurs when aquatic organisms that are acclimated to warm water (e.g., fish in a power plant's discharge canal are exposed to a sudden temperature decrease. This sometimes occurs when single-unit power plants shut down suddenly in winter. An NRC (1996) review found cold shock mortalities at nuclear power plants in the United States are relatively rare and typically involve small numbers of fish. Cold shock impacts occur less frequently at multiple-unit plants, because the temperature decrease from one unit shutting down moderates the heated discharge from the unit that continues to operate; thus, cold shock would be less likely after WBN Unit 2 begins operation. Cold shock is also less likely at plants like WBN because the water discharges to a river or reservoir where the volume of discharge is very small in comparison to the river flow.

Summary

The NRC staff concludes that any impact from additional thermal discharges from the operation of Unit 2 would be undetectable and would not destabilize or noticeably alter aquatic biota in the vicinity of the WBN site. This conclusion is based on the incremental rise in thermal discharge anticipated from Outfalls 101, 102, and 113 from operation of both WBN Units 1 and 2 (as regulated by the NPDES permit); TVA's modeling of the thermal plume; the data obtained from TVA hydrothermal studies of ichthyoplankton and their exposure to the SCCW thermal plume; the taxa of ichthyoplankton that would most be affected by the thermal plume; and the lack of an observed impact on the aquatic biota from current WBN Unit 1 operations.

4.3.2.4 Physical Changes Resulting from the Discharge

No impacts from scouring the bottom of the reservoir are anticipated on benthic organisms in the vicinity of, or immediately downstream of, the outfalls with the addition of WBN Unit 2. TVA indicates that water flow from the SCCW discharge would not increase, and the concrete structure at the discharge of the SCCW system (Outfall 113) continues to reduce the discharge's impact on the river bottom and direct the flow of water toward the river surface as it leaves the outfall (TVA 1998). As discussed in Section 3.2.2.4, using a diffuser that discharges at an angle of 45 degrees above horizontal in the downstream direction for Outfall 101 minimizes the amount of scouring discharge from this outfall. The plant has very infrequently used Outfall 102, which discharges emergency outflow from the YHP. This outfall discharges into a local stream channel that empties into the Chickamauga Reservoir at TRM 527.2 (TVA 2008a). The NRC staff has determined that physical changes such as scouring the bottom of the reservoir, at the outfalls as a result of the additional operation of Unit 2 would not affect the aquatic biota of Watts Bar Reservoir.

4.3.2.5 Chemical Discharges

Another discharge-related stressor involves chemically treated cooling water. As discussed in Section 3.2.4, the plant would control water chemistry for various plant water uses by adding biocides, algaecides, corrosion inhibitors, pH buffering, scale inhibitors, and dispersants. Table 3-2 lists chemicals and their discharge quantities included in the WBN site's NPDES permit request submitted on April 2009 (TVA 2009b). The NPDES permit issued for both WBN Unit 1 and WBN Unit 2 (TDEC 2011; TVA 2011b) provides additional detail about the chemicals that may be in water discharged through the outfalls as discussed in Section 3.3.2.1.

According to NPDES permit requirements, TVA conducts biotoxicity tests (3-brood *Ceriodaphnia dubia* survival and reproduction tests and 7-day fathead minnow [*Pimephales promelas*] larval survival and growth tests) on samples of final effluent from Outfalls 101, 102, 112, and 113. The NRC staff reviewed 12 years of toxicity testing data (TVA 2010b). The data showed that percentage survival in the highest concentration tested for 96-hour survival was a mean of 92.8 percent for Outfall 101 and 99 percent survival for Outfall 113. Compliance with the NPDES permit requirements should assure that the aquatic biota of Chickamauga Reservoir would not be affected further by chemical discharges resulting from the additional operation of WBN Unit 2.

4.3.2.6 Threatened and Endangered Species

The NRC staff used occurrence data and habitat information on aquatic organisms as discussed in Section 2.3.2.2 to determine which of the Federally threatened and endangered species occurring in the vicinity of the WBN plant could be adversely affected from operations of Unit 2. These species are the Eastern fanshell pearlymussel (*Cyprogenia stegaria*), the dromedary pearlymussel (*Dromus dromas*), the pink mucket mussel (*Lampsilis abrupta*), the orangefoot pimpleback (*Plethobasus cooperianus*), and the rough pigtoe (*Pleurobema plenum*).

Although adult mussels are not susceptible to entrainment or impingement by the IPS, the fish host onto which the glochidia implants can be entrained and impinged. The hosts for the rough pigtoe and the orange pimpleback are unknown. The hosts for the pink mucket include smallmouth, spotted, and largemouth bass (*Micropterus* spp.), as well as freshwater drum and sauger. None of these species was heavily represented in either entrainment or impingement studies and, as a result, the NRC staff considers it unlikely that entrainment or impingement due to operation of WBN Unit 2 would affect the population of pick mucket. A variety of darters and sculpins are hosts to the Eastern fanshell pearlymussel and the dromedary pearlymussel. The logperch (*Percina caprodes*), which is a host for the Eastern fanshell, has been found in the vicinity of the site. The other host fish for these two mussel species are not known to be present (based on sampling studies as far back as 1975).

As discussed previously, in an effort to limit detrimental effects to mussels in the vicinity of the SCCW discharge, a mussel relocation zone was established that extended 46 m (150 ft) from the right bank and 23 m (75 ft) upstream and downstream of the centerline of Outfall 113. TVA moved the mussels located in the relocation zone to a site on the opposite side of the river at TRM 528 to 528.9 (Harper and Smith 1999). The temperatures in the mussel relocation zone cannot exceed 33.5°C (92.3°F). In addition, TVA placed a ramp on the invert of the SCCW outlet to deflect the discharge upward and away from the bottom of the river (Hopping 2004). The diffuser from Outfall 101 is angled upwards at 45 degrees to keep the plume from staying on the bottom of the river where the benthic organisms could be affected.

Based on this information, the NRC staff concludes that the impact on threatened and endangered species from entrainment, impingement, and thermal, physical, and chemical discharge operations of WBN Unit 2 would be minimal. A biological assessment of potential adverse effects on the Federally listed species is located in Appendix F.

4.3.2.7 Aquatic Resource Summary

Based on the NRC's independent review of information since the 1978 FES-OL, the NRC staff concludes that the overall impacts on aquatic biota, including Federally listed threatened and endangered species, from impingement and entrainment at the SCCW and IPS intakes and from thermal, physical, and chemical discharges as a result of operating Unit 2 on the WBN site would be SMALL.

4.4 Socioeconomic Impacts

This section describes socioeconomic impacts on nearby communities from operating WBN Unit 2 and from activities and demands of the operating workforce on the surrounding region. Socioeconomic impacts include potential impacts on individual communities, the surrounding region, and minority and low-income populations.

4.4.1 Physical Impacts of Station Operation

Potential physical impacts of WBN Unit 2 plant operations that could affect socioeconomic conditions in the region include noise, odors, exhausts, thermal emissions, and visual intrusions. The 1978 FES-OL and the 1995 SFES-OL-1 (NRC 1978, 1995) did not address physical impacts. Because WBN Unit 1 is already operating at the WBN site, the incremental addition of physical impacts (e.g., noise, odors, exhausts) from WBN Unit 2 plant operations would not noticeably change the overall impact on the region around the site.

4.4.2 Social and Economic Impacts of Station Operation

Social and economic impacts are defined in terms of changes to the demographic and economic characteristics and social conditions of a region. For example, the number of jobs created by the operation of a new nuclear power plant could affect regional employment, income, and expenditures. Power plant operations jobs have a greater potential for permanent, long-term socioeconomic impacts.

The 1978 FES-OL and the 1995 SFES-OL-1 addressed socioeconomic impacts from operating both WBN Units 1 and 2 and both assessments concluded that no significant impacts would occur from plant operations. Since that time, the region around WBN Units 1 and 2 has experienced economic growth and increases in population and housing. The regional road network and public school systems have also grown. This section assesses the social and economic impact of WBN Unit 2 plant operations on the surrounding region.

The 1978 FES-OL projected that the onsite workforce for both operating units would be 200 workers (NRC 1978). The 1995 SFES-OL-1 estimated a total onsite workforce of about 1,300 workers, including 450 workers associated with WBN Unit 2 (NRC 1995). TVA currently expects to employ 200 workers to operate WBN Unit 2, which is the same number projected in the 1978 FES-OL (NRC 1978). This would be in addition to the 700 TVA personnel and 1,360 construction workers (PNNL 2009) currently employed at the WBN site (TVA 2008a, 2010c). The overall level of employment, while larger than originally predicted in the 1978 FES-OL, would be less than total current employment at the WBN site.

4.4.2.1 Demography

Approximately 200 workers would be required to operate WBN Unit 2 (TVA 2008a). Based on the demographic history of the WBN site, the 200 additional employees could result in a regional population increase of about 520 persons, assuming all 200 operations workers and their families relocate into the Watts Bar area (TVA 1987, 2010c). This would be a small increase in the overall regional population and would represent less than a 1 percent increase in the overall population of Rhea, McMinn, Meigs, and Roane counties. Even if all of the WBN Unit 2 workforce and their families were to reside in Rhea County, they would only represent a

1.6 percent increase in Rhea County's population. Based on this information, operating WBN Unit 2 would result in no noticeable change in demographic conditions in the socioeconomic region of influence (ROI).

The 1978 FES-OL and the 1995 SFES-OL-1 described the impacts of "large-scale" employment changes at the WBN site on regional population in the surrounding the WBN site. The 1978 FES-OL predicted significant changes on the region surrounding the WBN site because the regional population was smaller at the time of analysis. The 1995 SFES-OL-1 also predicted significant changes in the region, this time because the projected number of operations workers was greater than the estimated 200 workers needed to support WBN Unit 2 operations today.

4.4.2.2 Housing

Once construction is complete, TVA would require approximately 200 workers to operate WBN Unit 2 (TVA 2008a). Even if all WBN Unit 2 employees choose to reside in Rhea County, a sufficient supply of housing exists to meet housing needs (see Table 2-23). In addition, the number of available housing units has kept pace with population growth in the area. Based on this information, there would be little or no noticeable effect on the availability and cost of housing in the region. The 1978 FES-OL predicted significant housing impacts in the region surrounding the WBN site because of the limited availability of housing at the time of analysis. The 1995 SFES-OL-1 also predicted significant housing impacts, this time because the projected number of operations workers was greater than the estimated 200 workers needed to support WBN Unit 2 operations today.

4.4.2.3 Public Services

The impacts of WBN Unit 2 operation on regional public services, such as public water systems and wastewater-treatment facilities, depend on the demand and current and projected capacities of these systems as described in Section 2.4. The expected increase in demand for these public services from the operation of WBN Unit 2 would be proportional to the increase in operations workers at the WBN site. Because these systems are currently operating with excess capacity and the size of the WBN Unit 2 operations workforce is small (approximately 200 workers), there would be little or no noticeable public water system services impacts from operating WBN Unit 2. The 1978 FES-OL and the 1995 SFES-OL-1 did not address the impacts on public services from WBN Units 1 and 2 operations.

4.4.2.4 Education

Many schools in Rhea and Meigs counties are currently operating at capacity (see Section 2.4.2.3). As discussed in Section 4.4.2.1, 200 additional WBN Unit 2 operations workers could result in an overall regional population increase of about 520 persons (including families), approximately 220 of which could be school-aged children (TVA 1987, 2010b). This influx of students would represent a 1 percent increase in the total number of enrolled students in the four-county ROI (approximately 23,000 students in 2011) (NCES 2012a, b, c, d). The increase in the number of school-aged children in the four-county socioeconomic ROI could strain crowded public schools in Rhea and Meigs counties. However, the 1978 FES-OL predicted significant impacts on the regional public school systems in the region surrounding the WBN site because there were fewer schools in the region at the time of analysis. In addition, the 1995 SFES-OL-1 predicted significant impacts on the regional public school systems because it estimated a greater number of operations workers than the estimated 200 operations workers needed to support WBN Unit 2 today.

Any impacts (e.g., need for additional teachers and classrooms) could be mitigated in part through tax-equivalency payments paid by TVA to these regions as part of the WBN Unit 2 construction effort, which allows payment to go directly to counties designated as “impacted” (see Section 4.4.2.7 for more detail). Because these tax-equivalency payments would continue for 3 years after completion of the construction project, these payments could be used to mitigate impacts associated with the operation of WBN Unit 2.

4.4.2.5 Transportation

Operating WBN Unit 2 would result in 200 additional operations workers commuting to the WBN site. Workers access the WBN site from Tennessee State Route 68 (TN-68), which connects with U.S. Highway 27 (US-27) to the west and TN-302, TN-58, and Interstate 75 to the east (see Figure 2-2). Since the publication of 1978 FES-OL and 1995 SFES-OL-1, US-27 was expanded from a two-lane highway to a four-lane highway. Workers enter the site from both the east (Meigs County) and west (Rhea County) on TN-68. Because of the excess capacity and good condition of TN-68, operating WBN Unit 2 would have little or no noticeable effect on traffic volumes on the regional road network. The 1978 FES-OL and the 1995 SFES-OL-1 did not address transportation impacts.

4.4.2.6 Aesthetics and Recreation

The WBN site, intake and outfall structures, cooling towers, and Units 1 and 2 containment domes are visible from the Watts Bar and Chickamauga reservoirs near the site. This view would remain unchanged with the operation of WBN Unit 2. However, WBN Unit 2 operations would increase the size and volume of vapor plumes released from the site. Residents would notice the plumes mostly in winter months. Section 3.2.2.2 of this supplemental final environmental statement (SFES) describes these impacts in more detail. Because TVA built the plant and the transmission lines as planned, there would be no aesthetics impacts from operating WBN Unit 2 beyond those currently experienced with the operation of WBN Unit 1.

Chickamauga and Watts Bar reservoirs near the WBN site provide numerous recreational boating, swimming, and fishing opportunities in the area. A well-used boat ramp is located directly across Chickamauga Reservoir from the WBN plant. Because these activities currently are taking place, seemingly unhindered by the activities associated with WBN Unit 1 operation, they would continue unhindered if Unit 2 were in operation.

4.4.2.7 Economy and Tax Revenues

Socioeconomic impacts on the local and regional economy would depend on the number of new jobs, income, and tax revenue generated by WBN Unit 2 operations. The degree of impact would also depend on current socioeconomic conditions in the socioeconomic ROI around the WBN site as described in Section 2.4. The impacts from additional jobs would be sustained throughout the operating lifetime of the plant. The operation of WBN Unit 2 may increase the size of the refueling outage workforce.

Due to the relatively small workforce, the overall impact on the regional economy from WBN Unit 2 operations would be somewhat small. The demographic impact of workers and their families relocating to the region would represent less than a 1 percent increase in the overall population of the four-county socioeconomic ROI.

Under Section 13 of the Tennessee Valley Authority Act of 1933, TVA makes tax-equivalent payments to the State of Tennessee. The Act determines the amount TVA pays based on 50 percent of the book value of its property in Tennessee and 50 percent of the value of its State power sales. In turn, the State redistributes 48.5 percent of the increase in payments to local governments. It bases payments to counties on relative population (30 percent of the total), total acreage in the county (30 percent), and TVA-owned acreage in the county (10 percent). The State pays the remaining 30 percent to cities, based on population. Based on this calculation methodology, TVA estimates the annual increase in tax-equivalent revenues attributable to WBN Unit 2 to be approximately $4.5 million paid to the State of Tennessee. The State would redistribute this increase, in part, to local governments, resulting in a small increase in payments to Rhea and Meigs counties. Because the net distribution of tax-equivalent revenues to Rhea and Meigs counties are based on the total WBN site acreage, which is not changing, and the county populations, which are not expected to change significantly, the amounts paid to both Rhea and Meigs counties would increase in proportion with the overall increase in the State-allocated tax payments throughout the license period of WBN Unit 2. In addition to the TVA-generated tax-equivalent revenues, individuals employed during plant operation would generate sales and property tax revenues in the area. The magnitude of these increases could vary greatly, depending on the buying decisions of workers employed at the site.

The State of Tennessee sets aside 3 percent of TVA total annual tax-equivalent payments for distribution to counties that TVA designates as “impacted” by construction of facilities used to produce electric power. The State uses these impact payments to assist counties with the temporary increase in local population during the construction period. The counties of Rhea, Meigs, McMinn, Roane, and Monroe, as well as the cities within these counties, all receive impact payments related to the construction of WBN Unit 2. The State distributes impact payment allotments to county and city locations based upon expected population impacts. The payments will continue, at a decreasing rate, for 3 additional years after construction is complete. In fiscal year 2009, Rhea and Meigs counties each received impact payments from TVA of approximately $680,000, McMinn and Roane counties each received approximately $170,000, and Monroe County received $136,000. These payments are in addition to the TVA tax-equivalent funds distributed by the State to local governments (TVA 2009c).

The larger economic bases of Hamilton, Knox, Roane, and McMinn counties would diffuse the magnitude of the economic impacts. Economic impacts could be more noticeable in the smaller economic bases of Rhea and Meigs counties.

4.4.2.8 Social and Economic Impacts of Station Operation Summary

No new and significant socioeconomic information was identified during the NRC staff's review. Therefore, based on the its independent review of information provided, the NRC staff concludes the overall socioeconomic impact of operating WBA Unit 2 will be the same as those identified in the 1978 FES-OL.

4.4.3 Environmental Justice Impacts

The NRC staff addressed environmental justice matters through (1) identification of minority and low-income populations that may be affected by the proposed operation of WBN Unit 2, and (2) examination of any potential human health or environmental effects on these populations to determine if these effects may be disproportionately high and adverse. Section 2.4.3 of this SFES identifies the locations of minority and low-income block groups within the 80-km (50-mi) region of the WBN site. This area of impact is consistent with the impact analysis for public and occupational health and safety, which also considers the radiological effects on populations located within an 80-km (50-mi) radius of WBN Unit 2.

4.4.3.1 Analysis of Impacts

Radiation doses from operations associated with WBN Unit 2 are expected to similar to those of WBN Unit 1, as discussed in Section 4.6 of this SFES. Based on the analysis of environmental health and safety impacts presented in Chapter 4 of this SFES for other resource areas, there would be no disproportionately high and adverse impacts on minority and low-income populations from the operation of WBN Unit 2 during the license period. The NRC staff also analyzed the risk of radiological exposure through the consumption patterns of the special pathway receptors, including subsistence consumption of fish, native vegetation, surface waters, sediments, and local produce; absorption of contaminants in sediments through the skin; and inhalation of plant materials. The special pathway receptors analysis is important to the environmental justice analysis because consumption patterns may reflect the traditional or cultural practices of minority and low-income populations in the area.

4.4.3.2 Subsistence and Consumptive Practices

Section 4-4 of Executive Order 12898 (59 FR 7629) as amended by Executive Order 12948 (60 FR 6381) directs Federal agencies, whenever practical and appropriate, to collect and analyze information about the consumption patterns of populations who rely principally on fish and wildlife for subsistence and to communicate the risks of these consumption patterns to the public. The NRC staff considered whether any means existed for minority or low-income populations to be disproportionately affected by examining impacts on American Indian, Hispanic, and other traditional lifestyle special pathway receptors. Special pathways that took into account the levels of contaminants in native vegetation, crops, soils and sediments, surface water, fish, and game animals in the vicinity of WBN were considered.

The public and biota would receive radiation dose from a nuclear unit via the liquid effluent, gaseous effluent, and direct radiation pathways. As discussed in Section 4.6.1, TVA updated the estimated potential exposures to the public by evaluating exposure pathways typical of those surrounding a nuclear unit at the WBN site. For the liquid effluent release pathway (i.e., releases to the Chickamauga Reservoir and the Tennessee River), TVA considered the following exposure pathways in evaluating the dose to the maximally exposed individual (MEI): ingestion of aquatic food (i.e., fish), ingestion of water, and direct radiation exposure from shoreline activities. The analysis for population dose considered the following exposure pathways: ingestion of aquatic food and water. For the gaseous effluent release pathway, TVA considered the following pathways in evaluating the dose to the MEI; external exposure due to noble gases, internal doses from particulates due to inhalation, and the ingestion of milk, meat, and vegetables produced around the WBN site.

TVA used a code developed in-house to calculate the liquid effluent pathway and the NRC staff performed an independent analysis using the LADTAP II computer program (Strenge et al. 1986). Both found doses to total body and maximum organ from liquid effluents to be well within the design objectives of Title 10 of the Code of Federal Regulations (CFR) Part 50, Appendix I. TVA used a code developed in-house to calculate doses at the exclusion area boundary from gaseous effluents. NRC staff confirmed these results using the GASPAR II computer program (Strenge et al. 1987) (see Section 4.6 for more information on the use of these codes). Both found doses from gaseous effluences to be well within the design objectives of 10 CFR Part 50, Appendix I.

As discussed in Section 4.6.4 of this SFES, the NRC staff calculated doses to the biota, including fish, invertebrate, algae, muskrat, raccoon, herons, and ducks. Doses to biota were calculated for liquid effluents, using personal computer versions of the LADTAP II and

GASPAR II (Strenge et al. 1986, 1987) that are integrated into the NRCDose program (Chesapeake Nuclear Services, Inc. 2006). The results are within the guidelines discussed in Section 4.6.4 for protection of biota (IAEA 1992; NCRP 1991).

As discussed in Section 5.2, the results of the sampling demonstrate that the operation of WBN Unit 2 would have no significant or measurable radiological impact on the environment. No elevated radiation levels were detected. Consequently, no disproportionately high and adverse human health impacts would be expected in special pathway receptor populations in the region as a result of subsistence consumption of fish and wildlife. As previously discussed for the other resource areas in Chapter 4, the analyses of impacts for all environmental resource areas indicated that the impact from WBN Unit 2 operations would be SMALL. The 1978 FES-OL did not specifically address environmental justice impacts from station operation, because Executive Orders 12898 and 12948 (59 FR 7629 and 60 FR 6381), which direct Federal agencies to explicitly address impacts related to environmental justice, had not yet been written.

4.5 Historic and Cultural Resources

In accordance with 36 CFR 800.8(c), the NRC staff elected to use the National Environmental Policy Act, as amended (NEPA), process to comply with the obligations found under Section 106 of the National Historic Preservation Act, as amended (NHPA). The NRC staff determined the Area of Potential Effect (APE) for this operating licensing action to be the area at the power plant site and the immediate environs that may be affected by operating WBN Unit 2. TVA will restrict all new construction to the existing, previously built portion of the WBN plant property (TVA 2006).

This section provides the NRC staff assessment of effects from the proposed action for WBN Unit 2. For specific historic and cultural information around the WBN site, see Section 2.5.3. In a 2006 letter to the Tennessee Historical Commission, TVA noted that site construction activities and existing facilities had previously disturbed the majority of the APE for this undertaking (TVA 2006). As explained in Section 2.5.3, previous TVA cultural resource surveys indicated the presence of one archaeological site (40RH6) within the APE. Archaeologists have studied the site since the 1970s construction of WBN Units 1 and 2. The University of Tennessee in Knoxville partially excavated the site, a mound complex, in 1971 to mitigate construction activities (Calabrese 1976).

TVA does not know if intact portions of 40RH6 exist at this location. TVA prefers to avoid ground-disturbing activity in the buffer area established around 40RH6 (TVA 2006). TVA will restrict all new construction to the existing previously built portion of the WBN Units 1 and 2 site.

TVA did not identify any historic structures in the APE for this operating licensing action for WBN Unit 2. The recently demolished Watts Bar Fossil Plant was located adjacent to the APE, and the State Historic Preservation Office/Officer (SHPO) considered it eligible for listing in the National Register of Historic Places (TVA 2006) before it was demolished in December 2011

(TVA 2012c). TVA worked with the Tennessee SHPO to resolve the adverse effects as a result of the demolition activities of the Watts Bar Fossil Plant (TVA 2011f).

TVA determined in a letter dated December 28, 2006, that operating WBN Unit 2 does not have the potential to affect historic structures (TVA 2006). On January 4, 2007, the Tennessee Historical Commission responded to TVA and concurred that operating WBN Unit 2 will not affect any National Register of Historic Places listed or eligible properties (THC 2007).

On March 5, 2010, the NRC staff received a letter from the Tennessee Historical Commission (THC 2010) stating, "there are no National Register of Historic Places listed or eligible properties affected by this undertaking, thus completing the Section 106 consultation with the Tennessee Historical Commission for the WBN Unit 2 operating license action." The Eastern Band of Cherokee Indians informed the NRC staff that the Tribe would like to act as a consulting party for this Section 106 undertaking as mandated under 36 CFR Part 800. The NRC staff followed up via email and phone and did not receive additional comments from the Tribe. No additional cultural resources information was identified by seeking comments on the draft SFES or through public meetings held on December 8, 2011. The consultation process is complete.

During operation and maintenance of WBN Unit 2, TVA will identify actions to be taken if historic or cultural resources are encountered during operation or maintenance activities on the WBN site. TVA has operated using BMPs in managing cultural resources since Congress created the agency in 1933 (TVA 2009d).

Because the 1978 FES-OL did not address impacts on historic and cultural resources, the NRC staff analyzed them in this document to meet NEPA and NHPA requirements, as well as the requirements of the Archaeological Resources Protection Act, the Archaeological and Historic Preservation Act, the American Antiquities Act, American Indian Religious Freedom Act, and the Native American Graves Protection and Repatriation Act.

With respect to the NHPA 106 consultation, based on the (1) historic and cultural resources located within the APE, (2) Tennessee Historical Commission's concurrence with the TVA and the NRC staff determinations that no National Register of Historic Places listed or eligible properties would be affected by this undertaking, (3) the TVA existing best practice measures related to managing cultural resources, and (4) the NRC staff cultural resource analysis and consultation, the NRC staff concludes a finding of no historic properties affected (36 CFR Section 800.4(d)(1)).

With respect to the NRC staff's NEPA analysis, the NRC staff concludes that potential impacts on historic and cultural resources related to operating WBN Unit 2 would be SMALL. This finding is based on the (1) historic and cultural resources located within the APE, (2) Tennessee Historical Commission's concurrence with the TVA and the NRC staff determinations that no National Register of Historic Places listed or eligible properties would be affected by this undertaking, (3) the TVA existing best measures related to managing cultural resources, and (4) the NRC staff's cultural resource analysis and consultation.

4.6 Radiological Impacts of Normal Operations

This section discusses the radiological impacts of normal operations of Unit 2 on the WBN site, including the estimated radiation dose to members of the public and to the biota inhabiting the area around the WBN Unit 2. It also discusses estimated doses to workers at the proposed unit. Appendix I of this SFES contains a detailed discussion of the NRC staff's calculations and analysis.

4.6.1 Exposure Pathways

The public and biota would receive radiation dose from a nuclear unit via the liquid effluent, gaseous effluent, and direct radiation pathways. TVA updated the potential exposures to the public by evaluating exposure pathways typical of those surrounding a nuclear unit at the WBN site. As a result of their review, TVA adjusted several of the pathways from the 1972 FES-CP (TVA 2008a).

For the radioactive liquid effluent release pathway (e.g., releases to the Chickamauga Reservoir and the Tennessee River), TVA considered the following exposure pathways in evaluating the dose to a member of the public considered to be the MEI: ingestion of aquatic food (e.g., fish), ingestion of water, and direct radiation exposure from shoreline activities. The analysis for population dose considered the following exposure pathways: ingestion of aquatic food and water (Figure 4-2). TVA originally considered the swimming and boating pathway in its 1972 FES-CP. However, TVA no longer considers these pathways because doses from these pathways are orders of magnitude lower than the dose reviewed from shoreline recreation (TVA 2008a). For the radioactive gaseous effluent release pathway, TVA considered the following pathways in evaluating the dose to the MEI: external exposure due to noble gases, internal doses from particulates due to inhalation, and the ingestion of milk, meat, and vegetables produced around the WBN site. TVA (TVA 2008a) calculated population doses using the same exposure pathways as used for the individual dose assessment.

For the evaluation of the potential radiological impacts to aquatic biota, the NRC staff performed an independent assessment using the pathways shown in Figure 4-3 and included:

- ingestion of aquatic foods
- ingestion of water
- external exposure from water immersion or surface effect
- inhalation of airborne radionuclides
- external exposure to immersion in gaseous effluent plumes
- surface exposure from deposition of iodine and particulates from gaseous effluents (NRC 1977).

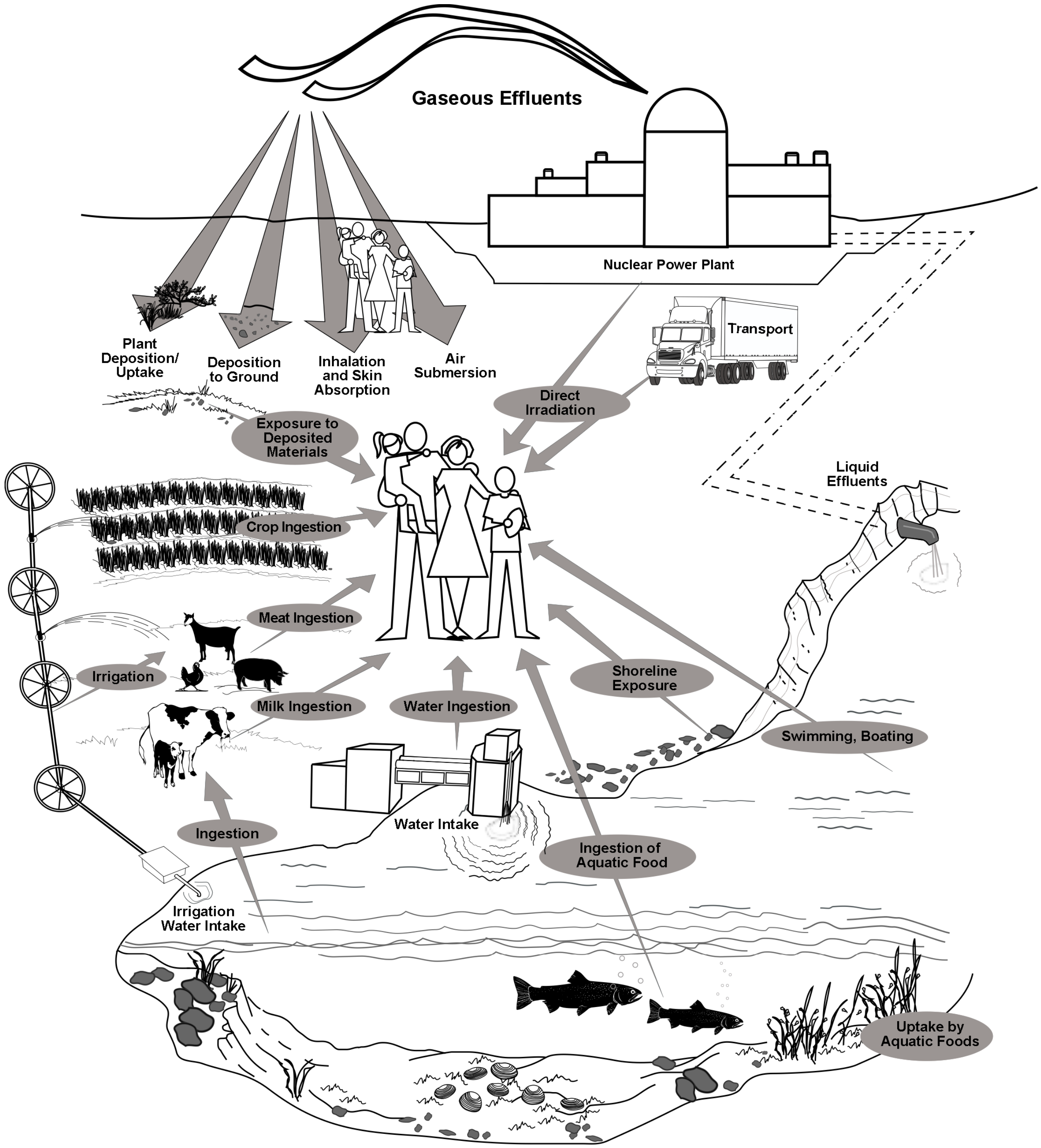


Figure 4-2. Exposure Pathways to Man (adapted from Soldat et al. 1974)

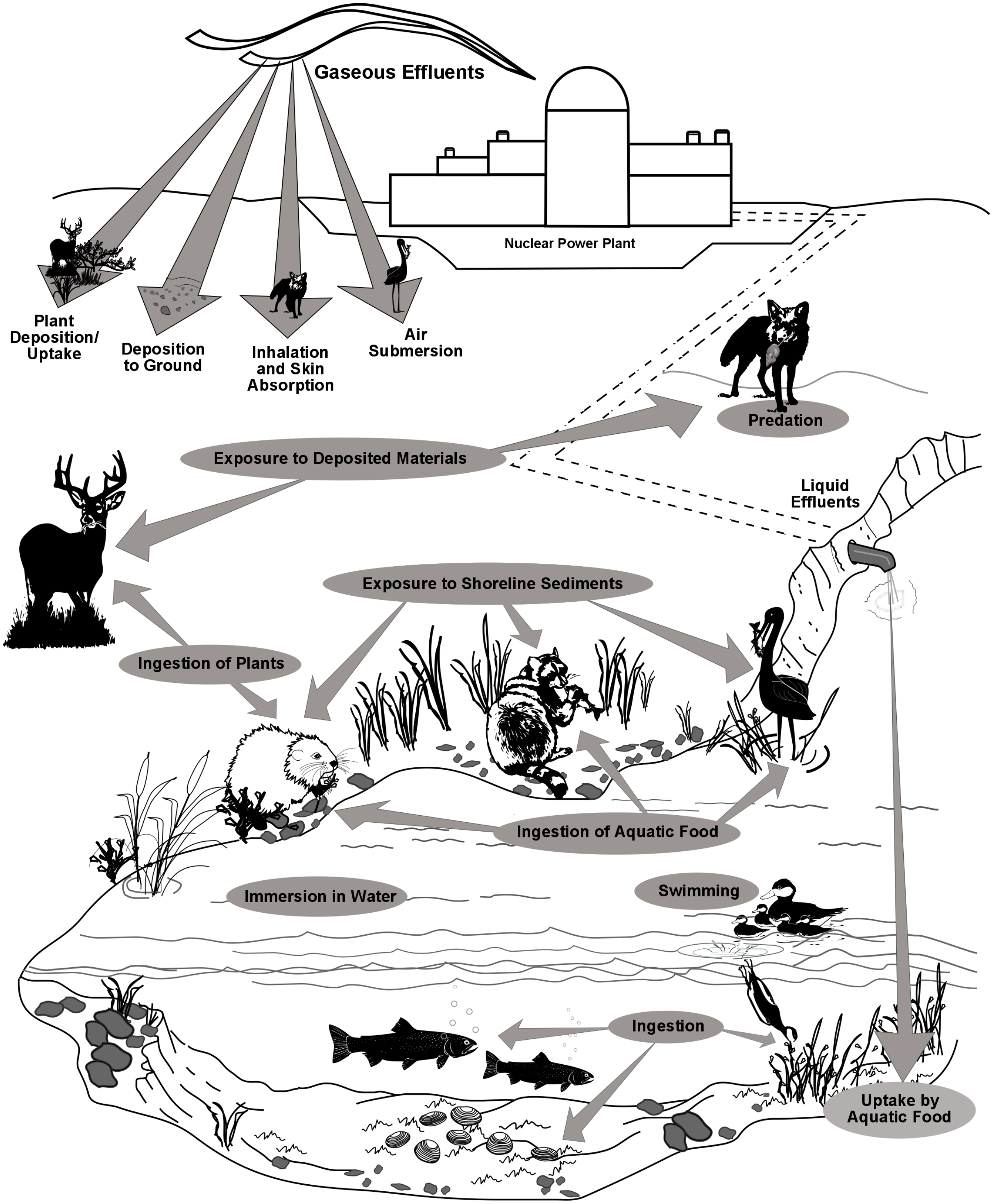


Figure 4-3. Exposure Pathways to Biota Other Than Man (adapted from Soldat et al. 1974)

For the evaluation of the potential radiological impacts to the public, the NRC staff reviewed the exposure pathways the TVA ER (TVA 2008a) identified for the public and found them to be appropriate, based on a documentation review, a tour of environs, and interviews with TVA staff and contractors during the site visit in October 2009.

TVA did not discuss dose to the MEI or dose to the population from direct radiation in the TVA ER (TVA 2008a). The NRC staff reviewed the data in the *Watts Bar Nuclear Plant Annual Radiological Environmental Operating Report* and the *Annual Radioactive Effluent Release Report* for the most recent reports available to the NRC staff during this evaluation (TVA 2011g, h), and agrees with the conclusion from the environmental operating report that "there is no indication that WBN activities increased the background radiation levels normally observed in the areas surrounding the plant." Based on WBN Unit 2 being similar in design to WBN Unit 1, the NRC staff determined that direct radiation from WBN Unit 2 does not warrant consideration in the dose to the public.

4.6.1.1 Liquid Effluent Pathway

TVA used a code developed in-house to calculate the liquid effluent pathway using the models presented in NUREG-0133 (NRC 1996) and Regulatory Guide 1.109, Revision 1 (NRC 1977) rather than using the LADTAP II computer program (Strenge et al. 1986). Table 3-16 of the TVA ER shows the source term for the liquid effluent releases TVA used in its dose estimates (TVA 2008a). Other parameters TVA used as inputs to the program include effluent discharge rate; 80-km (50-mi) populations; transit times to receptors; shoreline, swimming, and boating usage; and liquid pathway consumption and usage factors (e.g., sport fish consumption). These inputs come from various references, including the TVA ER, Offsite Dose Calculation Manual, responses to staff's requests for additional information (RAIs) (TVA 2011i, j) and Final Safety Analysis Report (TVA 2008a, 2009a). A number of assumptions in the TVA ER are different from the 1972 FES-CP. These differences are (1) the calculation of doses to kidney and lung; (2) river water use (i.e., ingestion, fish harvest, updated recreational use); (3) revised decay time between the source and consumption; (4) population dose area (within an 80-km [50-mi] radius of WBN); and (5) population data (updated and projected through the year 2040). Table 4-11 summarizes the results from the TVA assessment.

The code TVA used for calculating dose to the MEI for liquid effluents was not provided to the NRC staff, and therefore, was not reviewed. The NRC staff performed an independent analysis using the LADTAP II computer program for calculating dose to the MEI for liquid effluent releases.

The NRC staff's independent dose assessment to the MEI and the population dose were slightly higher for total body and maximum organ when compared to TVA estimates; however, all doses were below the dose design objective specified in 10 CFR 50, Appendix I. Appendix I of this SFES contains the results of the NRC staff's independent review.

Table 4-11. TVA Calculated Annual Doses to the Maximally Exposed Individual for Liquid Effluent Releases from WBN Unit 2

Age Group	Total Body (mrem/yr)	Maximum Organ (mrem/yr)	Thyroid (mrem/yr)
Adult	0.72	0.96 (liver)	0.88
Teen	0.44	1 (liver)	0.8
Child	0.188	0.92 (thyroid)	0.92
Infant	0.032	0.264 (thyroid)	0.264

Source: TVA 2008a. Table 3.17
To convert mrem/yr to mSv/yr, multiply by 0.01 mSv/mrem.

The results from the TVA analysis in the TVA ER, the NRC staff's analysis in the 1995 SFES-OL-1, and the NRC staff's current analysis are consistent.

4.6.1.2 Gaseous Effluent Pathway

Rather than using the GASPARII computer program (Strenge et al. 1987), TVA used a code developed in-house to calculate the gaseous effluent pathway at the nearest residence and the exclusion area boundary using the models presented in NUREG-0133 (NRC 1996) and Regulatory Guide 1.109, Revision 1 (NRC 1977). TVA considered the following activities in the dose calculations: (1) external doses from noble gases, (2) inhalation of gases and particulates, (3) ingestion of meat from animals eating contaminated grass, (4) ingestion of cow milk, and (5) ingestion of garden vegetables contaminated by gases and particulates (TVA 2008a). TVA (2011h) provided a revised TVA ER Table 3-20 that shows the total gaseous effluent releases used in the estimate of dose to the MEI and population.

The NRC recognizes the GASPAR II computer program (Strenge et al. 1987) as an appropriate tool for calculating dose to the MEI and population from gaseous effluent releases and performed independent analysis using this computer program. The NRC staff reviewed the input parameters and values TVA used and concluded that the assumed input parameters and values TVA used were generally appropriate. The NRC staff performed an independent evaluation of the gaseous pathway doses and obtained similar results for the MEI (see Appendix I for details). The results from the TVA analysis in the TVA ER, the NRC staff's analysis in the 1995 SFES-OL-1, and the NRC staff's current analysis are consistent.

4.6.2 Impacts to Members of the Public

This section describes the NRC staff's evaluation of the estimated impacts from radiological releases and direct radiation from WBN Unit 2. The evaluation addresses dose from operations to the MEI located at the WBN site and the population dose (collective dose) to the population within 80 km (50 mi) of the WBN site.

4.6.2.1 Maximally Exposed Individual

The TVA ER states that total body and organ dose estimates to the MEI from liquid and gaseous effluents for WBN Unit 2 would be within the design objectives of 10 CFR Part 50, Appendix I. Appendix I provides the design objectives for keeping levels of radioactive material in effluents to unrestricted areas (i.e., areas beyond the site boundary) as low as practicable. The NRC also uses a statement “as low as is reasonable achievable” (ALARA), defined as making every reasonable effort to maintain exposures to radiation as far below the dose limits as is practicable. Table 4-12 compares the TVA dose estimates for WBN Unit 2 to the Appendix I design objectives. The NRC staff completed an independent evaluation of compliance with 10 CFR Part 50, Appendix I design objectives and found similar results, as shown in Appendix I of this SFES.

Table 4-12. Comparisons of MEI Annual Dose Estimates from Liquid and Gaseous Effluents to 10 CFR Part 50, Appendix I Design Objectives

Radionuclide Releases/Dose	TVA Assessment	Appendix I Design Objectives
Gaseous effluents (noble gases only)		
Beta air dose (mrad/yr)	2.71	20
Gamma air dose (mrad/yr)	0.8	10
Total body dose (mrem/yr)	0.571	5
Skin dose (mrem/yr)	1.54	15
Gaseous effluents (radioiodines and particulates)		
Organ dose(bone) (mrem/yr)	9.15	15
Liquid effluents		
Total body dose (mrem/yr)	0.72	3
Maximum organ dose (liver; mrem/yr)	0.96	10

Source: TVA 2011i
To convert mrad/yr to mGy/yr, multiply by 0.01 mGy/mrad.
To convert mrem/yr to mSv/yr, multiply by 0.01 mSv/mrem.

The TVA ER compares the combined dose estimates from direct radiation and gaseous and liquid effluents from the existing WBN Unit 1 and new WBN unit 2 with the 40 CFR Part 190 standards (Table 4-13). TVA expects that the actual dose from the operation of the two units would be less than the estimates and well within the dose standards in 10 CFR Part 20; 10 CFR Part 50, Appendix I; and 40 CFR Part 190. Table 4-13 shows the TVA assessment that the total doses to the MEI from liquid and gaseous effluent, as well as direct radiation at the WBN site are well below the 40 CFR Part 190 standards. The NRC staff completed an independent evaluation of the site total dose (cumulative dose) for comparison with 40 CFR Part 190 standards and found similar results, as shown in Appendix I of this SFES.

Table 4-13. Comparison of Doses to 40 CFR Part 190

	Unit 1	Unit 2				
	Combined Liquid and Gaseous (mrem/yr)	**Liquid (mrem/yr)**	**Gaseous (mrem/yr)**	**Combined (mrem/yr)**	**Site Total (mrem/yr)**	**40 CFR Part 190 Dose Standards (mrem/yr)**
Whole body dose	1.3	0.72	0.57	1.3	2.6	25
Thyroid	3.6	0.92 (child)	2.7	3.6	7.2	75

Source: TVA 2008a for liquid information; TVA 2011i for gaseous data.
To convert mrem/yr to mSv/yr, multiply by 0.01 mSv/mrem.

4.6.2.2 Population Dose

TVA estimates the collective total body dose, called population dose, from radioactive effluents released during the operation of WBN Unit 2 within an 80-km (50-mi) radius to be 0.236 person-Sv/yr (23.6 person-rem/yr) (TVA 2008a). The NRC staff estimated collective dose to the same population from natural background radiation to be 4,738 person-Sv/yr (473,800 person-rem/yr). The NRC staff calculated the dose from natural background radiation by multiplying the 80-km (50-mi) population estimate for 2040 of approximately 1,523,385 people by the annual background dose rate of 311 mrem/yr.

The NRC staff performed an independent evaluation of population doses for the gaseous and liquid effluent pathways using the GASPAR II and LADTAP II computer codes, respectively (Strenge et al. 1986, 1987). Appendix I of this SFES shows TVA and the NRC staff's population doses. There are no regulatory requirements for population doses, but the comparison to population dose and dose from natural background demonstrates that the annual estimated population doses from WBN Unit 2 are not significant when compared to the population dose from natural background (0.236 person-Sv/yr [23.6 person-rem/yr] and 4,738 person-Sv/yr [473,800 person-rem/yr], respectively) (see Appendix I of this SFES).

Radiation protection experts assume that any amount of radiation may pose some risk of causing cancer or a severe hereditary effect and that the risk is higher for higher radiation exposures. Therefore, experts use a linear, no-threshold dose response relationship to describe the relationship between radiation dose and detriments such as cancer induction. A report by the National Research Council (2006), the Biological Effects of Ionizing Radiation VII report, uses the linear, no-threshold model as a basis for estimating the risks from low doses. The NRC staff accepts this approach as a conservative method for estimating health risks from radiation exposure, recognizing that the model may overestimate those risks (56 FR 23360). Based on this method, the NRC staff estimated the risk to the public from radiation exposure using the nominal probability coefficient for total detriment. This coefficient has the value of

570 fatal cancers, nonfatal cancers, and severe hereditary effects per 10,000 person-Sv (1,000,000 person-rem), equal to 0.00057 effects per person-rem. The coefficient is taken from International Commission on Radiological Protection (ICRP) Publication 103 (ICRP 2007).

Both National Council on Radiation Protection and Measurements (NCRP) and ICRP suggest that when the collective effective dose is smaller than the reciprocal of the relevant risk detriment (i.e., less than 1/0.00057, which is less than 1.754 person-Sv [1,754 person-rem]), the risk assessment should note that the most likely number of excess health effects is zero (NCRP 1995; ICRP 2007). The estimated collective whole body dose to the population living within 80 km (50 mi) of the proposed Unit 2 site is 0.0236 person-Sv/yr (2.36 person-rem/yr) (TVA 2008a), which is less than the 1.754 person-Sv (1,754 person-rem) value that ICRP and NCRP suggest would most likely result in zero excess health effects (NCRP 1995; ICRP 2007).

4.6.2.3 Summary of Radiological Impacts to Members of the Public

The NRC staff evaluated the health impacts from routine gaseous and liquid radiological effluent releases from WBN Unit 2. Based on the information provided by TVA and the NRC staff's independent evaluation, the NRC staff concludes there would be no observable health impacts on the public from normal operation of WBN Unit 2, and the health impacts would be SMALL.

4.6.3 Occupational Doses to Workers

The licensee of a new plant is required to maintain individual doses to workers within 0.05 Sv (5 rem) annually as specified in 10 CFR 20.1201 and incorporate provisions to maintain doses ALARA.

The NRC staff concludes that the health impacts from occupational radiation exposure would be SMALL, based on individual worker doses being maintained within 10 CFR 20.1201 limits and collective occupational doses being typical of doses found in current operating light water reactors (LWRs). TVA implements a radiation control program to limit doses to workers ALARA. This program includes personnel and workplace monitoring, the use of protective equipment and clothing, radiation shielding (permanent and temporary), as well as work control procedures and training of all radiation workers.

4.6.4 Doses to Biota

The NRC does not have a regulatory framework for the protection of biota from radioactive discharges from nuclear power reactors. The focus of NRC regulatory framework is for the protection of human beings (NRC 2009). To evaluate the potential radiological impacts to biota, the NRC staff used guidance from national and international scientific agencies. The ICRP (ICRP 1977, 1991, 2007) states that if humans are adequately protected, other living things are also likely to be sufficiently protected. The International Atomic Energy Agency (IAEA 1992) and the NCRP (1991) reported that a chronic dose rate of less than 10 mGy/d (1,000 mrad/d) to the MEI in a population of aquatic organisms would ensure protection of the population. IAEA (1992) also concluded that chronic dose rates of 1 mGy/d (1 rad/d) or less do not appear to cause observable changes in terrestrial animal populations.

Radiological doses to non-human biota are expressed in units of absorbed dose (rad) because dose equivalent (rem) only applies to human radiological doses. To calculate doses to the biota from liquid effluents, the NRC staff used personal computer versions of the LADTAP II and GASPAR II programs (Strenge et al. 1986, 1987) integrated into NRCDose Version 2.3.10 (Chesapeake Nuclear Services, Inc. 2006). The NRC staff obtained NRCDose through the Oak Ridge Radiation Safety Information Computational Center.

Appendix I of this SFES specifies the LADTAP II input parameters to include the source term, the discharge flow rate to the receiving freshwater system, the shore-width factor, and fractions of radionuclides in the liquid effluent reaching offsite bodies of water. The transit time from the effluent release location to the exposure location was zero hours.

The NRC staff assessed dose to terrestrial biota from the gaseous effluent pathway using GASPAR II (Strenge et al. 1987) by assuming doses for raccoons and ducks were equivalent to adult human doses for inhalation, vegetation ingestion, plume, and twice the ground pathways at the exclusion area boundary at 1.09 km (0.68 mi) east (Table 4-14). The doubling of doses from ground deposition reflects the closer proximity of these organisms to the ground. Muskrats and herons do not consume terrestrial vegetation, so that pathway was not included for those organisms.

Table 4-14. Doses to Biota (mrem/yr) Due to Liquid and Gaseous Releases from WBN Unit 2

Biota	Liquid Releases	Gaseous Releases	Total	IAEA/NCRP Guidelines for Protection of Biota Populations (mrad/d)
Fish	4.30	-	4.30	1,000
Invertebrate	11.41	-	11.4	1,000
Algae	19.22	-	19.2	1,000
Muskrat	10.80	1.29	12.1	100
Raccoon	4.84	2.24	7.08	100
Heron	55.51	1.29	56.8	100
Duck	10.30	2.24	12.5	100

To convert mrem/yr to mSv/yr, multiply by 0.01 mSv/mrem.
To convert mrad/yr to mGy/yr, multiply by 0.01 mGy/mrad.

Table 4-14 compares estimated total body dose rates to surrogate biota species that would be produced by releases from Unit 2 to the IAEA/NCRP biota dose guidelines (IAEA 1992; NCRP 1991).

Based on the assessment performed by the NRC staff (see the complete analysis in Appendix I), the NRC staff concludes that the radiological impact on biota from the routine operation of WBN Unit 2 would be SMALL.

4.7 Nonradiological Human Health

This section describes the potential impacts on the public and occupational health from operating the WBN Unit 2 cooling system. These impacts can be from onsite or offsite exposure. Health impacts include exposure to etiological agents (disease-causing thermophilic microorganisms), noise, and the transmission system.

4.7.1 Etiological Agents

Activities related to operating WBN Unit 2 that encourage growth of disease-causing microorganisms (etiological agents) could compromise public and occupational health. Thermal discharge from the blowdown of the WBN Unit 2 cooling tower into the Chickamauga Reservoir on the Tennessee River could increase the growth of thermophilic microorganisms. Section 2.7.1 discusses the types of etiological agents that thrive in waters around power plants and affect public and occupational health.

Exposure to etiological agents in discharge waters is a concern if the flow rate of the receiving waters is low. The NRC staff considers low flow in a river to be less than 2,800 m^3/s (100,000 cfs) (NRC 1996). As discussed in Section 2.2.1.1, the Watts Bar Dam releases water at a mean annual flow of approximately 778 m^3/s (27,500 cfs). Therefore, the receiving waters from the WBN site are similar to the low flows of a small river, and there could be a concern for effects on public health from etiological agents. Section 4.2.2.2 describes the thermal discharge from the cooling towers that would elevate the ambient river temperature in Chickamauga Reservoir. The current NPDES permit limits the discharge temperature to 35°C (95°F) for Outfalls 101 and 102, and 33.5°C (92.3°F) for Outfall 113. The mixing zone for Outfall 101 stays close to the river shoreline on the side of the WBN site and extends for 70 m (240 ft) downstream. Outfall 102 is only for emergency use and would only have infrequent use. Outfall 113 is generally in use, and two mixing zones are considered for different flow scenarios for the river. Under low-flow conditions, the mixing zone encompasses the entire width of the river and 300 m (1,000 ft) downstream of the outfall (TVA 2010e). The NPDES permit limits the temperature at the downstream edge of the mixing zone to less than 30.5°C (86.9°F). A review of summer and winter thermal monitoring data indicates that TVA has historically adjusted the operation of the cooling system to stay within the temperature limits set in the NPDES permit (e.g., TVA 2007a, b).

Exposure to etiological agents associated with WBN Unit 2 would be related to public swimming or boating in the vicinity of the diffuser outfall into the Chickamauga Reservoir or to onsite workers inside the cooling tower or working in the YHP (for temporary blowdown storage). The public uses the area in the vicinity of this thermal plume in the river for boating and fishing, and perhaps some waterskiing. No designated public swimming areas are in the area, although incidental swimming probably takes place. As discussed in Section 2.7.1, the thermal discharge from power production can encourage etiological agents in the river to grow. However, a review of the outbreaks of human water-borne diseases in Tennessee indicates that incidences of most such diseases (e.g., Legionellosis, Salmonellosis, Shigellosis, and primary amoebic meningoencephalitis) are uncommon. The NPDES temperature limits for WBN outfalls to the Tennessee River are at or below 35°C (95°F), which is below the optimal growth temperatures for most of the organisms that cause the above-mentioned diseases, and TVA has stated it would comply with the temperature requirement in the NPDES permit (see Table 4-1) (TVA 2010e). Although the thermal discharge will change the temperature of the receiving waters in the vicinity of the discharge, any change in temperature, especially after mixing, would still be within the organisms' range of tolerance. However, the organisms are ubiquitous in the aquatic environment, and it is unlikely the minor change in temperature would increase the populations by a significant amount.

Cooling towers can encourage microbial growth. TVA plans to use biocides to limit microbial growth in the cooling-tower basin and within the cooling tower (TVA 2008a). The types of biocides, frequency of application, and dosages are within the levels approved by the TDEC and specified in the NPDES permit for discharge to the Tennessee River (TDEC 2011; TVA 2011a) (Section 3.2.2). The TVA worker protection program has procedures that require workers to wear personal protective equipment to minimize potential exposure to *Legionella pneumophila* while they work with the cooling towers. The protective equipment meets Occupational Safety and Health Administration (OSHA) requirements and OSHA recommendations for respiratory protection of workers in a water aerosol area (TVA 2008b).

4.7.2 Noise

Common sources of noise from operating a nuclear plant include cooling towers and transformers and intermittent contributions from loudspeakers and auxiliary equipment (e.g., pumps and building ventilation fans). In addition, high-voltage transmission lines emit a corona discharge noise. Sources of noise at the WBN site are those associated with operation of WBN Unit 1, including transformers and other electrical equipment, circulating water pumps, cooling tower, and the public address system.

A document about the decommissioning of nuclear facilities (NRC 2002) based the criterion for assessing the level of significance on the effect of the noise on human activities and threatened and endangered species. The criterion is stated as follows:

> The noise impacts ... are considered detectable if sound levels are sufficiently high to disrupt normal human activities on a regular basis. The noise impacts ... are considered destabilizing if sound levels are sufficiently high that the affected area is

essentially unsuitable for normal human activities, or if the behavior or breeding of a threatened and endangered species is affected.

As discussed in Section 2.7.2, the WBN site noise sources are located sufficiently distant from the plant boundaries that the noise the plant generates attenuates to near-ambient levels before reaching critical receptors outside the plant boundary. The Tennessee Occupational Safety and Health Administration (TOSHA) has a Special Emphasis Program for occupational noise exposure and hearing conservation. TOSHA requires employers to provide hearing protection for workers when noise exposure exceeds 85 dBA over 8 hours. Compliance with these codes minimizes human health impacts from noise (TDLWD 2010).

4.7.3 Transmission Systems

This section describes potential impacts on humans from operating the transmission systems supporting WBN Unit 2. The transmission systems include transmission-line operation and transmission corridor maintenance. Transmission corridor maintenance, EMFs, and collisions with transmission structures could affect humans and the environment.

As discussed in Section 3.2.4, the WBN site connects to the regional power grid via existing 500-kV and 161-kV corridor and transmission lines (Figure 3-4). TVA performs routine maintenance on the 161-kV lines and the portions of the 500-kV lines with 161-kV underbuilds. The TVA Transmission and Power Supply–Transmission Operations and Maintenance organization routinely conducts maintenance activities on transmission lines in the TVA system (TVA Power Service Area). These activities include, but are not restricted to, removing vegetation from the corridor, replacing poles, installing lightning arrestors and balance weights, and upgrading existing equipment (TVA 2008a).

TVA uses a helicopter to inspect the 500-kV transmission lines at 6-month intervals and conducts ground observation every 1 to 2 years. The applicant conducts these investigations to locate damaged conductors, insulators, structures, and to report any abnormal conditions that might hamper normal operation of the transmission line or adversely affect the surrounding area (TVA 2008a). During these inspections, TVA notes the condition of vegetation within and immediately adjoining the transmission corridor. TVA uses these observations to plan corrective maintenance or routinely manage vegetation. Overall, TVA uses an integrated vegetation maintenance approach. Property owners are encouraged to plant low-growing crops in farming areas. Depending on the terrain and sensitive areas, TVA uses mechanical moving, hand-clearing, or herbicide application. TVA conducts this periodic vegetation management along the corridor to maintain adequate clearance between tall vegetation and transmission-line conductors (TVA 2008a, c).

For 500-kV transmission lines, corona noise, when present, typically ranges from 40 to 55 dBA; however, TVA has recorded corona noise levels as high as 61 dBA. During rain showers, the corona noise would likely not be readily distinguishable from background noise. During very moist conditions, such as heavy fog, the resulting small increase in the background noise levels likely occurs for only short durations. Periodic maintenance activities, particularly vegetation management, would produce noise from mowing, bush-hogging, and tree and limb trimming and grinding (TVA 2008a).

Transmission lines generate both electric and magnetic fields, referred to collectively as EMFs. Acute and chronic exposure to EMFs from power transmission systems, including switching stations (or substations) onsite and transmission lines connecting the plant to the regional electrical distribution grid, can compromise public and worker health.

A person standing on the ground can receive an electric shock by coming into contact with transmission lines because of the sudden discharge of the capacitive charge through the person's body to the ground. The National Electrical Safety Code (NESC) has design criteria that limit hazards from steady-state currents to the largest anticipated object (typically a vehicle like a school bus) of less than 5 milliamperes in a short-circuit current to ground. TVA transmission lines meet these design criteria (NRC 1995).

As mentioned in Section 2.7.3, researchers have studied long-term or chronic exposure to power transmission lines for a number of years (NIEHS 1999; AGNIR 2006; WHO 2007), and have determined that the extent of scientific evidence linking disease to EMF exposure is not conclusive. Therefore, the NRC staff is not able to come to conclusions on the chronic impacts of EMFs on human health.

TVA already has constructed, maintained, and operated the 500-kV and 161-kV transmission lines, which would carry power WBN Unit 2 generates, in compliance with Federal, State, and local codes. Compliance with these codes minimizes human health impacts from electric shock and noise. Therefore, the NRC staff concludes that impacts from transmission lines on human health would be SMALL. This conclusion is consistent with the conclusion reached in the 1978 FES-OL.

4.7.4 Summary

Based on the historically low incidence of diseases from thermophilic microorganisms in Tennessee, the small temperature increase in Chickamauga Reservoir expected from the operation of WBN Unit 2, as well as the expected compliance with the NPDES permit temperature limits, and the relative absence of swimming or activities resulting in water immersion in the vicinity of the discharge structures, the NRC staff concludes that impacts on human health would be SMALL.

Given the postulated noise levels for cooling towers, transformers, public address system, auxiliary equipment, and compliance with TOSHA requirements, the NRC staff concludes that noise impacts would be SMALL.

TVA already has constructed, maintained, and operated the 500-kV and 161-kV transmission lines, which would carry power Unit 2 generates, in compliance with Federal, State, and local codes. Compliance with these codes minimizes human health impacts from electric shock and noise. Therefore, the NRC staff concludes that impacts from transmission lines on human health would be SMALL.

4.8 Meteorology, Air Quality, and Greenhouse Gas Emissions

In its 1978 FES-OL (NRC 1978), the NRC staff evaluated potential impacts on meteorology and air quality from TVA operating two reactors at the WBN site. The NRC staff considered the impacts of cooling towers, releases other than cooling system releases, and potential air quality impacts of transmission lines and did not identify any significant impacts. In its 1995 SFES-OL-1 (NRC 1995), the NRC staff again evaluated the potential impacts of operation of WBN Units 1 and 2 on air quality and determined that the conclusions in the 1978 NRC FES-OL had not changed.

TVA considered the extensive environmental reviews of WBN Units 1 and 2 to identify which areas to address during the preparation of its ER. TVA did not identify the need to address air quality (TVA 2008a). However, the TVA ER contains information about dust control, cooling towers, and changes in plant systems related to air quality. The NRC staff reviewed results of its previous environmental reviews of WBN Units 1 and 2 as well as the TVA ER. In addition, during its site audit, the NRC staff explored potential impacts of operating WBN Unit 2 on air quality. The NRC staff did not identify any information that would cause it to alter conclusions from previous reviews. The TVA ER states that TVA made internal modifications to the WBN Unit 1 cooling tower in 1999 (TVA 2008a). The NRC staff also determined that TVA was making the same changes to the Unit 2 cooling tower. During its site audit, the NRC staff discussed the nature of changes TVA made to the cooling tower and determined they would not adversely affect air quality. The cooling-tower changes do not alter the NRC staff's previous conclusions regarding the environmental impacts of cooling-tower operations (NRC 1978, 1995). Based on the NRC staff's independent review of information since the 1978 FES-OL, the NRC staff concludes that the impact on the atmosphere from heat dissipation resulting from operating WBN Unit 2 would be SMALL.

Operating WBN Unit 2 will emit greenhouse gases (GHGs), primarily carbon dioxide. The 1978 FES-OL and 1995 SFES-OL-1 do not address GHG emissions because they were not a recognized issue at the time. Based on its analysis of the carbon dioxide footprint of a

1,000 MW(e) reference reactor (NRC 2011a), the NRC staff estimates that the direct and indirect GHG emissions from operating WBN Unit 2 are approximately 8,000 tons per year of carbon dioxide equivalent (tpy CO_2e). Diesel generators are the primary source of direct GHG emissions, accounting for an estimated 60 percent of the total. Workforce transportation accounts for most of the rest. Because these emission sources are relatively stable from year to year, the total GHG emissions over the 40-year license of WBN Unit 2 is approximately 320,000 tons of CO_2e from plant operations. On June 3, 2010, EPA published a final rule which set the applicability criteria that determine which stationary sources such as WBN Unit 2 will become subject to permitting requirements for GHG emissions under the Clean Air Act (75 FR 31514). This rule establishes a significance level for GHGs of 50,000 tpy CO_2e. Emissions less than the significance level represent a *de minimis* contribution to air quality problems. For the foreseeable future (at least through April 2016), no source with emissions below 50,000 tpy CO_2e (e.g., WBN Unit 2) will be subject to permitting. The emissions are also well below the 25,000 tpy presumptive threshold for direct CO_2e emissions in the Council on Environmental Quality (CEQ) draft guidance on consideration of climate change and GHG emissions (CEQ 2010).

Therefore, the NRC staff concludes that air quality impacts associated with TVA operating WBN Unit 2 would be SMALL.

4.9 Environmental Impacts of Waste

This section describes potential impacts on the environment resulting from generating, handling, and disposing of nonradioactive waste and mixed waste during the operation of WBN Unit 2.

4.9.1 Nonradioactive Waste System Impacts

The types of nonradioactive waste the plant would generate, handle, and dispose of while operating WBN Unit 2 include solid wastes, liquid effluents, and air emissions. Solid wastes include municipal waste-, water-, and sewage-treatment sludge, and industrial wastes. Liquid waste includes NPDES-permitted discharges such as effluents containing chemicals or biocides, wastewater effluents, site stormwater runoff, and other liquid wastes such as used oils, paints, and solvents that require offsite disposal.

4.9.1.1 Impacts on Land

WBN Unit 2 would generate solid and liquid wastes similar to those currently generated by WBN Unit 1. The total volume of solid and liquid wastes would increase at the site; however, TVA does not expect any new solid or liquid waste types to result from operating Unit 2 (TVA 2008a). TVA currently sends process wastes, such as waste oils, solvents, paints, and hydraulic fluids, offsite to a vendor for processing, storage and disposal. TVA collects and places precipitated material and sludge from the water-treatment system in a landfill (NRC 1995). TVA would bury nonradioactive and nonhazardous solid wastes, based on the waste and type, in State-approved sanitary landfills or in onsite approved landfills. Hazardous waste would be shipped offsite to the TVA Muscle Shoals Storage Facility for subsequent disposal (NRC 1995).

The Atomic Energy Act, the Solid Waste Disposal Act (1965), the Resource, Conservation, and Recovery Act of 1976, and the Hazardous and Solid Waste Amendments of 1984 regulate the generation, storage, treatment, or disposal of mixed waste (waste containing both low-level radioactive waste and hazardous waste). TVA has a waste minimization program for WBN Unit 1 to minimize the generation rates of solid waste including mixed waste. It is expected that the same waste minimization practices will be used at WBN Unit 2. However, any mixed waste generated at either of the units from WBN Unit 2 would be temporarily stored onsite until it can be moved offsite for disposal at an approved disposal facility.

4.9.1.2 Impacts on Water

The plant would discharge effluents containing chemical and biocides used in the condenser cooling system into the Chickamauga Reservoir primarily through Outfalls 101 and 113. Various water-treatment processes would use chemical and biocidal additives. The YHP collects these waste streams, which would be subject to dilution, aeration, vaporization, and chemical reactions. The YHP may discharge effluent into the Chickamauga Reservoir through Outfalls 101 and 102. TVA monitors all of these outfalls for conformance with existing NPDES permit limits for the WBN site (TVA 2008a, 2009c).

Other WBN Unit 2 effluents include sanitary system effluents as well as process and non-process wastewater. As the TVA ER states (TVA 2008a):

> WBN is authorized to discharge process and non-process wastewater, cooling water and storm water runoff from Outfall 101 and Outfall 102 turbine building sump water, alum sludge supernate, reverse osmosis reject water, drum dewatering water, water purification plant water, and stormwater runoff from internal monitoring point (IMP) 103; metal cleaning wastewater, turbine building station sump water, diesel generator coolant, and storm water through IMP 107; treated sanitary wastewater through IMP 111; HVAC cooling water, storm water, and fire-protection wastewater through Outfall 112; and SCCW from Outfall 113 to the Tennessee River (refer to Figure 1-2, Unit 2 Site Plan and Appendix B, NPDES Flow Diagram).

Since publication of the ER (TVA 2008a) treated sanitary wastewater no longer discharges through Outfall 111 and the waste previously discharged through Outfall 112 has been rerouted to the YHP for discharge through Outfall 101 (TDEC 2011). Sanitary wastewater is discharged offsite to the Spring City Wastewater Treatment Facility (PNNL 2009).

4.9.1.3 Impacts on Air

Federal, State, and local statutes, regulations, and ordinances control nonradioactive discharges to the air. Emissions from two oil-fired boilers the WBN plant uses for building heat and startup steam are currently permitted and meet applicable regulatory requirements for air quality (NRC 1995; TVA 2008a). TVA expects no additional emissions for WBN Unit 2 (TVA 2008a).

4.9.2 Summary

Solid and liquid wastes and air emissions from WBN Unit 2 would be managed by TVA according to applicable Federal, State, and local requirements and standards. Based on the NRC staff's independent review of new information submitted by TVA since the 1978 FES, the NRC staff concludes that impacts on land, water, and air from nonradioactive and mixed wastes generated during operation of WBN Unit 2 would be SMALL.

4.10 Uranium Fuel Cycle Impacts

This section discusses the environmental impacts from the uranium fuel cycle and solid waste management for the WBN Unit 2 pressurized-water reactor (PWR) constructed at the WBN site. The uranium fuel cycle includes uranium mining and milling, the production of uranium hexafluoride, isotopic enrichment, fuel fabrication, reprocessing of irradiated fuel, transportation of radioactive materials and management of low-level wastes and high-level wastes related to uranium fuel cycle activities.

The NRC staff reviewed the burnup levels and percent uranium-235 enrichment characteristics of the fuel to be used at WBN Unit 2. The proposed fuel burnup level at WBN Unit 2 is 33,000 MWD/MTU for the first core and 44,000 MWD/MTU for subsequent core reloads. The fuel enrichment is expected to range from 2.10 weight percent uranium-235 up to a maximum enrichment of 5.0 weight percent uranium-235 (TVA 2009a).

The NRC staff compared the fuel characteristics of TVA with criteria in 10 CFR 51.51, Table S–3, "Table of Uranium Fuel Cycle Environmental Data" which evaluates the environmental impacts of this design against specific criteria for LWR designs. Shortly after the publication of the 1995 SFES-OL-1, the NRC staff published the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants,* NUREG-1437 (NRC 1996). In NUREG-1437, there was a discussion regarding changes in fuel burnup levels and enrichment to fuel cycle operations since the original publication of Table S–3. NUREG-1437 concluded that increased fuel burnup levels to 62,000 MWD/MTU and 5 percent fuel enrichment in fuel cycle operation would not change the impacts described in Table S–3. With the exception of radiological waste, the NRC staff considered that no new information exists related to the fuel cycle and operating the WBN Unit 2 reactor; therefore, no further analysis is necessary for the impacts related to

Table S–3. The following section discusses some issues and provides conclusions related to spent fuel storage, disposal of waste, and climate change.

4.10.1 Radiological Wastes

TVA ships Class A low-level waste (LLW) to Oak Ridge for compaction. The compacted Class A LLW is then shipped to the Energy Solutions site in Clive, Utah for disposal. Other disposal sites may be available during WBN Unit 2 operation, but none of the other currently licensed sites are available to WBN Unit 2. A new disposal facility, the Texas Low-Level Radioactive Waste Disposal Compact Facility, located in Andrews County, Texas, opened on November 10, 2011. The facility is licensed by the State of Texas to dispose of Class A, B, and C LLW (Waste Control Specialists 2012). This LLW disposal facility is expected to be available to WBN Unit 2 for the disposal of LLW if TVA applies for, and receives approval from the Texas Low-Level Radioactive Waste Disposal Compact Commission. With the potential availability of this disposal facility, the current LLW handling and storage facilities are expected to be adequate to handle LLW waste generated at WBN Unit 2 without the need to expand WBN site storage capacity or ship the waste to Sequoyah Nuclear Plant for storage.

The NRC staff anticipates that TVA would temporarily store its Class B and C LLW onsite until an offsite disposal location become available. In addition, TVA could also store WBN Unit 2 Class B and C LLW at the Sequoyah Nuclear Plant located near WBN (TVA 2008a). Several operating nuclear power plants have successfully increased onsite storage capacity in the past in accordance with existing NRC regulations. This extended waste storage onsite resulted in no significant increase in dose to the public.

Based on the NRC staff's independent review of information since the 1978 FES-OL, the NRC staff concludes that the environmental impacts of low-level radioactive waste storage and disposal associated with WBN Unit 2 would be SMALL.

The onsite storage of spent fuel during the period the plant is operating has been evaluated by the NRC staff. The regulations relating to the onsite storage of spent fuel can be found in 10 CFR Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater Than Class C Waste." The NRC staff concludes that the environmental impacts of spent fuel storage during the period of plant operations would be SMALL.

The offsite radiological impacts resulting from spent fuel and high-level waste disposal, and the onsite storage of spent fuel, that will occur after the reactors have been permanently shut down, are addressed in the Commission's Waste Confidence Decision Rule (WCD), 10 CFR 51.23. In 2010, the Commission revised the WCD (i.e., WCD Update) to reflect information gained based on experience in the storage of spent nuclear fuel and the increased uncertainty in the siting and construction of a permanent geologic repository for the disposal of spent nuclear fuel.

On June 8, 2012, the United States Court of Appeals for the District of Columbia (D.C.) Circuit (*New York v. NRC* 2012), in response to a legal challenge to the WCD, vacated the NRC's WCD Update (75 FR 81032 and 75 FR 81037). The court decision was based on grounds relating to aspects of the National Environmental Policy Act (NEPA). The court decision held that the WCD Update is a major Federal action necessitating either an EIS or a finding of no significant environmental impact (FONSI), and the Commission's evaluation of the risks associated with the storage of spent nuclear fuel for at least 60 years beyond the licensed life for reactor operation is deficient.

In response to the court's ruling, the Commission, in CLI-12-16 (NRC 2012a), determined that it would not issue licenses dependent upon the WCD until the issues identified in the court's decision are appropriately addressed. In CLI-12-16, the Commission also noted that this determination extends only to final license issuance; all current licensing reviews and proceedings should continue to move forward.

In addition, the Commission directed (SRM-COMSECY-12-0016; NRC 2012b) the NRC staff to proceed with a rulemaking that includes the development of an EIS to support an updated WCD within 24 months (by September 2014). The Commission indicated that the EIS used to support the revised rule should build on the information already documented in various NRC studies and reports on the impacts associated with the storage of spent nuclear fuel that were developed as part of the 2010 WCD Update. It should primarily focus additional analyses on the deficiencies identified in the D.C. Circuit's decision. The NRC considers the WCD to be a generic issue that is best addressed through rulemaking and that the NRC rulemaking process provides an appropriate forum for public review and comment on both the draft EIS and the proposed WCD.

The updated rule and supporting EIS will provide the necessary NEPA analyses of waste confidence-related human health and environmental issues. As directed by the Commission, the NRC will not issue a license prior to the resolution of waste confidence-related issues. This will ensure that there would be no irretrievable or irreversible resource commitments or potential harm to the environment before waste confidence impacts have been addressed.

If the results of the WCD EIS identify information that requires a supplement to this FES, the NRC staff will perform any appropriate additional NEPA review for those issues before the NRC makes a final licensing decision.

4.10.2 Greenhouse Gases from the Uranium Fuel Cycle

The NRC staff's analysis of the carbon dioxide footprint of a 1,000 MW(e) reference reactor (NRC 2011a) shows that the largest source of GHG emissions associated with nuclear power is from the uranium fuel cycle, primarily from electricity consumed in the enrichment process. The NRC staff estimates that the GHG emissions of the fuel cycle to support one year of WBN Unit 2 operation is about 480,000 metric tons of CO_2. This estimate is conservative, as gaseous centrifuge (GC) technology is likely to eventually replace gaseous diffusion (GD) technology for uranium enrichment in the United States. The same amount of enrichment from a GC facility uses less electricity and therefore, results in lower amounts of air emissions, such as CO_2, than a GD facility. The carbon dioxide footprint of an equivalent coal-fired power plant would be about 20 times larger than that of WBN Unit 2 (i.e., about 9,600,000 MT).

On this basis, the NRC staff concludes that the fossil-fuel impacts, including GHG emissions, from the direct and indirect consumption of electric energy for fuel cycle operations associated with WBN Unit 2 would be SMALL.

4.11 Decommissioning

At the end of the operating life of a nuclear power reactor, NRC regulations require the facility to be decommissioned. The NRC defines decommissioning as the safe removal of a facility from service and the reduction of residual radioactivity to a level permitting termination of the NRC license. Sections 10 CFR 50.75 and 50.82 provide the NRC regulations governing decommissioning and termination of licenses of power reactors. The radiological criteria for termination of the NRC license are in 10 CFR Part 20, Subpart E. In accordance with NRC's requirements in 10 CFR 50.75(b)(I) and 10 CFR 50.33, TVA submitted its report certifying that TVA provided financial assurance regarding the decommissioning of WBN Unit 2 (TVA 2008a).

The *Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities Regarding the Decommissioning of Nuclear Power Reactors* (GEIS-DECOM), NUREG-0586, Supplement 1 (NRC 2002) evaluates environmental impacts of activities associated with decommissioning any LWR before or at the end of an initial or renewed license. There are three methods for decommissioning a nuclear power reactor. The GEIS-DECOM evaluates environmental impacts of the DECON, SAFSTOR, and ENTOMB decommissioning methods (NRC 2002). For the DECON method, the equipment, structures, and portions of the facility and site that contain radioactive contaminants are promptly removed or decontaminated to a level that permits termination of the license shortly after cessation of operations. For the second method, SAFSTOR, the facility is placed in a safe, stable condition and maintained in that state (safe storage) until it is subsequently decontaminated and dismantled to levels that permit license termination. The third method is called ENTOMB. In this method of decommissioning, radioactive structures and components are encased in a structurally long-lived substance, such as concrete. The entombed structure is appropriately maintained, and continued surveillance is carried out until the radioactivity decays to a level that permits termination of the license.

The NRC does not require an applicant requesting an operating license to identify a decommissioning method at the time of application. The GEIS-DECOM presents a range of impacts for each environmental issue for the activities conducted during decommissioning.

Therefore, the NRC staff relies on the bases established in GEIS-DECOM and concludes the following:

- Doses to the public would be well below applicable regulatory standards regardless of which decommissioning method TVA uses.
- Occupational doses would be well below applicable regulatory standards during the license term.
- The quantities of Class C or greater than Class C wastes generated would be comparable to or less than the amounts of solid waste generated by reactors licensed before 2002.
- Air quality impacts of decommissioning are expected to be negligible at the end of the operating term.
- Measures are readily available to avoid potential significant water-quality impacts from erosion or spills. The liquid radioactive waste system design includes features to limit release of radioactive material to the environment, such as pipe chases and tank collection basins. These features would minimize the amount of radioactive material in spills and leakage that would have to be addressed at decommissioning.
- Ecological impacts of decommissioning are expected to be negligible.
- Socioeconomic impacts would be short-term and could be offset by economic diversification.

The NRC staff concludes that as long as TVA meets the regulatory requirements on decommissioning activities to limit the impacts of decommissioning for WBN Unit 2, the environmental impacts would be SMALL. The GEIS-DECOM (NRC 2002) does not specifically address the carbon footprint of decommissioning activities. However, it does list the decommissioning activities and states that the decommissioning workforce would be expected to be smaller than the operational workforce and that the decontamination and demolition activities could take up to 10 years to complete. Finally, it discusses SAFSTOR, in which decontamination and dismantlement are delayed for a number of years. Given this information and the assumptions and procedure set forth in its evaluation of the carbon dioxide footprint of a 1,000 MW(e) reference reactor (NRC 2011a), the NRC staff estimates the CO_2 footprint of decommissioning WBN Unit 2 to be on the order of 1,700 MT/yr. This footprint is about equally split between decommissioning workforce transportation and equipment usage. The carbon footprint during a SAFSTOR period would be about 330 MT/yr. These CO_2 footprints are more than two orders of magnitude lower than the CO_2 footprint for the uranium fuel cycle.

Based on the GEIS-DECOM and the evaluation of air quality impacts from GHG emissions above, the NRC staff expects that TVA compliance with the regulatory requirements on decommissioning activities will limit the impacts of decommissioning of WBN units. Therefore, environmental impacts from decommissioning would be SMALL.

4.12 Transportation of Radioactive Materials

Regarding the issue of LLW, TVA, in the ER, stated that an evaluation of waste shipments from WBN Unit 1 were actually lower than what was analyzed in the 1972 FES and that the addition of a second unit at WBN would result in total shipments that would still be less than estimated in the 1972 FES. The 1995 SFES concluded that the impacts associated with the transportation of LLW were acceptable because the dose rates from the transport vehicle would be within Department of Transportation limits, and calculated doses to the public would be a small percentage of natural background radiation. Therefore, the NRC staff concludes that there would be no change in the conclusions from the 1978 FES-OL or the 1995 SFES-OL-1.

TVA did not identify any new information related to transportation fuel since the 1995 SFES-OL-1. However, the NRC staff evaluated information in the WBN Unit 2 Final Safety Analysis Report on the characteristics of the fuel expected to be used. TVA plans to use reactor fuel consisting of uranium-dioxide pellets that have been enriched up to 3.10 percent by weight with uranium-235 and enclosed in Zircaloy tubes. The fuel burnup levels are expected to be approximately 33,000 MWD/MTU for the first core load and will be increased to approximately 44,000 MWD/MTU for subsequent core reloads (TVA 2009a).

The NRC staff reviewed this information against NRC technical evaluation documents regarding the impacts associated with spent fuel. Addendum 1 to NUREG-1437 states that the use of fuel enriched up to 5 percent by weight with uranium-235 and an increase in burnup up to 62,000 MWd/MTU will not significantly change dose levels associated with spent fuel transportation (NRC 1999). A more recent study found that the environmental impacts associated with transportation of spent nuclear fuel up to 75,000 MWd/MTU burnup, provided that the fuel is cooled for at least five years before shipment would not change (Ramsdell et al. 2001). The expected burnup for WBN Unit 2 is within the bounding characteristics evaluated and found acceptable in the above referenced technical evaluation documents. In addition, as discussed in the 1995 SFES-OL-1, the NRC staff expects that TVA would comply with applicable transportation regulations issued by NRC and/or the U.S. Department of Transportation. The 1995 SFES concluded that estimated dose from the transportation of fuel are unchanged from the 1978 FES-OL and are acceptable because the dose rates from the transport vehicle would be within Department of Transportation limits, and calculated doses to the public would be a small percentage of natural background radiation.

4.13 Measures and Controls to Limit Adverse Impacts During Operation

In its evaluation of environmental impacts during operation of the Unit 2, the NRC staff relied on TVA compliance with the following measures and controls that would limit adverse environmental impacts:

- compliance with applicable Federal, State, and local laws, ordinances, and regulations intended to prevent or minimize adverse environmental impacts (e.g., solid waste management, erosion and sediment control, air emissions, noise control, stormwater management, spill response and cleanup, hazardous material management)
- compliance with applicable requirements of permits or licenses required for operation of the new unit (e.g., NPDES)
- compliance with existing Unit 1 processes and/or procedures applicable to Unit 2 environmental compliance activities for the WBN site (e.g., solid waste management, hazardous waste management, and spill prevention and response)
- implementation of BMPs.

TVA expects these measures and controls to be adequate for avoiding or mitigating potential adverse impacts associated with operation of the new unit. The NRC staff considered these measures and controls in its evaluation of station operation impacts. Specific measures and controls for each environmental review area are described in Sections 4.1 through 4.12.

4.14 Cumulative Impacts

The NRC staff considered potential cumulative impacts in the environmental analysis of operation of WBN Unit 2. Cumulative impacts may result when the environmental effects associated with the proposed action are overlaid or added to temporary or permanent effects associated with other past, present, and reasonably foreseeable future actions. Cumulative impacts can result from individually minor but collectively significant actions that take place over time. It is possible that an impact that may be SMALL by itself could result in a MODERATE or LARGE cumulative impact when considered in combination with the impacts of other actions on the affected resource. Likewise, if a resource is regionally declining or imperiled, even a SMALL individual impact could be important if it contributes to or accelerates the overall decline.

When evaluating the potential impacts of operating WBN Unit 2, the NRC staff considered potential cumulative impacts on the resources described in Chapter 2 that could be affected by operating WBN Unit 2. The 1978 FES-OL and 1995 SFES-OL-1 did not address cumulative impacts.

The NRC staff visited the WBN site from October 6 through October 8, 2009. The team then used the information provided in the TVA ER, historical TVA documents and previous EISs, responses to RAIs, information from other Federal and State agencies, and information gathered during the site visit to evaluate the cumulative impacts of operating two nuclear power plants at the site. To further inform the cumulative analysis, the NRC staff searched EPA databases for recent EISs and permits for water discharges in the geographic area (to identify water-use projects and industrial facilities). The NRC staff also used the www.recovery.gov website to identify projects in the geographic area funded by the American Recovery and Reinvestment Act of 2009 (ARRA). Actions and projects identified during this review and considered in the NRC staff's independent analysis of the potential cumulative effects are described in Table 4-15. Approximate locations are given with respect to the WBN site.

This section discusses potential cumulative impacts for each resource area. In the area of socioeconomics related to taxes, impacts may be considered beneficial and are described as such.

Table 4-15. Past, Present, and Reasonably Foreseeable Projects and Other Actions Considered in the Cumulative Analysis in the Vicinity of the WBN Site

Project Name	Summary of Project	Location	Status
Nuclear projects			
WBN Unit 1	Nuclear power plant, one 1,123-MW(e) Westinghouse four-loop reactor. NPDES TN0020168	Adjacent	Operational. WBN Unit 1 is currently licensed to continue operations through November 11, 2045 (NRC 2011b)
Clinch River Site	Up to six Babcock & Wilcox mPower design small modular reactor (SMR) modules	Roane County, Tennessee, approximately 48 km (30 mi) northeast	Proposed. Application not yet submitted (TVA 2010f)
Sequoyah Nuclear Plant, Units 1 and 2	Nuclear power plant, two 1,148-MW(e) Westinghouse four-loop reactors. NPDES TN0026450	Soddy-Daisy, Tennessee, approximately 50 km (31 mi) southwest	Operational. Sequoyah Units 1 and 2 are licensed to continue operations through September 17, 2020, and September 15, 2021, respectively (NRC 2011b). License renewal application submitted January 15, 2013 (TVA 2013). DOE issued draft SEIS that considers the potential use of mixed oxide (plutonium-based) fuel in TVA reactors including Sequoyah (DOE 2012).

Table 4-15. (contd)

Project Name	Summary of Project	Location	Status
Oak Ridge Reservation	Research and manufacturing park including Oak Ridge National Laboratory, The East Tennessee Technology Park, the Y-12 National Security Complex, and the TRU Waste Processing Facility	Oak Ridge, Tennessee, approximately 56 km (35 mi) northeast	Operational (DOE 2009)
Bellefonte Nuclear Plant, Units 1 and 2	Nuclear power plant, two 1,260-MW(e) Babcock and Wilcox-designed pressurized LWR	Scottsboro, Alabama, approximately 143 km (89 mi) southwest	Deferred. Bellefonte Units 1 and 2 construction permits were issued December 24, 1974. The construction permit for Unit 1 has been extended to October 1, 2020 (NRC 2011c).
Bellefonte Nuclear Plant, Units 3 and 4	Nuclear power plant, two 1,148-MW(e) Westinghouse four-loop reactors	Scottsboro, Alabama, approximately 143 km (89 mi) southwest	Deferred. Application for two new nuclear units submitted October 30, 2007 (TVA 2007d).
Coal-fired energy projects			
Kingston Fossil Plant	Nine-unit coal-fired plant, 1,398 MW. NPDES TN0005452	Kingston, Tennessee, approximately 40 km (25 mi) northeast	Operational (TVA 2012d)
Bull Run Fossil Plant	Single generator coal-fired plant, 870 MW	Oak Ridge, Tennessee, approximately 74 km (46 mi) northeast	Operational (TVA 2012e)
Dams and hydroelectric energy projects			
Watts Bar Dam	Hydroelectric power plant on the Tennessee River. Five units totaling 182 MW	Spring City, Tennessee, approximately 1.6 km (1 mi) north	Operational (TVA 2012f)
Fort Loudoun Dam	Hydroelectric power plant on the Tennessee River, Four units totaling 162 MW	Knoxville, Tennessee, approximately 53 km (33 mi) northeast	Operational (TVA 2012g)

Table 4-15. (contd)

Project Name	Summary of Project	Location	Status
Melton Hill Dam	Hydroelectric power plant on the Clinch River. Two units totaling 79 MW	Lenoir City, Tennessee, approximately 54 km (33.7 mi) northeast	Operational (TVA 2012h)
Apalachia Dam	Hydroelectric power plant on the Hiwassee River. Two units totaling 82 MW	Murphy, Tennessee, approximately 66 km (41 mi) southeast	Operational (TVA 2012i)
Chickamauga Dam	Located on the Tennessee River. Flood control for the city of Chattanooga, Tennessee.	Chattanooga, Tennessee, approximately 68 km (42.5 mi) southwest	Operational (TVA 2012j)
Calderwood Dam	Hydroelectric power plant on the Little Tennessee River. Three units totaling 140.4 MW.	Vonore, Tennessee, approximately 74.6 km (46 mi) southeast	Operational (Alcoa 2012)
Raccoon Mountain Pumped-Storage Plant	Hydroelectric power plant, four units totaling 1,616 MW	Chattanooga, Tennessee, approximately 81 km (50.5 mi) southwest	Operational (TVA 2012k)
Ocoee Dam #1	Hydroelectric power plant on the Ocoee River. Five generating units totaling 24 MW	Benton, Tennessee, approximately 58 km (36 mi) south-southeast	Operational, minor NPDES permit No. TN0027499 TVA 2012l)
Watts Bar Dam Safety Modifications	Installation of permanent measures for safety deficiencies related to probably maximum flood events. May include removing temporary barriers, installing permanent modifications in the form of a combination of concrete floodwalls, raised earthen embankments or berms and gap closure barriers.	Upstream from Watts Bar Dam in the vicinity of the Watts Bar Dam Recreation Area (opposite shore from WBN site). Potential construction staging area downstream of dam and adjacent to the lock canal.	Draft EIS published September 2012 (TVA 2012m).

Table 4-15. (contd)

Project Name	Summary of Project	Location	Status
Water supply and treatment facilities			
Spring City, Tennessee sewage treatment plant	Wastewater treatment facility on Watts Bar Lake	Approximately 10 km (6 mi) northwest	Operational, major NPDES permit No. TN0021261 (EPA 2012a)
Spring City, Tennessee water supply	Withdraws water from Watts Bar Reservoir	Approximately 11 km (7 mi) northwest	Operational (Spring City 2010)
Dayton, Tennessee sewage treatment plant	Wastewater treatment facility on Chickamauga Lake	Approximately 24 km (15 mi) southwest	Operational, major NPDES permit No. TN0020478 (EPA 2012b)
Dayton, Tennessee water supply	Withdraws water from Chickamauga Lake Reservoir	Approximately 22.5 km (14 mi) southwest	Operational (City of Dayton 2010)
Rockwood Water and Gas	Sewage treatment facilities on Watts Bar Lake	Roane County, Tennessee, approximately 29 km (18 mi) east-northeast	Operational, major NPDES domestic permit No. TN0026158 (EPA 2012c)
Loudon Utilities Board	Withdraws water from the Tennessee River	Approximately 43.5 km (27 mi) northeast	Operational, planning to expand capacity (LCEDA 2012)
Kingston sewage treatment plant	Sewage treatment facilities on the Lower Clinch River	Roane County, Tennessee, approximately 44 km (27.5 mi) northwest	Operational, major NPDES permit No. TN0061701 (EPA 2012d)
Roane County wastewater plant	Sewage treatment facilities on the Lower Clinch River	Roane County, Tennessee, approximately 50 km (31 mi) northeast	Operational, major NPDES permit No. TN0024473 (EPA 2012e)
Watts Bar Utility District	Withdraws groundwater and purchases surface water	Approximately 51 km (31.5 mi) northeast	Operational (WBUD 2010)
Lenoir City Utilities Board	Withdraws water from the Watts Bar Embayment	Approximately 52 km (32.5 mi) northeast	Operational, major NPDES permit No. TN0023582 (LCUB 2010)

Table 4-15. (contd)

Project Name	Summary of Project	Location	Status
Moccasin Bend wastewater treatment plant	Wastewater treatment facility on Chickamauga Lake	Chattanooga, Tennessee, approximately 74 km(46 mi) southwest	Operational, major NPDES domestic permit No. TN0024210 (EPA 2012f)
Tennessee American Water	Withdraws water from the Tennessee River	Chattanooga, Tennessee, approximately 76 km (47 mi) southwest	Operational (Tennessee American Water 2011)
Kuwahee wastewater treatment plant	Wastewater treatment facility on Watts Bar Lake	Approximately 87 km (54 mi) northeast	Operational, major NPDES permit No. TN0023582 (EPA 2012g)
Cleveland Utilities sewage treatment plant	Wastewater treatment facility on the Hiwassee River	Cleveland, Tennessee, approximately 32.5 km (20.2 mi) south	Operational, major NPDES permit No. TN0024121 (EPA |EPA 2012h)
Anderson County Utility Board	Wastewater treatment facility on the Clinch River	Clinton, Tennessee, approximately 74 km (46 mi) northeast	Planned, major NPDES permit TN0080438 pending (EPA 2012i)
Clinton Sewage Treatment Plant #1	Wastewater treatment facility on the Clinch River	Clinton, Tennessee, approximately 78.5 km (49 mi) northeast	Operational, major NPDES permit No. TN0026506 (EPA 2012j)
West Knox Utility District - Melton Hill Wastewater Treatment Plant	Wastewater treatment facility on the Clinch River	Knoxville, Tennessee, approximately 58 km (36 mi) northeast	Planned, major NPDES permit TN0080721 pending (EPA 2012k)
Manufacturing facilities			
General Shale Brick Inc. Plant 42	Brick and structural clay tile manufacturing	Spring City, Tennessee, approximately 27 km (17 mi) northeast	Operational, major air permit No. 4714300116; non-major NPDES permit Nos. TN0079839 and TN0079863 (EPA 2012l)

Table 4-15. (contd)

Project Name	Summary of Project	Location	Status
Resolute Forest Products (Formerly AbiBow)	Integrated Pulp and Paper Mill on the Hiwassee River	Calhoun, Tennessee, approximately 34 km (21 mi) south	Operational, major NPDES permit No. TN0002356 (EPA 2012m)
Olin Chemical Corporation	Manufacturer of chlorine and caustic soda on the Hiwassee River	Charleston, Tennessee, approximately 32 km (20 mi) south	Operational, major NPDES permit No. TN0002461 (EPA 2012n)
Various minor NPDES wastewater discharges	Various businesses with smaller wastewater dischargers to waterbodies	Within 16 km (10 mi)	Operational
Transportation			
Tennessee Route 30 Improvement	Improvement of SR-30 from SR-29/US-27/Rhea County Highway (SR-29) at log mile (LM) 9.18 in Rhea County to 2000’ east of the Tennessee River Bridge at LM 0.38 in Meigs County	Within 24 km (15 mi)	In environmental review stage (TDOT 2008)
Parks and recreation sites			
Yuchi Wildlife Refuge	957 ha (2,364 ac) with small game hunting	Approximately 5.5 km (3.4 mi) southwest	Managed by the Tennessee Wildlife Resources Agency (TWRA 2011)
Watts Bar Wildlife Management Area	1,570 ha (3,880 ac) with big and small game hunting	Includes both Thief Neck Island and Long Island. Approximately 24 and 35 km (15 and 22 mi) northeast	Managed by the Tennessee Wildlife Resources Agency (TWRA 2011)
Chickamauga Wildlife Management Area	1,620 ha (4,000 ac) in Bradley, Hamilton, McMinn, Meigs, and Rhea counties. Big and small game hunting	Throughout the region. Includes Yellow Creek, Washington Ferry, McKinley Branch, Goodfield Creek, Cottonport, Shelton	Managed by the Tennessee Wildlife Resources Agency (TWRA 2011)

Table 4-15. (contd)

Project Name	Summary of Project	Location	Status
		Bottoms, Moon Island, Gillespie Bend, Mud Creek, New Bethel, Sale Creek, and Soddy Creek wildlife management areas	
Recreational Areas	Various parks, boat launches, campgrounds, swimming areas on Watts Bar Lake	Within 16 km (10 mi)	Operational (TVA 2012n)
Cumberland Trail State Scenic Trail	A 480 km (300-mi) backcountry hiking trail from Cumberland Gap National Park in Kentucky to Chickamauga Chattanooga National Military Park	Throughout region	Approximately 280 km (175 mi) of the trail have been constructed. Managed by the Cumberland Trail Conference (CTC 2012)
Other projects			
ARRA Projects	Various decontamination and decommissioning projects at the Oak Ridge Reservation		ARRA 2012a, b, c, d
Future Urbanization	Construction of housing units and associated commercial buildings; roads, bridges, and rail; and water and/or wastewater treatment and distribution facilities and associated pipelines as described in local land-use planning documents	Throughout region	Construction would occur in the future, as described in State and local land-use planning documents

4.14.1 Land Use

Section 2.1 describes the affected environment. This information serves as a baseline for the cumulative impacts assessment related to land use and transmission lines. As described in Section 4.1, impacts on land use from operating WBN Unit 2 would be SMALL. In addition to land-use impacts from plant operation, the NRC staff evaluated whether interactions with other past, present, and foreseeable future actions could contribute to adverse cumulative impacts on land use. Potential land-use impacts on the entire 80-km (50-mi) region around the WBN site are considered; however, the primary geographic area of interest includes Rhea and Meigs counties, because these counties are adjacent to the site and house the communities most likely to experience any land-use impacts from WBN Unit 2 operation activities.

Historically, the WBN site and vicinity were sparsely populated and the terrain was primarily forested rolling hills. One of the most significant land-use changes in the neighboring counties occurred when TVA constructed Watts Bar Dam, which it completed in 1941. Dam construction flooded thousands of acres of land in Rhea, Meigs, and Roane counties along the Tennessee River.

Construction of Units 1 and 2 in the 1970s accelerated residential development in Rhea and Meigs counties. Plant construction affected much of the WBN site. Over the last few decades, residential areas, roads, utilities, and businesses have increased in the 80-km (50-mi) region around the WBN site, and wetlands and agricultural lands have decreased.

As described in Section 4.1, the only land WBN Unit 2 construction and operation activities would affect directly would be within the WBN site borders, and the activities would affect only previously disturbed land. TVA does not plan to build any new offsite transmission corridors or expand existing corridors to support operation of Unit 2. A 13-kV electric transmission system links the WBN site to the power grid system to provide temporary power to the site for construction and to support non-safety-related activities. Parts of this 13-kV system need to be upgraded or replaced. If TVA upgrades the 13-kV system, it would build a new substation onsite that would affect a 9-m^2 (100-ft^2) area. Although WBN Unit 2 construction could benefit from upgrading the temporary site power distribution system, TVA does not need or require these upgrades to support WBN Unit 2 operation (TVA 2008a).

Other reasonably foreseeable projects in the review area could contribute to additional decreases in undeveloped land and generally result in some increased urbanization and industrialization within the 80-km (50-mi) region around the WBN site. However, existing parks, reserves, and managed areas would help preserve wetlands and forested areas. Because the projects within the review area would be consistent with applicable land-use plans and control policies, these cumulative land-use impacts from the projects would likely be manageable.

The NRC staff expects the cumulative land-use impacts with the 80-km (50-mi) review area to be manageable because the activities would be consistent with existing land-use plans and zoning. In addition, the construction workforces for WBN Unit 2 are already onsite and TVA is mitigating impacts through tax-equivalent payments to affected areas. It is unlikely that constructing and operating Unit 2 would increase urbanization or conversion of land from existing uses. Based on its evaluation, the NRC staff concludes that the cumulative land-use impacts on the geographic area of interest related to operating WBN Unit 2 and other projects in the geographic area of interest would be SMALL.

TVA does not plan to build any new offsite transmission corridors or expand existing corridors to supporting operating Unit 2. Based on its evaluation, the NRC staff concludes that the cumulative impact on land use from the transmission-line corridor would be SMALL.

4.14.2 Air Quality

The air quality in the vicinity of the WBN Unit 2 site is described in Section 2.8, and the air quality impacts of operation of WBN Unit 2 were discussed in Section 4.8. This cumulative analysis considers WBN Unit 2 and other reasonably foreseeable projects that could affect air quality. For this cumulative analysis, the NRC staff considers the geographic area of interest to be Rhea County in the Eastern Tennessee-Southwestern Virginia Interstate Air Quality Control Region defined in 40 CFR 81.57. Rhea County is in attainment of all criteria pollutants. Air quality attainment status reflects the effects of past and present emissions from all pollutant sources in the region.

Reflecting on other projects in this region, most air quality effects would maintain the status quo. Any new industrial projects would either have minimal impacts or would be subject to regulation by the TDEC. Given these institutional controls, it is unlikely regional air quality would degrade significantly (i.e., degrade to the extent that the region is in nonattainment of national standards). Consequently, the NRC staff concludes that the cumulative impacts on air quality related to operating WBN Unit 2 would be SMALL.

4.14.3 Greenhouse Gas Emissions

Since NRC published its 1978 FES-OL and 1995 SFES-OL-1 (NRC 1978, 1995), global climate change has become a subject of national and international interest. Therefore, analyzing the impacts of global climate change associated with operating and decommissioning a nuclear power plant at WBN is part of the NRC staff's assessment.

As the state of the science report issued by the U.S. Global Change Research Program (GCRP) discusses, it is the "… production and use of energy that is the primary cause of global warming, and in turn, climate change will eventually affect our production and use of energy. The vast majority of U.S. GHG emissions, about 87 percent, come from energy production and use…" Approximately one-third of the GHG emissions are the result of generating electricity and heat (GCRP 2009).

Section 4.8 gives the NRC staff estimate of the annual GHG emissions from WBN Unit 2 operation as about 8,000 MT CO_2(e). This emission rate can be placed in context by comparison with the EPA new source CO_2 emissions threshold value of 100,000 MT (75 FR 31514) and the proposed CEQ presumptive threshold value of 25,000 MT (CEQ 2010). GHG emissions from the fuel cycle required to support WBN Unit 2 operation are discussed in Section 4.10.2. Similarly, GHG emissions associated with decommissioning WBN Unit 2 are discussed in Section 4.11. In these sections, the NRC staff concludes that the local atmospheric impacts of GHG emissions related to operating and decommissioning WBN Unit 2 would be SMALL. The NRC staff also concludes that the local impacts of the combined emissions for the full plant life cycle would be SMALL.

The GCRP report (GCRP 2009) synthesizes the results of numerous climate-modeling studies. The cumulative impacts of GHG emissions around the world, as presented in the report, are the appropriate basis for the NRC staff evaluation of cumulative impacts. Based on the impacts set forth in the GCRP report, the NRC staff concludes that the national and worldwide cumulative impacts from GHG emissions would be MODERATE. The NRC staff further concludes that the cumulative impact level would be MODERATE, with or without the GHG emissions of WBN Unit 2.

4.14.4 Water

4.14.4.1 Surface-Water Use

The description of the affected environment in Section 2.2 of this document serves as a baseline for surface-water use. As described in Section 4.2.2.1, the NRC staff concludes the impacts of operating WBN Unit 2 on surface-water use would be SMALL.

The U.S. Geological Survey (USGS) and TVA have extensively studied water use in the Tennessee Valley (Hutson et al. 2004; Bohac and McCall 2008). TVA uses this information to inform its policies and practices for operating reservoirs on the river (TVA 2004). The USGS did not consider the impacts of operating WBN Unit 2 in its initial water-use study (Hutson et al. 2004), and TVA did not consider Unit 2 in the Reservoir Operations Study (TVA 2004). However, TVA evaluated water use for WBN Unit 2 in its report, *Water Use in the Tennessee Valley for 2005 and Projected Use in 2030*, based on numbers available in 2005 (Bohac and McCall 2008). Information from Bohac and McCall (2008) was also used to prepare the EIS for the TVA Integrated Resource Plan (TVA 2011k). *Water Use in the Tennessee Valley for 2005 and Projected Use in 2030* (Bohac and McCall 2008) considers present and reasonably foreseeable uses of water in the Tennessee River Basin. The 2008 report indicates total consumptive use of water in the Tennessee River system is 19 m^3/s or 432 MGD (670 cfs) for irrigation, public water supply, and industrial and thermoelectric uses (Bohac and McCall 2008). This represents approximately 1 percent of the mean annual discharge of 1,860 m^3/s (65,600 cfs) at the outlet of the Tennessee River (USGS 1998). Consumptive use in the Tennessee River Basin above Watts Bar Dam totaled 10 m^3/s or 229 MGD (355 cfs) in 2005 or approximately 1.3 percent of the mean annual flow through the dam (see Section 2.2.1.1, Table 2-2).

Bohac and McCall (2008) assume in their analysis that TVA will replace some of the existing coal-fired generation with nuclear generation by 2030. The report states “This will reduce the amount of existing once-through cooling and will result in a reduction of water withdrawal for thermoelectric use compared to 2005. However, because the use of cooling towers will increase, the net water demand for thermoelectric [power generation] will increase compared to 2005." This increase, plus changes in consumptive use due to population growth, industrial development and irrigation is expected to result in an increase in consumptive use of Tennessee River water to 33 m^3/s or about 756 MGD (1,170 cfs) by 2030 or approximately 1.8 percent of the current mean annual discharge of the Tennessee River (Bohac and McCall 2008). Similar information is not available for the Tennessee River at Watts Bar Dam.

The NRC staff is also aware of the potential climate changes that could affect the water resources available for cooling and the impacts of reactor operations on water resources for other users. The NRC staff considered a recent compilation of the state of the knowledge in this area (GCRP 2009) in the preparation of this SFES. Projected changes in the climate for the region during the life of WBN Unit 2 include an increase in average temperature of 1.1 to 1.7°C (2 to 3°F) and a decrease in precipitation in the spring and summer and no anticipated change in the fall and winter. Changes in climate during the life of Unit 2 could result in either an increase or decrease in runoff (GCRP 2009). While the potential water resource changes attributed to climate change are not insignificant, the NRC staff did not identify any information suggesting that the projected cumulative impacts would substantially alter water availability.

Based on the current consumptive use of water in the Tennessee River and the small increase in consumptive use anticipated by 2030 coupled with a small change in river flow associated with climate change, the NRC staff determined that the cumulative consumptive use of surface water from the operation of WBN Units 1 and 2 and other consumptive uses (existing or reasonably foreseeable users) may be detectable, but such uses would be unlikely to noticeably alter the resource. Based on its evaluation, the NRC staff concludes the cumulative impacts on surface-water use would be SMALL.

4.14.4.2 Surface-Water Quality

The description of the affected environment in Section 2.2 of this document serves as a baseline for surface-water quality. As described in Section 4.2.2.2, the NRC staff concludes the impacts of operating WBN Unit 2 on surface-water quality would be SMALL.

The NRC staff considered the cumulative impacts of chemical and thermal discharges to the river. WBN Unit 2 will discharge water to the Tennessee River including blowdown from the condenser cooling system cooling-tower basins (through Outfall 101) and discharge from the SCCW system (through Outfall 113). Operating WBN Unit 2 would also increase discharges of HVAC cooling water, stormwater, fire-protection wastewater, and discharges from the YHP (through Outfalls 101 and 102). TVA must meet the requirements of the current NPDES permit with respect to discharging constituents. TVA (2008a) confirms its compliance with State water-quality criteria by routine semi-annual Whole Effluent Toxicity testing at Outfall 101, Outfall 112, and Outfall 113.

The concentration of chemical constituents in water samples collected in Chickamauga Reservoir adjacent to the WBN site are indicative of the cumulative impact of all activities upstream of the sampling point including industrial, agricultural, and municipal discharges. As presented in Section 2.2, the water quality in these samples is generally good. However, the Hiwassee River embayment of Chickamauga Reservoir is identified by TDEC as having an impaired use for fish consumption because of mercury. Watts Bar Reservoir is identified as having an impaired use for fish consumption because of polychlorinated biphenyls (PCBs). Portions of the reservoir are also identified as impaired for fish consumption due to mercury and chlordane. The Emory River Arm of Watts Bar Reservoir is identified as impaired for arsenic, coal ash deposits, and aluminum, as well as mercury, PCBs, and chlordane (TDEC 2010). The Emory River Arm is the area of the reservoir most affected by the ash spill that occurred at the Kingston Fossil Plant in 2008.

Water temperature in the Tennessee River is influenced by the operation of the river system as well as thermal discharge from the WBN units. The construction and operation of dams on the Tennessee River has extensively altered the flow of water in the river. The dams and reservoirs on the river and its tributaries provide many benefits, but also result in increased water temperature and thermal stratification of some reservoirs during summer months. Water temperature in the Tennessee River above and below the WBN site fluctuates throughout the year in response to many factors. Air temperature and solar radiation are the dominant meteorological variables influencing river system water temperatures. For example, one study indicated that in the Upper Tennessee River above Chickamauga Dam, a 0.6°C (1°F) increase in air temperature resulted in water temperatures generally increasing by 0.14°C to almost 0.28°C (0.25°F to almost 0.5°F), depending on the type of weather and location in the reservoir system (Miller et al. 1992). During July 1993, maximum air temperatures recorded in Chattanooga were above 32°C (90°F) each day, with temperatures reaching as high as 40°C (104°F). During this period, all nine mainstem Tennessee River reservoirs had surface-water temperatures that exceeded 30°C (86°F) and some had water temperatures as high as 32°C (90°F) (TVA 1994).

The NRC staff evaluated the thermal impact of plant discharges in the vicinity of the diffuser and the SCCW discharge in Section 4.2.2.2 and demonstrated that implementation of the TVA procedures (TVA 2010b) would result in compliance with temperature limits in the future and that impacts on surface-water quality would be negligible.

The NRC staff also evaluated the increase in temperature in the Tennessee River that would be caused by the discharge of heated water through Outfalls 101 and 113 by the WBN plant with both units operating once the discharge water was thoroughly mixed with the Tennessee River. The WBN plant will discharge 7.85×10^8 Btu/hr to the Tennessee River during July through Outfalls 101 and 113 (TVA 2010c). The definition of a British thermal unit (Btu) is the amount of heat required to raise a pound of water by one degree Fahrenheit. During periods of average flow, 778 m^3/s (27,500 cfs), this would raise the temperature of the water flowing past the plant approximately 0.06°C (0.1°F) once fully mixed with the Tennessee River water. When flows are as low as 280 m^3/s (10,000 cfs), the temperature would be raised approximately 0.2°C (0.4°F). Flow past the WBN site is greater than 280 m^3/s (10,000 cfs) 93 percent of the time (TVA 2009a). Average flow past the site for July has been 530.2 m^3/s (18,723 cfs) and 639.5 m^3/s (22,584 cfs) for August (TVA 2010c). As a result, the temperature impacts evaluated for 280 m^3/s (10,000 cfs) and 778 m^3/s (27,500 cfs) bound the historic flows for these warmest months of the year. The temperature increase attributable to operation of WBN Units 1 and 2 are predicted to be negligible compared to the temperature increase attributable to air temperature and solar heating as indicated by Miller et.al. (1992). Therefore, the NRC staff concludes that past, present, and reasonably foreseeable actions in the region have adversely affected the chemical and thermal conditions in the Tennessee River. Based on its evaluation, the NRC staff concludes that the cumulative surface-water-quality impacts would be MODERATE. Based on TVA conformance to NPDES permit requirements, the outcome of its routine outfall water-quality monitoring, and the results of water-quality monitoring in Chickamauga Reservoir the NRC staff concludes that the operation of WBN Unit 2 would not be a significant contributor to these impacts.

4.14.4.3 Groundwater Use

The description of the affected environment in Section 2.2 of this document serves as a baseline for groundwater use. As described in Section 4.2.2.3, the NRC staff concludes the impacts of operating WBN Unit 2 on groundwater use would be SMALL.

Current groundwater withdrawals are limited to water pumped from a French drain surrounding the power blocks for both units on the site. Withdrawals are limited to approximately 32 L/s (500 gpm) (TVA 2010c) and the operation of WBN Unit 2 would not result in an increase in water withdrawn on the site because WBN Unit 2 is already served by the French drain system. The Watts Bar Utility District provides potable water for the WBN site. As discussed in Section 4.2.2.3, the groundwater withdrawn to support the WBN plant during normal operation would be less than 3 percent of current withdrawals by the utility. Table 2-4 in Section 2.2.2.1 identifies other water districts in the vicinity that rely on groundwater. All of them are sufficiently distant from the Watts Bar Utility District well field (more than 10 km [6 mi]) that additional withdrawals to support WBN operations would not affect the operations of these other utilities. The volume of water the Watts Bar Utility District would withdraw to support operating WBN is small relative to current withdrawal. In addition, groundwater withdrawal and surface alterations affecting groundwater onsite have existed for some time. For these reasons, the NRC staff concludes the cumulative impact on groundwater use from the operation of WBN Unit 2 and other groundwater users in the site vicinity would be SMALL.

4.14.4.4 Groundwater Quality

The description of the affected environment in Section 2.2 of this document serves as a baseline for groundwater quality. As described in Section 4.2.2.4, the NRC staff concludes the impacts of operating WBN Unit 2 on groundwater quality would be SMALL.

Groundwater quality onsite has been affected by past tritium leaks from WBN Unit 1. Groundwater samples are collected from five wells onsite near the plant, one groundwater source onsite upgradient of the plant, and one well located offsite (TVA 2011g). The maximum tritium concentrations measured in the groundwater samples has declined from approximately 20,400 Bq/L (550,000 pCi/L) (TVA 2008a) in 2005 to 106 Bq/L (2,860 pCi/L) in 2010 (TVA 2011g). Current concentrations in groundwater are well below the EPA drinking water standard of 20,000 pCi/L (TVA 2011g). No other groundwater-quality impacts from past operations at the site have been identified and tritium concentrations in offsite groundwater wells have not been affected by site operations (TVA 2011g). Factors limiting the impacts of operations of WBN Unit 2 on groundwater quality in the area are discussed in Section 4.2.2.4 and include the TVA SPCCs, the groundwater monitoring program at the WBN site, and the relative isolation of the WBN site from local groundwater supply wells.

Based on the effect of previously identified leaks from WBN Unit 1 systems on groundwater and the implementation of SPCC plans, the groundwater monitoring program at the WBN site and the relative isolation of the site from local groundwater supply wells, the NRC staff concludes that the cumulative impacts on groundwater quality at the site have been detectable, but they are limited to the WBN site and would not noticeably alter the resource beyond the site boundary. Furthermore, the NRC staff concludes that the operation of WBN Unit 2 would not contribute significantly to the observed impact. For these reasons, the NRC staff concludes the cumulative impact on groundwater quality from the operation of WBN Unit 2 combined with other past, present, and reasonably foreseeable projects in the vicinity of the site would be SMALL.

4.14.5 Terrestrial Ecology

Section 2.3 describes the affected environment and Section 2.3.1 discusses terrestrial resources. This information serves as a baseline for evaluating impacts on terrestrial ecology from operating WBN Unit 2. As Section 4.3.1 describes, the impacts on terrestrial and wetland resources from operating Unit 2 would be SMALL. This conclusion is consistent with the conclusion NRC (1978) reached in its 1978 FES-OL regarding impacts on terrestrial resources from operating WBN Units 1 and 2.

In addition to evaluating impacts on terrestrial resources from operating WBN Unit 2, the NRC staff evaluated whether interactions with other past, present, and foreseeable future actions could contribute to adverse cumulative impacts on these resources. For this analysis, the geographic area of interest includes Rhea and Meigs counties. In addition, all lands that occur within 0.8 km (0.5 mi) of the transmission system that would support the proposed unit in Hamilton, Bradley, McMinn, Roane, Anderson, Knox, Blount, and Loudon counties are included in this analysis. Rhea and Meigs counties encompass the resource area the proposed WBN Unit 2 is expected affect because of the nature of the potential impacts on terrestrial resources and the characteristics of the resources such as home range size, distribution, abundance, and habitat preferences. Lands within 0.8 km (0.5 mi) of the transmission corridor would also bound the area expected to be affected by the operation of the transmission system for these same reasons.

As discussed in Sections 4.3.1, operating the heat discharge and transmission systems could affect terrestrial resources. Because WBN Unit 1 is co-located with Unit 2, the nature of impacts on resources attributable to Unit 2 also would be attributable to Unit 1. Operating the Unit 1 cooling tower would result in TDS deposition, localized fogging/icing, and increased potential for collision mortality. However, in its 1978 FES-OL, the NRC staff concluded that operating WBN Units 1 and 2 would not significantly affect terrestrial resources (NRC 1978).

Since 1978, private companies have erected many telecommunication towers in Tennessee. Operating both units may result in lower cloud ceilings. The FCC (2004) reports that lower cloud ceilings and lower visibility contribute to mass collision mortality of migrant birds when these conditions occur around telecommunication towers. Although it could be reasoned that the operation of WBN Units 1 and 2 could result in increased bird collision mortality, the density of telecommunication towers in the WBN vicinity is quite low because there is only one cell tower within the expected zone of influence from the cooling towers (MapMuse 2010). Although the NRC staff does not know the configuration (i.e., height, lighting, guy wires) of this tower, it does not expect the presence of an additional communication tower near the WBN cooling towers to contribute significantly to a regional tower mortality phenomena. No other structures have the potential to interact with the cooling towers and contribute to tower mortality.

The existing TVA transmission system spans the 10 counties listed above and already transmits power from numerous generation facilities in the region, including WBN Unit 1. TVA does not propose to build any new transmission lines to support increased electricity production in the region, and adding the electricity WBN Unit 2 generates to the grid would not affect terrestrial resources.

In the southeastern United States, the mean temperature is predicted to increase in all seasons during the next 50 to 100 years and annual precipitation is predicted to decrease from global climate change (GCRP 2009). Forest growth could slow, native plant and animal distribution could change, invasive species may increase, and wildfire frequency and intensity could increase. Because the gray bat requires very specific cave habitat conditions, changes in climate may also change the distribution and abundance of this species.

Little is known about a phenomenon known as white-nose syndrome that has caused massive mortality of many bat species in the northeastern United States (Cohn 2008). The name comes from a white *Geomyces* fungus that grows on affected bats' muzzles. The syndrome has affected at least six species of bats and is confirmed in at least eight states, including Tennessee, and three Canadian provinces (FWS 2010a). The mortality rate of affected bats is high, with bat colony reductions of over 90 percent in infected caves. White-nose syndrome may be affecting gray bats (FWS 2010b). Because little is known about white-nose syndrome, the extent that this may affect the gray bat in the Watts Bar vicinity is still unknown.

Based on information TVA provided and the NRC staff's independent review, the NRC staff concludes that impacts on terrestrial resources, including Federally and State-listed species, from cumulative impacts would be SMALL.

4.14.6 Aquatic Ecology

The description of the affected environment in Section 2.3 of this document evaluated impacts on aquatic resources in the vicinity of the WBN site. As described in Section 4.3.2.7, the NRC staff concludes that the overall impacts on aquatic biota, including Federally listed threatened and endangered species, from impingement and entrainment at the SCCW and IPS intakes and from thermal, physical and chemical discharges as a result of operating Unit 2 on the WBN site are SMALL. This information serves as one source of information for evaluating the cumulative impacts on aquatic ecology of operating WBN Unit 2. The cumulative analysis considers other past, present, and reasonably foreseeable future actions that were not previously considered in Chapters 2 or 4, that could affect aquatic ecology of the WBN site.

The geographical region for cumulative impacts for aquatic ecology primarily comprises the Watts Bar and Chickamauga reservoirs. The NRC staff selected the two reservoirs as the region of interest because the dams on the Tennessee River and its tributaries largely segment the biological communities. The direct effects of operation of WBN Units 1 and 2 would not be communicated in a discernible manner beyond one reservoir downstream—the Chickamauga Reservoir. The Watts Bar Reservoir is in the region of interest because the SCCW is located in that reservoir.

In its ER, TVA (2008a) discussed cumulative aquatic impacts primarily in terms of summary indices meant to communicate the current, general environmental health of the river and reservoir system. The NRC staff takes a longer view of past and present impacts while also examining finer scale data. Section 2.3.2 describes some of the changes that were made to the Tennessee River since the early 1900s. These changes include impoundment of the river. Historically, the Tennessee River was free flowing and flooded annually. Before 1936, the few power dams that obstructed streams in Tennessee backed up relatively small impoundments. In 1936, TVA completed its first reservoir on the Tennessee River—Norris Reservoir. Currently, TVA operates nine dams on the mainstem of the Tennessee River. The dams have fragmented the watershed, altered water temperatures, increased sedimentation, reduced dissolved oxygen concentrations, and altered flow regimes. This in turn has caused and will continue to cause extirpation of fish, mussels, and other aquatic biota (Neves and Angermeier 1990; Etnier and Starnes 1993; Neves et al. 1997). Other past actions that have changed the aquatic fauna in the geographical region include introduction of non-native species, overfishing of species such as paddlefish, harvesting of mussels, toxic spills, mining, and agriculture. Section 2.3.2 describes the introduction and success of non-native and invasive aquatic fish, invertebrate, and plant species that have clearly destabilized and changed Tennessee River aquatic communities. The aquatic communities can change slowly in response to stress: they have been changing for a long time, are changing now, and will probably continue to change for the foreseeable future. The aquatic resources are not stable in the sense of persisting as they were in the past or are today. In their review of the Tennessee River, White et al. (2005) observed that:

> Because reservoirs create ecosystem conditions that did not exist previously in the basin, conceptually these are "new" ecosystems. Reservoir ecosystems do not reach the longitudinal and temporal equilibriums of the parent river…, producing conditions ripe for invasions of true nonnative plants and animals that are highly adaptable. Although most species occurred in the system prior to impoundment, the dominant species now are those adapted to a new set of environmental conditions.

WBN Unit 1 is collocated with WBN Unit 2. The two units share the same intakes and discharges. As discussed in Section 3.2.2.1, the makeup flow rate through the IPS would be almost twice that for single-unit operation. Further, the intake flow rate of the SCCW system when both units are operating would be slightly less than the flow through the SCCW intake while operating only a single-unit, although the difference is within the uncertainty in the estimate of flow while operating one or two units.

The total flow through the two units operating (includes withdrawals from both the SCCW system and the IPS) would be approximately 12 m^3/s (440 cfs), which is approximately 1.6 percent of the mean annual flow past the WBN site (see Table 3-1 for anticipated water use). WBN Units 1 and 2 together would consume 1.8 m^3/s (62 cfs), which is approximately 0.2 percent of the mean annual flow past the WBN site.

As discussed in Section 4.3.2, the SCCW intake pulls water from the forebay of the Watts Bar Reservoir at the face of Watts Bar Dam. The IPS pulls water from Chickamauga Reservoir, approximately 3.1 km (1.9 mi) below Watts Bar Dam. The aquatic inhabitants of the two reservoirs are effectively separated by the Watts Bar Dam, except for organisms that pass through the dam and small numbers of organisms that may travel between reservoirs during operation of the boat lock system. However, the NRC staff considers an estimate of the total entrainment assuming that the two intakes actually withdraw water from the same location. The total entrainment of fish eggs and larvae, using the most recent estimates available and assuming both intakes were removing water from the same environment, is 2.45 percent for eggs (assuming twice the entrainment rate for the IPS during the 2010-2011 study (TVA 2012b) added to the entrainment rate for the SCCW) and 2.84 percent for larvae (assuming twice the entrainment rate during the 2010-2011 study (TVA 2012b) of 0.43 percent for the IPS added to the entrainment rate for the SCCW). The current operation of the SCCW for WBN Unit 1 accounts for the largest portion of the entrainment rates (which is the reason that this discussion occurs in cumulative impacts).

The NRC staff also considered impingement at both intakes, although the intakes draw water from populations in two different reservoirs. As discussed in Section 4.3.2, impingement rates on both intakes are low with the exception of shad. Again, the current operation of the SCCW for WBN Unit 1 accounts for the largest fraction of the impingements. Sections 2.3.2 and 4.3.2 discuss numerous preoperational and operational surveys, entrainment studies, impingement studies, and hydrothermal studies of the effects of operation of WBN Unit 1 on aquatic biota in Watts Bar and Chickamauga reservoirs. The impact determination of SMALL for WBN Unit 2 as given in Section 4.3.2.7 is based on the results of almost 15 years of surveys and studies performed on WBN Unit 1, which show that operation of WBN Unit 1 did not destabilize or noticeably alter the aquatic environment. As a result, the NRC staff concludes that the cumulative impact of operation of both WBN Units 1 and 2 will not destabilize or noticeably alter the aquatic environment.

Other facilities may potentially affect aquatic biota of Watts Bar and Chickamauga reservoirs by entrainment, impingement, or thermal, chemical, or physical discharges. These are listed in Table 4-15 and include Watts Bar Dam; Sequoyah Nuclear Plant, located on the Chickamauga Reservoir; the Kingston Fossil Plant, located at the junction of Emory River and Clinch River; and the Oak Ridge National Laboratory, located on the Clinch River.

Because of its proximity to the site, the Watts Bar Dam, which is located approximately 3.2 km (2 mi) upstream continues to adversely affect aquatic ecology in the vicinity of the WBN site. Watters (2000) and Chapter 2 of this SFES describe specific impacts on aquatic biota from impoundment of the reservoirs such as the extirpation of aquatic biota, which is detectable, and a symptom of ecosystem destabilization. The dam is a barrier to fish migration, and its placement altered the flow regimes and continues to alter the water quality, including the temperature of the river (as discussed in Section 4.14.4.2). In addition, the transport of fish, eggs, and larvae through the dam may result in some mortality (Cada 1991).

Increasing the volume of water released from Watts Bar Dam is one of five options TVA can use to ensure that the thermal discharge from operation of WBN Units 1 and 2 remains within the NPDES limits as discussed in Section 4.2.2.2. If this option is chosen, the water released from Watts Bar Dam could have a slight and indiscernible effect on the water levels in Tennessee River reservoirs and tributaries upstream and downstream of Watts Bar Dam and a slight and indiscernible effect on the biota in those reservoirs and tributaries.

Other sources of entrainment and impingement stress exist beyond the WBN site. The Sequoyah Nuclear Plant, on the west shore of Chickamauga Reservoir at TRM 484.5, is located approximately 71 river km (44 river mi) downstream of the WBN site in an area of the reservoir where the river takes on a more lake-like appearance. The Sequoyah Nuclear Plant consists of two units with an average daily intake flow of 71.81 m^3/s (2,536 cfs) and a 0.37 m/s (1.2 ft/s) velocity at the intake traveling screens. As a result, the Sequoyah Nuclear Plant is a source of entrainment and impingement stress within the same reservoir as WBN Unit 2. TVA researchers conducted impingement studies from January 25, 2005, through January 15, 2007 (TVA 2007b). TVA reported 22 species from 9 families during the impingement study. The estimated annual impingement (extrapolated from impingement rates from weekly samples) was 20,233 fish during the first year and 40,362 fish during the second year. Threadfin shad composed 91 percent of the total individuals, followed by bluegill (*Lepomis macrochirus*) (3 percent) and freshwater drum (2 percent). TVA researchers also conducted the impingement studies in the winter of December 2001 through February 2002 (Baxter and Kay 2002). During this study, TVA identified 15 fish species representing 8 families and 1 exotic mussel (zebra mussel) in the impingement samples (Baxter and Kay 2002). Again, threadfin shad was the numerically dominant species, composing 97 percent of the total number of individuals collected (74 percent of the total weight). All other species contributed less than 1 percent of the total, although freshwater drum composed 15 percent of the total weight.

TVA reported on entrainment sampling at Sequoyah Nuclear Plant from 1980 to 1985 and estimated the entrainment of total fish larvae to be 8.6 percent of those passing the plant (Baxter and Buchanan 2006). TVA estimated that the seasonal mean hydraulic entrainment for this period was 12.2 percent. TVA conducted entrainment monitoring in 2004 to meet the requirements of Section 316(a) of the Clean Water Act (Baxter and Buchanan 2006). From April 20 through July 12, 2004, hydraulic entrainment averaged 24.2 percent. This higher hydraulic entrainment likely resulted from lower reservoir flow rates caused by lower than average runoff from rainfall. The lower reservoir flow likely influenced the entrainment rate; it was the highest recorded during 2004. During this period, TVA estimated overall larval entrainment to be 15.6 percent, which was the highest ever recorded. Clupeids were the dominant taxon in the entrainment samples and had an estimated entrainment rate of 15.4 percent of the total passing the plant. TVA estimated freshwater drum larval entrainment to be 45.4 percent of the drum larvae transported past the plant. Freshwater drum eggs composed 98.8 percent of the total fish eggs. The seasonal entrainment estimate for drum eggs was 11.2 percent. The average seasonal densities of fish eggs and larvae in the reservoir near the Sequoyah Nuclear Plant in measurements taken in 2004 were 664 per 1,000 m^3 and 3,946 per 1,000 m^3, respectively. TVA attributed the seasonal larval drum entrainment at Sequoyah Nuclear Plant primarily to a sample taken on May 18, 2004, when peak density (717 per 1,000 m^3) occurred simultaneously with peak hydraulic entrainment (Baxter and Buchanan 2006).

The Kingston Fossil Plant, near Kingston, Tennessee, is located on a peninsula at the junction of the Emory River and Clinch River, approximately 68 river km (42 river mi) upstream from Watts Bar Dam. TVA conducted impingement studies and reported 30 species impinged during the first year and 33 in the second year of the study. The estimated annual impingement extrapolated from weekly samples was 185,577 fish during the first year and 225,197 fish during the second year. Similar to impingement results for the SCCW, threadfin shad accounted for 95 percent of the 2-year total of fish TVA collected during an impingement study conducted from November 16, 2004, through November 16, 2006 (TVA 2007c).

Historical entrainment studies (Schneider and Tuberville 1981) showed that, although the hydraulic entrainment of the Kingston Fossil Plant averaged 22.7 percent in 1975, the biological entrainment was significantly lower, at 0.84 percent. TVA attributed this difference, at least partially, to its use of a skimmer wall. The NRC staff does not anticipate cumulative impacts from entrainment and impingement at the Kingston Fossil Plant to affect the fish population observed in the forebay by Watts Bar Dam, because the home range of most species is less than the migration distance between the two locations.

Thermal impacts beyond the WBN site may add to cumulative impact. The NRC staff also considered the cumulative impacts that could potentially occur as a result of the thermal discharges at the Kingston Fossil Plant, or the Sequoyah Nuclear Plant and the thermal discharges at the WBN site. Because of the distances between these three sites, the travel time of the reservoirs, and the dissipation of heat from the discharge plumes, the NRC staff considers these impacts to be independent.

Chemical contamination can also adversely affect aquatic resources. In December 2008, a coal fly-ash slurry spill occurred at the Kingston Fossil Plant. The Tennessee Department of Health (TDOH) sampled water quality downstream of the Kingston Fossil Plant in response to the spill. It conducted the majority of sampling in the Clinch and Emory rivers. In addition, TDOH also sampled at TRM 568.2. According to the TDOH, except in the immediate vicinity of the coal ash release, the coal ash or the metals in the coal ash have not affected surface water in the Watts Bar Reservoir, and concentrations of radiation are below the regulatory limits that protect public health. In addition, TDOH sampling and analysis of metals associated with coal ash indicate that metals in all other areas of the Emory River and Clinch River have remained below any health comparison values. Although the TDEC and the Tennessee Wildlife Resource Agency advise citizens to avoid consuming striped bass and limit consumption of catfish and sauger in the Clinch and Emory rivers, the pollutants of concern in these rivers include PCBs and mercury from historical activities not related to TVA (TDOH 2009). PCBs and mercury are a long-term hazard to biota and, as discussed in Section 2.3.2.1, PCBs are known to impair the reproductive, endocrine, and immune system function in fish and increase lesions, tumors, and cause death, while mercury is also known to cause reproductive effects. The effects of contamination on the level of individual fish can alter population dynamics and destabilize natural populations and ecosystems.

Operations and waste disposal activities at the U.S. Department of Energy's (DOE's) Oak Ridge Reservation, located on the Clinch River at river mi 17.7, introduced PCBs, metals, organic compounds (including those with mercury), and radionuclides (including cesium-137) into local streams and, ultimately, into the Watts Bar Reservoir system. The highest discharges occurred in the mid-1950s. The mouth of the Clinch River is located at TRM 567.7, placing the Oak Ridge Reservation at approximately 89 river km (55 river mi) upstream of the Watts Bar Dam. The highest concentrations of chemical and radioactive contaminants lie in the subsurface sediments where 40 to 80 cm (16 to 32 in.) of sediment covers the deposits (Agency for Toxic Substances and Disease Registry 1996). Such legacy contaminants can adversely affect biota in the Tennessee River.

Potential climate changes could also have a cumulative effect the aquatic biota in the vicinity of the WBN site. GCRP (2009) projected that changes in the climate for the region during the life of WBN Unit 2 would cause an increase in the average temperature of 1.1 to 1.7°C (2 to 3°F) and a decrease in precipitation in the spring and summer and no anticipated change in the fall or winter. The raised air temperature, which would correspond to an increased water temperature in the reservoirs of the Tennessee River, would increase the potential for thermal effects on aquatic biota. Although the amount of temperature change is not great, even a slight change could further change the balance of the aquatic community in the reservoirs.

Based on information TVA provided and the NRC staff's independent review, the NRC staff concludes that the cumulative impacts on aquatic biota, including Federally and State-listed species in Watts Bar Reservoir and Chickamauga Reservoir are LARGE based on past, present, and reasonably foreseeable future actions. The environmental effects are clearly noticeable and sufficient to destabilize important attributes (e.g., freshwater mussel populations) of the aquatic biota in the vicinity of the WBN site. The incremental, site-specific impact from the operation of WBN Unit 2 would be minor and not noticeable in comparison to cumulative impact on the aquatic ecology.

4.14.7 Historic and Cultural Resources

The description of the affected environment in Section 2.5.3 serves as the baseline for the cumulative impacts assessment for historic and cultural resources. As described in Section 4.5, impacts on historic and cultural resources from the NRC licensing action for WBN Unit 2 would be SMALL. The NRC staff has determined that the APE for this review is the area at the power plant site and the immediate environs that may be affected by activities associated with operating WBN Unit 2.

The APE is the geographic area of interest defined for the assessment of cumulative impacts on historic and cultural resources. The cumulative impacts assessment has been considered and documented using the NHPA Section 106 process and played a role in determining the eligibility of historical properties for listing on the National Register of Historic Places. The Section 106 process and coordination with the SHPO and Tribes provides information on cultural resources and potential impacts on cultural resources with respect to other past, present, and foreseeable future actions in the State of Tennessee.

Historically, the WBN site and vicinity remained largely undisturbed by land development. It likely contains several intact archaeological sites associated with the last 10,000 years of human settlement in the area, as described in Section 2.5.3. More recent land development includes TVA (1) construction of WBN Units 1 and 2 and associated infrastructure, (2) construction and subsequent demolition of the adjacent Watts Bar Fossil Plant, and (3) construction of associated dams and reservoirs, which, taken together, have resulted in impacts on and/or the loss of historic and cultural resources in the vicinity of the WBN site.

As described in Section 4.5, the NRC staff concluded that the impact on historic and cultural resources related to operating WBN Unit 2 would be SMALL. TVA construction activities and existing facilities have disturbed the majority of the APE for this undertaking (TVA 2006). Operating WBN Unit 2 would only add small increments to cumulative cultural resource impacts in the region. Historic and cultural resources are non-renewable; therefore, the impact on historic and cultural resources is cumulative. Based on the information TVA provided, and the NRC staff's independent evaluation, the NRC staff concludes that the cumulative impacts on historic and cultural resources of operating WBN Unit 2 would be SMALL.

4.14.8 Radiological Health Impacts

The description of the affected environment in Section 2.6 serves as the baseline for the cumulative impacts assessment in this resource area. As described in Section 4.6, the NRC staff concludes that the radiological impacts from operations would be SMALL.

Cumulative impacts from operation also considers past, present, and reasonably foreseeable future actions that could contribute to cumulative radiological impacts. For this analysis, the geographic area of interest is the area within an 80-km (50-mi) radius of the proposed WBN Unit 2. Historically, the NRC staff has used the 80-km (50-mi) radius as a standard bounding geographical area to evaluate population doses from routine releases from nuclear power plants. Within the 80-km (50-mi) radius of the existing WBN site, there is also the TVA Sequoyah Nuclear Plant, located 51 km (32 mi) southwest of WBN, and DOE's Oak Ridge facility, located 66 km (41 mi) northeast of the WBN site. In addition, there are likely hospitals and industrial facilities using radioactive materials.

As stated in Section 2.6, TVA has conducted a preoperational and operational REMP around the WBN Units 1 and 2 since 1976. The REMP measures radiation and radioactive materials from all sources, including existing Units 1 and 2, area hospitals, and industrial facilities. In 2002, TVA discovered concentrations of tritium in onsite monitoring and increased its tritium monitoring efforts. Based on the results of the REMP, the levels of radiation and radioactive material in the environment around WBN Units 1 and 2 generally show little or no increase above natural background.

As described in Section 4.6, the public and occupational doses predicted from the proposed operation of the new unit at WBN Unit 2 are well below regulatory limits and standards. In addition, the site-boundary dose to the MEI from the existing Units 1 and new Unit 2 would be well within the regulatory standards in 10 CFR Part 20, 10 CFR Part 50, Appendix I, and 40 CFR Part 190.

WBN Unit 1 currently produces tritium under a contract with the DOE, but there are no plans for WBN Unit 2 to produce tritium for DOE. The REMP also monitors any potential impact from the production of tritium. The results of the REMP indicate effluents and direct radiation from WBN Unit 1 and area hospitals and industrial facilities that use radioactive materials do not contribute measurably to the cumulative dose.

Currently, no other new nuclear facilities are being considered within 80 km (50 mi) of the WBN site. TVA is planning on completing the construction of Bellefonte Unit 1, but it is beyond 80 km (50 mi). The NRC, the DOE, and the State of Tennessee would regulate or control any reasonably foreseeable future actions in the region that could contribute to cumulative radiological impacts. Therefore, the NRC staff concludes that the cumulative radiological impacts of operation of the WBN Unit 2 and existing Unit 1 would be SMALL.

4.14.9 Nonradiological Human Health

The description of the affected environment in Section 2.7 serves as a baseline for the cumulative impacts assessment related to nonradiological human health. The impacts the NRC staff considered from operations at the WBN site include etiological agents and noise. Impacts considered from the transmission system include noise, electric shock, and chronic exposure to EMFs. The impacts on nonradiological human health from operation of WBN Unit 2 and the transmission system would be SMALL. In addition, the NRC staff evaluated whether interactions with other past, present, and foreseeable future actions could contribute to adverse cumulative impacts on nonradiological human health. For this analysis, NRC staff considered the geographic area of interest to be Rhea and Meigs counties because the operation of WBN Unit 2 would primarily affect the communities in these counties.

Before TVA constructed Watts Bar Dam, the population in the vicinity of the WBN site was sparse, and recreational activities were limited to the Tennessee River. Subsequent development created a recreational resource, drawing people to the water, and a residential community that uses the waters around the WBN site for boating and fishing. Records on etiological agents in the vicinity of the WBN site are limited. However, neither the Chickamauga Reservoir nor the portion of the Tennessee River in the vicinity of the WBN discharge have been on the list of streams and reservoirs where human contact bacteriological advisories have been issued in the past three years (TDEC 2010). The NRC staff also reviewed studies of water-borne and notifiable diseases over the past 10 years for the state of Tennessee and found the number of cases is both unchanged and within the range of national trends.

The results of an evaluation of noise from constructing the WBN site probably were typical for large construction projects. Based on evaluations before construction, few residences in the area existed that could be disturbed. Currently, three residences are located within 1,800 m (6,000 ft) of the WBN site. Typical operational noises from WBN Unit 2, along with noise generated from Unit 1 would be expected to be attenuated to below the level the NRC staff considers significant (< 65 dBA) at the distance to the closest residences (TVA 2008a; NRC 1995, 1996, 2002).

TVA built the existing transmission lines according to Federal and State codes and standards. TVA does not expect impacts from noise generated by corona discharge from the transmission lines to change with time. TVA would have to mitigate electric shock from induced currents associated with the transmission lines during construction and keep lines in compliance with NESC standards. With regard to chronic effects of EMFs, the scientific evidence of their effects on human health does not conclusively link extremely low frequency EMFs to adverse health impacts.

Cumulative nonradiological human health impacts within the 80-km (50-mi) review area are expected to be negligible. Other reasonably foreseeable projects in the review area could contribute to additional development, residential growth in the vicinity of the area, and increased recreational use of the Chickamauga Reservoir. TVA does not plan to build any new offsite transmission corridors or expand existing corridors to support operating WBN Unit 2.

Operating WBN Unit 2 and the transmission system would only add small increments to cumulative nonradiological human health impacts in the region. Based on the information TVA provided and the NRC staff's independent evaluation, the NRC staff concludes that the cumulative impacts on nonradiological human health from operating WBN Unit 2 and the transmission system would be SMALL.

4.14.10 Socioeconomics and Environmental Justice

The description of the affected environment in Section 2.4 serves as a baseline for the cumulative impacts assessment for socioeconomics and environmental justice. For this cumulative analysis, the NRC staff considers the geographic area of interest related to environmental justice to be the 80-km (50-mi) region around the WBN site. The geographic area of interest related to socioeconomic impacts also includes the 80-km (50-mi) region; however, the primary socioeconomic ROI, as described in Section 4.4, includes Rhea, Meigs, McMinn, and Roane counties. Much of the analysis of socioeconomics and environmental justice impacts presented in Section 4.4 already incorporates cumulative impact analysis because the metrics used for analysis only make sense when placed in the total or cumulative context. For instance, the NRC staff can only evaluate the impact of the total number of additional housing units that may be needed with respect to the total number that will be available in the affected area. The geographic area of the cumulative analysis varies depending on the particular impacts considered and may depend on specific boundaries, such as taxation jurisdictions distance from the site.

Current TVA activities related to constructing WBN Unit 2 involve a large-scale project employing approximately 1,300 onsite workers. During construction of Unit 2, the State of Tennessee (TCA 67-9-101) allocates additional tax-equivalent payments from TVA to affected local governments (see Section 2.4). The State makes these additional payments to local governments that are designated as "impacted" by construction activities. The State makes these additional, in-lieu, tax payments during the construction period in decreasing amounts and for 3 years after TVA completes the construction of WBN Unit 2. All four counties evaluated as part of the four-county socioeconomic ROI (including Rhea, Meigs, McMinn, and Roane) are designated as "impacted" counties and are currently receiving additional tax revenue (TVA 2010b). These local governments could use these additional payments by TVA to address some impacts on public services that potentially could occur with an influx of workers to the region (TVA 2008a).

In addition to construction activities, periodic refueling outages[(a)] (for WBN Unit 1) would occur, which would involve approximately 500 additional temporary employees working onsite for a 3- to 4-week period. This additional workforce would likely pose temporary strains on short-term housing and hotel availability, but because of the limited period, the NRC staff does not expect any noticeable impacts on public services, transportation, the education system, and housing. Staggering the timing of working shifts could reduce any potential impacts on the regional road networks (TVA 2009c).

The operation of one additional unit at the WBN site would not likely significantly add to any cumulative socioeconomic impacts beyond those identified in Section 4.4. The NRC staff does not expect impacts on areas such as transportation or taxes to be detectable beyond the four-county ROI evaluated in Section 4.4, and expects the impacts would quickly decrease with increasing distance from the site. Thus, the NRC staff concludes that the cumulative impacts on socioeconomics and environmental justice related to operating WBN Unit 2 would be SMALL.

(a) A typical outage consists of fuel-reloading activities, equipment maintenance, inspections, and special projects, such as major equipment replacements and refurbishment and cleaning of chemicals.

However, because of current strains in the capacity of the Rhea and Meigs counties school systems, any additional in-migration to these counties could potentially have a MODERATE impact on the school systems. It is likely, however, the modest influx of workers (200) associated with operating WBN Unit 2 would coincide with an out-migration of some portion of the WBN Unit 2 construction workforce as construction activities ramp down. Thus, the NRC staff concludes that the cumulative impact on schools would be SMALL, and the cumulative impacts on regional economies would be SMALL and beneficial to the region around the WBN site.

Because the environmental justice impacts Chapter 4 analyzes are cumulative by nature, any environmental justice impacts associated with other activities have been considered as part of the environmental justice baseline Sections 2.4.3 and 4.4.3. The NRC staff found no unusual resource dependencies or practices or environmental pathways through which minority and low-income populations would be disproportionately affected. As a result, the NRC staff concludes that the cumulative environmental impacts on environmental justice from the operation of WBN Unit 2 would be SMALL.

4.14.11 Postulated Accidents

As described in Chapter 6, the NRC staff concludes that the potential environmental impacts (risk) from a postulated accident from the operation of WBN Unit 2 would be SMALL. Chapter 6 considers both design basis accidents (DBAs) and severe accidents. The NRC staff concludes that the severe accident probability-weighted consequences (i.e., risks) for WBN Unit 2 would be SMALL. DBAs are addressed specifically to demonstrate that a reactor design is robust enough to meet NRC safety criteria. The consequences of DBAs are bounded by the consequences of severe accidents.

The cumulative analysis considers risk from potential severe accidents at all other existing and proposed nuclear power plants that have the potential to increase risks at any location within 80 km (50 mi) of WBN Unit 2. The 80-km (50-mi) radius was selected to cover any potential risk overlaps from two or more nuclear plants. Existing reactors within the geographic area of interest include WBN Unit 1 and Sequoyah Units 1 and 2. TVA is also considering constructing nuclear plants at the Bellefonte site. Table 6-4 provides a comparison of estimated risk for WBN Unit 2 and other current-generation reactors. The estimated population dose risk of WBN Unit 2 is near the mean and median value for current-generation reactors. For the existing plants within the geographic area of interest, namely WBN Unit 1 and Sequoyah Units 1 and 2, the Commission has determined that the probability-weighted consequences of severe accidents are SMALL. The severe accident risk for a nuclear power plant gets smaller as the distance increases. The combined risk at any location within 80 km (50 mi) of the WBN site would be bounded by the sum of risks for all of these operating and proposed nuclear power plants. Even though there would be several plants included in the combination, this combined risk would still be low. On this basis, the NRC staff concludes that the cumulative risks from severe accidents at any location within 80 km (50 mi) of the WBN Unit 2 likely would be SMALL.

4.15 References

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

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

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

40 CFR Part 81. Code of Federal Regulations, Title 40, *Protection of Environment*, Part 81, "Designation of Areas for Air Quality Planning Purposes."

40 CFR Part 125. Code of Federal Regulations, Title 40, *Protection of Environment*, Part 125 "Criteria and Standards for the National Pollutant Discharge Elimination System."

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5.0 Environmental Measurements and Monitoring Programs

Tennessee Valley Authority (TVA) has conducted environmental monitoring at Watts Bar Nuclear (WBN) plant since the 1970s (NRC 1995). Currently, TVA conducts thermal, radiological, hydrological, meteorological, ecological, cultural, and chemical monitoring onsite and in the vicinity of WBN plant.

5.1 Thermal Monitoring

TVA monitors the temperature of the receiving water (Chickamauga Reservoir) associated with operating WBN Unit 1 to demonstrate that the thermal limits set in the National Pollutant Discharge Elimination System (NPDES) are met by the plant. NPDES permit limits are set to protect aquatic wildlife. TVA also monitors the temperatures of three outfalls where heated water from plant operations is or could potentially be released: Outfall 101, associated with the blowdown discharge from WBN Units 1 and 2 cooling towers and the Yard Holding Pond (YHP); Outfall 102, the emergency overflow for the YHP; and Outfall 113, associated with the Supplemental Condenser Cooling Water (SCCW) system. The NPDES permit has been updated to include discharges associated with the operation of both WBN Units 1 and 2. The revised permit issued by the Tennessee Department of Environment and Conservation (TDEC) contains no changes to the thermal monitoring required for Outfalls 101, 102, and 113 at the WBN site (TVA 2011a).

TVA measures the temperature of water to be discharged through Outfall 101 using a continuous monitor in the blowdown pipe. State water-quality requirements and the WBN site's NPDES permit (TVA 2011a) established a daily maximum discharge temperature limit of 35°C (95°F) for Outfall 101.

The plant discharges water from Outfall 102 infrequently. During discharge events, TVA monitors water temperature with a daily grab sample and as for Outfall 101, the daily maximum discharge temperature limit is 35°C (95°F) (TVA 2011a).

TVA monitors Outfall 113 continuously at the stream bottom to ensure the temperature does not exceed the permitted limit of 33.5°C (92.3°F) at this location. TVA also monitors water temperature in the Chickamauga Reservoir on the Tennessee River to demonstrate that discharges do not exceed permit limits and to verify the temperature models used to manage the cooling system. The NPDES permit identifies two mixing zones for Outfall 113: one for conditions when one or more turbines at Watts Bar Dam operate and one for when the dam discharges little or no water.

When TVA operates one or more turbines at Watts Bar Dam, water flows past Outfall 113 mixing with the heated discharge water and keeping the plume of heated water moving along the shoreline; as a result, the plant has established a monitoring program for an active mixing zone associated with Outfall 113 (the outfall for the SCCW system). TVA continuously monitors water temperature at the downstream edge of the mixing zone, located 610 m (2,000 ft) downriver from the discharge. Here, TVA suspends temperature sensors from floats in the river and measures the water temperature. Telemeters on the floats transmit temperature data every 15 minutes to the plant so operators can adjust the cooling system if the water approaches temperature limits. Sensors are located at 1, 1.5, and 2 m (3, 5, and 7 ft) below the water surface. For comparison, sensors are also located upstream of Outfall 113.

When turbines at the dam do not operate and minimal flow exists past the outfall, the NPDES permit allows for a passive mixing zone. Under these conditions, the mixing zone extends 300 m (1,000 ft) downriver and includes the entire width of the river. Under these conditions, fish can still pass the heat plume because it resides near the top of the water column. Twice a year TVA performs a temperature survey along a transect across the river through this mixing zone, and uses these data to verify its models that determine when to alter the operation of the SCCW or release additional water at the dam to comply with discharge permits. TVA reports temperature survey results annually, such as in its *Winter 2006 Compliance Survey for Watts Bar Nuclear Plant Outfall 113 Passive Mixing Zone* (Proctor and Hopping 2007).

5.2 Radiological Monitoring

TVA has conducted its radiological environmental monitoring program (REMP) at the WBN site since Unit 1 began operating in 1996, with its preoperational sample collection activities beginning in 1976 (TVA 2003a). The REMP includes monitoring the airborne exposure pathway, direct exposure pathway, water exposure pathways, aquatic exposure pathways from the Chickamauga Reservoir, and the ingestion exposure pathway within an 8-km (5-mi) radius of the station. The program also uses indicator locations near the plant perimeter and control locations at distances greater than 16 km (10 mi) from the plant. TVA conducts an annual survey of the surrounding area to verify the accuracy of the assumptions it uses in the analyses, including the occurrence of milk production. The preoperational REMP sampled various media in the environment to determine a baseline from which to observe the magnitude and fluctuation of radioactivity in the environment once the units began operating. The preoperational program included collecting and analyzing samples of air particulates, precipitation, crops, soil, well water, surface-water, fish, and silt as well as measuring ambient gamma radiation. After Unit 1 began operating in 1996, the monitoring program continued to assess the radiological impacts on workers, the public, and the environment. TVA summarizes radiological environmental monitoring data and radioactive effluent release data at the WBN site in two annual reports: the *Annual Radiological Environmental Operating Report* (e.g., TVA 2008a) and *Annual Radioactive Effluent Release Report* (e.g., TVA 2009a). WBN Offsite Dose Calculation Manual (ODCM) specifies the limits for all radiological releases (TVA 2008a). The REMP is a sitewide program that monitors the radiological impacts from all radiation sources on the site. Accordingly, TVA does not plan to establish an additional monitoring program for WBN Unit 2. To the greatest extent practicable, the REMP would use the procedures and sampling locations TVA uses for WBN Unit 1. U.S. Nuclear Regulatory Commission (NRC) staff reviewed the documentation for the existing REMP and the WBN ODCM, and determined that the current operational monitoring program is adequate to establish the radiological baseline for comparison with the expected impacts on the environment related to operating and maintaining WBN Unit 2.

In support of the Nuclear Energy Institute Ground Water Protection Initiative, TVA developed a Ground Water Protection Program (GWPP) to monitor the onsite plant environment for indication of leaks from plant systems and buried piping carrying radioactive liquids. The TVA 2010 *Annual Radioactive Effluent Release Report* (TVA 2011b) summarized results of groundwater sampling it performed in various locations around the plant that could be a source of groundwater contamination. Section 2.6 describes the GWPP. The NRC staff reviewed results of tritium monitoring from WBN Unit 1 for a period of 9 years (2003 through 2010). In 2010, the only observations of tritium offsite were trace levels of tritium in six samples collected from two downstream public water sampling locations. The highest downstream water sample was 1.8×10^{13} pBq/L (597 pCi/L), which is well below the U.S. Environmental Protection Agency (EPA) drinking standard of 7.4×10^{14} pBq/L (20,000 pCi/L). Onsite, tritium levels continue to decrease annually following the 2002 leak described in Section 2.2.3.2.

5.3 Hydrological Monitoring

Hydrological monitoring consists of surface-water and groundwater monitoring. At the WBN site, TVA monitors the thermal and chemical characteristics of water discharged to surface-water through WBN outfalls. TVA also monitors temperature in Chickamauga Reservoir. Section 5.1 describes thermal monitoring and Section 5.6 describes chemical monitoring, including chemical monitoring in surface-water and groundwater.

In addition, TVA uses information about the volume of water flowing past the WBN site to make decisions related to operating the cooling system in compliance with the NPDES permit for discharging water from Units 1 and 2 to Chickamauga Reservoir. TVA gathers this flow information at Watts Bar Dam immediately upstream of the WBN site.

Groundwater monitoring at WBN includes collecting groundwater samples for analysis of radionuclides and is described in Section 5.6.2.

5.4 Meteorological Monitoring

TVA has collected meteorological data at the WBN site since 1971 (TVA 2009b). It began operating a permanent meteorological data collection system in 1973. The plant has modified system instrumentation since then. Section 2.3 of the WBN Final Safety Analysis Report (FSAR) (TVA 2009b) describes in detail the data collection system as it currently exists. It consists of a 91-m (300-ft) tower with wind and temperature sensors at 10 m (33 ft), 46 m (150 ft), and 91 m (300 ft), a ground-level rain gauge, a dewpoint sensor on a separate 10-m (33-ft) tower, and associated data processing and recording equipment. The meteorological system provides meteorological data to support operating WBN Unit 1 and would support Unit 2. During the site audit, TVA indicated its intention to upgrade the meteorological instruments to meet the specifications set forth in Revision 1 of Regulatory Guide 1.23 (NRC 2007).

The NRC staff reviewed the meteorological system in 1994 in conjunction with preparing its 1995 supplement to the final environmental statement related to the operating license (1995 SFES-OL-1) (NRC 1978, 1995). The NRC staff reviewed the system again in preparing for this supplemental final environmental statement (SFES) related to operating WBN Unit 2. The NRC staff found in both reviews that the measurement location was representative of the WBN site, the instrument specifications were consistent with guidance in Regulatory Guide 1.23 (AEC 1972), and system calibration and maintenance procedures were sufficient to ensure reliable data for meteorological characterization of the site for environmental reviews.

5.5 Ecological Monitoring

5.5.1 Terrestrial Ecology

In the 1978 Final Environmental Statement related to the operating license for WBN Units 1 and 2 (1978 FES-OL), TVA committed to monitoring the effects of cooling-tower drift, bird collisions with the cooling tower, and maintaining the transmission lines (NRC 1978). TVA also committed to monitor the effects of total dissolved solids deposition on plants and to have qualified personnel inspect vegetation for evidence of damage during the growing season. Also, TVA agreed to initiate an aerial remote sensing program to detect terrestrial effects of cooling-tower drift (NRC 1978). TVA developed these two monitoring activities to address the potential for effects related to the WBN plant plume and the Watts Bar Fossil Plant plume merging. Because TVA has never operated these two plants simultaneously, it has not conducted this monitoring (NRC 1995). To determine the existence and extent of serious episodic collision mortality events, the NRC recommended TVA initiate a monitoring program capable of detecting and reporting such events during migratory periods (NRC 1978). After monitoring for bird collisions with the cooling towers for more than 15 years without any recorded notable episodes, NRC (1995) deemed this monitoring unnecessary. The NRC also required the applicant to provide an annual report regarding chemical control of vegetation along transmission corridors.

TVA does not conduct or propose to conduct any other terrestrial monitoring activities specific to the WBN site. However, TVA has committed to surveying transmission corridors for the presence of Federally protected species before conducting maintenance activities (NRC 1995) and continuing to identify ecologically sensitive areas within transmission corridors as part of the sensitive area review process (TVA 2010a).

5.5.2 Aquatic Ecology Monitoring

TVA has collected monitoring data since 1970. Table 5-1 lists the monitoring studies that have already been performed in the vicinity of the WBN site on both the Watts Bar Reservoir and the Chickamauga Reservoir.

TVA conducted characterization studies of aquatic communities in the vicinity of the WBN site as part of the preoperational monitoring program with the following objectives:

- phytoplankton and zooplankton to "describe natural variability associated with phytoplankton and zooplankton communities in the reservoir, and to document biologic trends occurring prior to operation of WBN" (TVA 1986)
- periphyton (1973 through 1977), primarily to describe the algal portion of the community (TVA 1986)
- benthic organisms (organisms living on the substrate) to describe the benthic community by analyzing the colonization of artificial substrates by macrobenthos, by sampling general macroinvertebrates, and by sampling unionid mussels in the vicinity of the WBN site
- ichthyoplankton (fish eggs and larvae) to determine the spatial and temporal concentrations and distributions of ichthyoplankton in the vicinity of the WBN site
- fish to provide a baseline on the fish community including cove rotenone data, electrofishing, experimental gill nets, and hoop net studies in Chickamauga Reservoir and creel surveys in Watts Bar and Chickamauga reservoirs to estimate the annual average sport harvest.

The NRC reported the preoperational data in the 1978 FES-OL (NRC 1978). This SFES does not discuss the data further except to compare them with more recent sampling results. Since the 1978 FES-OL was published, TVA has conducted additional studies of the aquatic communities in the Chickamauga and Watts Bar reservoirs in the vicinity of the WBN site. This SFES describes these data and uses the data to:

- Characterize potential differences between aquatic communities above and below the site and measure the impact of Unit 1 operations on aquatic communities (when possible).
- Characterize changes TVA observed in the environment as a result of operating WBN Unit 1 to measure any potential change that might be expected from operating proposed Unit 2.

Table 5-1. Aquatic Biota Sampling Studies Performed in the Vicinity of the WBN Site

Type of Sampling	Year	Purpose	Sampling Method	Schedule	Location	Reference
Phytoplankton and zooplankton	1973–1977	Preoperational monitoring	Phytoplankton – Mid-channel with 8-L Van Dorn bottle at 0.3, 1, 3 and 5 m (1, 3.3, 10, and 16 ft) depths Zooplankton - 0.5 m (1.6 ft) diameter plankton net fitted with #20-mesh nylon bolting cloth.	Quarterly	TRM 532.1, 529.5, 528.0, 527.4, 518, 506.6, 496.5	NRC (1978); TVA (1986)
	1982–1985	Preoperational monitoring	Same as above with samples collected in triplicate.	Quarterly	TRM 532.1, 529.5, 528.0, 527.4, 518, 506.6, 496.5	TVA (1986)
Periphyton	1973–1977	Preoperational monitoring	Plexiglas plates placed in metal or polyvinyl chloride support track, 1.5 dm^2 (23 $in.^2$) exposed area, 0.5 m (1.6 ft) from water surface	May/June; August/September	TRMs 506.6, 518.0, 527.4, 528.0, 529.5; TRM 496.5 (1977 only)	NRC (1978); TVA (1986)
	1982–1985	Preoperational monitoring	See above	Quarterly	TRMs 496.5, 506.6, 518.0, 527.4, 528.0, 529.5;	TVA (1986)
Benthic macroinvertebrates	1973–1976	Preoperational monitoring	Artificial substrates,	Quarterly 1973–1976, left for 90 days from 1973–winter 1975. Changed to 30 days 1975–1977.	496.5, 506.6, 518.0, 527.4, 528.0 and 529.9.	NRC (1978); TVA (1986)

Table 5-1. (contd)

Type of Sampling	Year	Purpose	Sampling Method	Schedule	Location	Reference
	1982–1985	Preoperational monitoring	Artificial substrates, Hess sampler or by hand for mussels	Artificial substrates – quarterly 1982–1985. 30-day colonization period. Hess sampler began in autumn 1983 and continued for two seasons.	Artificial substrates – TRM 496.5, 506.6, 518.0, 527.4, 528.0 and 529.5 Hess Sampling – TRM 521.0, 526.3, 527.4, 528.0, and 528.5	TVA (1986)
	1996–1997	Operational (Unit 1)	Hess sampler; substrate in sampler disturbed with hand or hand rake to depth of 15 cm (5.9 in.). Dislodged organisms caught in catch cup. Mussels and clams placed in mesh bags.	July–September; October–December	TRM 521.0, 526.3, 527.4, 528.0, and 528.5	Baxter et al. (2010)
	1999–current	Operational (Unit 1)	Ponar sampler and Peterson sampler; samples washed on 533 micron (0.02 in.) screen	Annually during the autumn	TRM 533.3; 527.4	Simmons and Baxter (2009); Simmons et al. (2010); Simmons (2011)
Mussels	1975–1976; 1978	Preoperational monitoring	Brailing and random scuba dives (1975–1976); timed scuba dives (1978)	July 1975–August 1977, June 1978	TRM 520.5–528.5; June 1978 – TRM 514.2 to 528.9	NRC (1978; TVA (1986)

Table 5-1. (contd)

Type of Sampling	Year	Purpose	Sampling Method	Schedule	Location	Reference
	Sept 1983 Nov 1983 July 1984 Nov 1984 July 1985 Oct 1985 July 1986 Oct 1986 July 1988 July 1990 1992, 1994	Preoperational	Timed scuba dives – 1983 to 1985 – two pairs of scuba divers collected for 11 minutes each in four sampling sites in each of three mussel beds. 1985 to 1994 – two divers 22 minutes each from each of three mussel beds.		TRM 520-521, TRM 526-527, TRM 528–529	TVA (1986); Baxter et al. (2010)
	July 1996, July 1997	Operational (Unit 1)	Timed scuba dives – two divers, 22 minutes at each of four sampling sites in each of three mussel beds.			Baxter et al. (2010)
	1997	Prior to operation of SCCW	General survey	May	TRM 529.2	TVA (1998)
	2010	Operational (Unit 1); Preoperational (Unit 2)	Four 100-m (330 ft) long sampling transects at each sampling location; 10-m^2 (110 ft^2) sampling area; additional sampling in boulder sampling site; quantitative samples at end of transect. Total of 120 semi-quantitative and 40 quantitative samples.	September 28 and 30, 2010	TRM 528-529L; TRM 526-527R; TRM 520-521L; Boulder field at approximately TRM 529.5	Third Rock Consultants (2010)

Table 5-1. (contd)

Type of Sampling	Year	Purpose	Sampling Method	Schedule	Location	Reference
Fish	1976–1993;	Preoperational monitoring	Cove rotenone studies		TRM 524.6	Simmons (2010)
	1995, 1997, 1999	Operational monitoring	Cove rotenone studies		TRM 524.6	Simmons (2010)
	1977–1979	Preoperational monitoring	5 electrofishing runs per month; timed 3 minutes per run	Monthly, March 1977–November 1979	TRM 528	NRC (1978); TVA (1986)
	1977–1979	Preoperational monitoring	experimental gill and hoop nets (5-cm [2-in.] mesh)	Winter 1977 through Fall 1979. Tended daily; fished bimonthly	TRM 527.4 to 528.4	Simmons (2010)
	1982–1985	Update of preoperational monitoring	5 electrofishing runs/month; 100 m (330 ft) per run; included young-of-the-year individuals	Monthly, March 1982–December 1985	TRM 528	Baxter et al. (2010)
	1982–1985	Preoperational monitoring	experimental gill and hoop nets	2 consecutive days each month	TRM 527.4 to 528.4	Simmons (2010)
	1990–1995	Preoperational monitoring	15 electrofishing runs; 200 m (660 ft) of shoreline/run; did not include young-of-the-year individuals	Once each fall (October–November)	TRM 526-529.9	Baxter et al. (2010)
	1996–1997	Operational monitoring (Unit 1)	15 electrofishing runs; 200 m (660 ft) of shoreline/run; did not include young-of-the-year individuals	Once each fall (October–November)	TRM 526-529.9	Baxter et al. (2010)

Table 5-1. (contd)

Type of Sampling	Year	Purpose	Sampling Method	Schedule	Location	Reference
Fish	1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010	Continued monitoring to evaluate impacts as required by WBN's NPDES permit TN0020168	Electrofishing – 15 boat runs near the shoreline – each 300 m (980 ft) long with a duration of approximately 10 minutes each. Nearshore area sampled was approximately 4500 m (14,800 ft); Gill nets – Five 6.1 m panels for a total length of 30.5 m (100.1 ft). Mesh size varied between panels; sizes 2.5, 5.1, 7.6, 10.2 and 12.7 cm (1, 2, 3, 4, 5 in.). Positioned perpendicular to river flow extending from nearshore to main channel of reservoir. Ten overnight gill nets.	Once each fall (October–November)	TRM 527.4 TRM 533.3; upstream and downstream of WBN	Simmons and Baxter (2009); Simmons 2011
	1995–2010	Spring sportfish surveys	Electrofishing – 30 minutes of continuous electrofishing per site.	Annually in the spring (typically March and April)	Watts Bar Reservoir – 12 sites – Watts Bar Dam, Blue Springs and Caney Creek; Chickamauga Reservoir – 12 sites – Harrison Bay, Sale Creek, and Ware Branch.	Simmons and Baxter (2009); Simmons 2011

Table 5-1. (contd)

Type of Sampling	Year	Purpose	Sampling Method	Schedule	Location	Reference
Impingement	2005–2006	Demonstration for SCCW intake	Weekly screen wash samples – 24-hour collection	August 2005 to 2007; weekly samples	SCCW intake screens	TVA (2008b)
	1996–1997	Operational monitoring (Unit 1)	Weekly screen-wash samples – 24-hour collection	March 1996 – February 1997 (36 samples; March 1997– September 1997 (21 samples)	IPS screens	Baxter et al. (2010)
	2010–2011	Operational monitoring (Unit 1); Preoperational (Unit 2)	Weekly screen wash samples – 24-hour collection	March 26, 2010 – March 17, 2011	IPS screens	TVA (2011c)
Ichthyoplankton and Entrainment	1975	Operational monitoring for Watts Bar Fossil Plant (intake in Watts Bar Reservoir)	Beam net (0.5 m [1.6 ft] square, 1.8 m [5.9 ft] long with 505 micron [0.02 in.] “nitex” mesh netting) towed upstream at speed of 1.0 m/s (3.3 ft/s) for 10 minutes. Approximately 150 m^3 (5,300 ft^3) of water filtered per 10-minute sample.	10 sampling periods between March 24, 1975 and July 28, 1975; biweekly sampling	Five transects on the reservoir. Pumped samples from three of the six intake screen wells.	TVA (1976)
	2000	Operational monitoring for WBN Unit 1 (SCCW in Watts Bar Reservoir)	Beam net (0.5 m [1.6 ft] square, 1.8 m [5.9 ft] long with 505 micron [0.02 in.] “nitex” mesh netting) towed upstream at speed of 1.0 m/s (3.3 ft/s) for 10 minutes. Approximately 150 m^3 (5,300 ft^3) of water filtered per 10-minute sample.	Weekly from April to June 2000	Same transects as the 1975 study	Baxter et al. (2001)

Table 5-1. (contd)

Type of Sampling	Year	Purpose	Sampling Method	Schedule	Location	Reference
	1976–1979	Preoperational monitoring (IPS in Chickamauga Reservoir)	Beam net (0.5 m [1.6 ft] square, 1.8 m [5.9 ft] long with 505 micron [0.02 in.] “nitex” mesh netting) towed upstream at speed of 1.0 m/s (3.3 ft/s) for 10 minutes. Approximately 150 m^3 (5,300 ft^3) of water filtered per 10-minute sample.	Biweekly on a diel schedule during March–August	Five stations along a transect perpendicular to river flow upstream of the intake channel (TRM 528)	TVA (1986)
	1984–1985	Update of preoperational monitoring	As described above. In addition, intake samples were collected (four 4-minute samples from plant intake pump building to mouth of intake channel).	Biweekly on a diel schedule during March–August	Five stations along a transect perpendicular to river flow upstream of the intake channel (TRM 528). In 1984–1985, towed samples also collected in intake channel.	TVA (1986)
	1996–1997	Operational monitoring (Unit 1)	As described above, except the intake channel samples were four 1-minute samples from trash boom to mouth of channel. Approximately 40-50 m^3 (1,400-1,500 ft^3) of water per intake sample	Biweekly on a diel schedule on six days between April 8 to June 17, 1996 and on seven days between March 31 to June 23, 1997	Five stations along a transect perpendicular to river flow upstream of the intake channel (TRM 528); and in intake channel (four 4-minute samples)	Baxter et al. (2010)

Table 5-1. (contd)

Type of Sampling	Year	Purpose	Sampling Method	Schedule	Location	Reference
	2010 - 2011	Operational monitoring (Unit 1); preoperational monitoring (Unit 2)	Beam net (0.5 m [1.6 ft] square, 1.8 m [5.9 ft] long with 505 micron [0.02 in.] "nitex" mesh netting) towed upstream at speed of 1.0 m/s (3.3 ft/s) for 10 minutes. Approximately 150 m^3 (5,300 ft^3) of water filtered per 10-minute sample.	Weekly samples from March 7, 2010 through August 29, 2010 and monthly from September 20, 2010 through March 25, 2011	Reservoir samples at five stations along transect TRM 528.4; within the IPS canal at TRM 528; transect at 530.2; in front of SCCW intake	TVA (2012)

TRM = Tennessee River Mile.
IPS = intake pumping station.
SCCW = supplemental condenser cooling water (system).

- Provide a more thorough characterization of the aquatic communities of Watts Bar Reservoir forebay in response to the continued use of the SCCW system, which began operating in 1999 to support WBN Unit 1 operations (after publication of the 1995 SFES-OL-1). The SCCW has an intake located above Watts Bar Dam (TRM 529.9). TVA will also use this system for WBN Unit 2, as discussed in Section 2.2.1 (Hydrology).

The following sections describe preoperational studies discussed in the 1978 FES-OL, additional survey studies performed since publication of the 1978 FES-OL, and planned future monitoring.

5.5.2.1 Phytoplankton and Zooplankton

As discussed in Section 2.3.2.1, plankton are small plants or animals that float, drift, or weakly swim in the water column of any body of water. There are two main categories of plankton; phytoplankton and zooplankton. Plankton, also known as “microscopic algae,” contain chlorophyll and require sunlight to live and grow. Zooplankton, are small microscopic animals, mainly invertebrates (animals that are lacking a true vertebrate or backbone). In a balanced ecosystem phytoplankton and zooplankton form the basis of the food chains and play key ecosystem roles in the distribution, transfer, and recycling of nutrients and minerals.

TVA has conducted two studies to characterize the phytoplankton and zooplankton in the vicinity of the WBN site (TVA 1986). The first study occurred from 1973 to 1976 at seven locations from TRM 496.5 to TRM 532.1. Between May 1982 through November 1985, TVA conducted phytoplankton and zooplankton sampling quarterly at the same seven stations. The purpose of the sampling was to obtain data to describe the phytoplankton community in the vicinity of the site in terms of community structure, abundance, biomass, and productivity; and the zooplankton community in terms of taxa, taxon dominance, and densities. TVA also investigated the variations in the communities at different locations upstream and downstream of the site, and looked at the variation between all four seasons.

5.5.2.2 Periphyton

As described in Section 2.3.2, periphyton is a complex community comprising organisms that grow on underwater surfaces. They can include algae, bacteria, fungi, and other organisms. Periphyton plays an important ecological role as a food source for invertebrates, frog larvae (commonly called “tadpoles”), and some types of fish.

Periphyton sampling measurements between 1973 and 1977 during May/June and August/September occurred initially at five stations, although a sixth station at TRM 496.5 was added in 1977. Sampling was discontinued and then resumed quarterly from 1982 through 1985 at the same six stations. The purpose was to describe the benthic community by analyzing what types of periphyton grew (specifically algal growths) and how quickly they grew on artificial substrates (TVA 1986).

5.5.2.3 Benthic Macroinvertebrates

As described in Section 2.3.2, benthic macroinvertebrates are animals that live all or part of their lives on or near the bottom of streams or reservoirs. Invertebrates, as defined previously, are animals that do not have a true backbone. Macroinvertebrates are animals that are large enough to see with the human eye. Macroinvertebrates include animals such as flatworms, roundworms, leeches, crustaceans, aquatic insects, snails, clams, and mussels. Benthic macroinvertebrates are an important food source for other aquatic organisms, including fish. Researchers use studies of benthic macroinvertebrate abundance and distribution to detect major environmental changes because these animals do not migrate rapidly and generally do not make major changes in location.

TVA conducted four sets of studies. The first set was conducted from spring 1973 through autumn 1976. Sampling was conducted using artificial substrates that were made of wire barbeque baskets filled with river stones of uniform size. They were placed at each station and left to colonize for 90 days (1973–1975) or 30 days (1975–1977). Six sampling stations were located at TRMs 496.5 to 529.9; however, the upstream station was relocated to 529.5 after autumn 1976 because the original site was not consistently exposed to river currents (TVA 1986).

During the period from 1983 to 1985, TVA conducted the second set of preoperational studies again using artificial substrates between TRMs 496.5 and 529.5. Hess samplers (circular frame with an attached net of 0.5-mm [0.02-in.] mesh that encloses a surface area of approximately 0.09 m^2 [1 ft^2]) (TVA 1998) were used from 1983 to 1985 between TRMs 521 and 528.5 (TVA 1986).

TVA conducted the third set of studies as operational (1996 to 1997) studies using a Hess sampler during summer (July to September) and autumn (October to December) quarters at TRMs 521.0, 526.3, 527.4, 528.0, and 528.5 in the upper Chickamauga Reservoir to determine the structure of the community, spatial distribution, and temporal variability (Baxter et al. 2010).

TVA initiated the fourth set of studies starting in 1999 (autumn), continuing to the present. TVA collects benthic macroinvertebrates in the forebay of the Watts Bar Dam (TRM 533.3) and in the inflow of the Chickamauga Reservoir (TRM 527.4) as part of its annual monitoring program (Simmons and Baxter 2009). TVA staff performs ten benthic grab samples using a Ponar sampler in most areas and a Peterson sampler when it encounters heavier substrates (Simmons and Baxter 2009). The samplers penetrate the substrate and then enclose bottom substrate material with either spring- or gravity-operated mechanisms. The surface area sampled ranges from 0.02 m^2 (0.21 ft^2) for the Ponar to 0.089 m^2 (0.96 ft^2) for the Peterson sampler. TVA is continuing to conduct benthic macroinvertebrate sampling as part of the Reservoir Vital Signs Monitoring program (Simmons 2011).

5.5.2.4 Freshwater Mussels

TVA has conducted two sets of preoperational monitoring and two different operational monitoring studies of the mussels in the three known concentrations of mussels (mussel beds) downstream of the Watts Bar Dam near the WBN site.

TVA conducted preoperational monitoring during five qualitative or quantitative collections from July 1975 through August 1977 between TRMs 520.5 and 528.5 and in June 1978 between TRMs 514.2 and 528.9 (TVA 1986).

TVA also conducted a second set of preoperational monitoring surveys 12 times before the start of operation of WBN Unit 1 starting in 1983 and continuing to 1994, to identify the species of mussels in the vicinity of the site and their abundance. Scuba divers performed timed dives to sample the mussels in three known monitoring sites located from TRM 520 to 521 on the left descending bank of the river, from TRM 526 to 527 on the right descending bank, and from TRM 528 to 529 on the left descending bank (Baxter et al. 2010). TVA also surveyed the vicinity of the SCCW discharge (TRM 529.2) in 1997 (TVA 1998).

TVA conducted two operational studies at the same sites and using the same techniques as used in the previous sets of preoperational monitoring in 1996 and 1997 after WBN Unit 1 began operation (Baxter et al. 2010).

To supplement the previous studies, TVA conducted additional mussel surveys in 2010 to characterize species composition and relative abundance of juveniles and adult freshwater mussel fauna (Third Rock Consultants 2010; Baxter 2011). Section 2.3.2.1 reports the results of the surveys from 2010. In addition, during 2010, TVA (Third Rock Consultants 2010) conducted a survey of the four experimental plots discussed in Section 2.3.2 that occur within a boulder field approximately 1.6 km (1 mi) downstream from Watts Bar Dam (TRM 528.3 to 528.8) to determine if habitat enhancement has improved the survival of the freshwater mussels. However, only two historic sampling stations were located and few mussels were identified, as discussed in Section 2.3.2.1.

5.5.2.5 Fish

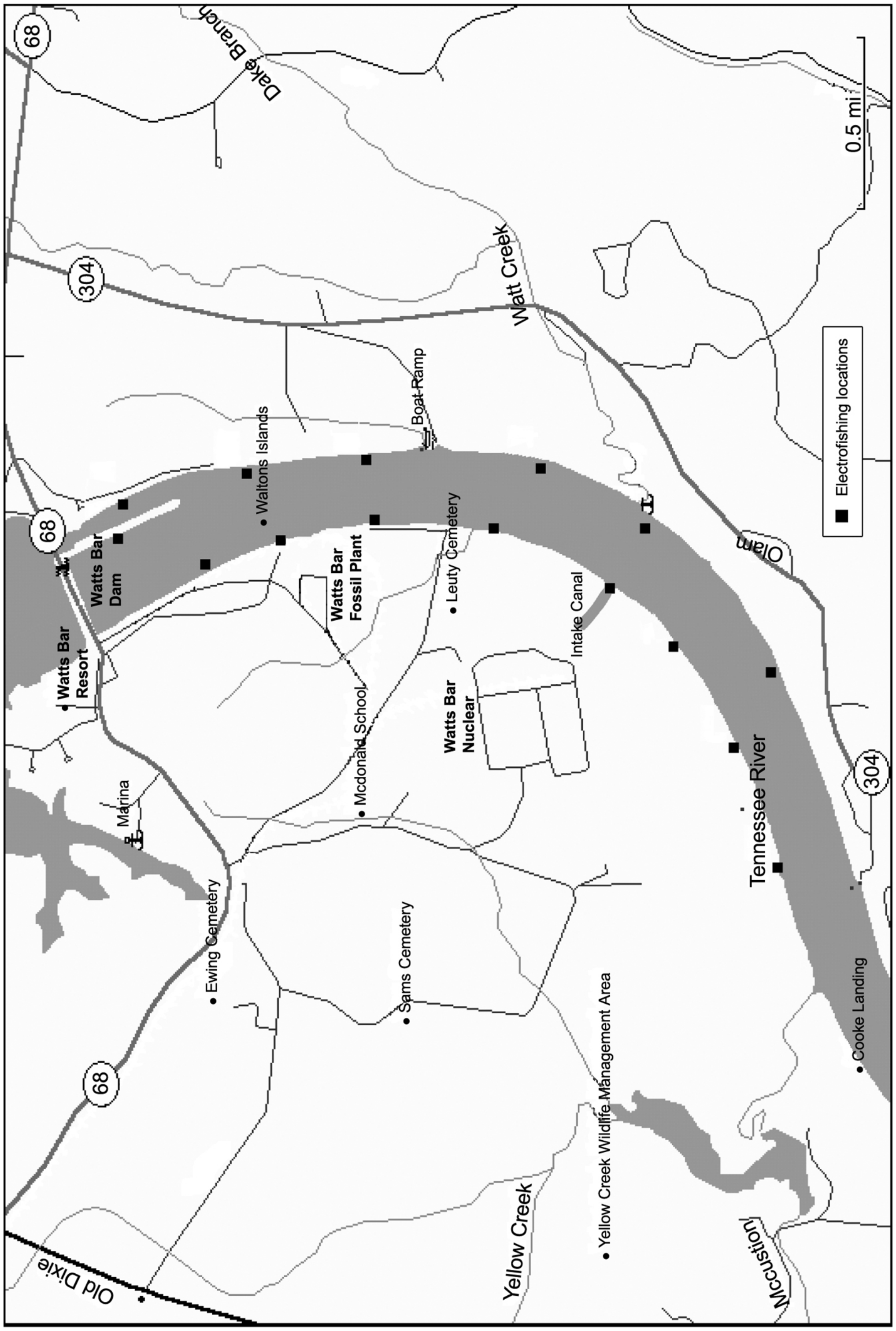
TVA has conducted sampling studies to determine the populations of fish and ichthyoplankton (fish eggs and larvae) in the Tennessee River in the vicinity of the WBN site. Sampling of fish populations, especially near the WBN site, has occurred fairly consistently over the past 40 years.

TVA performed sampling on the fish community in the vicinity of the WBN site prior to the start of operations of WBN Unit 1. Coves located downstream of the plant were sampled using rotenone in the early 1970s (1970, 1972, and 1973) (NRC 1978), and sampling continued until 1993 on an annual basis at 22 locations throughout the Chickamauga Reservoir. In addition, sampling occurred biennially from 1995 to 1999. The closest cove sampled to the WBN site is located at TRM 524.6, downstream of the WBN site (Simmons 2010).

Starting in 1977, sampling was also conducted using electrofishing techniques (TVA 1986; Simmons 2010). TVA conducted a second set of sampling studies from March 1977 through November 1979. The sampling consisted of timed (five 3-minute duration) electrofishing runs performed monthly. From March 1982 to December 1985, TVA conducted a third set of sampling studies on a monthly basis to update the preoperational fish community monitoring data. These sampling studies used five distance-based 100-m (328-ft) electrofishing runs. Beginning in 1990, the sampling schedule changed to once each fall with 15 electrofishing runs of 200 m (660 ft). The sampling was continued through 1995 as preoperational studies (Baxter et al. 2010). TVA continued the sampling in 1996 and 1997 after the start of WBN Unit 1 operations (Baxter et al. 2010).

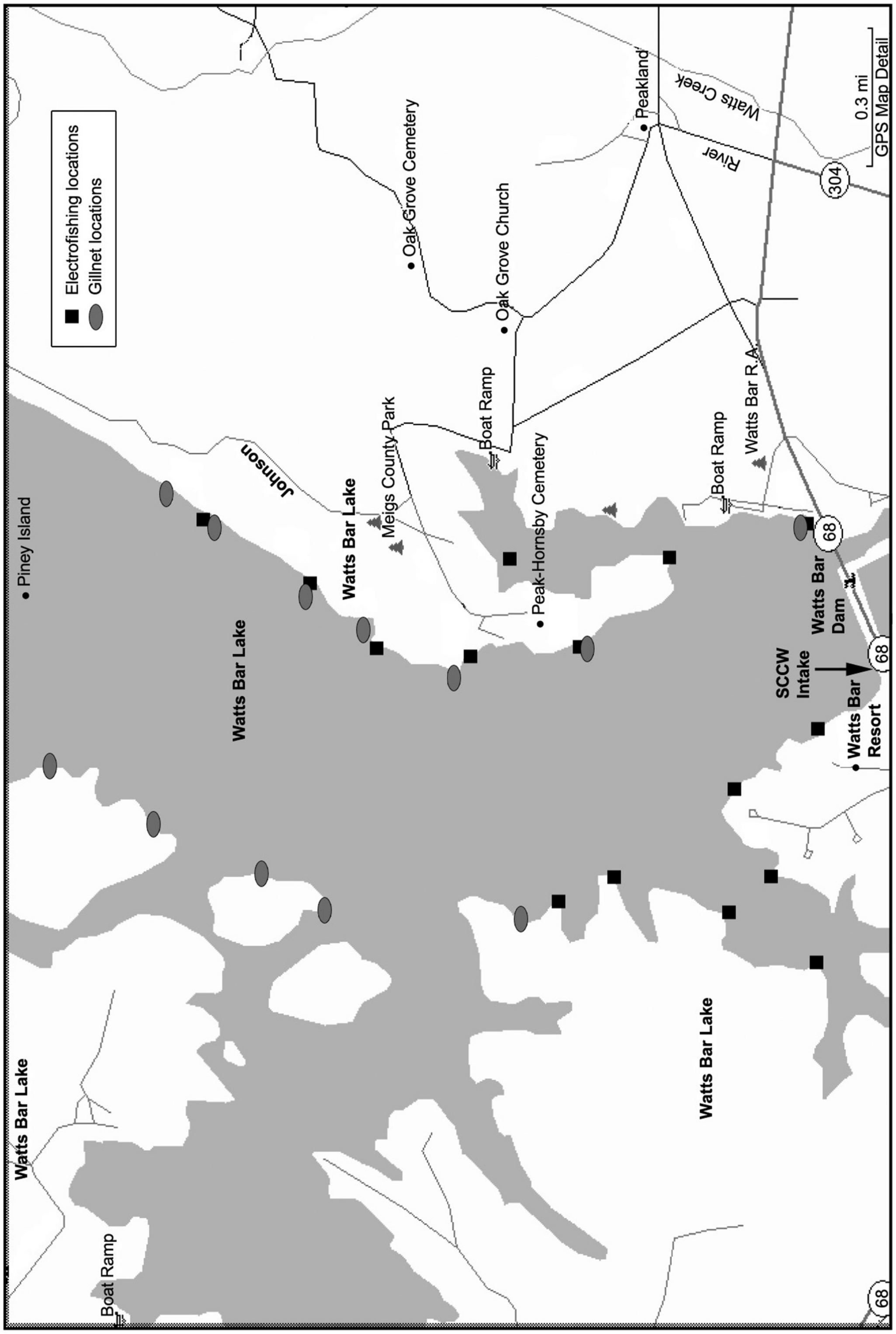
As requested by EPA Region IV, TVA conducts additional aquatic community monitoring for facilities, including the WBN plant, that have alternative thermal limits to verify that balanced indigenous populations of aquatic life are being maintained (Simmons and Baxter 2009; Simmons 2011). Since 1999, TVA researchers have conducted fish sampling downstream of Watts Bar Dam (and largely downstream of the WBN plant discharge) using boat electrofishing, and upstream of the Watts Bar Dam using electrofishing and gillnetting. Electrofishing samples consist of 15 electrofishing boat runs near the shoreline. Each run covers about 300 m (980 ft) and takes approximately 10 minutes. Researchers use gill nets to collect fish from deeper habitats above the Watts Bar Dam, which are not easily sampled using electrofishing techniques. TVA does not use gill nets downstream of the WBN site because of high water velocities, with the exception of some experimental gill nets that were used from TRM 527.4 to 528.4 for preoperational monitoring (TVA 1986). Figure 5-1 and Figure 5-2 show the sampling locations for electrofishing and gillnetting (Figures 2 and 3 from Simmons and Baxter 2009). Sampling locations on Chickamauga Reservoir occur upstream and downstream of the intake canal, the SCCW system discharge, and the submerged diffuser.

TVA also conducts sportfishing surveys annually in March/April on both the Watts Bar and Chickamauga reservoirs using a boat-mounted electrofishing unit. These surveys are conducted to evaluate the sport fish population on TVA reservoirs. The surveys have been conducted since 1995 and target three species of black bass (largemouth, smallmouth, and spotted bass) and black and white crappie. TVA samples 12 locations on each reservoir at three different sites for 30 minutes per location. Sampling sites are located at Harrison Bay, Ware Branch, and Sale Creek on the Chickamauga Reservoir. Sampling sites on the Watts Bar Reservoir are located at Watts Bar Dam, Blue Springs, and Caney Creek (Simmons and Baxter 2009).



(To convert miles [mi] to kilometers [km], multiply by 1.6 km/mi)

Figure 5-1. Electrofishing Stations Downstream of Watts Bar Dam (Simmons and Baxter 2009)



(To convert miles [mi] to kilometers [km], multiply by 1.6 km/mi)

Figure 5-2. Electrofishing and Gillnetting Locations Upstream of Watts Bar Dam (Simmons and Baxter 2009)

5.5.2.6 Impingement

TVA conducted a fish impingement demonstration for the SCCW intake as part of the Clean Water Act Section 316(b) monitoring program from August 2005 to August 2007 (TVA 2008b). TVA conducted weekly impingement monitoring by rotating the intake screens and washing them on prearranged schedules. Every 24 hours, TVA rotated and washed the screens, and collected the fish and debris from the sluice pipe with dip nets. It sorted, identified, separated into length classes, enumerated, and weighed the fish. The majority of fish collected were dead when processed. TVA did not include fish that appeared to have been dead for more than 24 hours in the sample. TVA extrapolated impingement data from the weekly 24-hour samples to estimate the total fish impinged by week and fish impingement for the year.

TVA began monitoring impingement at the intake pumping station (IPS) shortly before WBN Unit 1 began producing power (TVA 1998). TVA collected weekly screen-washing samples. After leaving screens stationary for 24 hours to collect samples, TVA rotated and backwashed them to remove impinged fish. Thirty-six samples were collected from March 1996 through February 1997, and 21 samples from March 1997 through September 1997. As discussed in Section 4.3.2.2, TDEC approved a request by TVA to discontinue sampling due to the extremely low numbers of fish impinged (TVA 1998, 2010b).

TVA conducted impingement monitoring at the IPS from March 26, 2010, through March 17, 2011 (TVA 2011c). TVA collected weekly screen-washing samples. TVA followed the same procedures used in the 1996 to 1997 study to ensure consistency between the two studies. In addition TVA has committed to conduct weekly impingement mortality sampling at the IPS for one year of operational monitoring following the start of WBN Unit 2 (TVA 2010c).

5.5.2.7 Entrainment (includes ichthyoplankton studies)

Three studies related to entrainment or ichthyoplankton density on the Watts Bar Reservoir exist for the SCCW system. The first (TVA 1976) was conducted in 1975 when the SCCW system was used as the intake for the Watts Bar Fossil Plant. The flow of water into the intake ranged from 0.45×10^6 m^3/d (1.6×10^7 ft^3/d) or 5.23 m^3/s (185 cfs) to 1.11×10^6 m^3/d (3.9×10^7 ft^3/d) or 12.8 m^3/s (452 cfs) (TVA 1976), which is almost twice the flow that will be used for both WBN Units 1 and 2. Sampling occurred during ten sampling periods between March 24, 1975, and July 28, 1975, at five transects in the reservoir. TVA obtained pumped samples from three of the six intake screen wells. TVA conducted sampling biweekly.

In spring 2000, TVA conducted the second study, a study of ichthyoplankton density to examine the spatio-temporal concentrations of ichthyoplankton near the WBN SCCW intake (Baxter et al. 2001). Sampling was conducted weekly from April through June 2000 along the same transect and using equipment similar to that used in the 1975 study. The third study (TVA 2012) was conducted by sampling in front of the SCCW intake structure and at a transect located at TRM 530.2 in the Watts Bar Reservoir between March 7, 2010, and March 25, 2011.

TVA conducted two sets of entrainment or ichthyoplankton density studies in the Chickamauga Reservoir to characterize entrainment from the IPS. In the first set of studies, TVA collected ichthyoplankton samples during preoperational (1976 to 1979, 1984, and 1985) and operational (1996 and 1997) monitoring surveys (TVA 1998) in the Chickamauga Reservoir adjacent to the WBN site. TVA researchers sampled biweekly on a diel schedule (day and night) at TRM 528.0, just upstream of the IPS intake channel. Sampling occurred from March through August (preoperational) and from April through June (operational). TVA took samples at five stations along a transect perpendicular to river flow using a beam net (0.5 m^2 [1.6 ft], 1.8 m [5.9 ft] long with a 505-micron [0.02-in.] "nitex" mesh netting). The samples were collected by towing the beam net upstream for 10 minutes at a speed of 1.0 m/s (3.3 ft/s), resulting in approximately 150 m^3 (5,300 ft^3) of water in each 10-minute sample. In 1984 and during operational monitoring, TVA collected additional samples in the cooling-water intake channel. In addition, preoperational samples from 1984 and 1985 also included four, 4-minute samples taken biweekly on a diel schedule from the plant intake pump building to the mouth of the channel. Each intake sample filtered approximately 40 to 50 m^3 (1,400 to 1,766 ft^3) of water. In comparison, the operational samples consisted of four, 1-minute samples (combined) from the intake trash boom to the mouth of the intake channel.

In the second study, TVA collected weekly ichthyoplankton samples from March 7 through August 29, 2010, and monthly from September 20, 2010, through March 25, 2011, at the IPS to estimate entrainment mortality in fish as part of the preoperational monitoring for WBN Unit 2 (TVA 2012). TVA collected samples of the reservoir from five stations along a transect at TRM 528.4, using the same procedures used in the 1996 and 1997 sampling program discussed previously.

TVA plans to continue entrainment sampling at the IPS and the SCCW intake for at least 2 years after WBN Unit 2 begins operation (TVA 2010c).

5.6 Chemical Monitoring

5.6.1 Surface-Water Monitoring

TVA chemical monitoring focuses on the three WBN facility outfalls. TVA performs semi-annual Whole Effluent Toxicity (WET) tests (also called biotoxicity tests) of Outfall 101 and Outfall 113 samples to confirm compliance with State water-quality criteria (TVA 2008c). WET tests measure the wastewater effects on the test organisms' ability to survive, grow, and reproduce. Section 4.3.2.5 describes the tests in more detail.

In addition, TVA monitors chlorine or Total Residual Oxidant (TRO) 5 days per week at Outfall 101 and Outfall 113 to ensure it meets discharge limits. The daily maximum discharge limit for chlorine is 0.10 ppm and 0.158 Mg/L for TRO. Results of chemical monitoring are reported in monthly discharge monitoring reports (for example TVA 2003b). Annual nonradiological environmental operating reports (for example TVA 2011d) summarize any noncompliance with monitoring requirements.

TVA historically monitored discharge from the construction runoff holding pond (see Section 3.2 and Figure 3-3) using an automated sampler at Outfall 112. This pond once received sewage-treatment plant effluent and now receives only stormwater runoff. The NPDES permit for the site (TVA 2011a) no longer requires monitoring this outfall.

5.6.2 Groundwater Monitoring

At the WBN site, TVA monitors groundwater for radionuclide concentrations at six REMP groundwater monitoring locations. These wells are equipped with automatic samplers. The plant collects samples daily, composites them for 3 months, then analyzes the samples for gross beta, gamma, and tritium. In addition to the six REMP monitoring wells, TVA monitors 19 non-REMP wells to track the onsite groundwater plume to indicate the presence or increase of radioactivity in the groundwater (TVA 2011b).

5.7 Historic and Cultural Resource Monitoring

The National Historic Preservation Act (NHPA) (16 USC 470 et seq.) and the Archaeological Resources Protection Act of 1979 (ARPA) (16 USC 470aa et seq.) address the protection of significant archaeological resources and preservation of historic properties located on Federal lands or Federal undertakings (TVA 2009c). As a result, TVA operates an extensive cultural resources management program and employs several archaeologists, a historian, and a historic architect to identify, monitor, manage, and protect historic and cultural resources on TVA lands or land affected by TVA actions (TVA 2009c).

The TVA Watts Bar Reservoir Land Management Plan examines the potential effects of several alternative ways of managing its public lands on the Watts Bar Reservoir and includes the WBN site (TVA 2009d). The TVA Watts Bar Reservoir Land Management Plan describes the a programmatic agreement (PA) that was signed in 2005 between TVA, the Advisory Council on Historic Preservation, and the Tennessee State Historic Preservation Office/Officer (SHPO). The PA guides Section 106 (NHPA) compliance for TVA land considered in the Watts Bar Reservoir Land Management Plan (TVA 2009e).

The TVA cultural resources management program reviews undertakings on its plant properties on a project-by-project basis. TVA conducts surveys and completes projects in consultation with the SHPO and Federally recognized Indian Tribes. TVA considers transmission-line maintenance reviews as sensitive area reviews. TVA conducts the reviews for its transmission-line operations and maintenance activities associated with WBN Unit 1 and would use them for WBN Unit 2 (TVA 2009f). TVA coordinates the sensitive area reviews with TVA cultural resources staff to conduct specific Section 106 reviews. In addition, TVA developed erosion control measures for WBN Unit 1, which it would also use for WBN Unit 2 (TVA 2009e).

During operation and maintenance of WBN Unit 2, TVA would implement procedures identifying actions it would take if historic or cultural resource materials are encountered. TVA follows the requirements of implementing regulations of the Native American Graves Protection and Repatriation Act (25 USC 3001 et seq.) for the inadvertent discovery of human remains. TVA has identified Federally recognized Indian Tribes with a demonstrated interest in the Tennessee Valley. When human remains are inadvertently discovered on TVA-managed lands, all work ceases, remains secured, and TVA notifies all Tribes within 3 working days of discovery (TVA 2009e).

5.8 References

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6.0 Environmental Impacts of Postulated Accidents Involving Radioactive Materials

Previous environmental reports and impact statements have evaluated the environmental consequences of postulated accidents related to the construction and operation of Watts Bar Nuclear (WBN) Units 1 and 2. This chapter summarizes those evaluations and presents the results of the U.S. Nuclear Regulatory Commission (NRC) staff's independent review of the consequences of postulated accidents for WBN Unit 2 based on changes occurring since the last NRC assessment.

The term "accident," as used in this chapter, refers to any off-normal event not addressed in Section 4.6, Radiological Impacts of Normal Operations, resulting in release of radioactive materials into the environment. The focus of this review is on events that could lead to releases substantially greater than permissible limits for normal operations. Normal release limits are specified in Title 10 of the *Code of Federal Regulations* (CFR) Part 20, Appendix B, Table 2.

Numerous features combine to reduce the risk associated with accidents at nuclear power plants. Safety features in the design, construction, and operation of the plants, which compose the first line of defense, are intended to prevent the release of radioactive materials from nuclear plants. Additional measures are designed to mitigate the consequences of failures in the first line of defense. These measures include the NRC's reactor site criteria in 10 CFR Part 100, which require the site to have certain characteristics reducing the risk to the public and the potential impacts of an accident, and emergency preparedness plans and protective action measures for the site and environs, as set forth in 10 CFR 50.47, 10 CFR Part 50, Appendix E, and NUREG-0654/FEMA-REP-1 (NRC 1980). All of these safety features, measures, and plans make up the defense-in-depth philosophy to protect the health and safety of the public and the environment.

On March 11, 2011, and for an extended period thereafter, several nuclear power plants in Japan experienced the loss of important equipment necessary to maintain reactor cooling after the combined effects of severe natural phenomena (i.e., an earthquake followed by a tsunami). In response to these events, the Commission established a task force to review the current regulatory framework in place in the United States and to make recommendations for improvements. The task force reported the results of its review (NRC 2011d) and presented its recommendations to the Commission on July 12 and July 19, 2011, respectively. As part of the short-term review, the task force concluded that while improvements are expected to be made as a result of the lessons learned, the continued operation of nuclear power plants and licensing activities for new plants did not pose an imminent risk to public health and safety. A number of areas were recommended to the Commission for long-term consideration. Collectively, these recommendations are intended to clarify and strengthen the regulatory framework for protection against severe natural phenomena, mitigation of the effects of such events, coping with emergencies, and improving the effectiveness of NRC programs. To the extent that any revisions are made to NRC regulatory requirements, they would be made applicable to nuclear power reactors regardless of whether the utility possesses a renewed license or an operating license. Therefore, no additional analyses have been performed in this SFES as a result of the Fukushima events.

Radioactive material exists in a variety of physical and chemical forms. The majority of the material in reactor fuel is in the form of nonvolatile solids. However, a significant amount of material is in the form of volatile solids or gases. The gaseous radioactive materials include the chemically inert noble gases (e.g., krypton and xenon), which have a high potential for release. Radioactive forms of iodine, created in substantial quantities in the fuel by fission, are volatile. Other radioactive materials formed during the operation of a nuclear power plant have lower volatilities and, therefore, have lower tendencies to escape from the fuel than the noble gases and iodines.

Radiation exposure to individuals is determined by their proximity to radioactive material, the duration of their exposure, and the extent to which they are shielded from the radiation. Pathways leading to radiation exposure include (1) external radiation from radioactive material in the air, on the ground, and in the water; (2) inhalation of radioactive material; and (3) ingestion of food or water containing material initially deposited on the ground and in water.

Radiation protection experts assume that any amount of radiation may pose some risk of causing cancer or a severe hereditary effect and that the risk is higher for higher radiation exposures. Therefore, a linear, no-threshold dose response relationship is used to describe the relationship between radiation dose and detriments such as cancer induction. A recent report by the National Research Council (2006), the Biological Effects of Ionizing Radiation VII report, uses the linear, no-threshold dose response model as a basis for estimating the risks from low doses. This approach is accepted by the NRC as a conservative method for estimating health risks from radiation exposure, recognizing the model may overestimate those risks.

Physiological effects are clinically detectable if individuals receive radiation exposure resulting in a dose greater than about 0.25 Sv (25 rem) over a short period (hours). Doses of about 2.5 to 5 Sv (250 to 500 rem) received over a relatively short period (hours to a few days) can be expected to cause some fatalities.

6.1 Design Basis Accidents

The postulated environmental consequences of design basis accidents (DBAs) for WBN were initially evaluated in the 1972 Tennessee Valley Authority (TVA) final environmental statement related to the construction permit for WBN Units 1 and 2 (1972 FES-CP) (TVA 1972).

Appendix D of the 1972 FES-CP describes the evaluation of a full range of accidents ranging from those which "may reasonably be expected to occur during the lifetime of the plant" to accidents with a probability of occurrence that is "very small." This latter group of accidents is currently referred to as DBAs. The predicted dose at the site boundary for each accident was well within the 0.25-Sv (25-rem) limit set in 10 CFR Part 100 and the 80-km (50-mi) population dose commitment for each accident was less than 1 person-Sv (100 person-rem) (TVA 1972). In commenting on the 1972 TVA draft environmental statement, the Atomic Energy Commission (AEC) provided its own estimates of the site-boundary doses. These dose estimates, found on page 7.1-8 and 7.1-9 of the 1972 FES-CP, are slightly lower than the TVA dose estimates. Dose estimates for DBAs in the NRC's 1978 Final Environmental Statement related to the operating license for WBN Units 1 and 2 (1978 FES-OL) (NRC 1978a) are consistent with and slightly lower than the dose estimates in the AEC comments on the 1972 TVA draft environmental statement.

In preparation of the NRC 1995 supplement to the final environmental statement related to the operating license (1995 SFES-OL-1) (NRC 1995), the NRC staff reviewed its earlier DBA calculations and noted that the only change in technical bases from the original DBA analyses was in the population projection. The NRC staff then added the evaluation of an accident involving the failure of a spent fuel resin storage tank. The projected consequence of this accident was also less than 5 mSv (500 mrem).

At the time of the early environmental reviews in the 1970s, a proposed Annex to Appendix D of 10 CFR Part 50 contained guidance related to the calculation of the consequences of DBAs for environmental reviews. Appendix D of 10 CFR Part 50 has been replaced by 10 CFR Part 51, and the proposed Annex to Appendix D is Appendix I of Regulatory Guide 4.2 (NRC 1976), which is still used. This guidance permits applicants to modify the accident assumptions from those used in the conservative analysis for safety reviews to more realistic assumptions for environmental reviews. This guidance related to evaluation of potential environmental consequences of DBAs indicates the only difference between the conservative DBA dose calculations for the safety review and realistic dose calculations for the environmental review is in the atmospheric dispersion factors (χ/Qs) used in the calculations.

Table 6-1 lists χ/Qs the NRC staff considers pertinent to the environmental review of DBAs for the WBN site. The first column lists the time periods and boundaries for which χ/Q and dose estimates are needed. For the exclusion area boundary, the postulated DBA dose and its χ/Q are calculated for a short term (i.e., 2 hours), and for the low population zone, they are calculated for the course of the accident (i.e., 30 days [720 hours]) composed of four time periods. Section 2.8.4 discusses the calculation of the χ/Q values.

Table 6-1. Atmospheric Dispersion Factors for WBN Site Environmental DBA Calculations

Time Period and Boundary	χ/Q (s/m^3)
0 to 2 hours, exclusion area boundary	5.78×10^{-5}
0 to 8 hours, low population zone	7.15×10^{-6}
8 to 24 hours, low population zone	6.16×10^{6}
1 to 4 days, low population zone	4.46×10^{-6}
4 to 30 days, low population zone	2.81×10^{-6}

Table 6-2 lists the set of DBAs the NRC staff considered and presents estimates of the environmental consequences of each accident in terms of whole body for external radiation and thyroid dose from inhaled radionuclides. The NRC presented the consequences in terms of whole body and thyroid dose because the WBN Unit 2 application was submitted prior to January 1997. The entries in Table 6-2 are from NRC staff dose calculations based on the χ/Qs in Table 6-1 and TVA DBA calculations described in information supplied by TVA in response to NRC Requests for Additional Information (RAIs) (TVA 2010a, b). For consistency with the licensing basis, NRC staff based thyroid dose calculations on the thyroid dose factors from International Commission on Radiological Protection Publication 2 listed in Table E-7 of Regulatory Guide 1.109 (NRC 1977). The review criteria used in the NRC staff's safety review of DBA doses are included in Table 6-2 to illustrate the magnitude of the calculated environmental consequences (doses) because there are no environmental criteria related to the potential consequences of DBAs. In all cases, the calculated values are considerably smaller than the doses used as safety review criteria. The NRC staff notes that Supplement 21 of the NRC WBN safety evaluation report (NRC 2009a) lists as open items several DBAs that are not discussed in the Final Safety Analysis Report (FSAR). These accidents include Feedwater System Pipe Break, Reactor Coolant Pump Rotor Seizure, Reactor Coolant Pump Shaft Break, and Failure of Small Line Carrying Coolant Outside Containment. Because the NRC staff's independent review of the DBAs determined that the DBA doses were considerably smaller than the safety review criteria, the NRC staff concluded the environmental consequences are SMALL.

Table 6-2. Design Basis Accident Doses for WBN Unit 2

Accident	Standard Review Plan Section[b]	Doses in rem[a]					
		EAB		LPZ		Review Criterion	
		Whole Body	Thyroid	Whole Body	Thyroid	Whole Body	Thyroid
Main Steamline Break							
Pre-Existing Iodine Spike	15.1.5	0.0024	0.41	0.0007	0.15	25[c]	300[c]
Accident Initiated Spike	15.1.5	0.0068	0.49	0.0066	0.059	2.5	30[c]
Loss-of-Coolant Accident	15.6.5	0.19	3.9	0.18	5.1	25[c]	300[c]
Steam Generator Tube Rupture							
Pre-Existing Iodine Spike	15.6.3	0.034	2.7	0.0061	0.46	25[c]	300[c]
Accident Initiated Spike	15.6.3	0.038	1.2	0.0068	0.21	2.5	30[c]
Loss of Alternating Current Power[d]		<0.0001	<0.0001	<0.0001	<0.0001		
Waste Gas Decay Tank Rupture[d]		0.055	0.0017	0.0091	0.0003		
Fuel Handling Accident	15.7.4	0.039	5.2	0.0065	0.86	6[e]	75[e]
Control Rod Ejection Accident[f]							

(a) To convert rem to Sv divide by 100.
(b) NUREG-0800 (NRC 2007).
(c) 10 CFR 100.11 and 10 CFR 50.34(a)(1) Criterion.
(d) The TVA FSAR evaluated these accidents in the FSAR (TVA 2009a) but they do not have a corresponding SRP section. Nevertheless, the doses must meet the 10 CFR 100.11) criteria.
(e) Standard Review Plan (SRP) criterion.
(f) The TVA FSAR discusses the Control Rod Ejection Accident and concludes that the doses from a Control Rod Ejection Accident are bounded by the doses from a Loss-of-Coolant Accident.

6.2 Severe Accidents

TVA briefly addresses severe accidents for WBN Unit 2 in Section 3.1.1 of its environmental impact statement (EIS) (TVA 2008) and more detailed information in a subsequent submittal on severe accident mitigation design alternatives (SAMDAs) (TVA 2009b). TVA subsequently submitted an updated SAMDA assessment using the latest dual-unit probabilistic risk assessment (PRA) model for WBN (TVA 2010c). Potential impacts are presented for four severe accident release categories—early containment failure, late containment failure, containment bypass, and small pre-existing leak. In response to an NRC staff RAI, TVA states that a fifth release category, intact containment, was not used because it accounts for minimal offsite consequences (TVA 2011a). The TVA assessment of the potential environmental consequences incorporates the results of the MELCOR Accident Consequence Code System (MACCS2) computer code (Chanin and Young 1998) run using WBN Unit 2 reactor source-term information and WBN site-specific meteorological, population, and land-use data. WinMACCS Version 3.6.0 was used to assess consequence. WinMACCS is an updated version of the MACCS2 code that has an improved user interface.

Following initial review of the TVA environmental report (ER), the NRC staff asked TVA to provide additional information related to severe accidents. TVA responded by providing the requested information under cover letters dated October 22, 2009 (TVA 2009c); December 23, 2009 (TVA 2009d); February 25, 2010 (TVA 2010a); April 9, 2010 (TVA 2010d); and January 31, 2011 (TVA 2011a). In addition to evaluating this information, the NRC staff considered the severe accident analysis for WBN Unit 1 contained in its 1995 SFES-OL-1 and the TVA WBN Unit 2 Individual Plant Examination Summary Report dated February 9, 2010 (TVA 2010e).

The MACCS2 computer code was developed to evaluate the potential offsite consequences of severe accidents for the sites covered by NUREG-1150 (NRC 1990). The MACCS2 code evaluates the consequences of atmospheric releases of material after a severe accident. The pathways modeled include exposure to the passing plume, exposure to material deposited on the ground and skin, inhalation of material in the passing plume and resuspended from the ground, and ingestion of contaminated food and surface water.

NRC staff assessed two types of severe accident consequences: human health and economic costs. The NRC staff expressed human health effects in terms of the number of cancers that might be expected if a severe accident were to occur. These effects are directly related to the cumulative radiation dose received by the general population. NRC staff based population health-risk estimates on the population distribution within an 80-km (50-mi) radius of the WBN site.

Economic costs of a severe accident include the costs associated with short-term relocation of people; decontamination of property and equipment; interdiction of food supplies, land, and equipment use; and condemnation of property.

Risk is the product of the frequency and the consequences of an accident. For example, the frequency of a severe accident with early containment failure for WBN Unit 2 is estimated to be 1.26×10^{-6}/reactor-year (Ryr), and the cumulative population dose associated with a severe accident with early containment failure at the site is calculated to be 2.96×10^{4} person-Sv (2.96×10^{6} person-rem). The population dose risk for this class of accidents is the product of 1.26×10^{-6}/Ryr and 2.96×10^{4} person-Sv (2.96×10^{6} person-rem), or 3.73×10^{-2} person-Sv/Ryr (3.73 person-rem/Ryr). The following sections discuss the estimated risks associated with each pathway.

The risks presented in the following tables are risks per year of reactor operation for WBN Unit 2. However, two of the tables also include an estimate of population dose risk for WBN

Unit 1. At multi-unit sites such as the WBN site, where there are few shared support systems, the designs minimize the likelihood that a severe accident affecting one unit will adversely affect other units onsite. Consequently, for this evaluation, the severe accident risk at the site is estimated as the sum of the risks for the individual units.

6.2.1 Air Pathway

The WinMACCS code directly estimates consequences associated with releases to the air pathway. Table 6-3 presents risks based on results of the combination WinMACCS results provided by TVA (TVA 2011f) and the results of recent PRA insights (TVA 2010d). The core damage frequencies (CDFs) and release frequencies given in these tables are for internally initiated accident sequences (e.g., sequences initiated by human error, equipment failures, loss of offsite power) while the facility is at power.

Table 6-3. Staff Estimates of Mean Environmental Risks from a WBN Unit 2 Reactor Severe Accident

Release Category Description (Accident Class)	Release Frequency (per Ryr)	Population Dose Risk (person-rem/Ryr)[(a)]	Latent Fatalities (per Ryr)	Population Dose from Water Ingestion (person-rem/Ryr)[(a)]	Cost[(b)] ($/Ryr)
Small pre-existing leak	3.8×10^{-6}	1.2	7.4×10^{-4}	3.8×10^{-3}	2,250
Early containment failure	1.3×10^{-6}	3.7	2.2×10^{-3}	4.5×10^{-2}	8,000
Late containment failure	1.3×10^{-5}	14	8.5×10^{-3}	0.12	41,500
Containment bypass	3.5×10^{-7}	0.84	5.0×10^{-4}	1.4×10^{-2}	1,860
Total	1.8×10^{-5}	20	1.2×10^{-2}	0.18	53,600

(a) To convert person-rem to person-Sv, divide by 100.
(b) Cost risk includes costs associated with short-term relocation of people, decontamination, interdiction, and condemnation. It does not include costs associated with health effects.

Table 6-3 shows the probability-weighted consequences (i.e., risks) of severe accidents for WBN Unit 2 are small for all risk categories considered. For perspective, Table 6-4 compares the health risks from severe accidents for WBN Unit 2 with the risk range for current operating plants reported in license renewal applications.

Table 6-4 compares WBN Unit 2 with statistics summarizing the results of contemporary severe accident analyses performed for 78 reactors at 46 sites and with the CDF and population dose estimate for WBN Unit 1. The results of these analyses are included in the final site-specific Supplements 1 through 42 to the Generic Environmental Impact Statement (GEIS) for License Renewal, NUREG-1437 (NRC 1996, 1999), and in the ERs included with license renewal applications for those power stations for which supplements have not been published as yet. The analyses for 74 of the reactors used MACCS2, which was released in 1997. Table 6-4 shows the CDF estimated for the WBN Unit 2 reactor is about the same as the mean and median CDFs for currently operating reactors. However, the population doses estimated for WBN Unit 2 are slightly higher than the mean and median values for currently operating reactors that have undergone license renewal. The NRC staff does not consider this difference to be significant.

Table 6-4. Comparison of Environmental Risks from Severe Accidents Initiated by Internal Events for WBN Unit 2 with Risks Initiated by Internal Events for Current Nuclear Power Plants That Have Undergone Operating License Renewal Review and WBN Unit 1

	Core Damage Frequency (per year)	**50-mi Population Dose Risk (person-rem/Ryr)[(a)]**
Current reactor maximum[(b)]	2.4×10^{-4}	69
WBN Unit 2	1.8×10^{-5}[(c)]	20
Current reactor mean[(b)]	2.6×10^{-5}	17
Current reactor median[(b)]	1.6×10^{-5}	14
WBN Unit 1	5.8×10^{-5}	5.3
Current reactor minimum[(b)]	1.9×10^{-6}	0.34

(a) To convert person-rem to person-Sv, divide by 100.
(b) Based on MACCS (Chanin et al. 1990) and MACCS2 (Chanin and Young 1998) calculations for 78 current plants at 46 sites.
(c) Sum of the release frequencies presented in Table 6-3.

6.2.2 Surface-Water Pathway

Surface-water dose pathways are an extension of the air pathway and address the effects of radioactive material deposited on open bodies of water. The MACCS2 code provides an evaluation of risks from water ingestion. The water-ingestion dose risk calculated for WBN Unit 2 of about 1.8×10^{-3} person-Sv/Ryr (1.8×10^{-1} person-rem/Ryr) is small compared to the total dose risk of 0.20 person-Sv/Ryr (20 person-rem/Ryr).

The surface-water pathways also can include external radiation from (1) submersion in water and activities near the water and (2) ingestion of aquatic food. The GEIS (NUREG-1437; NRC 1996) relies on the analysis in the Fermi final environmental statement (NUREG-0769; NRC 1981) and the Liquid Pathway Generic Study (NUREG-0440; NRC 1978b). These analyses indicate that the aquatic-food pathway dose is about a factor of 20 larger than the water-ingestion pathway dose, which is slightly larger than the dose from shoreline activities and significantly larger than the dose from swimming. They also indicate interdiction can reduce doses by as much as a factor of 10. The MACCS2 results in Table 6-3 show that the water-ingestion dose is a small fraction of the air-pathway dose. This indicates the doses from shoreline activity and swimming would also be small. The NRC staff concludes that the risks associated with shoreline activities and swimming would be significantly smaller than the air-pathway dose risk, particularly if interdiction were considered.

The NRC staff notes that Table 5.16 of the GEIS contains an estimate of aquatic-food doses and dose risks for generic river sites. The GEIS estimates the aquatic-food dose risk as about 0.005 person-Sv/Ryr (0.5 person-rem/Ryr) without interdiction. On this basis, the NRC staff believes that the aquatic-food pathway risk with interdiction would be significantly smaller than the air-pathway risk.

6.2.3 Groundwater Pathway

The groundwater pathway involves a reactor core melt, reactor vessel failure, and penetration of the floor (basemat) below the reactor vessel. Ultimately, core debris reaches the groundwater, which transports soluble radionuclides. In the GEIS, the NRC staff assumed the frequency of a severe accident with basemat penetration was 1×10^{-4}/Ryr and concluded that the groundwater pathway risks were small.

The frequency of core melt with a basemat melt-through should be no larger than the total CDF estimate for the reactor. Table 6-4 shows the total CDF for WBN Unit 2 as 1.8×10^{-5}/Ryr. NUREG-1150 indicates the conditional probability of a basemat melt-through ranges from 0.05 to 0.25 for currently operating reactors. On this basis, the NRC staff believes a severe accident with basemat melt-through frequency of less than 1×10^{-5}/Ryr is conservative and a reasonable estimate. The groundwater transport pathway is also slower and affords more time for implementing protective actions than the air pathway and, therefore, results in a lower risk to the public. As a result, the NRC staff concludes that the risks associated with releases to groundwater are sufficiently small that they would not have a significant effect on the overall plant risk.

6.2.4 Summary of Severe Accident Impacts

The NRC staff conducted an independent review of the severe accident analysis presented by TVA in its ER for completion of WBN Unit 2. The results of the NRC staff review of environmental risks of severe accidents associated with the air exposure pathway are presented in Table 6-3 and Table 6-4. The NRC staff qualitatively evaluated the environmental risks of severe accidents associated with the surface-water and groundwater pathways in Section 6.2.2 and 6.2.3 and concludes that the probability-weighted environmental consequences of severe accidents are SMALL.

6.3 Severe Accident Mitigation Alternatives

Pursuant to the Third Circuit's opinion in *Limerick Ecology Action, Inc. v. NRC*, 869 F.2d 719, 723 (3d Cir. 1989), the NRC must analyze SAMDAs as part of its National Environmental Policy Act (NEPA) review. As a result, the NRC considers the alternative of plant operations with the installation of SAMDAs in the NEPA review for all operating license applications to ensure that plant changes (i.e., hardware, procedures, and training) with the potential for improving severe accident safety performance are identified and evaluated. SAMDAs have not been previously considered by TVA for WBN Unit 2; therefore, the remainder of Section 6.3 addresses those alternatives. A more general term, severe accident mitigation alternatives (SAMAs), is frequently used. SAMAs include mitigation measures such as changes in procedures and training in additions to design alternatives.

TVA submitted an initial assessment of SAMDAs for WBN Unit 2 as part of its EIS (TVA 2009b), based on the then most recently available WBN Unit 1 PRA, modified to reflect the expected operation for WBN Unit 2. Subsequently TVA submitted an updated SAMDA assessment using the latest Computer Aided Fault Tree Analysis (CAFTA) based dual-unit PRA (TVA 2010c). Both submittals were supplemented by a plant-specific offsite consequence analysis performed using the MACCS2 computer code and insights from the WBN Unit 1 individual plant examination (IPE) (TVA 1992), the WBN Unit 1 individual plant examination of external events (IPEEE) (TVA 1998), and, in the updated assessment, the WBN Unit 2 IPE (TVA 2010e). In identifying and evaluating potential SAMDAs, TVA considered SAMDAs that addressed the major contributors to CDF and large early release frequency (LERF) at WBN, population dose at WBN, and SAMA candidates for operating plants which have submitted license renewal applications. TVA initially identified 283 potential SAMDAs, followed by an additional 24 in the updated submittal, all of which were reduced to 38 by eliminating those inapplicable to WBN Unit 2 due to (1) design differences; (2) prior implementation at WBN Unit 2; (3) similarity in nature so as to be combined with another SAMDA candidate; (4) excessive implementation cost such that the estimated cost would exceed the dollar value associated with completely eliminating all severe accident risk at WBN Unit 2; or (5) determined to provide very low benefit. TVA assessed the costs and benefits associated with each potential SAMDA, and concluded in the EIS that several are potentially cost-beneficial.

Based on its review, the NRC staff issued RAIs to TVA (NRC 2009b, 2011a, b, c) requesting additional and clarifying information on the PRA used for the SAMA analysis, including the breakdown of the internal event core damage frequency by initiating event; selection and screening of Phase I SAMDA candidates; information on 30 additional SAMDA candidates; additional information regarding several specific SAMDAs; and information regarding the Phase II cost-benefit evaluations. The TVA RAI responses adequately addressed the NRC staff's questions (TVA 2010f, g; TVA 2011a, b, c, d, e, f).

6.3.1 Risk Estimates for Watts Bar Nuclear Plant Unit 2

TVA combined two distinct analyses to form the basis for the risk estimates used in the SAMDA analysis: (1) the WBN Level 1 and 2 dual-unit PRA model, which is updated from the WBN Unit 2 IPE, and (2) a supplemental analysis of offsite consequences and economic impacts (essentially a Level 3 PRA model) developed specifically for the SAMDA analysis. The updated

SAMDA analysis is based on the most recent WBN Level 1 and Level 2 PRA models available at the time of the assessment (TVA 2010c), which does not include external events.

The WBN Unit 2 CDF is approximately 1.7 × 10^{-5}/yr for internal events (including internal flooding) as determined from quantification of the Level 1 PRA model. The CDF is based on the risk assessment for internally initiated events, which includes internal flooding. The breakdown of CDF by initiating event is shown in Table 6-5, which indicates that events initiated by loss of offsite power and internal floods are the dominant contributors to CDF (TVA 2011a).

Table 6-5. WBN Unit 2 Core Damage Frequency for Internal Events

Initiating Event	CDF (Per Year)	% Contribution to CDF[(a)]
Loss of Offsite Power (Grid Related)	3.2 × 10^{-6}	19
Loss of Offsite Power (Plant Centered)	2.8 × 10^{-6}	16
Total Loss of Component Cooling Unit 2	1.6 × 10^{-6}	10
Loss of Offsite Power (Weather Induced)	1.1 × 10^{-6}	6
Flood Event Induced by Rupture of Raw Cooling Water (RCW) Line in Room 772 0 – A8	1.1 × 10^{-6}	6
Flood Event Induced by Rupture of RCW Line in Room 772 0 – A9	1.1 × 10^{-6}	6
Total Loss of Essential Raw Cooling Water (ERCW) Cooling	9.6 × 10^{-7}	6
Small Loss-of-Coolant Accident (LOCA) Stuck Open Safety Relief Valve	6.5 × 10^{-7}	4
Flood Event Induced by Rupture of High Pressure Fire Protection (HPFP) in Common Areas of the Auxiliary Building	3.2 × 10^{-7}	2
Turbine Trip	3.0 × 10^{-7}	2
Others (each 1% or less)	4.1 × 10^{-6}	24
Total CDF (internal events)	1.72 × 10^{-5}	100

(a) May not total to 100 percent due to round off.

TVA did not include the contribution from external events in the WBN risk estimates, but rather accounted for their potential risk-reduction benefits by multiplying the estimated benefits for internal events by a factor of 2, which was subsequently increased to 2.28 in response to an NRC staff RAI (TVA 2011a).

The Level 2 portion of the SAMDA model represents an updated version of the WBN Unit 2 IPE Level 2 model, which was based on enhancements to NUREG/CR-6595 (NRC 2004a) and included quantification of containment threats resulting from high-pressure failure of the reactor vessel and hydrogen deflagrations/detonations as well as additional detail on the treatment of interfacing system LOCAs and induced steam generator tube rupture. Two large containment event trees (CETs) were developed; one for station blackout (SBO) and one for non-SBO sequences. The result of the Level 2 model is a set of four release categories with their respective frequency and release characteristics and one category for intact containment, which is considered to have a negligible release. The frequency of each release category was obtained by summing the frequency of the contributing Level 2 sequences.

The offsite consequences and economic impact analyses use the WinMACCS code, the current version of the MACCS2 code, to determine the offsite risk impacts on the surrounding environment and public. Code inputs include plant-specific values for core radionuclide inventory, source term and release characteristics, site-specific meteorological data, projected population distribution (within an 80-km [50-mi] radius) for the year 2040, emergency response evacuation modeling, and economic data. The magnitude of the onsite impacts (in terms of cleanup and decontamination costs and occupational dose) is based on information provided in NUREG/BR-0184 (NRC 1997a). The release characteristics are based on the SEQSOR (NRC 1990) emulation spreadsheet methodology. TVA estimated the dose to the population within 80 km (50 mi) of the WBN site to be approximately 0.20 person-Sv (20 person-rem) per year (TVA 2011e). The breakdown of the total population dose by release category is summarized in Table 6-6 (TVA 2011e). Late containment overpressure failure is the dominant contributor to population dose risk at WBN Unit 2.

Table 6-6. Breakdown of Population Dose by Containment Release Category

Containment Release Category	Population Dose (Person-Rem[(a)] Per Year)	Percent Contribution
Early Containment Failure	3.7	19
Containment Bypass	0.8	4
Late Containment Failure	14.1	71
Small Pre-existing Leak	1.2	6
Intact Containment	negligible	negligible
Total	20.0[(b)]	100

(a) One person-rem = 0.01 person-Sv.
(b) Total is not equal to the sum of the above due to roundoff.

6.3.2 Adequacy of the WBN Unit 2 PRA for SAMDA Evaluation

Since WBN Units 1 and 2 are essentially identical, the history of both units' PRA models is relevant to this evaluation. There have been eight revisions to the WBN PRA model since the 1992 WBN Unit 1 IPE submittal (TVA 1992), including the 2009 dual-unit model which utilized the CAFTA PRA software, whereas earlier versions utilized the RISKMAN® PRA software (PLG 1992). A description of the most significant changes made to each revision was provided by TVA in the original and updated assessments and in response to NRC staff RAIs (TVA 2009b, 2010c, f, 2011a, b, c, d). A comparison of internal events CDF between the 1994 WBN Unit 1 IPE (TVA 1994a) update and the initial WBN Unit 2 PRA model (2009) indicates a decrease from 8.0×10^{-5}/yr to 1.5×10^{-5}/yr, primarily due to the resolution of various 2001 peer review findings. The WBN Unit 2 PRA used for the SAMDA model has a similar internal events CDF (1.7×10^{-5}/yr), which includes credit for cross-tying Unit1 and Unit 2 shutdown boards and recovery of total loss of Emergency Raw Cooling Water (ERCW) by use of a portable diesel driven fire pump (TVA 2011a).

6.3.2.1 Internal Events CDF

TVA states that the WBN Unit 2 IPE is based on the WBN Unit 1 design and operation as of April 1, 2008. Since the IPE 2008 freeze date, a significant number (but not all) of mainly procedural changes that were identified in the initial WBN Unit 2 SAMDA assessment have been implemented and incorporated in the current SAMDA PRA (TVA 2011a). The NRC staff concludes that those changes that have not been incorporated will tend to reduce the CDF and thus make the current results conservative. The NRC staff considered the peer reviews performed for the WBN PRA, and the potential impact of the review findings on the SAMDA evaluation. The most relevant review is that performed by the Westinghouse Owners Group (WOG) in November 2009, for which a summary of the results is provided in the WBN Unit 2 IPE submittal along with a listing of the peer review findings (TVA 2010e). While most of the findings have been resolved as part of the updated SAMDA model, a significant number remain open in two categories: those considered by TVA to be documentation-only issues and those pertaining to internal flooding (See Appendix H) (TVA 2011a). TVA also indicated that the changes between the WBN Unit 2 IPE model and the SAMDA model were independently reviewed internally and externally.

The WBN CAFTA model utilizes a single fault tree constructed with systems and components for each unit and includes common systems. Shared system initiating events fail the supporting function for both units. Model quantification for each unit accurately tracks the dependent failure for each unit (TVA 2011a). Given that the WBN internal events PRA model has been peer-reviewed, the peer review findings have been addressed, and TVA has satisfactorily addressed NRC staff questions regarding the PRA, the NRC staff concludes that the internal events Level 1 WBN Unit 2 SAMDA PRA model is of sufficient quality to support the SAMDA evaluation.

6.3.2.2 Fire CDF

Since the WBN PRA does not include external events, the SAMDA submittals cite the WBN Unit 1 IPEEE, submitted in November 1998 (TVA 1998), in response to Supplement 4 of Generic Letter 88-20 (NRC 1991), for which the only vulnerability found has been corrected. The only vulnerability identified was related to the Auxiliary Building tornado concrete canopy and the modifications needed were made (TVA 1998). The WBN Unit 2 IPEEE was submitted in April 2010 and uses the same methodology and, to a large extent, the same assessment as the WBN Unit 1 IPEEE, subject to validation that the WBN Unit 1 assessments are applicable to the as built WBN Unit 2 (TVA 2010h). This submittal included a summary of the seismic margin analysis (EPRI 1991), the fire-induced vulnerability evaluation (EPRI 1992), and the screening analysis for other external events. No fundamental weaknesses or vulnerabilities to severe accident risk were identified in the WBN Unit 1 IPEEE with the exception of one item related to tornado missiles, for which corrective action has been completed. No seismic, fire, high winds, external floods, or other external hazard improvements were identified. The NRC staff concluded that the licensee's Unit 1 IPEEE process is capable of identifying the most likely severe accidents and severe accident vulnerabilities, and therefore, that the WBN IPEEE has met the intent of Supplement 4 to Generic Letter 88-20 (NRC 2000).

The dominant fire areas, defined as those having a fire CDF ≥ 3×10^{-7}/yr, and their contributions to the fire CDF are listed in Table 6-7. The total fire CDF is not given in the IPEEE submittal, but the total for those subjected to the final stage of screening is stated to be 9.3×10^{-6}/yr (TVA 2011a).

Table 6-7. Dominant Fire Areas and Their Contribution to Fire CDF

Fire Area Description	CDF (per year)
Main Control Room	9.7×10^{-7}
Corridor in Auxiliary Building (713.0-A1 & A2)	9.3×10^{-7}
125V Vital Battery Board Room IV	8.4×10^{-7}
Refueling Room	7.5×10^{-7}
Auxiliary Instrument Room 2	6.8×10^{-7}
Turbine Building	5.9×10^{-7}
Corridor (737.0-A1B)	5.1×10^{-7}
Corridor (737.0-A1A)	4.2×10^{-7}
Auxiliary Building Roof	3.1×10^{-7}
Corridor (737.0-A1C)	2.9×10^{-7}
Total	9.3×10^{-6} [(a)]

(a) The remaining contribution from all other fire areas is ~3×10^{-6}.

The WBN Unit 2 IPEEE did not identify any vulnerabilities due to fire events or any improvements to reduce fire risk.

TVA identified both conservatisms and non-conservatisms in the fire analysis (TVA 2011a), among which are conservative fire ignition frequencies, control room severity factors, and non-suppression probabilities; non-conservatively assuming that fires do not propagate between analysis volumes and excluding some spurious actuations as well as the increased probability of the 182 gpm per pump seal LOCA. TVA concludes that the conservatisms outweigh the non-conservatisms so that the fire contribution to risk is less than that given by the sum of the final screen results. To account for this conservatism, TVA reduced the fire CDF for the dominant fire areas in the IPEEE (9.3×10^{-6} /yr) by a factor of 2.29 to yield a fire CDF of 4.1×10^{-6}/yr for the SAMDA evaluation. This factor is the ratio of the internal events CDF of 2.68×10^{-5}/yr given by the modified PRA used for the fire analysis with no fire-induced failures nor flood failures to the CDF of 1.17×10^{-5}/yr given by the October 2010 SAMDA PRA for internal events only, excluding floods (TVA 2011a). Based on the conservatisms in the fire analysis, the NRC staff concludes that a fire CDF of 4.1×10^{-6}/yr is reasonable for the SAMA analysis.

6.3.2.3 Seismic CDF

The WBN Unit 1 IPEEE used a focused-scope Electric Power Research Institute (EPRI) seismic margins analysis, which is qualitative and does not provide numerical estimates of the CDF (EPRI 1991). The components in the safe shutdown equipment list were screened using an overall high confidence of low probability of failure (HCLPF) capacity of 0.3 g, the review level earthquake (RLE) value for the plant, and the screening level that would be used for a focused-scope plant. No significant seismic concerns were identified, although some maintenance and housekeeping items were noted and corrected (TVA 1998, 2010h). While the Unit 2 seismic assessment makes considerable use of the Unit 1 assessment, individual aspects are repeated and/or the Unit 1 results were reviewed to confirm that they are applicable to Unit 2. TVA considered this an acceptable approach since the designs of the units are nearly identical and use the same design criteria. The WBN Unit 2 IPEEE did not identify any seismic or improvements to reduce seismic risk.

To provide insight into the appropriate estimate of the seismic CDF to use for the SAMDA evaluation, the NRC staff noted that, in the attachments to NRC Information Notice 2010-18, Generic Issue (GI)-199 (NRC 2010), the NRC staff estimated a “weakest link model” seismic CDF for WBN Unit 1 of 3.6×10^{-5}/yr using updated seismic hazard curves developed by the U.S. Geological Survey (USGS) in 2008 (USGS 2008) and requested TVA provide an assessment of the impact of the updated USGS seismic hazard curves on the SAMDA evaluation (NRC 2011a). The NRC Information Notice referenced the August 2010 NRC document, “Safety/Risk Assessment Results for GI-199, Implications of Updated Probabilistic Seismic Hazard Estimates in Central and Eastern United States on Existing Plants” (ADAMS Accession No. ML100270582 (package)), that discusses recent updates to estimates of the seismic hazard in the central and eastern United States. Appendix A of that document describes how the seismic CDF estimate can be acceptably derived using various approaches; including a maximum estimate, averaging estimates, and the weakest link estimate. All these approaches use the plant-specific ground motion characterization (i.e., spectral accelerations at various frequencies and/or peak ground accelerations). For WBN Unit 1, the peak ground acceleration estimate is greater than the spectral acceleration estimates derived at 1 Hz, 5 Hz, and 10 Hz. As a result, the peak ground acceleration estimate is equal to the maximum estimate and dominates the weakest link model estimate at 3.6×10^{-5}/yr.

In response to the NRC staff request, TVA noted that the WBN site was used as the test case for closure of GI-194, "Implications of updated probabilistic seismic hazard estimates" (NRC 2003a; TVA 2011a). For GI-194, the NRC staff initially estimated the seismic CDF using the updated peak ground acceleration and derived a value similar to the latest updated value. However, the NRC staff noted that the WBN site's updated seismic spectral acceleration values differed significantly from the design safe shutdown earthquake spectrum. To account for the effect of this difference in spectrum shape on the estimated seismic CDF, the WBN plant HCLPF capacity of 0.3 g was scaled to the spectral acceleration values at 5 hertz (Hz) and 10 Hz, based on the natural frequency range for most structures and equipment in nuclear power plants being below 10 Hz (NRC 2003a) and used an averaging approach to derive the estimate of the seismic CDF. Based on the GI-194 staff analysis, TVA concluded that 1.8×10^{-5}/yr is an appropriate estimate of the seismic CDF for use in the WBN Unit 2 SAMA evaluation.

The seismic CDF estimated by the NRC staff for WBN Unit 1 using the 2008 USGS seismic hazard curves resulted in seismic CDFs of 1.3×10^{-5}/yr and about 2.8×10^{-5}/yr for spectral ground accelerations of 5 Hz and 10 Hz, respectively (NRC 2010). The average of the seismic CDF for these two acceleration values is about 2.0×10^{-5}/yr, which is comparable to the GI-194 result for WBN based on the same methodology. Based on this being essentially the same as the spectral-average seismic CDF of 1.8×10^{-5}/yr determined for closure of GI-194, the NRC staff agrees that 1.8×10^{-5}/yr is an acceptable estimate of the seismic CDF for use in the WBN Unit 2 SAMDA evaluation.

6.3.2.4 "Other" External Event CDF

The IPEEE analysis of "other" external events, which include high winds, external floods, transportation accidents, etc. (high winds, floods and other [HFO] events), followed the screening and evaluation approaches described in Supplement 4 of GL 88-20 (NRC 1991) and focused on demonstrating that the design and construction of the plant in the HFO areas met the 1975 SRP Criteria (NRC 1975). As a result, TVA completed a corrective action to design and install a steel shield to close an opening on the WBN Unit 2 side of the Auxiliary Building that had the potential for allowing tornado missiles to penetrate into the auxiliary building and damage safety-related equipment. TVA did not identify any other vulnerabilities or need for improvements. Based on this result, TVA did not consider specific SAMDAs for HFO events. The risks from deliberate aircraft impacts were explicitly excluded since this was being considered, along with other sources of sabotage by other parts of the NRC that deal with plant security.

6.3.2.5 Level 2 and LERF

The NRC staff reviewed the general process used by TVA to translate the results of the Level 1 PRA into containment releases, as well as the results of the Level 2 analysis, as described in the SAMDA submittal and in response to NRC staff RAIs (TVA 2011a, b, c, d). Accident progression was modeled using a 32 node containment model in MAAP4.0.7. Two large CETs were developed; one for SBO and one for non-SBO sequences (TVA 2010e). The reactor core radionuclide inventory assumes 5 percent enrichment and a burnup of 1,000 effective full power days for WBN Unit 2 at 3,565 MW(t) as evaluated using the ORIGEN code. TVA states that these conditions bound that expected for the WBN Unit 2 fuel management program for the license period (TVA 2010f). Each Level 1 core damage sequence is assigned to one of eight plant damage state bins, based on characteristics such as bypass containment or not, the type of bypass and high or low reactor coolant pressure. Each core damage sequence is linked to one of 11 Level 2 CET end state groups (plus intact containment), which are then binned into four release categories, used in the Level 3 consequence analysis, that represent similar containment failure modes, release magnitudes and timing.

The frequency of each release category is the sum of the frequencies of the contributing Level 2 sequences. Source terms and other release parameters for the Level 3 consequence analysis were determined for 11 scenarios that are representative of the sequences that contribute to the release categories. Based on the NRC staff's review of the Level 2 methodology, the fact that the LERF model was reviewed by the WOG and the review findings have all been addressed in the SAMDA Level 2 model, the updated Level 2 model was reviewed by an external contractor and independently reviewed by the TVA PRA team, and TVA has provided an adequate level of additional information in response to the RAIs concerning the Level 2 model, the NRC staff concludes that the Level 2 PRA provides an acceptable basis for evaluating the benefits associated with various SAMDAs (TVA 2010f, 2011b).

6.3.2.6 Level 3 – Population Dose

The process used by TVA to extend the containment performance (Level 2) portion of the PRA to an assessment of offsite consequences (essentially a Level 3 PRA) included consideration of the source terms and other parameters used to characterize fission product releases for the applicable representative release scenarios that contribute to the containment release categories and the major input assumptions used in the offsite consequence analyses. The WinMACCS code, the current version of the MACCS2 code, was utilized to estimate offsite consequences. Plant-specific input to the code includes the source terms for each release category and the reactor core radionuclide inventory; site-specific meteorological data for the 2002 calendar year; projected population distribution within an 80-km (50-mi) radius for the year 2040, based on the U.S. Census Bureau population data for 2000; emergency evacuation modeling, which assumed that 99.5 percent of the population would evacuate, NUREG-1150 (NRC 1990); and economic data from SECPOP2000 (NRC 2003b; TVA 2010c).

Sensitivity analyses were performed on some of the WinMACCS input parameters, including variation in the year chosen for meteorological data (data from 2001 through 2005 were available) and evacuation speed. TVA noted that previous SAMA analyses typically show little sensitivity to variations in many of the WinMACCS parameters, e.g., release height and plume buoyancy. The NRC staff concluded that the release parameters, methods, and assumptions for estimating population, evacuation assumptions, and approach taken for determining the site-specific economic data are acceptable for the purposes of the SAMDA evaluation. The NRC staff concludes that the methodology used by TVA to estimate the offsite consequences for WBN provides an acceptable basis from which to proceed with an assessment of risk-reduction potential for candidate SAMDAs. Accordingly, the NRC staff based its assessment of offsite risk on the CDF and revised offsite doses reported by TVA.

6.3.3 Potential Plant Improvements

The TVA process for identifying potential plant improvements (SAMDAs) consisted of the following elements:

- Review of other industry documentation discussing potential plant improvements as developed in NEI 05-01 (NEI 2005)
- Review of Phase II SAMAs from license renewal applications for five other U.S. nuclear sites
- Review of potential plant improvements identified in the WBN IPE and IPEEE
- Review of the most significant basic events and systems from the WBN Unit 2 PRA submitted in support of the original Unit 2 SAMDA assessment (TVA 2009b)
- Review of the most significant basic events from the WBN Unit 2 IPE based PRA submitted in support of the updated SAMDA assessment (TVA 2010c).

Based on this process, an initial set of 307 candidate “Phase I” SAMDAs was identified. TVA performed a qualitative screening of this initial list to eliminate 269 SAMDAs, leaving 38 for further evaluation, using the following criteria:

- The SAMDA is not applicable to the WBN design
- The SAMDA or its equivalent has already been implemented at WBN
- The SAMDA is similar in nature and can be combined with another SAMDA
- The SAMDA has estimated costs that would exceed the dollar value associated with completely eliminating all severe accident risk at WBN
- The SAMDA is related to a non-risk significant system known to have negligible impact on risk.

For these remaining Phase II SAMDAs, TVA performed a detailed evaluation, accounting for the potential impact of external events using a multiplier of 2.28 (TVA 2011a). This was derived as the ratio of the sum of the internal events, fire, and seismic CDFs ($1.7 \times 10^{-5} + 4.1 \times 10^{-6} + 1.8 \times 10^{-5} = 3.9 \times 10^{-5}$/yr) to the internal events CDF (1.7×10^{-5}/yr). The NRC staff agrees that the applicant's use of a multiplier of 2.28 to account for external events is reasonable for the purposes of the SAMDA evaluation.

Overall, TVA efforts to identify potential SAMDAs focused primarily on areas associated with internal initiating events based on the systems and basic events considered to be important to internal event CDF and LERF from a risk-reduction worth (RRW) perspective at WBN. This included selected SAMDAs from prior SAMA analyses for other plants. Also in response to NRC staff RAIs, TVA identified an additional 31 candidate SAMDAs resulting from the enhancements identified in the WBN Unit 1 SAMDA analysis (TVA 1994b), review of the WBN Unit 2 PRA down to a lower value of RRW, and the dominant fire zones as identified in the IPEEE. All were, however, screened from detailed analysis (TVA 2011a).[a]

The NRC staff reviewed the TVA process for identifying and screening potential SAMDA candidates, as well as the methods for quantifying the benefits associated with potential risk reduction. The NRC staff concludes that the set of SAMDAs evaluated in the EIS, together with those identified in response to NRC staff RAIs, addresses the major contributors to internal events CDF. Based on the licensee's IPEEE and the expected cost associated with further risk analysis and potential plant modifications, the NRC staff further concludes that the opportunity for seismic and fire-related SAMDAs has been adequately explored and that it is unlikely that there are any additional cost-beneficial seismic or fire-related SAMDA candidates.

The NRC staff notes that the set of SAMDAs submitted is not all inclusive, since additional, possibly even less expensive, design alternatives can always be postulated. However, the NRC staff concludes that the benefits of any additional modifications are unlikely to exceed the benefits of the modifications evaluated and that the alternative improvements would not likely cost less than the least expensive alternatives evaluated, when the subsidiary costs associated with maintenance, procedures, and training are considered. The NRC staff further concludes that TVA used a systematic and comprehensive process for identifying potential plant improvements for WBN, and that the set of potential plant improvements identified by TVA is reasonably comprehensive and therefore acceptable. While explicit treatment of external events in the SAMDA identification process was limited, it is recognized that the absence of external event vulnerabilities reasonably justifies examining primarily the internal events risk results for this purpose.

(a) TVA subsequently provided a revised Level 3 consequence analysis. In assessing the impact of the corrected consequence analysis on the SAMDA identification process, TVA identified one additional candidate SAMDA, which was screened out (TVA 2011e).

6.3.3.1 Risk Reduction

TVA evaluated the risk-reduction potential of the 38 Phase II SAMAs in a bounding fashion by assuming that the SAMDA would completely eliminate the risk associated with the proposed enhancement. TVA stated such bounding calculations overestimate the benefit and are conservative. TVA used model re-quantification to estimate the risk reduction for each of the evaluated SAMDAs, the estimated risk reduction in terms of percent reduction in CDF and population dose, and the estimated total benefit (present value) of the averted risk. The estimated benefits combined benefits in both internal and external events through the use of the external events multiplier, as well as incorporating a number of changes to the analysis methodology subsequent to the original submittal.

The NRC staff has reviewed the TVA bases for calculating the risk reduction for the various plant improvements as described in the SAMDA assessments and in response to NRC staff RAIs and concludes that the rationale and assumptions for estimating risk reduction are reasonable and generally conservative (i.e., the estimated risk reduction is higher than what would actually be realized). Accordingly, the NRC staff based its estimates of averted risk for the various SAMDAs on the TVA risk-reduction estimates.

6.3.3.2 Cost Impacts

TVA estimated the costs of implementing the 38 Phase II SAMAs by focusing on labor (e.g., craft, engineering) and component cost related to installing the proposed physical change. Costs do not include lifetime operation, testing or maintenance, procedural development and training associated with the physical changes (except for those SAMDAs which were solely procedural and/or training activities), or contingency for unforeseen obstacles or inflation (TVA 2010f, 2011a). Concerning per-unit cost savings associated with implementing the changes to both WBN units, TVA stated that the cost of procedural or training module development is only marginally increased to apply to a second unit and that, for physical unit design changes, the costs are for the affected unit only (TVA 2011a). Therefore, TVA opted not to divide the cost of procedural and training SAMDAs in half. The NRC staff concludes that the per-unit cost of physical changes (for the scope of the cost estimate as described above) would be less than that given by TVA. However, since the scope of the TVA cost estimates excludes lifetime costs associated with the procedure and training, these should be conservative, as borne out by comparison with similar costs given in license renewal SAMA submittals. Therefore, with regard to physical changes, the NRC staff concludes that, while there may be some savings with respect to sharing engineering cost between units, other factors such as lifetime costs and procedure and training associated with the change that are not included in the TVA estimate result in a conservative estimate. The NRC staff thereby concludes that the cost estimates provided by TVA are sufficient and appropriate for use in the SAMDA assessments.

6.3.3.3 Cost-Benefit Comparison

The methodology used by TVA is based on NEI 05-01, *Severe Accident Mitigation Alternatives (SAMA) Analysis Guidance Document* (NEI 2005), which in turn is based on NRC's guidance for performing cost-benefit analysis, i.e., NUREG/BR-0184, *Regulatory Analysis Technical Evaluation Handbook* (NRC 1997b). The guidance involves determining the net value for each SAMA according to the following formula:

$$\text{Net Value} = (\text{APE} + \text{AOC} + \text{AOE} + \text{AOSC}) - \text{COE}$$

where: APE = present value of averted public exposure ($)
AOC = present value of averted offsite property damage costs ($)
AOE = present value of averted occupational exposure costs ($)
AOSC = present value of averted onsite costs ($)
COE = cost of enhancement ($)

If the net value of a SAMDA is negative, the cost of implementing the SAMDA is larger than the benefit associated with the SAMDA and it is not considered cost-beneficial. TVA performed the SAMDA analysis using a 7 percent discount rate and provided a sensitivity analysis using a 3 percent discount rate to capture SAMDAs that may be cost-effective based on either (TVA 2011a). This analysis is sufficient to satisfy NRC policy in Revision 4 of NUREG/BR-0058 (NRC 2004b). Using the above equations, TVA estimated the total present dollar value equivalent associated with completely eliminating severe accidents from internal events at WBN Unit 2 to be about $1,930,000. Use of a multiplier of 2.28 to account for external events increases the value to $4,401,000. This represents the dollar value associated with completely eliminating all internal and external event severe accident risk at WBN Unit 2, and is also referred to as the Modified Maximum Averted Cost Risk (MMACR).

As a result of the TVA baseline analysis, eight SAMDAs (SAMDAs 4, 156, 256, 285, 292, 299, 305 and 306) were cost-beneficial. In addition to considering the impact of discount rate, TVA also estimated the effect of incorporating CDF uncertainties and parameter choices on the results of the SAMDA assessment (TVA 2011a). The change in discount rate from 7 percent to 3 percent changed the conclusion concerning cost-benefit of two SAMDAs (SAMDAs 215 and 300). Moreover, these results indicated that the impact of the 3 percent discount rate was less than that of the CDF uncertainty (discussed below). Hence, the SAMDAs that are cost-beneficial based on the CDF uncertainty incorporate those that are cost-beneficial considering the 3 percent discount rate. The TVA limited sensitivity studies relative to the parameter choices for the consequence analysis showed no impact on the calculated risk. Based on the parameters used and the results of previous SAMA consequence analysis sensitivity studies, the NRC staff concludes that the parameter selection for the consequence analysis is acceptable for the purposes of the SAMDA assessment.

TVA considered the impact that possible increases in benefits from analysis uncertainties would have on the results of the SAMDA assessment. Because no uncertainty distributions on CDF were available for the CAFTA-based SAMDA model, TVA used the results of the uncertainty analysis of the earlier RISKMAN-based PRA model (TVA 2009b) to establish an uncertainty multiplier based on the ratio of the 95th percentile CDF to the mean CDF, or 2.70. TVA subsequently determined that six additional SAMDAs (SAMDAs 8, 70, 93, 215, 226, and 300) would be cost-beneficial. The NRC staff notes that the CAFTA results are point estimates, not means, and hence the ratio of the 95th percentile CDF to the point estimate CDF, or 2.78, should be used in the CDF uncertainty analysis instead of 2.70. However, this difference is small and potentially impacts the cost-benefit analysis only of SAMDA 70, changing it from just slightly below to just slightly above the threshold to render it cost-beneficial. TVA has committed (TVA 2011b) to provide a new capability to allow the operators from the control room to transfer from normal compressed air supply to the station nitrogen system for control of the level control valves (LCVs). This new capability, identified as SAMDA 339, will have a greater benefit then that associated with SAMDA 70 and thus supersedes it. TVA also re-examined the initial set of SAMDAs to determine if any additional Phase I SAMDAs would be retained for further analysis if the benefits (and MMACR) were increased by the uncertainty factor of 2.70. None were identified (TVA 2011b, c, e). Use of an uncertainty factor of 2.78 would not change this conclusion.

The NRC staff concludes that, with the exception of the potentially cost-beneficial SAMDAs that have been identified, the costs of the other SAMDAs evaluated would be higher than the associated benefits, such that no additional SAMDAs would be expected to be cost-beneficial.

6.3.4 Cost-Beneficial SAMAs

A SAMDA cost-benefit analysis is presented in Table 6-8. Potentially cost-beneficial SAMAs are shown in ***bold italics***.

Table 6-8. SAMDA Cost-Benefit Analysis for WBN Unit 2

SAMDA	% Risk Reduction: CDF	% Risk Reduction: Population Dose	Total Benefit ($): Baseline (Internal + External)	Total Benefit ($): Baseline With Uncertainty	Cost ($)
4 – Improve DC bus load shedding	1.1	1.2	***40K***	***110K***	***32K***
8 – Increase training on response to loss of two 120V AC buses which causes inadvertent actuation signal	0.8	~0	12K	***35K***	***27K***
26 – Provide an additional high-pressure injection pump with independent diesel	1.4	1.4	65K	180K	3.6M

Table 6-8. (contd)

SAMDA	% Risk Reduction		Total Benefit ($)		Cost ($)
	CDF	Population Dose	Baseline (Internal + External)	Baseline With Uncertainty	
32 – Add the ability to automatically align emergency core cooling system to recirculation mode upon refueling water storage tank depletion	7.4	12	400K	1.1M	2.1M
45 – Enhance procedural guidance for use of cross-tied component cooling or service water pumps	0.3	~0	5K	14K	32K
46 – Add service water pump	7.0	3.7	150K	410K	1.0M
56 – Install an independent reactor coolant pump seal injection system, without dedicated diesel	24	29	1.1M	3.2M	8.2M
70 – Install accumulators for turbine-driven auxiliary feedwater pump flow control valves[a,b]	2.5	2.2	100K	***280K***	***260K***
71 – Install a new condensate storage tank (auxiliary feedwater storage tank)	~0	~0	~0	~0	1.7M
87 – Replace service and instrument air compressors with more reliable compressors which have self -contained air cooling by shaft driven fans	0.2	~0	2.2K	6.0K	890K
93 – Install an unfiltered hardened containment vent to eliminate the containment overpressure failure[c]	0	38	1.2M	3.5M	3.1M
101 – Provide a reactor exterior cooling system to cool a molten core before vessel failure	0	8.5	210K	580K	2.5M
103 – Institute simulator training for severe accident scenarios	33	32	1.4M	3.9M	8.0M
109 – Install a passive hydrogen control system	0	12	300K	840K	3.7M
110 – Erect a barrier that would provide enhanced protection of the containment walls (shell) from ejected core debris following a core melt scenario at high pressure.	0	4.0	100K	290K	1.2M
112 – Add redundant and diverse limit switches to each containment isolation valve	<0.1	0.0	3.2K	8.9K	690K

Table 6-8. (contd)

SAMDA	% Risk Reduction: CDF	% Risk Reduction: Population Dose	Total Benefit ($): Baseline (Internal + External)	Total Benefit ($): Baseline With Uncertainty	Cost ($)
136 – Install motor generator set trip breakers in the control room	0.9	0.0	13K	37K	240K
156 – Eliminate reactor coolant pump (RCP) thermal barrier dependence on condenser cooling water (CCW), such that loss of CCW does not result directly in core damage *(Enhance procedural guidance for use of ERCW for RCP thermal barrier cooling)*[d,e]	13	20	***780K***	***2.2M***	***32K***
176 – Provide a connection to alternate offsite power source	19	17	780K	2.2M	9.1M
191 – Provide self-cooled emergency core cooling system seals	~0[b]	~0	~0	~0	1.0M
215 – Provide a means to ensure RCP seal cooling so that RCP seals LOCAs are precluded for SBO events[c]	26	31	1.3M	***3.7M***	***1.5M***
226 – Provide permanent self-powered pump to back up normal charging pump[c]	26	31	1.3M	***3.7M***	***2.7M***
255 – Install a permanent, dedicated generator for the normal charging pump, one Motor Driven Pump and a Battery Charger	18	20	840K	2.3M	3.2M
256 – Install fire barriers around cables or reroute the cables away from fire sources (Enhance procedure for controlling temporary alternatives to reduce fire risk from temporary cables)[d]	25	25	***1.1M***	***3.1M***	***20K***
276 – Provide an auto start signal for the AFW on loss of standby feedwater pump	0.7	0.6	25K	70K	620K
279 – Provide a permanent tie-in to the construction air compressor	1.8	1.6	72K	200K	910K
280 – Add new WBN Unit 2 air compressor similar to the Unit 1 D compressor	1.8	1.6	72K	200K	810K
282 – Provide crosstie to WBN Unit 1 RWST	1.3	~0	21K	58K	10M
285 – Improve training to establish feed and bleed cooling given no centrifugal charging pumps (CCPs) are running or a vital instrument board fails	6.4	0.3	***100K***	***290K***	***27K***

Table 6-8. (contd)

SAMDA	% Risk Reduction: CDF	% Risk Reduction: Population Dose	Total Benefit ($): Baseline (Internal + External)	Total Benefit ($): Baseline With Uncertainty	Cost ($)
292 – Improve training to reduce failure probability to terminate inadvertent safety injection prior to water challenge to power-operated relief valves	4.2	13	***400K***	***1.1M***	***27K***
295 – Increase frequency of containment leak-rate testing	0	6.1	144K	400K	2.5M
299 – Initiate frequent awareness training for plant operators/maintenance/testing staff on key human actions for plant risk (Initiate frequent awareness training for maintenance and testing staff as on key human actions for plant risk)[(d)]	4.6	6.6	***290K***	***793K***	***27K***
300 – Revise procedure FR-H.1 to eliminate and/or simplify complex decision logic for establishing feed and bleed cooling and to improve operator recovery from initial mistakes	3.4	0.2	57K	***160K***	***100K***
303 – Move indicator/operator interface for starting igniters to front main control room (MCR) panel	0	~0	1.7K	4.8K	50K
304 – Add annunciator or alarm signaling parameters to initiate hydrogen igniters to front panel in the MCR	0	~0	1.7K	4.8K	50K
305 – Revise procedure E-1 to include recovery steps for failure to initiate hydrogen igniters[(f)]	0	6.2	***150K***	***420K***	***100K***
306 – Improve operator performance by enhancing likelihood of recovery from execution errors[(f)]	2.4	5.3	***170K***	***470K***	***100K***
307 – Make provisions for connecting ERCW to CCP 2B-B	0.1	0.0	0.6K	1.7K	99K
339 – Provide a capability to allow the operators from the control room to transfer from normal compressed air supply to the station nitrogen system for control of the AFW LCVs[(b)]	NA	NA	***NA***	***NA***	***NA***

Table 6-8. (contd)

SAMDA	% Risk Reduction CDF	Population Dose	Total Benefit ($) Baseline (Internal + External)	Baseline With Uncertainty	Cost ($)
340 – Install flood detection in areas 772.0-A8 and 772.0-A9[(g)]	NA	NA	***NA***	***NA***	***NA***

(a) As discussed in Section 6.3.3, the evaluation of the benefits of this SAMDA is deemed conservative, such that the potential slight exceedance of the cost-beneficial threshold does not render it cost-beneficial. It is therefore not highlighted.
(b) TVA has committed to provide a new capability to allow the operators from the control room to transfer from normal compressed air supply to the station nitrogen system for control of the LCVs. This new capability, identified as SAMDA 339, will have a greater benefit then that associated with SAMDA 70 and thus supersedes it (TVA 2011b).
(c) SAMDAs 93, 215, and 226 relate to preventing RCP seal failures. TVA has committed to follow the progress and experience with an improved RCP seal package design that has been installed at the Farley Nuclear Power Plant and, if proven reliable during operation, to install it at the earliest refueling outage following startup during normal seal package replacements (TVA 2011a). As a result, final decision as to the disposition of these potentially cost-beneficial SAMDAs is pending, and they are not highlighted.
(d) SAMDA title given in parentheses is considered a more accurate description of the actual SAMDA.
(e) Due to time constraints, procedure change envisioned for SAMDA 156 is not considered to be effective; hence the benefit would be essentially negligible. It is therefore not highlighted. Hardware change is considered in SAMDA 215.
(f) While potentially cost-beneficial, this SAMDA has already been implemented. It is therefore not highlighted.
(g) This SAMDA captures a previous commitment by TVA to install this flood detection equipment.
NA = not applicable
CCP = centrifugal charging pump

As stated in the November 1, 2010 submittal, TVA has indicated that the following potentially cost-beneficial SAMDAs will be implemented: SAMDAs 4, 8, 256, 285, 292, 299, and 300.[(a)] For reasons beyond a cost-beneficial analysis, TVA will be implementing SAMDAs 339 and 340 as committed by letters dated May 13 and 25, 2011.

6.3.5 Conclusions

TVA compiled a list of SAMDAs based on a review of: the most significant basic events from the plant-specific PRA, insights from the plant-specific IPE and IPEEE, Phase I SAMAs from license renewal applications for other plants, and NEI's list of generic SAMAs. An initial screening removed SAMDA candidates that (1) were not applicable to WBN, (2) were already

(a) The Third Circuit's opinion in *Limerick Ecology Action, Inc., v. NRC*, 869 F.2d 719, 723 (3d Cir. 1989) requires the agency to consider severe accident mitigation design alternatives under NEPA. NEPA requires the NRC to reasonably discuss and consider such alternatives. Consequently, the NRC must fully consider all cost-beneficial SAMDAs and if they are not implemented explain why that is a reasonable conclusion. However, because TVA has committed to implementing all identified cost-beneficial SAMDAs in this proceeding, a further explanation is not needed.

implemented at WBN, (3) were similar to and could be combined with other SAMDAs, (4) had estimated costs that would exceed the dollar value associated with completely eliminating all severe accident risk at WBN, or (5) determined to have negligible impact on risk. Based on this screening, a number of these SAMDAs were eliminated leaving the remaining candidate SAMDAs for Phase II evaluation.

For the remaining SAMDA candidates, more detailed design and cost estimates were developed. The cost-benefit analyses showed that eight of the SAMDA candidates were cost-beneficial in the baseline analysis (SAMDAs 4, 156, 256, 285, 292, 299, 305, and 306). TVA performed additional analyses to evaluate the impact of parameter choices and uncertainties on the results of the SAMDA assessment. As a result, six additional SAMDAs (SAMDAs 8, 70, 93, 215, 226, and 300) were identified as cost-beneficial. Six of these SAMDAs (SAMDAs 93, 156, 215, 226, 305, and 306) have been dispositioned as not needing implementation because (1) one would not be effective due to time constraints on the operators to perform the action; (2) accumulating operating experience with a recently installed, improved RCP seal design at Farley Nuclear Power Plant may result in TVA installing the same design at WBN Unit 2; or (3) two have already been implemented at WBN Unit 2.[a]

The NRC staff reviewed the TVA analysis and concludes that the methods used and the implementation of those methods were sound. The treatment of SAMDA benefits and costs support the general conclusion that the SAMDA evaluations performed by TVA are reasonable and sufficient for the license submittal. Although the treatment of SAMDAs for external events was somewhat limited, the likelihood of there being cost-beneficial enhancements in this area was minimized by improvements that have been realized as a result of the IPEEE process and inclusion of a multiplier to account for external events. The NRC staff concurs with the TVA identification of areas in which risk can be reduced in a cost-beneficial manner through the implementation of the identified, potentially cost-beneficial SAMDAs. TVA has committed to implement all but five cost-beneficial SAMAs, and provided adequate justification for why those five will not be implemented. Therefore, the NRC staff finds that the TVA analysis meets the requirements of NEPA.

(a) SAMDAs 215 and 226 relate to preventing RCP seal failures. TVA has committed to follow the progress and experience with an improved RCP seal package design that has been installed at the Farley Nuclear Power Plant and, if proven reliable during operation, to install it at the earliest refueling outage following startup during normal seal package replacements (TVA 2011a). As a result, final decision as to the disposition of these potentially cost-beneficial SAMDAs is pending.

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7.0 Consideration of New Information on the Environmental Impacts of Alternatives

The National Environmental Policy Act (NEPA) requires the consideration of reasonable alternatives to the proposed action in an environmental impact statement (EIS). In this case, the proposed action is whether to issue a 40-year operating license to the Tennessee Valley Authority (TVA) for Watts Bar Nuclear (WBN) Unit 2. However, a license is just one of a number of conditions that a licensee must meet in order to operate its nuclear plant. After the U.S. Nuclear Regulatory Commission (NRC) issues an operating license, state regulatory agencies and the owners of the nuclear power plant ultimately decide whether the plant will operate, and economic and environmental considerations play a primary role in this decision.

The NRC is responsible for ensuring the safe operation of commercial nuclear power facilities in the United States and does not formulate energy policy or encourage or deter the development of alternative power generation. The NRC also has no authority or regulatory control over the ultimate selection of alternative power generation and cannot ensure that environmentally preferable energy alternatives are used in the future. While the NRC staff considers a range of reasonable alternatives to issuing an operating license, the only alternative within NRC's decision-making authority is not to issue it.

In this chapter, the NRC staff has considered the environmental consequences of no-action (i.e., not issuing the license) and new information on various energy alternatives that could replace the generating capacity of WBN Unit 2. The assessment is limited to a description of each energy alternative and its environmental impact. The no-action alternative is discussed in Section 7.1, and alternative power generation in Section 7.2.

If the NRC issues an operating license, all of the alternatives, including the proposed action, would be available to energy-planning decision-makers. Conversely, if NRC does not issue the operating license (or takes no action at all), then energy-planning decision makers would have to resort to finding alternative ways of generating electricity—which may or may not be one of the energy alternatives discussed in this section—to meet their energy needs.

In its final environmental statement (FES) for the construction of WBN Units 1 and 2 (1972 FES-CP) (TVA 1972), TVA considered a number of alternatives to constructing and operating WBN Units 1 and 2. Among those alternatives were construction and operation of coal-fired units, hydroelectric units, gas-fired units, oil-fired units, and the no-action alternative. These alternatives were either deemed not feasible, more costly, and/or more environmentally detrimental than construction and operation of WBN Units 1 and 2. Since that time, TVA evaluated a range of alternatives as part of its integrated resource planning process, which the NRC staff considered and evaluated in its Supplement No. 1 to the FES related to the operating license (1995 SFES-OL-1) in December 1995 (NRC 1995). In tiering off the original 1972 FES-CP, the 1995 SFES-OL-1, and the balance of the environmental record pertinent to WBN, TVA did not identify any new alternatives or resource options beyond those already addressed in previous documents (TVA 1972; NRC 1995). In addition to factors considered in the 1972 FES-CP, TVA stated that completing WBN Unit 2 would provide baseload power in the region of interest, help reduce fossil plant emissions, and lower the cost of power in its service area (TVA 2008a, 2011a). Since the 1978 FES-OL, TVA has produced two publicly available long-term (i.e., 20 or more years) integrated resource plans (IRPs), which evaluate an assortment of power supply alternatives to meet the power demand in the TVA service area. In December 1995, TVA completed an IRP identifying and selecting long-range electricity generation strategies intended to meet the electricity needs of its customers with a forecast period extending from 1996 to 2020 (TVA 1995). On March 2, 2011, TVA issued its most recent IRP with a forecast period extending from 2011 to 2029 (TVA 2011a). On April 14, 2011, the TVA Board of Directors accepted the IRP and authorized the Chief Executive Officer to use its recommended planning direction as a guide in energy resource planning and selection. On July 6, 2011, TVA issued its Record of Decision stating that TVA will adopt the preferred alternative in its final EIS for the IRP (76 FR 39470).

As discussed in Chapter 1, the purpose for this SFES is to update the prior environmental review and only cover matters that differ from the final EIS or that reflect significant new information concerning matters discussed in the final EIS. The current rule governing environmental review at the operating license stage (10 CFR 51.95) states that, unless otherwise determined by the Commission, a FES supplement on the operation of a nuclear power plant will not include a discussion of alternative energy sources, or of alternative sites. For WBN Unit 2, the Commission stated its expectation that the staff would take the requisite "hard look" at new information on alternative sources of energy (NRC 2010) and authorized the NRC staff to supplement the FES if the NRC staff concluded that there was new and significant information on alternative sources of energy (NRC 2010). The Commission indicated that new and significant information would be information that would likely tip the cost-benefit balance against issuance of the operating license for WBN Unit 2. While the Commission recognized that technologies might change, the Commission stated that it was unlikely that such changes would "tip the NEPA cost-benefit balance against issuance of the operating license (NRC 2010; 47 FR 12940).

After taking the requisite hard look at new information, the NRC staff concludes that the new information on alternative energy sources is not new and significant because it does not tip the cost-benefit balance against issuance of the WBN Unit 2 operating license. Although energy alternatives have changed in terms of performance and viability since TVA submitted its WBN Unit 2 construction permit EIS in 1972, the NRC staff's hard look at energy alternatives did not identify any new and significant information related to energy alternatives. The NRC staff did not identify a viable alternative that was clearly and substantially environmentally superior to operation of WBN Unit 2 (i.e., an alternative that would tip the cost-benefit balance). Below is a summary of the information the NRC staff examined in taking its hard look at the issue.

7.1 No-Action Alternative

As previously discussed, under the no-action alternative the NRC would not issue an operating license to TVA, and WBN Unit 2 would not operate. If the NRC does not issue the operating license, there would be no environmental impacts from operation of WBN Unit 2; the environmental impacts of construction of WBN Unit 2 have largely occurred, and so would not be avoided. Under the no-action alternative, an expected 1,160-MW(e) net electrical output from WBN Unit 2 would not be generated, thus the benefits associated with the proposed new power production would not be realized in the TVA service area (i.e., no electricity would be generated).

TVA has indicated that if the WBN Unit 2 operating license is not issued, it would not be able to maintain an adequate reserve margin and would fail to meet its public service obligations to provide sufficient power within its service territory. The determination of the need for power in the TVA service area is discussed in Chapter 8 of this FES. TVA would also not be able to meet its obligations to provide capacity to other suppliers of electricity within the Southeastern Electric Reliability Corporation (SERC) region. Therefore, TVA would likely pursue various replacement power options by implementing one or some combination of the following actions (TVA 2008b, 2011a):

- Demand-side management (DSM): DSM programs consist of planning, implementing, and monitoring activities that enable and encourage consumers to reduce and/or modify their levels and patterns of electricity usage. By reducing customers' demand for energy through energy efficiency, conservation, and load management, the need for additional generation capacity can be reduced, postponed, or even eliminated. In addition to existing and planned DSM programs, TVA would need to implement more aggressive programs as conditions necessitate. However, even with additional DSM activities, alternative power sources would need to be acquired. TVA refers to its DSM activities as energy efficiency and demand response. Demand response shifts energy use to periods of lower demand, while energy efficiency reduces energy consumption.
- Purchase power: TVA could attempt to purchase power from other suppliers of electricity within the SERC region to fill short-term needs.
- Construct alternative replacement power generation: TVA could pursue the construction and operation of a replacement power plant using alternative energy sources, such as a coal-fired or combined-cycle gas-fired power plant.

TVA already offers several DSM programs to its customers to reduce peak electricity demands and daily power consumption. The impacts of these programs have been incorporated in the TVA demand forecast and included in its need-for-power analysis, which is discussed in Chapter 8 of this SFES. Current programs provide incentives to install and implement energy-efficient equipment and technologies, weatherization and insulation programs, and programs that provide technical assistance and educational material in an effort to assist customers in conserving energy. TVA anticipates fiscal year 2010 demand reductions from DSM activities to offset approximately 100 MW(e) of power-generation capacity. Although these DSM programs play an important role in reducing peak load power, they would not significantly reduce baseload consumption, and would not be a reasonable alternative for the 1,160-MW(e) capacity expected from WBN Unit 2 (TVA 2011a).

To the extent that TVA would rely on new or existing resources from outside the TVA region to offset the power that would otherwise be produced by WBN Unit 2, these resources would likely produce impacts (e.g., air, groundwater, socioeconomics) from construction (for new resources) and operations (for new and existing resources) in areas outside the TVA region.

7.2 Energy Alternatives

The current rule governing environmental review at the operating license stage (10 CFR 51.95) states that, unless otherwise determined by the Commission, a supplement on the operation of a nuclear power plant will not include a discussion of alternative energy sources. For WBN Unit 2, the Commission authorized the staff to supplement the FES if, through its requisite "hard look," the NRC staff concluded that there was new and significant information available on alternative energy sources (NRC 2010). After taking the requisite hard look, the NRC staff concludes that the new information on alternative energy sources is not new and significant because it does not tip the cost-benefit balance against issuance of the WBN Unit 2 operating license.

TVA is seeking an operating license for WBN Unit 2 to produce an additional 1,160-MW(e) net electrical baseload power for the TVA service area. This section describes the new information on potential environmental impacts associated with constructing and operating replacement baseload power plants using alternative energy sources. Alternatives considered, but eliminated from detailed study, are described in Section 7.2.3. Section 7.2.4 describes the environmental impacts from the natural-gas-fired power-generation alternative. A combination alternative is discussed in Section 7.2.5. A comparison of the environmental impacts from natural-gas-fired power generation and a combination alternative of power generating options at or near the WBN site are presented in Section 7.2.6.

The NRC staff selected new information on a reasonable set of energy alternatives to the operation of WBN Unit 2, which was limited to power-generation technologies that are technically reasonable and commercially viable (NRC 2000). The staff considered analyses supporting the *Generic Environmental Impact Statement* (GEIS), as well as other sources including the U.S. Department of Energy (DOE), the Environmental Protection Agency (EPA), and TVA.

For this analysis, a bounding value of 1,160-MW(e) electrical output replacement baseload power was used for comparison purposes, because this is the proposed generation capacity of WBN Unit 2. When reasonable, the WBN site would be used as the location for alternative replacement power generation and existing structures would be used to support these alternatives to minimize impacts and for ease of comparison. The WBN site occupies approximately 427 ha (1,055 ac) within the Watts Bar Reservation, which is 690 ha (1,700 ac) of land owned by the U.S. Federal Government in the custody of TVA. The reservation includes the WBN site, the Watts Bar Dam and Hydro-Electric Plant, the site of the recently demolished Watts Bar Fossil Plant (TVA 2012), the TVA Central Maintenance Facility, and the Watts Bar Resort Area (TVA 2008a). Closed-cycle cooling with natural-draft or mechanical cooling towers is assumed for all thermal plants. It is also assumed that the existing 500-kV electric power transmission lines could be used to serve a new baseload power-generation facility at the WBN site.

7.2.1 EIA Power Generation Outlook

Each year, the Energy Information Administration (EIA), a component of DOE, issues an annual energy outlook. In its Annual Energy Outlook 2011 (DOE/EIA 2011), the EIA reference case projects that coal-fired capacity will account for approximately 40 percent of the total electric generation mix between 2011 and 2035, but will only account for 11 percent of the electric generating capacity additions during the same period. Natural gas-fired plants are projected to make up approximately 25 percent of generation mix in 2035, while accounting for 60 percent of capacity additions between 2011 and 2035. The EIA projects that by 2035, renewable energy sources and nuclear plants will account for approximately 14 percent and 17 percent of the generating mix, respectively; however, renewable sources are projected to account for approximately 25 percent of the capacity additions between 2011 and 2035, while new nuclear plants will account for 3 percent. The EIA projections are based on the assumption that providers of new generating capacity would seek to minimize cost while meeting applicable environmental requirements (DOE/EIA 2011).

7.2.2 TVA Resource Planning

TVA states that the purpose and need of its proposal to operate WBN Unit 2 is to meet the need for additional baseload capacity in the TVA service area (TVA 2008b). The TVA current and planned power-generation system uses a range of technologies to produce electricity and meet the needs of the TVA service area. In 2010, coal-fired generation made up approximately

40 percent of the TVA capacity electricity generation mix, while nuclear generation made up approximately 19 percent, combustion turbines and combined-cycle (primarily fueled with natural gas) generation together made up 24 percent, and hydro power provided 8 percent. The remaining 9 percent of the TVA electricity generation capacity was made up of diesel-fired generation, pumped storage, renewable energy sources, and DSM activities (TVA 2011a).

In its most recent IRP, TVA evaluated resource options that it considers to be developed and proven technologies, or that have reasonable prospects of becoming commercially available before 2029. TVA also only considers resource technologies that are available to TVA either within the TVA region or importable through market purchases and that are economical and contribute to the reduction of emissions of air pollutants, including greenhouse gases. As part of its IRP process, TVA evaluated 100 supply-side (i.e., generation) and 60 demand-side (i.e., DSM) resource options. By 2020, TVA expects DSM activities to offset approximately 3,600 to 5,100 MW(e) of capacity and renewable generation additions to provide approximately 1,500 to 2,500 MW(e) of generation capacity. TVA also plans to increase its pumped storage capacity, nuclear, and natural-gas-fired generation capacity. TVA idled three coal-fired units in 2010 for environmental and economic reasons and is considering idling an additional 2,400 to 7,000 MW(e) of coal-fired capacity over the next 20 years to reduce emissions. TVA recommended planning direction includes up to 900 MW(e) of new coal-fired capacity, but these coal-fired additions consist solely of integrated gasification combined-cycle (IGCC) units equipped with carbon capture and sequestration technologies. TVA projects that these units would not come online until 2025 and 2029 (TVA 2011a), well after WBN Unit 2 is needed.

7.2.3 Alternatives Considered but Dismissed

This section discusses the NRC staff's hard look at new information on alternatives to licensing WBN Unit 2 and why the information was not considered significant (i.e., the NRC staff did not identify a viable alternative that was clearly and substantially environmentally superior to operation of WBN Unit 2 that could tip the cost benefit balance against issuance of the WBN Unit 2 operating license). Alternatives were eliminated due to technical, resource availability, or commercial limitations. NRC believes that these limitations would continue to exist when WBN Unit 2 begins operation. Any reasonable alternative to WBN Unit 2 would need to generate an equivalent amount of baseload power. Under each of the following technology headings, the NRC explains why each alternative is not reasonable or new and significant information. Offsite coal and gas-fired alternatives were not considered because constructing and operating a new power plant at an offsite location would generally cause greater impacts than constructing and making use of existing infrastructure at the WBN site. Therefore, these alternatives would not be clearly and substantially environmentally superior to the operation of WBN Unit 2.

7.2.3.1 Alternatives Not Requiring the Construction of New Power Generating Capacity

Four alternatives to the proposed action that do not require the construction of new power generating capacity are as follows:

- Purchasing power
- Extending the operating life of existing plants
- Reactivating retired plants
- Implementing DSM programs.

TVA is part of SERC, which is the largest of eight regional reliability councils within the North American Electric Reliability Corporation (NERC). TVA regularly reviews purchased power supply options through its Bulk Power Trading Group, and TVA already has entered into several long-term purchase contracts to meet future capacity estimates. As previously discussed, although some percentage of the TVA forecasted baseload replacement power might be met with purchased power (if available), purchased power is already included in TVA current and future capacity estimates. Therefore, any power that is purchased to replace WBN Unit 2 power would be dependent on the availability of baseload power and would need to be some amount above and beyond what is already accounted for in current and planned purchase power agreements (TVA 2011a).

Under the purchased power alternative, the environmental impacts of power production would still occur but would be located elsewhere within the region, nation, or in another country. The environmental impacts would depend on the generation technology and location of the generation site. In addition, new transmission line rights-of-way may be required.

TVA currently has purchase power agreements with generators producing power fueled by natural gas, coal, diesel, wind, biomass, municipal waste, and hydroelectricity. These facilities are in various locations, including Alabama, Mississippi, Tennessee, Illinois, Kentucky, Iowa, and North Carolina. In addition, TVA has pending power purchase agreements for renewable energy from Iowa, Illinois, Kansas, South Dakota, and North Dakota. TVA notes that the execution of the pending power purchase agreements for renewable energy is dependent on meeting applicable environmental review requirements and securing firm transmission paths for the delivery of the power to the TVA system (TVA 2011a). The construction of new lines could have environmental consequences. Overall impacts from purchased power would be SMALL when existing transmission line right-of-ways are used and operational impacts are minor (i.e., impacts are not noticeable or do not affect important attributes of the resources) to LARGE if acquisition and conversion of new right-of-ways is required, or when operational impacts alone destabilize resources or important attributes of the resources.

TVA existing nuclear power facilities were initially licensed by the NRC for a period of 40 years. The operating license can be renewed for up to 20 years, and NRC regulations permit additional license renewal. TVA currently operates three nuclear plants with a combined capacity of 6,900 MW(e); this includes three reactors on the Browns Ferry site in Alabama, two at the Sequoyah Nuclear Plant site in Tennessee, and one on the WBN site. The Browns Ferry Plant has received renewed operating licenses from the NRC (extending the licenses for its Unit 1 to 2033, Unit 2 to 2034, and Unit 3 to 2036). The environmental impacts of continued operation of a nuclear power plant are significantly less than construction of a new plant; however, TVA has assumed that these units will continue to operate and has included their continued operation in its forecast, so the NRC staff does not separately consider continued operation of existing nuclear facilities here. The impacts of operating and uprating other nuclear units in the TVA service area either have been examined by the NRC in separate EISs or environmental assessments, or will be so examined if and when TVA applies to NRC for future license renewals or power uprates. The expected generating capacity of all TVA nuclear power plants, including the approved uprates at all three nuclear plants, is included in the power supply forecast of the need-for-power assessment included in Chapter 8 of this SFES (TVA 2011a).

As previously discussed, three of the TVA coal-fired units were idled in fall 2010, and future idling of units is anticipated in the coming years. TVA decides which plants to idle based on environmental compliance costs, operational and maintenance costs, outage rates, waste disposal costs, operational flexibility, and carbon dioxide and other greenhouse gas emissions. In August 2010, TVA announced that the following nine coal units with a total capacity of about 1,000 MW(e) would be idled (TVA 2011a):

- Two units at Widows Creek in 2011
- Shawnee Unit 10 in 2011, which will be evaluated for conversion to a dedicated biomass-fueled unit
- The remaining four older units at Widows Creek by 2015
- Units 1 and 2 at John Sevier by 2015.

Older fossil-fueled power plants needing extensive and costly refurbishment have difficulty meeting current and more restrictive environmental standards, and thus TVA does not have plans to retrofit the idled coal facilities. Also, TVA plans to phase out all petroleum-based (i.e., oil and diesel) generation over the next 20 years (TVA 2011a), although gas-fired generation will retain the capacity to use diesel as a backup fuel (TVA 2011b). TVA has already included the planned capacity of fossil plants in its existing fleet that are upgraded with additional environmental controls in its need-for-power assessment in Chapter 8 of this SFES. According to the TVA IRP, natural-gas-fired plants will be the only fossil-fueled generation TVA plants to be added to its generation mix over the next 10 to 15 years (TVA 2011a).

TVA has an existing portfolio of DSM programs, which include energy-efficiency and demand-response programs. Demand-response programs are designed to temporarily reduce a customer's use of electricity, typically during peak periods when demand is highest. Demand-response programs do not typically reduce overall energy consumption, but may help a utility reduce the need for peaking, and in some cases, intermediate duty-cycle facilities. Energy-efficiency programs are designed to reduce overall energy consumption without any decrease in services to the customer.

By reducing customers' demand for energy through energy efficiency, conservation, and load management, the need for additional generation capacity can be reduced, postponed, or even eliminated. The impacts of existing programs are already incorporated in the TVA demand forecast and are included in its need-for-power analysis presented in Chapter 8 of this SFES. Current programs provide incentives to install and implement energy-efficient equipment and technologies, weatherization and insulation programs, and programs that provide technical assistance and educational material in an effort to assist customers in conserving energy. TVA currently has a DSM portfolio that is estimated to reduce peak capacity by approximately 770 MW(e) in 2012 (TVA 2011b). TVA plans to continue supporting DSM programs; however, although the DSM strategies can play an important role in reducing peak load power, they are not expected to adequately reduce baseload consumption by 2012 to offset WBN Unit 2 capacity. As a result, they would not be a reasonable alternative to operating WBN Unit 2 and would not tip the cost-benefit balance against the issuance of the WBN Unit 2 operating license.

7.2.3.2 Coal-Fired Power Generation

Coal-fired power plants are primarily used to provide baseload power. DOE projects that coal-fired power plants will account for approximately 40 percent of the total electric generation mix in the United States between 2011 and 2035 (DOE/EIA 2011). In general, a 1,160 MW(e) coal-fired power plant would have noticeable effects on the environment. Some of these effects would include increased sulfur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), carbon dioxide (CO_2) and particulate matter (PM) emissions, water quality and thermal impacts, loss of terrestrial habitat, and potential impacts to cultural resources at WBN Unit 2. Coal-fired power plants also produce a substantial waste stream of ash and scrubber sludge, which would either be disposed of or recycled. Ash and scrubber sludge disposal for a 1,160 MW(e) plant over a 40-year operating life would require approximately 200 ac (81 ha) of land.

Currently, approximately half of TVA electric power generation is coal-fired; however, TVA idled three coal-fired units in 2010 for environmental and economic reasons and is considering idling an additional 2,400 to 7,000 MW(e) of coal-fired capacity over the next 20 years to reduce emissions of SO_2, NO_x, CO, CO_2, PM, and mercury (Hg) in the TVA service area (TVA 2011a). Reducing fossil-fuel emissions in the TVA service area is part of the TVA overarching goal of providing an affordable, clean, and reliable supply of electricity. The TVA *Integrated Resource Plan: TVA's Environmental & Energy Future* (TVA 2011a) includes five resource planning strategies, and only one strategy includes an expansion of coal-fired generation. In addition, the one strategy that includes coal-fired generation specifies that 900 MW(e) of coal-fired capacity could be added between the years 2025 and 2029 and that this capacity would consist entirely of IGCC units equipped with carbon capture and sequestration technologies (TVA 2011a). IGCC generation technology, which combines modern coal gasification technology with both gas turbine and steam turbine power generation, could reduce some environmental impacts associated with conventional coal-fired generation. The IGCC technology is cleaner than conventional, pulverized coal plants because major pollutants can be removed from the gas stream before combustion, and plants produce smaller volumes of wastes. Despite IGCC's environmental advantages when compared to conventional coal facilities, IGCC plants are more expensive than comparable pulverized coal plants, and system reliability and capacity factors of existing IGCC plants (operating without carbon capture and sequestration) have been lower than pulverized coal plants (NETL 2010). In addition, IGCC with carbon capture and sequestration has not yet been implemented anywhere in the United States.

TVA currently has three idled coal-fired units in its generation fleet with a combined capacity of 226 MW (e) (TVA 2011a). If these plants were to be kept online and other older previously retired coal-fired plants were brought back online, they could potentially serve as alternative baseload generation to proposed WBN Unit 2. This option, however, would likely prevent TVA from achieving its environmental goals to reduce carbon emissions. In addition, any retired coal-fired plant would likely need to be refurbished to extend the plant life and meet current environmental requirements, which would be costly. The integrated resource strategy recommended to the TVA executive board in its EIS for the TVA IRP (TVA 2011b) includes the idling of 2,400 to 4,700 MW(e) of coal capacity during the next 20 years as part of its goal to reduce carbon dioxide emissions to meet environmental stewardship goals (TVA 2011a, b). Although the EIS for the IRP recommends a plan that includes a 900-MW(e) expansion of coal-fired capacity, this coal-fired option would not come online until the 2025–2029 timeframe (TVA 2011b). Based on the TVA IRP and recommendations from the TVA EIS for the IRP, as well as the experience to date with IGCC plants, constructing and operating a coal-fired power plant and or repowering existing retired or idled coal-fired plants would not be a reasonable alternative to operating WBN Unit 2 as a baseload power plant by 2012. This alternative would not tip the cost-benefit balance against issuance of the WBN Unit 2 operating license.

7.2.3.3 Oil-Fired Power Generation

The DOE's EIA reference case projects that oil-fired power plants would not account for any new electric power-generation capacity in the United States through 2035 (DOE/EIA 2011). Oil-fired generation is more expensive than nuclear, natural-gas-fired, or coal-fired power-generation options. In addition, future increases in oil prices are expected to make oil-fired generation increasingly more expensive. The high cost of oil has resulted in a decline in its use for electricity generation and oil-fired generation currently makes up less than two percent of the existing capacity within the SERC region (SERC 2010). Oil-fired plants are designed to start up quickly and are used exclusively during periods of peak power demand. TVA has no additional petroleum-based power-generation options proposed for future capacity needs in the TVA service area, and TVA plans to phase out petroleum power purchases by 2029 (TVA 2011a).

For the preceding economic and environmental reasons, constructing and operating an oil-fired power plant at the WBN site would not be a reasonable alternative to operating WBN Unit 2 as a baseload power plant.

7.2.3.4 Wind Power

Estimates of the wind resource potential in a region are expressed in wind power classes ranging from Class 1 (low) to Class 7 (high), with each class representing a range of mean wind power density or equivalent mean speed at specified heights above the ground. Areas designated Class 4 or greater are suitable for siting advanced wind turbine technology under development today (USACE 2004). The generation capacity is low within the overall TVA region, which has Class 1 or 2 wind power ratings (DOE 2005). TVA is already using potential wind power-generation sites such as the Buffalo Mountain Ridge in Tennessee, which produces 29 MW(e) of wind-generated power (TVA 2011a). Outside of the TVA service area, TVA has power purchase agreements with a 300-MW(e) windfarm in Illinois, a 115-MW(e) windfarm in Iowa, and a pending power purchase agreement with an additional 1,080 MW(e) of wind-generated power from six windfarms outside the TVA service area (TVA 2011a). A utility-scale wind-generation plant would generally require about 1 ha (2.5 ac) per MW(e) of installed capacity, although a portion of this land could be used for other purposes (Denholm et al. 2009).

Based on regional wind resource studies, it is estimated that approximately 4,200 MW(e) of wind capacity energy is available within the TVA service area; however, some of this acreage may be in protected areas unavailable for development and the average capacity factor for this wind resource would be about 25 percent (TVA 2011a). Newer wind turbines typically operate at approximately a 36-percent capacity factor (DOE 2008a). In comparison, the average capacity factor for a nuclear power-generation plant in 2010 in the United States was 91.2 percent (NEI 2011).

Because of the intermittent nature and limited regional availability of wind resources in the TVA region of interest, wind generation would not be a reasonable alternative to the proposed 1,160-MW(e) baseload generation, and would not tip the cost-benefit balance against issuance of the WBN Unit 2 operating license. Some neighboring regions outside of the TVA service area, such as Illinois, have higher classes of wind resources and are eligible to receive production tax credits for wind generation (TVA is not eligible for such credits); therefore, TVA has determined that the least-cost solution to integrating more wind into their generation portfolio is to purchase wind through power purchase agreements (TVA 2011a, b).

7.2.3.5 Energy Storage

Wind turbines and other renewable generation generally can serve as an intermittent baseload power supply and TVA currently generates intermittent wind power in its region of interest. Energy storage, such as battery storage, compressed air energy storage (CAES) facility, or a pumped storage facility can be coupled with wind or other intermittent power sources to simulate baseload generation. A storage facility can capture the power of the wind during low load times and use it during higher load times. Because storage facilities do not directly generate electricity, but instead convert electric energy to potential (pumped storage and CAES) or chemical (batteries) energy, they are not suitable stand-alone alternatives to WBN Unit 2. Furthermore, this conversion process results in some efficiency losses, so storage facilities tend to have net negative effect on generating capacity.

TVA has an existing 1,600-MW(e) pumped storage plant at Raccoon Mountain, near Chattanooga, Tennessee. An additional pumped storage resource option of 850 MW(e) was included in all five of the TVA IRP future strategies going forward and TVA also includes an expanded CAES option as part of its IRP. TVA did not evaluate any electric battery storage options because of operational limitations (TVA 2011a). With the Raccoon Mountain facility, excess energy from lower cost generating resources is used to pump water from Nickajack Reservoir to the upper reservoir during periods of low power demand. The pumps are reversible and used as turbines to produce power using water from the upper reservoir during periods of high demand. Additional pumped storage sites are available in the TVA region and could be developed to store excess wind energy from off-peak periods and produce power in periods when wind power is not available; however, these facilities would be associated with noticeable environmental impacts. Pumped storage plants require 2,000 to 3,000 ac for the upper pool, the generating plant, and a lower pool if another reservoir is not available. There would be impacts on terrestrial and aquatic resources as well as socioeconomic and cultural resource impacts. Additional operational impacts for pumped storage facilities include environmental impacts of the operation of thermal plants that might be used to supply power to the plant in pumping mode (TVA 2010a).

With CAES, the wind turbines provide the power to compress the air into a storage volume, such as an underground salt cavern or aquifer. The compressed air is discharged from the storage volume into a set of gas turbines that are fired with natural gas. The efficiency of the turbines is improved because compression of the inlet air is provided by the CAES facility instead of by the turbine itself. The only operating CAES system in the United States is the 110 MW(e) facility in Alabama, the McIntosh Power Plant (TVA 2010a). Although coupling wind with CAES reduces the problem of intermittency, it increases the air quality impacts by combusting natural gas. In addition, CAES technology is still in the demonstration phase and is not technologically mature.

Although it is technically feasible to couple wind or other intermittent resources with energy storage to reduce intermittency, doing so increases environmental impacts (particularly for pumped storage facilities), creates a net loss in energy (because some energy is lost in the operation of the energy storage facility), and many storage technologies (e.g., CAES and batteries) are not yet available in the capacities necessary to support an intermittent replacement for WBN Unit 2. As a result, the NRC staff does not consider any intermittent generating options coupled to energy storage technologies as a reasonable alternative to operating WBN Unit 2 and would not tip the cost-benefit balance against issuance of the WBN Unit 2 operating license.

7.2.3.6 Solar Power

There are currently two practical methods of producing electricity from solar energy: photovoltaics and solar thermal power. Photovoltaics (also referred to as solar cells) convert sunlight directly into electricity using semiconducting materials. Solar thermal technologies use concentrating devices to create temperatures suitable for power production. Concentrating thermal technologies are currently less costly than photovoltaics for bulk power production. They also can be provided with energy storage or auxiliary boilers to allow operation during periods when the sun is not shining (NWPCC 2006).

Solar technologies produce more electricity with more intense and direct sunlight. For solar power generation using concentrating solar power, the annual average amount of solar energy reaching the ground needs to be 6 kWh/m^2 per day or higher (NREL 2002). Based on solar radiation maps developed by the National Renewable Energy Laboratory, TVA has an estimated average solar radiation of 4.9 kWh/m^2 per day (TVA 2011a). Average annual capacity factors for solar power systems in the TVA region are about 24 percent for photovoltaics and 30 to 32 percent for solar thermal power (TVA 2008b). In comparison, the average capacity factor for a nuclear power plant in 2009 in the United States was 90.5 percent (NEI 2011). The lands with the best solar resources are usually arid and semi-arid. In the United States, the largest operational solar thermal plant is the 64 MW(e) Nevada Solar One plant located near Las Vegas, Nevada (DOE/EIA 2009).

TVA currently has experience with solar power technologies through its Green Power Switch and Generation Partners programs. As part of these programs, TVA owns 15 photovoltaic installations with a combined capacity of about 400 kW (TVA 2011b) and pays consumers for energy generated by renewable resource technologies, such as solar photovoltaics. In early 2011, 310 facilities with a total generating capacity of about 4.8 MW(e) were enrolled in the program and generating about 34,000 kWh per month (TVA 2011b).

Because of solar power generation's intermittent nature as well as the regional solar radiation characteristics, the acreage requirements, and expense of solar power generation, a solar-energy facility at the WBN site would not currently be a reasonable alternative to operating WBN Unit 2 and would not tip the cost-benefit balance against issuance of the WBN Unit 2 operating license.

7.2.3.7 Hydropower

TVA currently operates 110 conventional hydroelectric generating units at 29 dams with a combined capacity of 3,538 MW(e). TVA hydroelectric plants are primarily operated to provide peaking power; during periods of abundant precipitation, they may also be operated to provide intermediate power (TVA 2011b). In addition, their availability is dependent on the availability of water and the necessity to control water flow to meet broad multi-purpose goals as established in the TVA Reservoir Operations Policy. Approximately 10 percent of the TVA current generation capacity is met with hydropower. TVA currently has an ongoing effort to gain megawatt capacity through modernization of aging hydropower systems, and this additional capacity is included in the TVA forecast as presented in the assessment of the need for power, found in Chapter 8 of this SFES (TVA 2011b).

A 2006 study by the Idaho National Engineering and Environmental Laboratory identified an approximate additional 1,770 MW(e) of undeveloped hydropower resources in the TVA service area (INEEL 2006). However, none of the feasible capacity is categorized as large power sources (greater than 60 MW(e)). Approximately 70 percent of the feasible hydropower capacity was categorized as small hydro and the remaining 30 percent was categorized as low power resources (less than 2 MW(e)) (TVA 2011b).

Because of the relatively low amount of undeveloped hydropower resources in the TVA region and the large land-use and related environmental and ecological resource impacts associated with siting hydroelectric facilities large enough to produce 1,160 MW(e), hydropower would not be a reasonable alternative to operating WBN Unit 2 and would not tip the cost-benefit balance against issuance of the WBN Unit 2 operating license.

7.2.3.8 Geothermal Energy

Geothermal energy has an average capacity factor of 90 percent and can be used for baseload power where available. Hydrothermal resources (i.e., steam or hot water), which are the most common geothermal resources, are available primarily in the western states, Alaska, and Hawaii. Other geothermal resources (e.g., hot dry rock and magma) are awaiting further technology development (DOE 2006). Geothermal technology is not widely used for baseload power generation because of the limited geographical availability of the resource and immature status of the technology (NRC 1996). The TVA region of interest does not have high-temperature geothermal reservoirs available to produce geothermal power (DOE 2006).

Because of the lack of regionally available hydrothermal resources and the current status of geothermal technology, a geothermal-energy facility at the WBN site would not be a reasonable alternative to operating WBN Unit 2.

7.2.3.9 Wood Waste

As part of its generation mix, TVA co-fires wood waste in a boiler at Colbert Fossil Plant and also has power purchase agreement for 70 MW(e) of biomass wood-waste power from Columbus, Mississippi, and 3.2 MW(e) from Jackson, Tennessee (TVA 2011b). Approximately 11 million tons of wood waste is generated each year in the TVA service area (TVA 2003).

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

Because of uncertainties associated with obtaining sufficient wood and wood waste to fuel a baseload power plant, the ecological impacts of large-scale timber cutting (e.g., soil erosion and loss of wildlife habitat), and high inefficiency, wood waste would not be a reasonable alternative to operating WBN Unit 2 and would not tip the cost-benefit balance against issuance of the WBN Unit 2 operating license.

7.2.3.10 Municipal Solid Waste

Municipal solid-waste combustors incinerate waste and use the resultant heat to produce steam, hot water, or electricity. The combustion process can reduce the volume of waste by up to 90 percent and the weight by up to 75 percent (EPA 2009). Municipal waste combustors use three basic types of technologies: mass burn, modular, and refuse-derived fuel (DOE/EIA 2001). Mass-burning technologies are most commonly used in the United States. This group of technologies processes raw municipal solid waste “as is,” with little or no sizing, shredding, or separation before combustion. In the GEIS for license renewal (NRC 1996), the NRC determined that the initial capital cost for municipal solid-waste plants is greater than for comparable steam turbine technology at wood-waste facilities because of the need for specialized waste-separation and waste-handling equipment for municipal solid waste.

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

In 2010, 86 waste-to-energy plants operated in the United States. These plants generated approximately 2,572 MW(e), or an average of approximately 30 MW(e) per plant (IWSA 2010). TVA does not plan to construct or operate facilities using municipal solid waste in the next 20 years; however, it would consider purchasing power from such a facility (TVA 2011b). Given the small size of existing plants, generating electricity from municipal solid waste would not be a reasonable alternative to operating WBN Unit 2 and would not tip the cost-benefit balance against issuance of the WBN Unit 2 operating license.

7.2.3.11 Other Biomass-Derived Fuels

In addition to wood and municipal solid-waste fuel, several other biomass-derived fuels are available for fueling electric generators, including burning crops, converting crops to a liquid fuel such as ethanol, and gasifying crops. Biomass power plants can provide baseload power and are one of few renewable power plants with generation that can be scheduled. EIA estimates that hydropower, wind, and biomass will be the three largest sources of renewable electricity generation renewable fuels through 2035 (DOE/EIA 2011). TVA also considers biomass to be one of its largest renewable energy resources in the Tennessee River Valley. Crops grown specifically to produce biomass for use as fuels (dedicated energy crops) are a potentially important commodity in the TVA region. Studies project that approximately 10 million tons of switchgrass, a native, high-yielding grass, could be grown annually as an energy crop in the TVA service area. TVA estimates that in combination, these biomass resources (including wood waste, see Section 7.2.3.9) could potentially produce an energy equivalent of approximately 900 MW(e) in the TVA service area. However, the cost of converting some of these biomass resources to electricity is twice the cost of coal on an energy basis (TVA 2003).

TVA currently integrates biomass-derived fuels into the generation mix by co-firing methane from a nearby sewage-treatment plant at Allen Fossil Plant (TVA 2011a). TVA currently purchases about 80 MW(e) of biomass-fueled generation and has purchased power agreements for 11 MW(e) of biomass-fired generation from corn milling residue. In addition, TVA plans to evaluate the Shawnee 10 fossil plant for conversion to a dedicated biomass-fueled unit (TVA 2011b). In the GEIS for license renewal (NRC 1996), the NRC determined that none of these biomass conversion technologies has progressed to the point of being competitive on a large scale or of being reliable enough to replace a large baseload power-generation plant. Nevertheless, TVA included up to 490 MW(e) of biomass generation and landfill gas generation as a potential resource option for evaluation over the next 20 years in its IRP (TVA 2011a). The

NRC staff notes that this is less than half the proposed capacity of WBN Unit 2, and will not be available until long after WBN Unit 2 is proposed for operation.

Construction of a biomass-fired plant would have an environmental impact that would be similar to that for a coal-fired plant, although facilities using wood waste and agricultural residues for fuel would be built on smaller scales. Like coal-fired plants, biomass-fired plants require areas for fuel storage, processing, and waste (i.e., ash) disposal. Additionally, operation of biomass-fired plants has environmental impacts, including potential impacts on the aquatic environment and air; however, biomass feedstocks have lower levels of sulfur and sulfur compounds compared with coal. Because of the limited availability and environmental impacts, biomass-derived fuels would not be a reasonable alternative to operating WBN Unit 2 and would not tip the cost-benefit balance against issuance of the WBN Unit 2 operating license.

7.2.3.12 Fuel Cells

Fuel cells work without combustion and its associated environmental side effects. Power is produced electrochemically by passing a hydrogen-rich fuel over an anode, air over a cathode, and then separating the two by an electrolyte. The only byproducts are heat, water, and CO_2. Hydrogen is typically derived from hydrocarbon-based fuels, such as natural gas, by subjecting them to steam reforming or partial oxidation, through gasification of coal or biomass, or through the electrolysis of water.

Phosphoric-acid fuel cells are generally considered first-generation technology. During the past three decades, significant efforts have been made to develop more practical and affordable fuel-cell designs for stationary power applications and the first-generation technologies have given way to membrane and solid-oxide-based fuel cells operating consistently at above 50-percent electrical efficiency (DOE 2008b). High-temperature, second-generation fuel cells have achieved increased fuel-to-electricity and thermal efficiencies, giving second-generation fuel-cell systems the ability to generate steam for cogeneration such as in distributed generation type combined heat and power applications.

On-going research in both stationary and transportation-based fuel cells is intended to provide continuing improvements of both materials and components as they relate to system cost and durability. Currently, the cost of fuel-cell power systems must be reduced before they can be competitive with conventional technologies (DOE 2008c). At the present time, fuel cells are not economically or technologically competitive with other alternatives for baseload electricity generation. Because fuel cells have not been developed to the point where they are capable of supplying power equal to 1,160 MW(e), fuel-cell-based electricity generation does not offer a reasonable alternative to operating WBN Unit 2 and would not tip the cost-benefit balance against issuance of the WBN Unit 2 operating license.

7.2.4 Natural-Gas-Fired Power Generation

For the natural-gas-fired alternative, the NRC assumed construction and operation of a natural-gas-fired plant with a closed-cycle cooling system and cooling towers located at the WBN site. The natural-gas-fired plant would use combined-cycle combustion turbines and two units would be needed with a net capacity of 580 MW(e) per unit for a total capacity of 1,160 MW(e). The natural-gas-fired alternative would use existing transmission lines and rights-of-way to the WBN site, as discussed in Section 3.2 of this SFES.

TVA currently operates 11 natural-gas-fired generating facilities – 9 combustion turbine plants with a total capacity of 5,326 MW(e) and 2 combined-cycle plants with a total capacity of 1,327 MW(e). TVA is constructing the John Sevier combined-cycle plant with a proposed capacity of 880 MW(e) (TVA 2010b, 2011a).

7.2.4.1 Air Quality

Natural gas is a relatively clean-burning fuel. A natural-gas-fired plant releases similar types of emissions as a coal-fired plant, but in lower quantities. A new natural-gas-fired power plant in the WBN region would likely need a Prevention of Significant Deterioration (PSD) and an operating permit under the Clean Air Act. PSD is an EPA program in which state or Federal permits are required to restrict air emissions from new or modified sources in places where air quality currently meets ambient air quality standards.

A new natural-gas-fired, combined-cycle plant also would be subject to the new source performance standards specified in Title 40 of the Code of Federal Regulations (CFR) Part 60, Subpart KKKK ("Standards of Performance for Stationary Combustion Turbines"). This subpart establishes standards for SO_2 and NO_x.

The EPA has various regulatory requirements for visibility protection in 40 CFR Part 51, Subpart P ("Protection of Visibility"), including a specific requirement for review of any new major stationary source in areas designated as in attainment or unclassified under the Clean Air Act. Most of the "designated areas" around the WBN site are designated as "Unclassifiable/Attainment" for all criteria pollutants. However, the area around Chattanooga, Tennessee-Georgia (Hamilton County) and the area around Knoxville, Tennessee (Anderson, Blount, Knox, London, and part of Roane counties), are "Nonattainment" for $PM_{2.5}$ (40 CFR 81.343).

Section 169A(a)(2) of the Clean Air Act (42 USC 7491) establishes a national goal of preventing future, and remedying existing, impairment of visibility in Mandatory Class I Federal Areas when impairment occurs because of air pollution resulting from human activities. The Great Smokey Mountains National Park and the Joyce Kilmer Slickrock Wilderness are identified Mandatory Class I Federal Areas, where visibility is an important value (40 CFR 81.428). The Great Smoky

Mountains National Park comprises 514,758 ac overall, of which 273,551 ac are in North Carolina, and 241,207 ac are in Tennessee. Joyce Kilmer Slickrock Wilderness comprises 14,033 ac overall, of which 10,201 ac are in North Carolina, and 3,832 ac are in Tennessee. They are located approximately 80 km (50 mi) from the site to the west and northwest, respectively. If a new gas-fired power-generation facility were located near a mandatory Class I area, additional air-pollution control requirements could be imposed.

The emissions from the natural-gas-fired alternative at the WBN site, based on EPA emission factors and performance characteristics for this alternative and its emission controls, would be as follows:

- SO_2 – 91 T/yr (83 MT/yr)
- NO_x – 291 T/yr (264 MT/yr)
- CO – 61 T/yr (55 MT/yr)
- PM_{10} – 51 T/yr (44 MT/yr) (all particulates are PM_{10}).

A natural-gas-fired power plant also would have unregulated CO_2 emissions that could contribute to climate change. The NRC staff estimates that the natural-gas-fired alternative would emit approximately 3.1 million T/yr (2.8 MT/yr) of CO_2.

The combustion turbine portion of the combined-cycle plant would be subject to EPA's National Emission Standards for Hazardous Air Pollutants for Source Categories (40 CFR 63) if the site is a major source of hazardous air pollutants. Major sources have the potential to emit 10 T/yr (9 MT/yr) or more of any single hazardous air pollutant or 25 T/yr (23 MT/yr) or more of any combination of hazardous air pollutants (40 CFR 63.6085(b)).

The fugitive dust emissions from construction activities could impact air quality on or near the WBN site; however, these impacts would be temporary and mitigated using best management practices. In addition, exhaust emissions would come from vehicles and other motorized equipment used during the construction of the plant.

The impacts of emissions from a natural-gas-fired power plant could be noticeable, but given the variety of air quality regulations with which the plant must comply, the impacts would not destabilize air quality. Overall, air quality impacts resulting from construction and operation of new natural-gas-fired power plant at the WBN site would be SMALL to MODERATE.

7.2.4.2 Water Use and Quality

The impacts on water use and quality from operating a natural-gas-fired plant at the WBN site would be comparable to the impacts associated with operating a nuclear power plant on the site. Closed-cycle cooling with cooling towers is assumed. The impacts on water quality from sedimentation during construction of a natural-gas-fired plant are characterized in NUREG-1437 as SMALL (NRC 1996). NRC also noted in NUREG-1437 that the impacts on water quality from operations are similar to, or less than, the impacts from other generating technologies. Overall, water use and quality impacts from construction and operation of a new natural-gas-fired plant at the WBN site would be SMALL.

7.2.4.3 Aquatic and Terrestrial Resources

Much of the aquatic and terrestrial resource impacts that would occur from constructing and operating a gas-fired plant on the WBN site would occur in areas previously disturbed during the construction of WBN Unit 2. Constructing a new underground gas pipeline to the site would cause temporary ecological impacts. Construction and operation of a natural-gas pipeline would be subject to various state and Federal environmental requirements depending on how and where it would be constructed. Ecological impacts on the plant site and utility easements would not affect threatened and endangered species, although some wildlife habitat loss and fragmentation, reduced productivity, and local reduction in biological diversity would be likely. Withdrawal and discharge of makeup water for the cooling system could affect aquatic resources, and drift of condensation from the cooling towers could affect terrestrial ecology. Overall, the NRC concludes that ecological impacts from construction and operation of a new natural-gas-fired plant at the WBN site would be SMALL to MODERATE.

7.2.4.4 Human Health

In NUREG-1437, the NRC identified cancer and emphysema as potential health risks from natural-gas-fired plants (NRC 1996). The risk may be attributable to NO_x emissions that contribute to ozone formation, which in turn contributes to health risk. The Tennessee Department of Environment and Conservation (TDEC) would regulate air emissions from a natural-gas-fired power plant located at the WBN site. The human health effect would be expected to be either undetectable or minor. Overall, the NRC concludes that the impacts on human health from natural-gas-fired power generation would be SMALL.

7.2.4.5 Socioeconomics

Land Use

The GEIS generically evaluates the onsite and offsite impacts of nuclear power plant construction and operation on land use. This analysis of land-use impacts focuses on the land area that would be affected by the construction and operation of a natural-gas-fired power plant at the WBN site.

Based on GEIS estimates, approximately 128 ac (51 ha) of land would be needed to support a natural-gas-fired alternative to replace WBN Unit 2. This amount of land use would include other plant structures and associated infrastructure.

In addition to onsite land requirements, land would be required offsite for natural-gas wells, collection stations, and gas pipelines. Most of this land requirement would occur on land where gas extraction already occurs. In addition, some natural gas could come from outside the United States and be delivered as liquefied gas.

The elimination of uranium fuel for WBN Unit 2 could partially offset offsite land requirements needed for mining and processing uranium during the operating life of the plant. Overall land-use impacts from construction and operation of a new natural-gas-fired plant at the WBN site would be in the range of SMALL to MODERATE.

Socioeconomics

Socioeconomic impacts are defined in terms of changes to the demographic and economic characteristics and social conditions of a region. For example, the number of jobs created by the construction and operation of a new natural-gas-fired power plant could affect regional employment, income, and expenditures. Two types of jobs would be created by this alternative: (1) construction-related jobs, which are transient, short in duration, and less likely to have a long-term socioeconomic impact; and (2) operation-related jobs in support of power plant operations, which have the greater potential for permanent, long-term socioeconomic impacts. Workforce requirements for the construction and operation of the natural-gas-fired power plant alternative were evaluated in order to measure their possible effects on current socioeconomic conditions.

In its Environmental Report for two combined nuclear licenses at the Bellefonte plant site, TVA indicated that construction of an alternative new natural-gas-fired power plant in the TVA region would typically peak at 400 workers on site over a 3-year period (TVA 2008b). The NRC staff finds these estimates to be similar to other TVA estimates related to construction of the John Sevier gas-fired plant (TVA JS EA) and considers the estimates to be reasonable for construction of a gas-fired power plant at the WBN Unit 2 site. During construction of a natural-gas-fired plant, the communities surrounding the power plant site would experience increased demand for rental housing and public services. The relative economic effect of construction workers on the local economy and tax base would vary over time.

After construction, the loss of construction jobs and associated loss in demand for business services may temporarily affect local communities. Additionally, the rental housing market could experience increased vacancies and decreased prices. Since WBN is located near the relatively populous cities of Knoxville and Chattanooga, these effects would be smaller because workers are likely to commute instead of relocating closer to the construction site. Because of the WBN site’s proximity to this large population center, the impact of construction on socioeconomic conditions could range from SMALL to MODERATE.

Based on previous experience, operating a two-unit natural-gas-fired plant with a total net capacity of 1160 MW(e) would require approximately 60 workers (TVA 2008b). During plant operations, demand for housing and public services would diminish due to the relatively small workforce required to operate the plant and considering the surrounding population and infrastructure. Overall, the socioeconomic impacts from constructing and operating a gas-fired plant would be noticeably less than impacts associated with the construction and operation of a coal-fired alternative due to the smaller size of the construction and operations workforce. Operational impacts would be SMALL.

Transportation

Transportation impacts associated with construction and operation of a gas-fired power plant would consist of commuting workers and truck deliveries of construction materials to the WBN site. During periods of peak construction activity, up to 400 workers could be commuting daily to the site. In addition to commuting workers, trucks would be transporting construction materials and equipment to the worksite, thus increasing the amount of traffic on local roads. The increase in vehicular traffic would peak during shift changes, resulting in temporary levels of service impacts and delays at intersections. Pipeline construction and modification to existing natural-gas pipeline systems could also have an impact. Traffic-related transportation impacts during construction would likely be MODERATE.

During plant operations, traffic-related transportation impacts would almost disappear. Operating a gas-fired plant would require approximately 60 workers. Since fuel is transported by pipeline, the transportation infrastructure would experience little to no increased use from plant operations. Overall, the gas-fired alternative transportation impacts would be SMALL during plant operations.

Aesthetics

The aesthetics impact analysis focuses on the degree of contrast between the natural-gas-fired alternative and the surrounding landscape and the visibility of the natural-gas-fired plant.

The gas-fired units could be approximately 100 ft (30 m) tall, with four exhaust stacks up to 200 ft (61 m) tall. The facility would be visible offsite during daylight hours, and some structures may require aircraft warning lights. The power plant would be smaller and less noticeable than that of WBN Unit 2. Cooling towers would continue to generate condensate plumes and operational noise. Additional noise during power plant operations would be limited to industrial processes and communications. Pipelines delivering natural-gas fuel could be audible offsite near compressors.

In general, aesthetic changes would be limited to the immediate vicinity of the WBN site and would be SMALL.

Historic and Cultural Resources

Cultural resources are the indications of human occupation and use of the landscape as defined and protected by a series of Federal laws, regulations, and guidelines. Prehistoric resources are physical remains of human activities that predate written records; they generally consist of artifacts that may alone or collectively yield information about the past. Historic resources consist of physical remains that postdate the emergence of written records; in the United States, they are architectural structures or districts, archaeological objects, and archaeological features dating from 1492 and later. Ordinarily, sites less than 50 years old are not considered historic, but exceptions can be made for such properties if they are of particular importance, such as structures associated with the development of nuclear power (e.g., Shippingport Atomic power Station) or Cold War themes. American Indian resources are sites, areas, and materials important to American Indians for religious or heritage reasons. Such resources may include geographic features, plants, animals, cemeteries, battlefields, trails, and environmental features. The cultural resource analysis encompassed the power plant site and adjacent areas that could potentially be disturbed by the construction and operation of alternative power plants.

The potential for historic and archaeological resources can vary greatly depending on the location of the proposed site and supporting infrastructure. To consider a project's effects on historic and archaeological resources, any affected areas would need to be surveyed to identify and record historic and archaeological resources, identify cultural resources (e.g., traditional cultural properties), and develop possible mitigation measures to address any adverse effects from ground-disturbing activities. The cultural resource analysis encompassed the power plant site and adjacent areas that could be disturbed by the construction and operation of a replacement gas-fired plant at the WBN site.

A cultural resources survey would be needed for any onsite property not previously surveyed. Additionally, other lands acquired to support the plant would likely need to be surveyed to identify and record historic and archaeological resources. These surveys would be needed for all areas of potential disturbance, both onsite and offsite (e.g., mining and waste disposal sites). If project activities adversely affect historic and cultural resources, mitigation measures would be taken in consultation with the State Historic Preservation Officer (SHPO). Historic and cultural resource impacts would be SMALL to LARGE, depending on the location and degree to which supporting infrastructure (e.g., collection stations and natural gas pipelines) will be needed offsite.

Environmental Justice

The environmental justice impact analysis evaluates the potential for disproportionately high and adverse human health and environmental effects on minority and low-income populations that could result from the construction and operation of a new natural-gas-fired power plant. Adverse health effects are measured in terms of the risk and rate of fatal or nonfatal adverse impacts on human health. Disproportionately high and adverse human health effects occur when the risk or rate of exposure to an environmental hazard for a minority or low-income population is significant and exceeds the risk or exposure rate for the general population or for another appropriate comparison group. Disproportionately high environmental effects refer to impacts or risk of impacts on the natural or physical environment in a minority or low-income community that are significant and appreciably exceed the environmental impact on the larger community. Such effects may include biological, cultural, economic, or social impacts. Some of these potential effects have been identified in resource areas evaluated in this SFES. For example, increased demand for rental housing during power plant construction could disproportionately affect low-income populations. Minority and low-income populations are subsets of the general public residing in the vicinity of WBN, and all are exposed to the same hazards generated from constructing and operating a new natural-gas-fired power plant.

As discussed in Section 2.4.3.1 of this SFES, within the 80-km (50-mi) region of the WBN site, approximately 15 percent of the population identified themselves as a minority. Approximately 238 census block groups wholly or partly within the 80-km (50-mi) radius of the WBN site were determined to have a minority population of 15 percent of the total population (see Figure 2-8). Of these 238 block groups, 71 had aggregate minority population percentages that exceed the regional (within 80-km [50-mi] radius of the WBN site) average by 20 percentage points or more, and 52 census block groups had aggregate minority population percentages that exceed 50 percent. These block groups are primarily located near the town centers of Maryville (Blount County), Oak Ridge (Anderson County), Cleveland (Bradley County), and the City of Chattanooga (Hamilton County). Some more rural concentrations are located in Whitfield County, Georgia. No block groups with high-density minority populations were found in Rhea or Meigs counties (USCB 2010).

According to census data estimates, 57 block groups exceeded the 80-km (50-mi) average (15.5 percent) by 20 percent or more, while only 16 block groups had low-income populations of 50 percent or more (see Section 2.4.3.2). These block groups are distributed throughout the 80-km (50-mi) radius in relatively rural areas of Scott, Cumberland, Grundy, Roane, Sequatchie, and White counties. In addition, some low-income concentrations are found near the town centers of Dayton (Rhea County), Oak Ridge (Anderson County), Cookeville (Putnam County), Athens (McMinn County), Cleveland (Bradley County), and the City of Chattanooga (Hamilton County). No high-density low-income block groups were found in Meigs County (USCB 2011).

Potential impacts on minority and low-income populations from the construction and operation of a new natural-gas-fired power plant at WBN would mostly consist of environmental and socioeconomic effects (e.g., noise, dust, traffic, employment, and housing impacts). Noise and dust impacts from construction would be short-term and primarily limited to onsite activities. Minority and low-income populations residing along site access roads would also be affected by increased commuter vehicle traffic during shift changes and truck traffic. However, these effects would be temporary during certain hours of the day and not likely to be high and adverse. Increased demand for rental housing during construction in the vicinity of the WBN could affect low-income populations. However, given the close proximity to populated areas, most construction workers would likely commute to the site thereby reducing the potential demand for rental housing.

Based on this information and the analysis of human health and environmental impacts from a natural-gas-fired alternative presented in this section of the SFES, the construction and operation of a new natural-gas-fired power plant would not have disproportionately high and adverse human health and environmental effects on minority and low-income populations residing in the vicinity of the WBN site.

7.2.4.6 Waste Management

According to the 1996 GEIS (NUREG-1437), waste generation from natural-gas-fired technology would be minimal (NRC 1996). The only significant waste generated at a natural-gas-fired power plant would be spent Selective Catalytic Reduction (SCR) catalyst, which is used to control NO_x emissions. The spent catalyst would be regenerated or disposed of offsite. Other than spent SCR catalyst, waste generation at an operating natural-gas-fired plant would be largely limited to typical operations and maintenance waste. Construction-related debris would be generated during construction activities. Overall, waste impacts from natural-gas-fired power generation would be SMALL.

The impacts of natural-gas-fired power generation at the WBN site are summarized in Table 7-1.

Table 7-1. Summary of Environmental Impacts of the Natural Gas-Fired Alternative

	Natural-Gas Combined-Cycle Generation
Air quality	SMALL to MODERATE
Water use and quality	SMALL
Aquatic and terrestrial resources	SMALL to MODERATE
Human health	SMALL
Socioeconomics (including land, cultural resources, and environmental justice)	SMALL to LARGE
Waste management	SMALL

7.2.5 Combination of Energy Alternatives

Individual alternatives to the operation of an additional nuclear unit at the proposed site might not be sufficient on their own to generate the equivalent of 1,160 MW(e), because of the small size of the resource or lack of cost-effective opportunities. Nevertheless, it is conceivable that a combination of alternatives might be cost-effective. There are many possible combinations of alternatives. Based, in part, on resources identified in the TVA IRP (TVA 2011a), the NRC staff has assembled a combination of alternatives that could reasonably serve as a generation option for WBN Unit 2, considering the proposed capacity of WBN Unit 2 (1,160 MW(e) operated as baseload plant), the proposed start date (2012), proposed license period (40 years), and the availability of resources in the TVA service area.

Any combination of alternative sources that incorporates renewable sources of energy (e.g., solar or wind power) also would need to be combined with some form of 100 percent load capacity fossil-fuel-fired power generation to accommodate the intermittent power generation from renewable sources. The natural-gas-fired power generation option, evaluated as part of the baseload alternatives, would be the most likely fossil-fuel-generated option in the TVA region of interest. The impacts of natural-gas-fired power generation previously discussed would form the basis of evaluating this portion of the combination of power generating alternatives. When considering the combined environmental impacts (e.g., land-use, aesthetics) from a natural-gas-fired generation unit, solar, wind, biomass sources, or any number of renewable alternatives, the combination of alternatives, would likely have environmental impacts that exceed the environmental impacts of operating WBN Unit 2.

Construction and operation of two natural-gas-fired, combined-cycle generating units (generating 580 MW(e) each) at the WBN site using closed-cycle cooling with cooling towers was discussed in Section 7.2.4. For a combined alternatives option, the environmental impacts of two 380-MW(e) natural-gas-fired, combined-cycle power generating units at the WBN site using closed-cycle cooling with cooling towers was considered. In addition, it is assumed that a combination of alternatives could reasonably include 400 MW(e) of wind energy (assuming a 36 percent capacity factor), 100 MW(e) from biomass sources, and 150 MW(e) from energy-efficiency programs. Due to wind availability limitations, TVA would likely purchase some portion of the wind energy from neighboring regions. A summary of the environmental impacts associated with the construction and operation of this combination of alternatives is provided in Table 7-2.

Table 7-2. Summary of Environmental Impacts of a Combination of Power Sources

Impact Category	Impact	Comment
Air Quality	SMALL to MODERATE	Emissions from the natural-gas-fired plant and biomass facilities could affect air quality.
Water Use and Quality	SMALL	Impacts would be comparable to the impacts for a new power plant located at the WBN site.
Ecology	SMALL to MODERATE	Many of the impacts would occur in areas previously disturbed during the construction of WBN Units 1 and 2; however, biomass plant would require areas for fuel storage, processing, and waste (i.e., ash) disposal. Impacts on terrestrial ecology from cooling-tower drift could occur. Land requirements for wind farm could result in habitat loss and some avian mortality.
Human Health	SMALL	Regulatory controls and oversight would be protective of human health.
Socioeconomics	SMALL to LARGE	Construction and operations workforces would be relatively small. However, construction-related impacts would be noticeable. Impacts during operation would be minor because of the small workforce involved. Wind farm and new transmission lines associated with generation would create aesthetic impacts.
Land Use	MODERATE	A biomass plant and natural-gas-fired plant would require land for the powerblock, fuel storage/natural-gas pipeline, and waste disposal. Wind farms and associated transmission lines would require a large amount of land.
Historic and Cultural Resources	SMALL to LARGE	Most of the facilities and infrastructure at the site would likely be built on previously disturbed ground. Site surveys would have to be conducted and the effects to cultural resources assessed and mitigated, if necessary, prior to any ground-disturbing activities.
Environmental Justice	SMALL	Depending on their location, construction and operation of these facilities may affect minority and low-income populations.
Waste Management	SMALL to MODERATE	Waste would be from spent SCR catalyst used for control of NO_x emissions from natural-gas-fired plant and ash from biomass waste sources.

7.2.5.1 Air Quality

As discussed in Section 7.2.4, although natural gas is a relatively clean-burning fossil fuel, any gas-fired generation option would be associated with emissions of SO_2, NO_x, CO, CO_2, and PM. Similarly, biomass-powered plants produce emissions in the form of NO_x, CO_2 and a small amount of SO_2. The amounts emitted depend on the type of biomass burned and generator used. Wood waste is relatively abundant in the TVA service area, with approximately 11 million tons of wood waste generated each year (TVA 2003). If wood waste fueled a 100-MW(e) biomass plant, the NRC staff calculates that it could produce 124 T (112 MT) of SO_2 per year, 608 T (552 MT) of NO_x, 744 T (675 MT) of CO, 370 T of PM_{10}, and 968,000 T (878,000 MT) of CO_2 per year, based on likely fuel and power plant characteristics. Wind generation and energy-efficiency programs would not affect air quality in the TVA region of interest.

In addition to operation impacts, the construction of this combination of alternatives would produce temporary fugitive dust emissions from construction activities. The exhaust emissions from vehicles and other motorized equipment used during the construction of the facilities would also have temporary air quality impacts in the TVA region of interest.

The impacts of emissions from a natural-gas-fired power plant and biomass/municipal waste generation would be noticeable, but would not be sufficient to destabilize air resources. Overall, air quality impacts resulting from construction and operation of the combination of alternatives would be MODERATE.

7.2.5.2 Water Use and Quality

The impacts on water use and quality from operating a natural-gas-fired and biomass plant at the WBN site would be comparable to the impacts discussed in the GEIS for license renewal (NRC 1996) associated with the operation of a nuclear power plant. Closed-cycle cooling with cooling towers would be used. The impacts on water quality from sedimentation during construction are characterized in the GEIS as SMALL (NRC 1996). NRC also noted in the GEIS that the impacts on water quality from operations are similar to, or less than, the impacts from other generating technologies.

Wind generation and energy efficiency would not have noticeable impacts on water use or quality in the TVA region of interest. Overall, water use and quality impacts would be SMALL.

7.2.5.3 Aquatic and Terrestrial Resources

Constructing a new underground gas pipeline to the WBN site would cause temporary ecological impacts. Impacts on the plant site and utility easements would not affect threatened and endangered species, although some wildlife habitat loss and fragmentation, reduced productivity, and local reduction in biological diversity would be likely. Like coal-fired plants, biomass-fired plants require areas for fuel storage, processing, and waste (i.e., ash) disposal, which could potentially impact aquatic and terrestrial resources on the site. Most of the aquatic and terrestrial resource impacts of constructing and operating and gas-fired plant and biomass plant on the WBN site would occur in areas previously disturbed during construction of WBN Unit 2. Withdrawal and discharge of makeup water for the cooling system could affect aquatic resources, and drift of condensation from the cooling towers could affect terrestrial ecology.

A wind farm would also affect terrestrial resources. The total impact would depend on the location and acreage. Wind generation with a capacity of 400 MW(e) would permanently impact approximately 290 ac (120 ha), and temporarily impact an additional 690 ac (280 ha) during construction (Denholm et al. 2009). The energy-efficiency programs would not have any impact on aquatic and terrestrial resources in the region of interest. Overall, the NRC concludes that ecological impacts from the combination of alternatives would be SMALL to MODERATE.

7.2.5.4 Human Health

In the GEIS, the NRC identified cancer and emphysema as potential health risks from natural-gas-fired plants (NRC 1996). Health risks from the gas-fired plant and biomass plant may be attributable to NO_x emissions. TDEC would regulate air emissions from the natural-gas-fired and biomass power plants located at the WBN site. No human health effects are associated with wind generation and energy-efficiency components. The human health effect would be expected to be either undetectable or minor. Overall, the NRC concludes that the impacts on human health from the combination of alternatives would be SMALL.

7.2.5.5 Socioeconomics

Land Use

This analysis of land-use impacts focuses on the land area that would be affected by the construction and operation of a natural-gas-fired power plant and a biomass power plant at the WBN site, as well as the construction and operation of a wind farm located offsite but within the TVA service area.

Based on TVA estimates, approximately 80–100 ac (30–40 ha) of land would be needed to support a natural-gas-fired and biomass plants (TVA 2011b). In addition, the biomass-fired plant would require areas for fuel storage, processing, and waste (i.e., ash) disposal. In addition to onsite land requirements, land would be required offsite for natural-gas wells, collection stations, and gas pipelines. The construction of wind turbines and associated transmission lines would require a large amount of land spread over several offsite locations. Wind generation with a capacity of 400 MW(e) would permanently affect approximately 290 ac (120 ha), and temporarily affect an additional 690 ac (280 ha) during construction (Denholm et al. 2009). The elimination of uranium fuel for WBN Unit 2 could partially offset offsite land requirements;

however, the combined land-use impacts from the construction and operation of a gas-fired plant, wind farm, and biomass plant would be noticeable in the region of interest.

Energy-efficiency programs could have minor land-use impacts if they involve the rapid replacement and disposal of old energy inefficient appliances and other equipment that would generate waste material and could increase the size of landfills. However, given the time for program development and implementation, the cost of replacements, and the average life of equipment, the replacement process would probably be gradual. More efficient appliances and equipment would replace older equipment (especially in the case of frequently replaced items, such as light bulbs). In addition, many items (such as home appliances and industrial equipment) have recycling value and would not be disposed of in landfills. Overall land-use impacts from the combination of alternatives would be MODERATE.

Socioeconomics

As previously discussed, socioeconomic impacts are defined in terms of changes to the demographic and economic characteristics and social conditions of a region. For example, the number of jobs created by the construction and operation of new power plants could affect regional employment, income, and expenditures. Two types of jobs are created by this alternative: (1) construction-related jobs, which are transient, short in duration, and less likely to have a long-term socioeconomic impact; and (2) operation-related jobs, which have greater potential for permanent, long-term socioeconomic impacts.

Section 7.2.4.5 states that the socioeconomic impacts from the construction of two gas-fired units at the WBN site would be SMALL to MODERATE. Similarly, the construction of a gas-fired and biomass plant onsite would require a construction workforce to commute to the site. Additional construction workers would be required offsite for the construction of a wind farm. These workers could cause a short-term increase in the demand for services and temporary (rental) housing in the region around the construction site.

After construction, the loss of construction jobs and associated loss in demand for business services may temporarily affect local communities. Additionally, the rental housing market could experience increased vacancies and decreased prices. However, these effects would likely be spread over a large area, as the wind farms may be constructed in more than one location. The combined effects of these construction activities would range from SMALL to MODERATE.

Additional estimated operations workforce requirements for this combination alternative would include operations workers for the natural-gas-fired and biomass energy power plants and wind farm. Given the small number of operations workers at these facilities, socioeconomic impacts associated with operation of the natural-gas-fired and biomass power plant at the WBN site, and the wind farm would be SMALL. Socioeconomic effects of energy-efficiency programs would be SMALL.

Transportation

Construction and operation of natural-gas-fired and biomass energy power plants, and a wind farm would increase the number of vehicles on the roads near these facilities. During construction, cars and trucks would deliver workers, materials, and equipment to the worksites. The increase in vehicular traffic would peak during shift changes, resulting in temporary levels of service impacts and delays at intersections. Transporting components of wind turbines could have a noticeable impact, but is likely to be spread over a large area. Pipeline construction and modification to existing natural-gas pipeline systems could also have transportation impacts to the extent that transportation and pipeline networks intersect. Traffic-related transportation impacts during construction could range from SMALL to MODERATE depending on the location of the wind farm site, current road capacities, and average daily traffic volumes.

During plant operations, transportation impacts would not be noticeable. Given the small numbers of operations workers at these facilities, the levels of service traffic impacts on local roads from the operation of the gas-fired power plant at the WBN site, biomass energy facility, and at the wind farm would be SMALL. Transportation impacts at the wind farm site or sites would also depend on current road capacities and average daily traffic volumes, but are likely to be small given the low number of workers employed by that component of the alternative. Any transportation effects from the energy-efficiency component would be widely distributed across the state and would not be noticeable.

Aesthetics

The aesthetics impact analysis focuses on the degree of contrast between the surrounding landscape and the visibility of the power plant. In general, aesthetic changes would be limited to the immediate vicinity of the WBN site and the wind farm facilities.

Aesthetic impacts from the gas-fired power plant component of the combination alternative would be essentially the same as those described for the gas-fired alternative in Section 7.2.4.5 of this SFES. Power plant infrastructure would be generally smaller and less noticeable than WBN Unit 1 and Unit 2 containment, cooling tower, and turbine buildings. The natural-draft cooling towers would continue to generate condensate plumes and operational noise. Noise during power plant operations would be limited to industrial processes and communications. In addition to the power plant structures, construction of natural-gas pipelines would have a short-term aesthetic impact. Noise from the pipelines could be audible offsite near compressors. However, in general, aesthetic changes would be limited to the immediate vicinity of the WBN site and would be SMALL.

The wind farm would have the greatest visual impact. The wind turbines, up to 450 ft (137 m) tall and spread across multiple sites, would dominate the view and likely become the major focus of attention. Depending on its location, the aesthetic impacts from the construction and operation of the wind farm would be MODERATE to LARGE.

Impacts from the energy-efficiency programs would be SMALL. Some noise impacts could occur in instances of energy conservation and efficiency upgrades to major building systems, but this impact would be intermittent and short lived.

Historic and Cultural Resources

The same considerations discussed in Section 7.2.4.5 of this SFES for the impact of the construction of two gas-fired plants on historic and cultural resources apply to the construction activities that would occur on the WBN site for a new gas-fired power generating plant. As previously noted, the potential for historic and archaeological resources can vary greatly depending on the location of the power plant. To consider a project's effects on historic and cultural resources, any affected areas would need to be surveyed to identify and record historic and archaeological resources, identify cultural resources (e.g., traditional cultural properties), and develop possible mitigation measures to address any adverse effects from ground-disturbing activities.

As discussed earlier, much of the WBN site has been previously disturbed by the construction of WBN Units 1 and 2. In addition, previous WBN site cultural resource surveys have already resulted in the identification of archaeological sites.

Surveys would be needed to identify evaluate and address mitigation of potential impacts prior to the construction of any new power generating facility. Studies would be needed for all areas of potential disturbance (e.g., roads, transmission corridors, or other rights-of-way). Areas with the greatest sensitivity should be avoided. Because TVA would conduct a survey and apply its established protection plan for future resources, the impact of a new gas-fired power plant and biomass plant at the WBN site on historic and cultural resources would be SMALL. However, depending on the location and degree to which supporting infrastructure (e.g., collection stations and natural gas pipelines) will be needed offsite, impacts could range from SMALL to LARGE.

Depending on the resource richness of the wind farm site chosen, the impacts could range between SMALL to LARGE. Therefore, the overall impacts on historic and cultural resources from the combination alternative could range from SMALL to LARGE.

Impacts to historic and cultural resources from implementing energy-efficiency programs would be SMALL and would not likely affect land use or historic or cultural resources elsewhere in the State.

Environmental Justice

The environmental justice impact analysis evaluates the potential for disproportionately high and adverse human health and environmental effects on minority and low-income populations that could result from the construction and operation of a new natural-gas-fired power plant at the

WBN site, biomass energy facility, wind farm, and energy-efficiency programs. Adverse health effects are measured in terms of the risk and rate of fatal or nonfatal adverse impacts on human health. Disproportionately high and adverse human health effects occur when the risk or rate of exposure to an environmental hazard for a minority or low-income population is significant and exceeds the risk or exposure rate for the general population or for another appropriate comparison group. Disproportionately high environmental effects refer to impacts or risk of impact on the natural or physical environment in a minority or low-income community that are significant and appreciably exceeds the environmental impact on the larger community. Such effects may include biological, cultural, economic, or social impacts. Some of these potential effects have been identified in resource areas discussed in this SFES. For example, increased demand for rental housing during power plant construction could disproportionately affect low-income populations. Minority and low-income populations are subsets of the general public residing around a power plant, and all are exposed to the same hazards generated from constructing and operating gas-fired and biomass energy power plants and wind farm.

As mentioned previously in this chapter, of the approximately 238 census block groups within the 50-mi radius of the WBN site, 71 block groups have high concentrations of minority populations (see Section 2.4.3.1). These block groups are primarily located near the town centers of Maryville (Blount County), Oak Ridge (Anderson County), Cleveland (Bradley County), and the City of Chattanooga (Hamilton County). Some more rural concentrations are located in Whitfield County, Georgia. No block groups with high-density minority populations were found in Rhea or Meigs counties (USCB 2010). There are also 57 block groups that have relatively high concentrations of low-income populations (see Section 2.4.3.2). These block groups are distributed throughout the 80-km (50-mi) radius in relatively rural areas of Scott, Cumberland, Grundy, Roane, Sequatchie, and White counties. In addition, some low-income concentrations are found near the town centers of Dayton (Rhea County), Oak Ridge (Anderson County), Cookeville (Putnam County), Athens (McMinn County), Cleveland (Bradley County), and the City of Chattanooga (Hamilton County). No high-density low-income block groups were found in Meigs County (USCB 2011).

Low-income families could benefit from energy-efficiency programs related to residential weatherization and insulation improvements, as lower-income households pay a relatively high proportion of their household income for home energy expenses. Overall impacts to minority and low-income populations from energy conservation and efficiency programs would be nominal, depending on program design and enrollment. Potential impacts to minority and low-income populations from the construction and operation of a natural-gas-fired and biomass power plant at the WBN site, and a wind farm offsite would mostly consist of environmental and socioeconomic effects (e.g., noise, dust, traffic, employment, and housing impacts). Noise and dust impacts from construction would be short-term and primarily limited to onsite activities. Minority and low-income populations residing along site access roads would also be affected by increased commuter vehicle traffic during shift changes and truck traffic. However, these effects would be temporary during certain hours of the day and not likely to be high and adverse.

Increased demand for rental housing during construction in the vicinity of the WBN site, and the wind farm could affect low-income populations. Given the close proximity to relatively populous cities, Knoxville and Chattanooga, most construction workers would likely commute to the site thereby reducing the potential demand for rental housing.

Based on this information and the analysis of human health and environmental impacts presented in this SFES, the construction and operation of a natural-gas-fired power plant, biomass energy facility, and the wind farm (depending on its location) would not have a disproportionately high and adverse human health and environmental effects on minority and low-income populations.

7.2.5.6 Waste Management

According to the NUREG-1437, waste generation from natural-gas-fired technology would be minimal (NRC 1996). The only significant waste generated at a natural-gas-fired power plant would be spent SCR catalyst, which is used to control NO_x emissions. The spent catalyst would be regenerated or disposed of offsite. Biomass based power plants produce a fly ash waste stream; however, much of this waste could be recycled. Other waste would be largely limited to typical operations and maintenance waste. The operation of wind generation and energy-efficiency activities would not produce waste streams. Construction-related debris would be generated during construction activities. Overall, waste impacts from the combination of alternatives would be SMALL to MODERATE.

7.2.6 Summary Comparison of Alternatives

Table 7-3 contains a summary of the NRC's environmental impact characterizations for constructing and operating a natural-gas-fired power plant alternative and a combination of power-generation alternatives. Both alternatives would have an impact on air quality. There would also be construction impacts to terrestrial resources and socioeconomic impacts. Based on the NRC staff's review of a natural-gas-fired power plant or a combination of power-generation alternatives, no new and significant information was identified. Neither of these two alternatives is clearly and substantially environmentally superior to operating a nuclear power plant and therefore, would not tip the cost-benefit balance against issuance of the WBN Unit 2 operating license.

Table 7-3. Summary of Environmental Impacts of Construction and Operation of Natural-Gas-Fired Generating Units and Combination of Alternatives

Impact Category	Natural Gas	Combination of Alternatives
Air quality	SMALL to MODERATE	SMALL to MODERATE
Water use and quality	SMALL	SMALL
Aquatic and terrestrial resources	SMALL to MODERATE	SMALL to MODERATE
Human health	SMALL	SMALL
Socioeconomics (including land, cultural resources, and environmental justice)	SMALL to LARGE	SMALL to LARGE
Waste management	SMALL	SMALL to MODERATE

7.3 References

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40 CFR Part 51. Code of Federal Regulations, Title 40, *Protection of Environment*, Part 51, "Requirements for Preparation, Adoption, and Submittal of Implementation Plans."

40 CFR Part 60. Code of Federal Regulations, Title 40, *Protection of Environment*, Part 60, "Standards of Performance for New Stationary Sources."

40 CFR Part 63. Code of Federal Regulations, Title 40, *Protection of Environment*, Part 63, "National Emission Standards for Hazardous Air Pollutants for Source Categories."

40 CFR Part 81. Code of Federal Regulations, Title 40, *Protection of Environment*, Part 81, "Air Quality Control Regions (AQCRs)."

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8.0 Consideration of New Information on the Need for Power

The current rule governing environmental review at the operating license stage (10 CFR 51.95) states that, unless otherwise determined by the Commission, a final environmental statement (FES) supplement on the operation of a nuclear power plant will not include a discussion of need for power. For Watts Bar Nuclear (WBN) Unit 2, the Commission stated its expectation that the staff would take the requisite “hard look” at new information on the need for power, and authorized the NRC staff to supplement the FES if they concluded that there was new and significant information on the need for power (NRC 2010). The Commission indicated that new and significant information would be information that would likely alter the cost-benefit balance of issuing the operating license for Watts Bar Unit 2 (NRC 2010; 47 FR 12940). After taking the requisite hard look at new information, the NRC staff concludes that the new information on need for power is not new and significant information because it does not alter the cost-benefit balance of issuing the Watts Bar Unit 2 operating license. Below is a summary of the information the staff examined in taking its hard look at the issue.

The Nuclear Regulatory Commission’s (NRC’s) original 1978 FES Operating License (FES-OL) included a need-for-power assessment for WBN Units 1 and 2 (NRC 1978). The 1978 assessment was based on electric load estimates from 1978 and included load forecasts out to 1983. Since 1979, the Tennessee Valley Authority (TVA) has updated its analysis of its overall need for power. TVA annually undertakes a long-term capacity expansion planning effort focused on achieving a least-cost portfolio plan that identifies the long- and short-term actions (TVA 2008a). In addition, since the 1978 FES-OL TVA has produced two publically available long-term (i.e., 20 or more years) Integrated Resource Plans (IRPs). In December, 1995, TVA completed an IRP identifying and selecting long-range electricity generation strategies intended to meet the electricity needs of its customers with a forecast period extending from 1996 to 2020 (TVA 1995). On March 2, 2011, TVA issued its most recent IRP, with a forecast period extending from 2011 to 2029. On April 14, 2011, the TVA Board of Directors accepted the IRP and authorized the Chief Executive Officer to use its recommended planning direction as a guide in energy resource planning and selection. On July 6, 2011, TVA issued its Record of Decision stating that TVA will adopt the preferred alternative in its final environmental impact statement (EIS) for the IRP (76 FR 39470).

The purpose of this section is to document the NRC staff's consideration of the significance of new information related to the need for power in the TVA service area, including information related to current and projected electricity supply and demand within the time span proposed for operation of WBN Unit 2. This chapter presents the conclusion that the new information developed since publication of the FES-OL is not significant. The TVA service area has a need for baseload power to meet increased demand and to support the displacement of power from older, less economical, and less environmentally favorable generating capacity. The NRC staff also took a hard look at new information related to alternatives in Chapter 7 of this SFES. The Staff did not identify any significant information as there are no viable energy generation alternatives that would be clearly environmentally preferable to the operation of WBN Unit 2.

The following sections describe new information the Staff reviewed regarding the TVA's need for electric generating capacity. Section 8.1 reviews the current power system, including geographic considerations, and describes the regional characteristics. Section 8.2 provides a review of the demand for power, including an assessment of aspects that can affect the demand for power (e.g., energy efficiency and demand-side management [DSM], and econometric indicators). Section 8.3 discusses power supply, including a review of past, present, and future generating capacity in the TVA service area. Section 8.4 presents some conclusions regarding the need-for-power analysis.

8.1 Description of Power System

TVA provides service to an 80,000-mi^2 (207,200-km^2) region encompassing almost all the State of Tennessee and portions of the States of Kentucky, Mississippi, Alabama, Georgia, North Carolina, and Virginia (Figure 8-1). This is approximately the same size as the TVA service territory identified in the 1978 FES-OL (NRC 1978). The TVA service area includes the area mandated by the TVA Act, as amended, in 1959 and the area in which TVA has transmission capability, and is the region for which TVA demonstrated a need for power (TVA 2008a). TVA states that the purpose and need of its proposal to operate WBN Unit 2 is to meet the need for additional baseload capacity in the TVA service area and maximize the use of existing assets (TVA 2008b). TVA is proposing to operate a four-loop pressurized-water nuclear reactor (WBN Unit 2) (NRC 1995) that is wholly owned by TVA (TVA 2009). WBN Unit 2 would be operated on the WBN site in Rhea County, Tennessee, and would operate at 3,425 MW(t). The net electrical output would be 1,160 MW(e), and the gross electrical output would be 1,218 MW(e) for the rated core power (TVA 2009). Although TVA originally expected to complete Unit 2 by April 2012, it recently announced that completion is delayed until December 2015, and requested an extension of the construction permit to September 30, 2016 (TVA 2012).

In 2008, the population of the service territory was estimated to be 9 million (TVA 2010), while in 1978, the population was approximately 6.7 million (NRC 1978). TVA currently serves 155 municipal and cooperative customers as their sole wholesale supplier of electricity, and 58 directly served industries as retail customers. The total number of businesses and residential customers served in 2008 was 4,571,600. TVA supplies almost all electricity needs (99 percent) in Tennessee, 31 percent in Mississippi, 24 percent in Alabama, and 26 percent in Kentucky. TVA contributes 3 percent or less to meeting the electricity needs in the States of

Virginia, North Carolina, and Georgia (TVA 2010). The major load centers are the cities of Memphis, Nashville, Chattanooga, and Knoxville, Tennessee, and Huntsville, Alabama (TVA 2008a), while the load centers that were identified by TVA in 1978 included Paducah, Kentucky, and Columbia, Tennessee (NRC 1978).

TVA is not subject to the jurisdiction of the Federal Energy Regulatory Commission (FERC) under the Federal Power Act, but it is subject to certain limited aspects of FERC jurisdiction, including the provision of open access transmission service, interconnections, and compliance with FERC-approved reliability standards. In addition, TVA has voluntarily chosen to follow FERC rules and orders to the extent they remain consistent with meeting TVA obligations under the TVA Act (TVA 2008a).

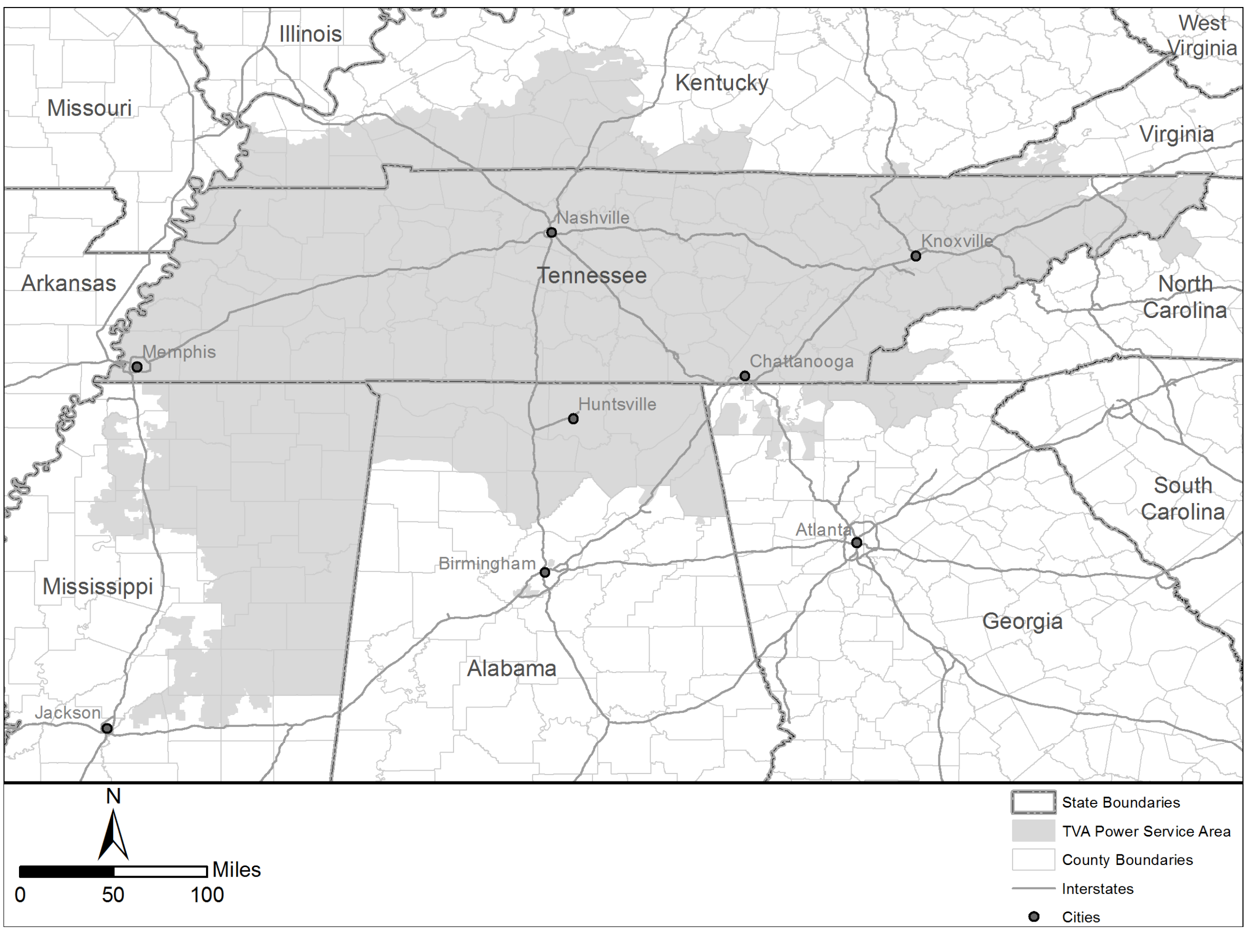

Figure 8-1. TVA Power Service Area

Figure 8-2 illustrates the electrical transfer capabilities between TVA and neighboring utilities. TVA has interconnection agreements with its neighboring systems, and these agreements typically provide for emergency backup power. The TVA service area composes one of five major geographical sub-regions of the Southeastern Electric Reliability Corporation (SERC) that are identified as Entergy, Gateway, Southern Company, TVA (also referred to as the Central sub-region), and the Virginia-Carolinas Area (see Figure 8-3). SERC, a regional reliability organization within the North American Electric Reliability Corporation (NERC), promotes, coordinates, and ensures the reliability and adequacy of the bulk power supply systems in the service areas of its member systems.

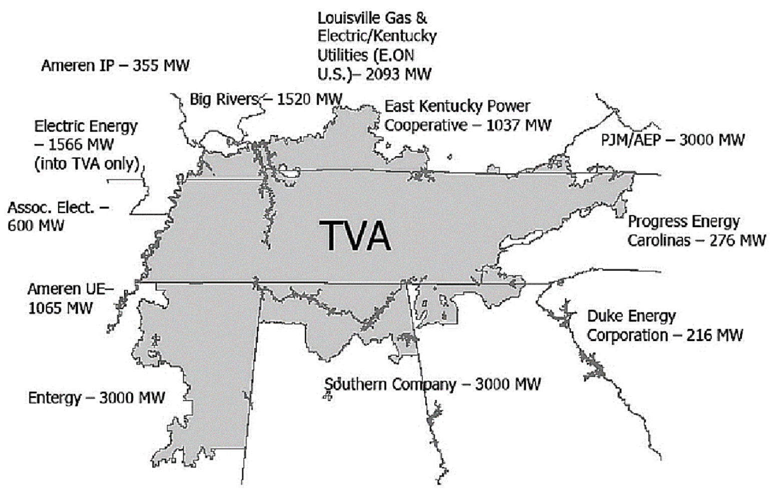

Figure 8-2. TVA Electrical Transfer Capabilities (TVA 2008a)

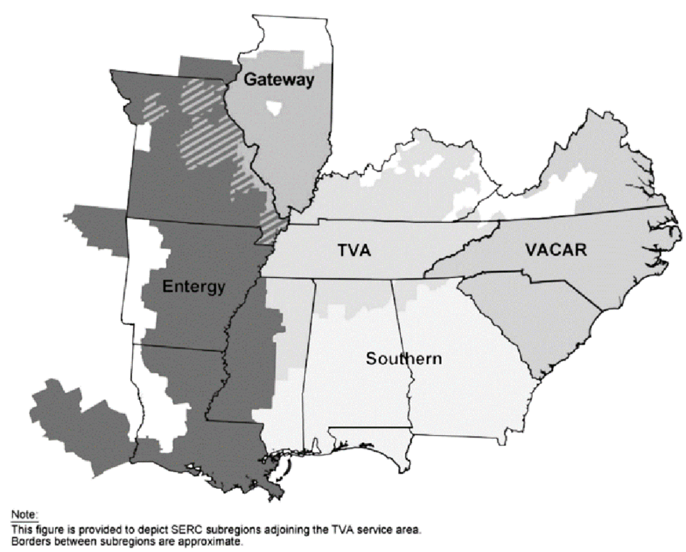

Figure 8-3. Major Geographical Sub-Regions of the Southeastern Electric Reliability Corporation (TVA 2008a)

Being a SERC member obligates TVA to exchange information on planning and operating its systems with other sub-regions to ensure continued reliability of the interconnected systems and facilitate periodic reviews of reliability-related activities within the SERC region. SERC's Reliability Review Subcommittee (RRS) conducts seasonal and annual reliability assessments of the SERC region by reviewing the data and studies submitted by SERC member systems and performing related tasks in the assessment of the reliability of the SERC region's interconnected bulk power system. The RRS also assesses future reliability and adequacy of the region based on the region's data collection efforts. In addition, the RRS independently assesses the ability of the region and sub-regions to serve their obligations, given the demand growth projections and overall capacity in the system (SERC 2008; TVA 2008a).

Although the Federal Power Act requires NERC to conduct annual reliability assessments to perform these analyses, NERC must rely on reports its component regional entities create. References to the "NERC Assessment" in this section should be interpreted as the SERC report within the NERC Assessment. NERC results are used to confirm the applicant's conclusions regarding the need for power in the TVA service area. NERC forecasts are subject to peer review and adhere to academic standards for the analysis and reporting of scientific information (NERC 2010).

8.2 Long-Term Capacity Expansion Planning and Power Demand

The 1992 National Energy Policy Act (EPACT) directs TVA to use a least-cost energy-planning process (also referred to as integrated resource planning) to add new energy resources to its power system, with congressional oversight. The EPACT also requires TVA to provide distributors of its power an opportunity to participate in the planning process. TVA continues to use least-cost energy planning today per EPACT requirements, carried out under congressional oversight. As part of the Federal oversight process, the U.S. General Accounting Office (GAO; now the Government Accountability Office) in 1995 reviewed the financial conditions of TVA, including its integrated planning load forecasting methodology. While GAO expressed concern about the financial condition of TVA, it concluded that the TVA forecasting methodology was "reasonable and state of the art when compared to other forecasting tools available in the electric utility industry" (GAO 1995). The NRC defers to independent integrated planning efforts implemented or overseen by regional, State, or other public authorities in analyzing the need for power. Although a state or regional utility regulatory commission does not regulate TVA, it is structured and self-regulated in a manner similar to a regulated utility monopoly, with Federally mandated least-cost planning requirements, congressional oversight, and a board of directors.

TVA annually undertakes a long-term capacity expansion planning effort focused on achieving a least-cost portfolio plan that identifies the long- and short-term actions (TVA 2008a). TVA anticipates additional baseload generation is necessary to meet the future demand for peak load and overall energy needs (TVA 2008b, 2011). The last NRC staff review of the TVA need for power from the WBN Unit 2 project occurred when NRC developed the FES-OL in 1978. The TVA forecast period ended in 1983.

8.2.1 Power Demand Forecasts

Today, the NRC staff finds that TVA systematically prepares near-term and long-term forecasts of demand and energy use applying methods tailored to the available data and customer requirements. TVA uses several quantitative models, including econometric and economic end-use models, to evaluate the relationship between major causal factors and the corresponding impacts on future electricity consumption. The variety of models used by TVA allows for comprehensive forecasting. TVA executives review and approve all outcomes and assumptions. Various forecasting outcomes also are subject to confirmation by external parties such as SERC's RRS. The load forecast represents a critical element of the process to establish SERC region capacity obligations. As a result, TVA and the SERC RRS scrutinize the load forecast to ensure it represents a reliable estimate of future peak loads and provides basis upon which to evaluate future capacity requirements (SERC 2008). The NRC staff further addresses the TVA forecast in Section 8.2.2.

Figure 8-4 illustrates the actual and forecasted net system demand requirements for the TVA service area through 2030. Historically, net system requirements grew at an average rate of 2.3 percent (1990 through 2008) before the 2009 economic downturn. TVA uses a medium-load forecast, which shows a 1.3 percent average annual growth from 2010 through 2030, to project future power needs. It also uses high and low forecasts to help make more informed power supply decisions. These high, medium, and low forecasts address the uncertainty associated with a future outside of normal expectations. The NRC staff examined these forecasts for purposes of determining whether there was new and significant information related to the need-for-power.

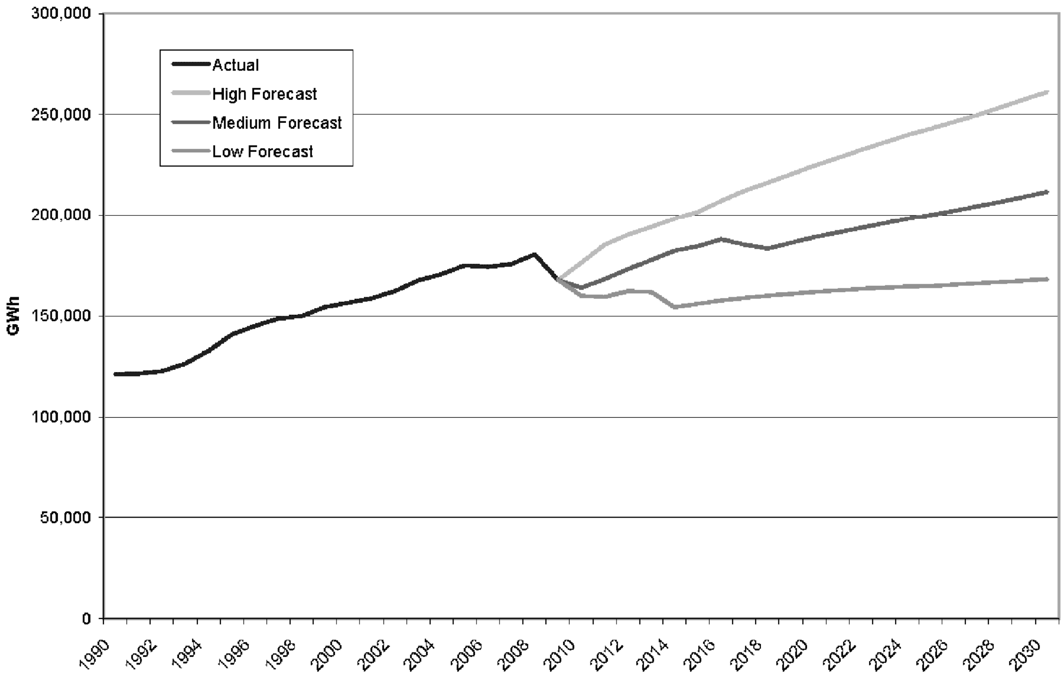

Figure 8-4. Actual and Forecast Net System Requirements (TVA 2010)

Figure 8-5 compares actual and forecasted net system requirements expressed in total annual energy in terms of gigawatt-hours (GWh). The annual forecast error for the TVA net system requirements has remained 1 percent over the 10-year time period from 1999 to 2008 (TVA 2008a, 2011). However, as shown in Figure 8-5, the sharp decline in energy usage in 2009, primarily due to the sudden regional economic downturn, presented an anomaly in energy trends not well characterized by previous forecasts. TVA expects future growth to be lower than historical averages for a number of reasons, including impacts of the 2008 to 2009 recession and subsequent recovery, declining U.S. manufacturing, and projected loss of some TVA customer load. TVA indicates that increased financial market regulation, tighter credit conditions, and large Federal budget deficits may all restrain growth to a level lower than previously predicted. All long-term planning forecasts consider the most current economic indicators (TVA 2010).

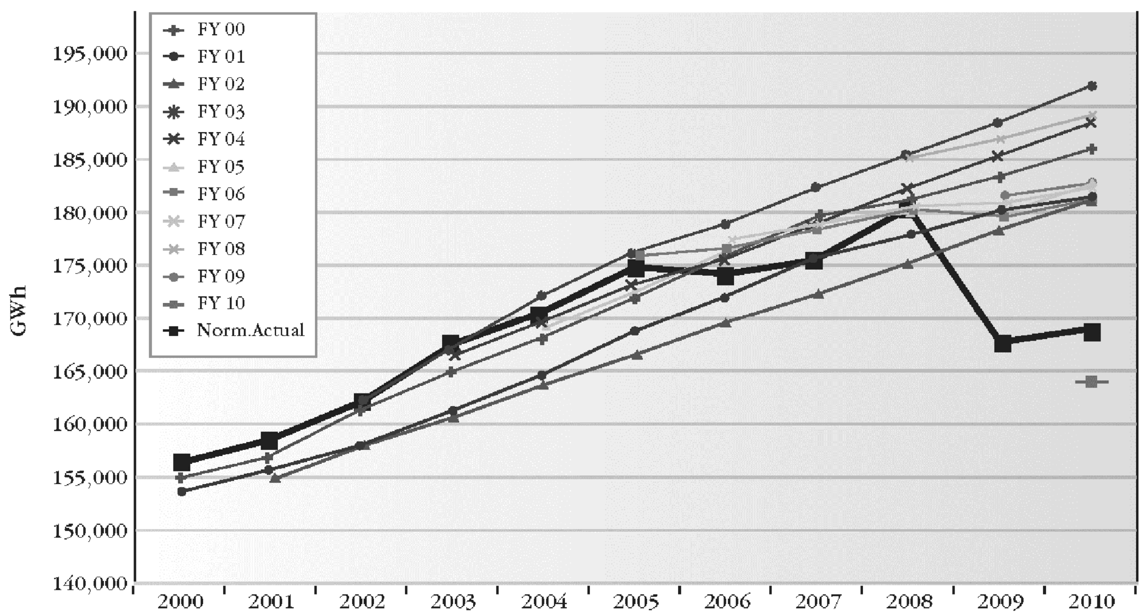

Figure 8-5. Comparison of Actual and Forecast Net System Requirements (TVA 2011)

8.2.2 Factors Affecting Demand

In general, economic and demographic trends, price and rate structure, energy efficiency and substitution, and DSM programs all affect demand. The following paragraphs provide the NRC's review of the TVA demand-forecast methodology and the NRC staff's findings based on this review.

TVA indicates that economic growth remains the single most important driver of electricity sales. TVA uses Gross Regional Product forecasts to estimate power demand forecasts. Population and demographic factors also represent key variables in forecasting energy demand. TVA develops energy forecasts for each economic sector (e.g., commercial, industrial, and residential) based on factors and trends relevant to each sector. Based, in part, on these forecasts, TVA develops annual near- and long-term forecasts. It bases near-term forecasts primarily on the number of customers, employment, and usage trends, adjusted for seasons and weather. TVA bases long-term forecasts primarily on the growth in the economy, price of electricity, price of natural gas as a competing fuel, and expected growth or decline in direct served customers (TVA 2008a, 2010). The NRC staff finds that TVA power demand forecasts are comprehensive because they incorporate key factors such as regional economic and demographic trends, price of electricity, energy efficiency and substitution effects, and weather. The NRC staff finds that the TVA approach to demand forecasting is systematic because it occurs on an annual basis and includes similar classes of information as inputs in each demand forecasting effort.

To quantify overall uncertainty in the load forecast, TVA indicates that it evaluates the potential uncertainty in future values of the input drivers (e.g., demographic variables) to the forecast model. To address the uncertainty inherent in single-point forecasts, TVA evaluates inputs such as inflation rates, electricity prices, and the price of fuel across probable ranges to develop high, medium, and low future scenarios (TVA 2010).

Electricity use varies inversely with the retail price of electricity. Prices and rate structure play a key role in determining energy demand. TVA uses its published rates (constant wholesale prices) for current prices and then forecasts future prices based on revenue requirements, including targeted net income and debt repayment. TVA simulated the impact of adding an additional generation unit on overall system demand using an iterative production cost model. TVA also used advanced analytical techniques, such as Monte Carlo simulation of select key random variables (e.g., load, fuel prices, weather) to assess the overall robustness of its long-term plans (TVA 2008a; PNNL 2009).

Natural gas competes with electricity for a number of end-uses in the residential, commercial, and manufacturing sectors. TVA incorporates substitution effects that occur when higher gas prices encourage more use of electrically powered equipment, and vice versa, into its energy demand forecasts. TVA uses Henry Hub[a] natural-gas price forecasts as input to the energy demand forecast to determine the natural-gas and electricity market shares for various end-uses (e.g., heating, cooling, water heating). TVA also factors in trends in household appliance usage and substitution to more efficient systems and appliances for heating, cooling, water heating, and other household uses (TVA 2008a).

DSM programs, which are essentially interventions in the market to promote adopting more efficient end-uses and changing consumer behavior, also can influence electricity demand. Programs that reduce customers' energy usage through energy efficiency, conservation, and load management can significantly affect demand and demand growth. TVA offers several conservation and DSM programs to its customers to reduce peak electricity demands and daily power consumption. The effects of these DSM programs are included in the forecast for net system requirements and summer peak load (PNNL 2009; TVA 2011).

The NRC staff finds that the TVA demand forecasts consider variations in multiple factors that contribute to forecasting uncertainty. TVA presents these forecasts as low-, medium-, and high-demand cases. As a result, the NRC staff finds that the TVA forecasts are both comprehensive and responsive to forecasting uncertainty.

SERC develops a supply forecast for the Central/TVA sub-region in terms of reserve requirements, measured by the margin of generation resources held in reserve for unexpected

(a) Henry Hub is the pricing point for natural gas futures contracts traded on the New York Mercantile Exchange.

outages of any kind. SERC does not implement a regional reserve requirement for the SERC Central sub-region, but the TVA desired total reserve margin is 15 percent, which aligns with established reserve margins in the utility industry (TVA 2011). This means that for every 100 kW of power needed to meet demand service area demand, TVA must be able to produce at least 115 kW of electricity at any time. This reserve margin allows TVA to address unexpected plant outages, take units offline for maintenance or repair, and to address higher-than-expected peak loads. SERC's RRS committee conducts seasonal and annual reliability assessments by reviewing the data and studies submitted by SERC member systems, which includes TVA (SERC 2008). In addition, the EPACT 1992 directs TVA to use a least-cost energy-planning process with congressional oversight, which included a comprehensive review of TVA methodology by the GAO (GAO 1995). Because TVA systematically submits comprehensive power demand forecasts and supporting data to regulatory authorities including SERC, NERC, GAO and U.S. Congress, the NRC staff finds that the TVA demand forecasts are subject to confirmation.

8.3 Power Supply

In developing the power supply or capacity forecasts for the TVA service area, TVA factors in its present and planned generating capabilities as well as present and planned purchases and sales of power and planned retirements. As noted in Section 8.2, the last forecast NRC staff reviewed in preparing the FES-OL included forecasts through 1983 (NRC 1978), which could not adequately address present and planned capabilities, purchases, or sales in the TVA system.

TVA, as directed by EPACT, uses a least-cost generation planning approach that includes a mix of baseload, intermediate, and peak load resources. Generating capacity comes from a combination of existing TVA-owned resources, budgeted and approved projects (such as new plant additions), and purchased power arrangements (PPAs). TVA includes monetary costs, risk assessments, and environmental impacts as part of its cost minimization assessment. Baseload generators are primarily used to meet TVA service area energy needs during most hours of the year due to their relatively lower operating costs and high availability (TVA 2011). TVA states that the purpose and need of its proposal to operate WBN Unit 2 is to meet the need for additional baseload capacity in the TVA service area (TVA 2008b). The TVA power generation system uses a range of technologies to produce electricity and meet the needs of the TVA service area. In 2010, coal-fired generation (which primarily serves baseload and intermediate duty cycles) made up approximately 40 percent of the TVA capacity electricity generation mix, while nuclear generation made up approximately 19 percent, combustion turbines and combined-cycle (primarily fueled with natural gas) generation together made up 24 percent, and hydro power provided 8 percent. The remaining 9 percent of the TVA electricity generation capacity was made up of diesel-fired generation, pumped storage, renewable energy sources, and DSM activities.

Current TVA forecasts already account for license renewal and power uprates for all operational TVA nuclear plants (TVA 2011). TVA also included in its capacity estimates potential generation from renewable energy sources (e.g., wind power). In addition, TVA assessed the generation potential of distributed- and self-generation (e.g., solar power). TVA currently operates a demonstration program, Green Power Switch Generation Partners, which pays participating consumers for energy generated by renewable resource technologies (e.g., solar photovoltaics). TVA continues to collect data from this program for its system capacity estimates (TVA 2008a, 2011).

TVA long-term capacity resources decline over time as a result of planned generation plant retirements, including idling approximately 2,400 MW to 4,700 MW of coal-fired electricity generation over the next 5 years (TVA 2011). The TVA strategic planning goal to reduce carbon generation sources to less than 50 percent of the electricity generation mix by 2020 influences the capacity retirement/expansion decisions (PNNL 2009). As the NRC staff noted in Chapter 7, TVA chooses which coal-fired plants to idle based on environmental compliance costs, economic operational and maintenance costs, outage rates, waste disposal costs, operational flexibility, and potential carbon dioxide emissions costs.

Although TVA belongs to a power pool with no standing arrangements for ongoing exchange of power or joint ownership of generating facilities, its current and future capacity forecasts consider purchased power potential (TVA 2010). Any location can generate power for purchase and transmit it to the TVA system. Purchased power can contribute to TVA regional capacity, provided it is technically and economically viable. TVA regularly reviews purchased supply options through its Bulk Power Trading Group, which currently holds several long-term purchase contracts to obtain firm capacity (TVA 2008a).

8.4 Need-for-Power Assessment and Conclusions

In the foregoing sections of this chapter, the NRC staff addressed the TVA processes for demand and supply forecasts. Both demand and supply forecasts are crucial to the NRC staff's consideration of need for power from WBN Unit 2.

The NRC staff notes that TVA assesses the need for power in its service area systematically and comprehensively on an annual basis, while occasionally documenting its long-term planning processes in an IRP. TVA provides documentation and results of its most recent long-term expansion planning process in its 2011 IRP, *Integrated Resource Plan: TVA's Environmental & Energy Future* (TVA 2011).

The NRC staff, in reviewing the new need-for-power assessment from TVA, found the following:

- TVA has a systematic iterative process for load forecasting that is updated annually. TVA maintains a forecasting department that develops annual load forecasts. The TVA internal review process includes an analysis and explanation of the historical predictive capability of the TVA load forecast for its service area. Figure 8-4 and Figure 8-5 illustrate the accuracy of the TVA energy and demand forecasts (1990–2009) (TVA 2011). GAO has reviewed the TVA process and determined that it uses power industry best practices and methodological approaches to determine its need for power. The NRC staff also finds that, as required by EPACT 1992, TVA continues to use least-cost energy planning with congressional oversight. The NRC staff finds that the TVA need-for-power assessment is systematic.

TVA power demand estimates and forecasts, as noted in this Section 8.2, incorporate key factors such as regional economic and demographic trends, price of electricity, energy efficiency and substitution effects, and weather. TVA generates different forecasts for each sector of the economy and develops separate forecasts to determine long-term and near-term demand. Power supply forecasts include a comprehensive evaluation of present and planned generating capabilities in the TVA service area, as well as present and planned power purchases and sales. TVA also considers the potential of DSM strategies and distributed generation in the analysis. TVA performed all analyses with forecasting and statistical modeling and methodological approaches appropriate for the utility industry. The NRC staff finds that power demand estimates and forecasts are, thus, comprehensive.

- The TVA forecasting department subjects its processes and models to peer review, as well as review and approval by the TVA Board of Directors. In addition, external parties, including SERC's RRS, confirm various outcomes of the TVA energy forecasts. The RRS conducts seasonal and annual reliability assessments of the SERC region by reviewing data and studies member systems submit (SERC 2008). The SERC's annual reliability review and NERC's annual long-term reliability assessment confirm the TVA forecast estimates and generation needs. The NRC staff finds that the TVA need-for-power assessment is subject to confirmation.

- As the NRC staff discussed earlier in this chapter, TVA quantifies uncertainty in the load forecast by evaluating uncertainty in the future values of the input drivers and evaluating uncertainty in relationships among input drivers. TVA evaluates the impact of alternative demand-forecast levels (high, medium, and low) on key variables to determine impacts on future electricity consumption. TVA develops forecasts under a range of scenarios, and analyzes and explains the historical predictive capability of its load forecast for its service area. TVA also uses advanced analytical techniques such as Monte Carlo simulation of select key random variables, including load, fuel prices, and weather to assess the overall robustness of its long-term plans (TVA 2011). The NRC staff finds that the TVA forecasts and estimates are responsive to forecasting uncertainty.

In reviewing the TVA need-for-power analysis, the NRC staff found that TVA determines need for power in its service area by comparing forecasted power capacity with forecasted demand. It factors planning and operating power reserve margins into these estimates. The desired total reserve margin of TVA is 15 percent. TVA considers need for capacity to be demonstrated when forecasted actual reserve margins are less than desired reserve margins. To determine baseload needs, TVA compares existing and planned resources to the average loads (peak and base) (TVA 2008a).

The NRC staff also looked to new non-TVA data in examining whether there was new and significant information related to the need–for-power. The NERC 2009 Long-Term Reliability Assessment reported a decline in the net winter capacity resource margins in the TVA region from 26 percent in 2010 to 17 percent over a 10-year period, considering only existing and planned[(a)] capacity. The report also showed a decline in net summer capacity resource margins from 25 percent in 2010 to 6 percent over a 10-year period, considering only existing and planned capacity. The report considers WBN Unit 2 a "planned" capacity addition and assumes plant operation to begin in 2012. Without WBN Unit 2 operation, the report estimates a decline in the winter reserve margin to approximately 18 percent in 2014. Without WBN Unit 2's added capacity, the NERC report projects the summer reserve margin to decline to approximately 12 percent in 2014 (NERC 2010), which is less than the TVA reserve margin goal. These numbers are based on demand and planned capacity (including retirements) forecasts in the TVA service area. SERC's evaluation confirms that WBN Unit 2 will address a need for power in the Central sub-region. Table 8-1 provides a comparison of the supply and demand forecast in the TVA service area based on maintaining the targeted 15 percent reserve margin.

Table 8-1. Comparison of the Supply and Demand Forecasts for Service Area (NERC 2010)

SERC Central Sub-Region Projections for 2014	MW
Final Electricity Demand for Service Area (winter)	45,662
Final Electricity Demand for Service Area (summer)	46,314
TVA Service Area Winter Capacity Without WBN Unit 2 (net of 15 percent reserve)	44,769
TVA Service Area Summer Capacity Without WBN Unit 2 (net of 15 percent reserve)	42,762
Expected Excess Winter Supply/Capacity (Demand) Assuming 15 percent Reserve Margin Maintained	(893)
Expected Excess Summer Supply (Demand) Assuming 15 percent Reserve Margin Maintained	(3,552)
Rated Capacity of the Proposed Project (Proposed Operation in 2013)	1,160
Net Excess Winter Supply (Demand) if Proposed Project Goes Online in 2013 and (assuming 15 percent reserve maintained)	267
Net Excess Summer Supply (Demand) if Proposed Project Goes Online in 2013 and (assuming 15 percent reserve maintained)	(2,392)

(a) Where "planned capacity" includes both capacity that is under construction and existing units that are to be retired and deactivated or reactivated during the specified year.

The results of the TVA need-for-power analysis suggest that additional baseload generation capacity from operating WBN Unit 2 could maintain reserve margins above 15 percent, which would allow TVA to meet the expected growing demand for electricity in its service area. TVA proposes to operate WBN Unit 2 with an expected baseload net electrical rating of 1,160 MW(e) (TVA 2008b). Under the medium-load forecast, TVA estimates the total capacity needs by 2012 will equal the capacity of WBN Unit 2. Under the low-load forecast, TVA estimates this capacity would not be needed until 2014 (TVA 2011). The current TVA timeline for WBN Unit 2 operation calls for a facility to complete construction by the end of 2015 (TVA 2012).

Based on NRC's independent review of the need-for-power analysis presented in the TVA ER (TVA 2008b), the TVA IRP (TVA 2011), the Final Supplemental Environmental Impact Statement for Bellefonte Unit 1 (TVA 2008a), discussions with TVA (PNNL 2009), and the foregoing analysis presented in this chapter, the NRC staff concludes that TVA provided a need-for-power determination with a process that is (1) systematic, (2) comprehensive, (3) subject to confirmation, and (4) responsive to forecasting uncertainty. The need-for-power assessment suggests that a need for baseload power exists in the TVA service area to meet increased demand and to support the displacement of power from older, less economical, and less environmentally favorable generating capacity (TVA 2011). After reviewing the new information developed since the FES-OL on need-for-power, the NRC staff concludes that the new information is not significant because it does not alter the cost-benefit balance of issuing the Watts Bar Unit 2 operating license. Chapter 7 of this SFES evaluates and discusses whether there is new and significant information regarding viable energy alternatives to the operation of WBN Unit 2. This evaluation did not identify any new and significant information related to alternatives as it did not reveal any viable alternatives that would be clearly environmentally preferable to the operation of WBN Unit 2.

8.5 References

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9.0 Unavoidable Adverse Environmental Impacts

This supplemental final environmental statement (SFES) provides the results of the U.S. Nuclear Regulatory Commission (NRC) staff's preliminary analyses, which consider and weigh the environmental effects of operating one new unit (Unit 2) at the Watts Bar Nuclear (WBN) plant in Rhea County, Tennessee.

This chapter summarizes (1) any adverse environmental impacts that cannot be avoided if the proposed action were implemented, (2) the relationship between local short-term uses of the environment and maintaining and enhancing long-term productivity, (3) any irreversible and irretrievable commitments of resources involved if the proposed action were implemented, (4) the environmental impacts of alternatives to the proposed action, (5) the benefits and costs of the proposed action, and (6) the NRC staff's recommendation regarding the proposed action based on its environmental review.

9.1 Unavoidable Adverse Environmental Impacts During Operation

The NRC's regulations in Title 10 of the Code of Federal Regulations (CFR) Part 51 implement Section 102(2)(C)(ii) of the National Environmental Policy Act of 1969, as amended (NEPA), which requires an environmental impact statement (EIS) include a discussion about any adverse environmental effects that cannot be avoided if the proposed action is implemented. Under NEPA, unavoidable adverse environmental impacts at WBN Unit 2 would be those potential impacts of operation for which no practical means of mitigation are available. Construction of WBN Unit 2 was initiated in the 1970s under a construction permit that was issued through a regulatory action that is separate from the currently proposed operating license.

In 1972, Section 3.0 of the Tennessee Valley Authority (TVA) Final Environmental Statement, Watts Bar Nuclear Plant Units 1 and 2 (FES) discussed the following adverse environmental effects that could not be avoided: (1) water pollution, (2) air pollution, (3) impact on land use, (4) damage to life systems, and (5) threats to health (TVA 1972). TVA's FES discussed both construction and operation of Watts Bar and methods to mitigate the impacts (TVA 1972). Six years later, when evaluating the operating license request, the NRC staff did not identify any additional adverse effects that would be caused by operation of Unit 2 (NRC 1978). During consideration of the operating license in 1995, the NRC staff once again did not identify any additional adverse environmental effects that would be caused by operation of WBN Unit 2 (NRC 1995).

In the present review, the NRC staff sought additional information developed on unavoidable adverse environmental effects, and Chapter 4 provides a detailed discussion of the potential impacts from operating WBN Unit 2. In terms of the five unavoidable adverse environmental impacts identified by TVA (TVA 1972), the NRC staff makes the following conclusions based on review of additional information.

Regarding water quality, assessments in Chapter 4 indicate that unavoidable adverse environmental impacts due to operation would be small. Consumption of surface water from the Tennessee River would increase with the operation of WBN Unit 2 due to increased evaporation in the cooling towers, but the rate of consumptive water loss would be small compared to the flow of the Tennessee River. Discharge of chemicals and heat due to operation would continue to meet the requirements of the National Pollutant Discharge Elimination System (NPDES) permit, so that the impact on surface-water quality would be minimal. Potential physical impacts of the discharge would be mitigated by a diffuser system and by a concrete incline at the supplemental condenser cooling water discharge, and the physical effects of the discharge on surface-water quality would also be small. Changes in groundwater withdrawal and groundwater quality due to operation of WBN Unit 2 would also be small.

Air pollution is primarily a consideration during construction, and changes in air quality due to operation would be minimal. Regarding land use, operation of the plant would not change present land use on the site or in transmission corridors from that prior to operation, so operation would not result in additional unavoidable adverse environmental impacts.

Chapter 4 speaks to “damage to life systems” in terms of impacts on terrestrial and aquatic natural resources. The unavoidable impacts of operating WBN Unit 2 on terrestrial resources, including Federally and State-listed species, would be small. Some loss of surface water through evaporation is unavoidable, but the the total withdrawal and the consumptive withdrawal would have a very minor impact, if any, on the aquatic biota in Watts Bar Reservoir, Chickamauga Reservoir, and downstream. Although some entrainment and impingement of fish is unavoidable, after an extensive review including new information, NRC staff found that the adverse effects of entrainment and impingement would be minor and would not destabilize or noticeably alter the aquatic biota of the Chickamauga Reservoir. Mitigation measures and the requirements of the NPDES permits would minimize the physical and thermal effects of the heated discharge on aquatic resources.

Regarding threats to human health, NRC staff concluded in Chapter 4 that the information provided by TVA and the NRC’s own independent evaluation indicated no observable health impacts on the public would result from normal operation of Unit 2 and the health impacts would be negligible. The NRC staff concludes that unavoidable adverse environmental impacts for all resource areas are of SMALL significance.

9.2 Relationship Between Short-Term Uses and Long-Term Productivity of the Human Environment

The Commission, in implementing Section 102(2) of NEPA through 10 CFR Part 51, requires an EIS to include a discussion of the relationship between short-term uses of the environment and the maintenance and enhancement of long-term productivity. The NRC staff evaluated the relationship between local, short-term uses of the environment and the maintenance and enhancement of long-term productivity of WBN Unit 2. Most of the short-term uses of the site will result in no significant effect on the long-term productivity of the land, and the operation of WBN Unit 2 will not result in any significant long-term environmental degradation. All effluents discharged to the air, water, and land will be within levels allowed by permits so they are considered acceptable by regulatory agencies for short-term uses of the environment. Environmental monitoring programs discussed in Chapter 5 provide a means for detecting and evaluating concentrations of monitored parameters that, if out of permitted ranges could lead to long-term effects, so that timely corrective action could be taken if required.

In the NRC staff's 1978 FES, the staff reevaluated the assessment performed in consideration of the final environmental statement related to the construction permit for WBN Units 1 and 2 (FES-CP) and concluded that presence of this plant in Rhea County, Tennessee, would continue to influence the future use of other land in its immediate environs as well as the continued removal of county land from agricultural use as the result of any increased industrialization. Subsequently, in 1995, the NRC staff determined there were no changes to this conclusion.

The local use of the human environment by the operation of WBN Unit 2 can be summarized in terms of the unavoidable adverse environmental impacts of operation of the unit and the irreversible and irretrievable commitments of resources. With the exception of the consumption of depletable resources as a result of operation, these uses may be classed as short term. The principal short-term benefit of the plant is represented by the production of electrical energy. The site is already used for power generation through the operation of WBN Unit 1. WBN Unit 2 structures already occupy the land, effectively precluding the land from other productive uses. Initiating operation of Unit 2 and is a more productive use of the facility than not starting the unit.

The maximum long-term impact on productivity would result if the plant is not immediately dismantled at the end of the period of plant operation, and, consequently, the land occupied by the plant structures would not be available for any other use. In addition, most long-term impacts resulting from land-use preemption by plant structures can be eliminated by removing these structures or by converting them to other productive uses. Once the units are shutdown the plant would be decommissioned according to NRC regulations. Once decommissioning is complete and the NRC license is terminated, the land would be available for other uses.

9.3 Irreversible and Irretrievable Commitments of Resources

The NRC's rules in 10 CFR Part 51 implementing Section 102(2)(C) of NEPA require an EIS to include a discussion of any irreversible or irretrievable commitments of resources that would be involved in the alternative if it is implemented.

In 1972, the FES-CP discussed the extent to which operation of the facility curtails the range of beneficial uses of the environment. The FES-CP presumed that the site on the Watts Bar Reservation will continue to be dedicated to power production for the foreseeable future. The FES-CP noted the construction and operation of the WBN plant would involve the use of a certain amount of air, water, and land. Furthermore, except for the plant site itself, the range of beneficial uses of the environment would not be curtailed. The FES-CP discussed the use of fuel oil, industrial chemicals, and nuclear fuel consumption as examples of irreversible and irretrievable uses of resources. It presumed that land and construction materials were irreversibly and irretrievably committed for the foreseeable future. The FES-CP concluded that the commitments were small when evaluated against the production of electricity from the plant.

The NRC staff reevaluated the commitment of resources in its 1978 Final Environmental Statement related to the operating license for WBN Units 1 and 2 (1978 FES-OL) and concluded no changes have occurred since then, except for the continuing escalation of costs, which have increased the dollar values of materials used for fueling the station (NRC 1978).

As discussed in the 1978 FES-OL and the 1995 supplemental FES (NRC 1995), uranium is the principal natural resource irretrievably committed by operating the WBN facility (NRC 1978). Other materials consumed, for practical purposes, include fuel-cladding materials, reactor control elements, other replaceable reactor core components, chemicals used in water treatment, ion-exchange resins, and minor quantities of materials used in maintenance and operation. The resource commitment for WBN Unit 2 is not particularly large when compared to the consumption of these resources worldwide. Approximately 0.9 m^3/s (32 cfs) of cooling water from the Tennessee River would be lost through consumptive use (i.e., evaporation) through operation of WBN Unit 2. In addition, some aquatic biota would be lost through entrainment or impingement; however, the losses would not destabilize populations.

During operations, vehicle exhaust emissions would continue in the vicinity of the plant and the facility would release other air pollutants and chemicals, including very low concentrations of radioactive gases and particulates, into the air and surface water. Because these releases would conform to applicable Federal and State regulations, their impact on the public health and the environment would be limited. The resources associated with WBN Unit 2 and associated plant structures are already committed through the construction of the facilities. The additional resources required to operate the plant are small in comparison.

9.4 Environmental Impacts of Alternatives

The NRC staff characterized the environmental impacts of constructing and operating a natural-gas-fired power plant alternative and a combination of power-generation alternatives. Both alternatives would have an impact on air quality. There would also be construction impacts to terrestrial resources and socioeconomic impacts. Based on this information, neither of the viable energy alternatives would be preferable to the operation of WBN Unit 2.

9.5 Benefit-Cost Balance

NEPA requires that all agencies of the Federal government prepare detailed environmental statements on proposed major Federal actions significantly affecting the quality of the human environment. One of NEPA's principal objectives is to require each Federal agency to consider, in its decision-making process, the environmental impacts of each proposed major action. In particular, as stated below, Section 102 of NEPA requires all Federal agencies to the fullest extent possible to

> (B) identify and develop methods and procedures, in consultation with the Council on Environmental Quality established by Title II of this Act, which will insure that presently unquantified environmental amenities and values may be given appropriate consideration in decision making along with economic and technical considerations (42 USC 4321).

However, neither NEPA nor CEQ requires the benefits and costs of a proposed action to be quantified in dollars or any other common metric. NUREG-1555 (NRC 2000), Section 10.4.2 recommends the NRC staff "…express all internal costs, either provided by the applicant or estimated by the NRC staff, in monetary terms."

The intent of this section is not to identify and quantify all potential societal benefits of the proposed action and compare them to potential costs. Rather, it focuses only on those benefits and costs of such magnitude or importance that including them in this analysis can inform the decision-making process. This section compiles and compares the pertinent analytical conclusions reached in earlier chapters of this SFES. It gathers the expected impacts from operations of the proposed Unit 2 and aggregates them into two final categories: (1) the expected costs and (2) the expected benefits derived from approving the proposed action.

General issues related to the financial viability of TVA are outside of NRC's mission and authority and, thus, this SFES will not consider them. The NRC will address issues related to the applicant's financial qualifications in the NRC staff's safety evaluation report. It is not possible to quantify and assign a value to all benefits and costs associated with the proposed action. However, this analysis attempts to identify, quantify, and provide monetary values for benefits and costs when reasonable estimates are available.

Section 9.5.1 discusses the benefits associated with the proposed action. Section 9.5.2 discusses the costs associated with the proposed action. Table 9-1 summarizes the benefits and costs of the proposed action. Internal costs include annual costs of operating and maintaining WBN Unit 2. Section 9.5.3 summarizes the impact assessments and brings previous sections together to establish a general impression of the relative magnitude of the proposed project's costs and benefits.

Table 9-1. Summary of Benefits, Costs, and Impact Assessment of the Proposed Action

Benefit-Cost Category	Description	Impact Assessment[(a)]
Benefits		
Electricity generated	9,145,440 MWh per year for the 40-year life of the plant (assuming 90% capacity factor).	---
Generating capacity	1,160 MW(e).	---
Fuel diversity	WBN Unit 2 would increase the TVA nuclear fleet. The TVA generation mix is heavily coal-fired.	---
Progress toward TVA environmental stewardship goals	Avoidance of sulfur dioxide, nitrogen oxide, carbon monoxide, carbon dioxide, and particulate emissions typical for other alternative fossil-fuel burning baseload power, as nuclear generation has neglible air quality impacts.	---
Long-term price stability	Historically, the price of nuclear power generation has been relatively stable.	---
Tax revenues	Tax-equivalent "impact payment" distributions from TVA to the counties of Rhea, Meigs, McMinn, Roane, and Monroe during construction period and 3 years after construction is complete. Rhea County property tax revenues would also increase over the 40-year life of the units (see Sections 2.4 and 4.4.2).	---
Local economy	Increased jobs would benefit the area economically and increase economic diversity of region (see Sections 2.4 and 4.4.2).	---
Costs		
Internal Costs[(b)]		
Annual fixed operation and maintenance (O&M) costs	Estimated based on cost of staffing, materials, insurance, fees, and O&M projects (TVA 2010).	$49.1 million per year
Variable O&M costs	Scheduled maintenance outage costs[(c)] (TVA 2010).	$18 million per year

Table 9-1. (contd)

Benefit-Cost Category	Description	Impact Assessment[a]
Fuel expenses	TVA has allocated $126 million for WBN initial core fueling (TVA 2010). Recent fuel costs on average (throughout the United States) are approximately 0.7 cents per kWh (WNA 2010; MIT 2009).	0.7 cents per kWh
Spent fuel management	Estimated, on average, throughout U.S. industry as 0.1 cent per kWh.[d]	0.1 cents per kWh
Decommissioning	TVA estimates annual decommissioning expenses (in 2008 dollars) of $5.45 million based on average net megawatts expected for WBN Unit 2 (TVA 2010).	$5.45 million annually
Tax payments	In-lieu taxes paid by TVA to State of Tennessee based on power sales and book value of property.	---
Land use	TVA will acquire no additional land as part of this proposal.	$0
<u>External Costs</u>		
Land use	Negligible impacts on previously disturbed land (Sections 2.1 and 4.1).	SMALL
Air quality	Negligible air quality impacts (see Sections 2.8 and 4.8).	SMALL
Terrestrial ecology	Terrestrial ecology impacts expected to be small (see Sections 2.3.1 and 4.3.1).	SMALL
Aquatic ecology	Aquatic ecology impacts expected to be small (see Sections 2.3.2 and 4.3.2).	SMALL
Hydrology	Hydrological impacts expected to be small (Sections 2.2.2 and 4.2).	SMALL
Socioeconomic	Potential short-term strains on local schools, but the overall impact is expected to be minor (see Sections 2.4.2 and 4.4).	SMALL
Cultural resources	Negligible impacts on historical and cultural resources (see Sections 2.5 and 4.5).	SMALL

(a) Impact assessments are listed, for all impacts evaluated in detail, as part of this SFES. The details on impact assessments are found, in the indicated sections of this SFES.
(b) Internal costs are costs incurred by TVA to implement proposed operation and maintenance of WBN Unit 2. All internal costs are listed in 2008 dollars. Note that no impact assessments are provided for these private financial impacts.
(c) Based on an estimated $27 million expense per outage, where scheduled maintenance outages occur approximately every 18 months.
(d) A 0.1-cent/kWh levy funds the United States used fuel program (WNA 2010).

9.5.1 Benefits

The most apparent benefit from operating a power plant is generating power that provides electricity to thousands of residential, commercial, and industrial consumers in almost all of Tennessee and portions of Kentucky, Mississippi, Alabama, Georgia, North Carolina, and Virginia. For the electricity to benefit the region, however, the region of interest must have a demonstrated need for baseload power.

The TVA load forecast indicates a need for additional baseload power in the region of interest by the years 2012–2013. The proposed WBN Unit 2 would generate approximately 1,160 MW(e) net, which would meet a portion of the baseload needs in the TVA service area. Chapter 8 of this SFES discusses the need for power in the TVA service area. Assuming a capacity factor of 90 percent, the plant's average annual electrical energy generation would be more than 9,145,440 MWh.

9.5.1.1 Societal Benefits

From a societal perspective, nuclear power offers three primary benefits relative to most other power generating systems: long-term price stability, fuel diversity, and avoidance of greenhouse gas emissions (relative to fossil-based power generation).

Nuclear power has relatively low and nonvolatile fuel costs. Historically, the price of nuclear generation has been relatively stable as well. Uranium fuel constitutes only 3 percent to 5 percent of the cost of a kilowatt-hour of nuclear-generated electricity (WNA 2010). In 2010, coal-fired generation made up approximately 40 percent of the TVA capacity electricity generation mix, while nuclear generation made up approximately 19 percent, combustion turbines and combined-cycle (primarily fueled with natural gas) generation together made up 24 percent, and hydro power provided 8 percent. The remaining 9 percent of the electricity generation capacity of TVA was made up of diesel-fired generation, pumped storage, renewable energy sources, and demand-side management activities. The operation of WBN Unit 2 along with the recent idling of three coal power plants would modestly increase the percent of nuclear power generation in the fleet while modestly decreasing the coal-fired (TVA 2011). Unlike electricity generated from coal and natural gas, operating a nuclear power plant does not result in large emissions of air pollutants associated with climate change (e.g., nitrogen oxides, sulfur dioxide, carbon dioxide) or methyl mercury.

9.5.1.2 Regional Benefits

The tax-equivalent payments TVA makes to the State of Tennessee related to existence and operation of WBN Unit on the WBN site are redistributed to contribute property tax revenues to Rhea County and other neighboring counties in the vicinity of WBN Unit 2 (see Section 4.4.2). TVA expects that operating WBN Unit 2 would increase its tax-equivalency payments distributed to Rhea County. Operations workers' retail expenditures (e.g., restaurants, hotels, merchant sales) would generate sales, use, and income taxes for the county. Although a small local sales and use tax exists, the State would collect most of this, both from individual workers and corporate entities in the general region of the site. No estimate of day-to-day expenditures in the region during Unit 2 operations currently exists.

Operating WBN Unit 2 would require an operational workforce of about 200 people (see Section 4.4.2 of this SFES) and would generate additional income and value for the State of Tennessee and local economies for a period of at least 40 years. The economic multiplier effect of increased spending by the direct and indirect workforce created as a result of one new unit would increase the economic activity in the region, most noticeably in Rhea County. Section 4.4.2 provides additional information about the economic impacts of operating WBN Unit 2. Table 9-1 summarizes benefits.

9.5.2 Costs

Nuclear power plants are expensive to construct relative to other power generation sources, but have lower fuel costs relative to fossil-fired generation. TVA had completed about 80 percent of WBN Unit 2 when construction work halted in 1985. In 2007, TVA resumed construction of WBN Unit 2 with the aim of completing construction by 2012 and operating the plant by 2013 (TVA 2008). Although TVA used components from WBN Unit 2 between 1985 and 2007 to replace portions of Unit 1 and other TVA facilities, substantial construction costs and environmental impacts were associated with constructing WBN Unit 2. Sunk costs are not relevant to the question of whether the plant should operate. The relevant economic decision variables NRC considered for this SFES are costs for O&M fuel, waste disposals, and decommissioning, because these expenses could be potentially avoided if the NRC did not grant TVA an operating license for WBN Unit 2. The costs of construction were addressed in NRC's final environmental statement for the construction of WBN Units 1 and 2 (1978 FES-CP) (NRC 1978).

TVA would incur internal costs and external costs to the surrounding region and environment during operation of WBN Unit 2.

9.5.2.1 Internal Costs

Internal costs include O&M costs, fuel costs, waste disposal costs, and the cost of decommissioning the facility at the end of its operating life.

Operating and Maintenance Costs

TVA provided annual fixed and variable O&M costs associated with the operation of WBN Unit 2, which are included in Table 9-1. Fixed O&M costs include the cost of staffing, materials, insurance, fees, and other miscellaneous maintenance and contract services. Variable O&M costs include the cost of performing scheduled refueling and maintenance outages, which occur approximately every 18 months. Operating costs would also include the cost of nuclear fuel. TVA has estimated a fuel cost of approximately $126 million for the initial core fueling of WBN Unit 2 (TVA 2010).

Studies from 2003 through 2005 have estimated that the levelized cost (i.e., price per kilowatt-hour of producing electricity, including the cost of capital) to operate a new-generation nuclear plant would be in the range of $36 to $65 per MWh (3.8 to 6.5 cents per kWh) (University of Chicago 2004; MIT 2003; DOE 2004; OECD/IEA 2005). The Massachusetts Institute of Technology (MIT) updated its results in 2009 (MIT 2009) estimating the levelized cost of electricity at 8.4 cents per kWh (in 2007 dollars). Factors affecting the range include choices for discount rate, construction duration, plant life span, capacity factor, cost of debt and equity, and split between debt and equity financing, depreciation time, tax rates, and premium for uncertainty. Levelized operation cost estimates include decommissioning costs; however, because of the effect of discounting a cost that would occur as much as 40 years in the future, decommissioning costs have relatively little effect on the levelized cost. Because the construction of WBN Unit 2 has taken place over the past 30 years, TVA has not calculated a levelized cost analogous to those presented in the previously mentioned studies; however, TVA has estimated its annual ongoing cost of capital (financing of debt) for WBN Unit 2 during operation to be $15.3 million (2008 dollars), based on $13 million per 1,000 MW(e) capacity (TVA 2010). Table 9-1 presents O&M costs associated with operating WBN Unit 2.

Fuel Costs

The calculation of levelized cost includes the cost of fuel. Nuclear fuel costs have increased in recent years, from about 0.48 cents per kWh in 2002 to 0.69 cents per kWh in 2007. The most recent MIT (2009) report on nuclear operation costs indicates that the cost of nuclear fuel in 2007 was, on average, 0.69 cents per kWh. The MIT estimate corresponds with World Nuclear Association (WNA) estimates of 0.71 cents per kWh based on January 2010 spot prices for uranium (WNA 2010).

Waste Disposal

Waste disposal costs of nuclear power contribute a small share of total cost of operating a nuclear plant because of the long lifetime of a nuclear reactor and because provisions for waste-related costs can be accumulated over that time. Radioactive nuclear waste poses unique disposal challenges for long-term management, however. The WNA and U.S. Department of Energy estimate spent fuel management costs to be 0.1 cents per kWh (WNA 2010).

Decommissioning

The NRC requires licensees to provide reasonable assurance that funds would be available for the decommissioning process (10 CFR 50.75). Because of the effect of discounting a cost that would occur as much as 40 years in the future, decommissioning costs have relatively little effect on the levelized cost of electricity generated by a nuclear power plant. The WNA estimates decommissioning costs to be about 9 to 15 percent of the initial capital cost of a nuclear power plant. However, when discounted, decommissioning costs contribute only a few percent to the investment cost and even less to the generation cost. In the United States, they account for 0.1 to 0.2 cents per kWh, which is no more than 5 percent of the cost of the electricity produced (WNA 2010). TVA has estimated its annual decommissioning expenses related to the operation of WBN Unit 2 to be approximately $5.5 million (2008 dollars) annually (TVA 2010).

9.5.2.2 External Costs

External costs are those social and/or environmental effects resulting from operating Unit 2 at the WBN site and could include such things as the loss of regional productivity, environmental degradation, or the loss of habitat for wildlife. This SFES includes the NRC staff's analysis that considers and weighs the environmental impacts of operating WBN Unit 2 and mitigation measures available for reducing or avoiding these adverse impacts.

Although available information does not exist to assign monetary values to the impacts of operating WBN Unit 2, Chapter 4 identifies and analyzes these impacts and assigns a significance level of potential adverse impacts (i.e., SMALL, MODERATE, or LARGE). Chapter 4 also addresses the environmental impacts from the (1) uranium fuel cycle and solid waste management, (2) transportation of radioactive material, and (3) decommissioning of WBN Unit 2. Table 9-1 summarizes projected internal and external costs for WBN Unit 2. Unlike electricity generated from coal and natural gas, operating a nuclear power plant does not result in large emissions of air pollutants associated with climate change (e.g., nitrogen oxides, sulfur dioxide, carbon dioxide) or methyl mercury; however, the radioactive nuclear waste associated with nuclear power generation poses a unique disposal challenge for long-term management. Chapter 7 of this SFES provides a comparison of the environmental impacts of various power generation alternatives.

9.5.3 Summary

As discussed in Chapter 8, the need-for-power assessment suggests that a need for baseload power exists in the TVA service area to meet increased demand and to support the displacement of power from older, less economical, and less environmentally favorable generating capacity (TVA 2011). WBN Unit 2 would help meet the increasing baseload demand in the region by supplying an average annual electrical energy generation capacity of about

9,000,000 MWh. Table 9-1 summarizes both internal and external costs of operating WBN Unit 2 and the identified benefits. The table references other sections of this SFES when more detailed analyses and impact assessments are available for specific topics.

Although the NRC staff cannot reasonably assign any specific monetary values to the identified societal benefits, it would appear that the potential societal benefits of operating WBN Unit 2, in addition the power generated, would include reducing the coal-fired dependence of the TVA power-generation fleet and, thus, furthering the environmental stewardship goals of TVA to reduce greenhouse gas emissions in its service area (TVA 2011). Local benefits would include the addition of jobs and tax revenues in the region. In comparison, the external costs imposed on the region are relatively minor.

9.6 Conclusions and Recommendations

This SFES contains the environmental review of the TVA application for an operating license for WBN Unit 2 as required by 10 CFR Part 51 and NRC regulations that implement the NEPA. This section presents conclusions and recommendations from the environmental review and summarizes environmental impacts from operation of WBN Unit 2 identified during the review.

The NRC staff's evaluations are based on (1) the application, including the environmental report (TVA 2008), previous EISs, and historical documents submitted by TVA; (2) consultation with Federal, State, Tribal, and local agencies; (3) the NRC staff's independent review; and (4) the NRC staff's consideration of comments related to the environmental review received during the public scoping process and on the draft SFES. The NRC staff based its conclusions on changes in the environment, plant design, and proposed methods of plant operation since the publication of the 1978 FES-OL.

The NRC staff concludes that impacts from operation of WBN Unit 2 associated with water use, aquatic ecology, terrestrial resources, design basis accidents, socioeconomics, the radiological exposure and nonradiological wastes and effluents, decommissioning, air quality, and land use are generally consistent with those reached in the 1978 FES-OL and the 1995 supplement to the final environmental statement related to the operation of WBN Units 1 and 2 (NRC 1995). In some cases, the impacts are less than those identified in the 1978 FES-OL.

Groundwater quality, public services, noise, transportation infrastructure, historic and cultural resources, environmental justice, greenhouse gas emissions, severe accidents, severe accident mitigation alternatives, and cumulative impacts were not addressed in the1978 FES-OL but are addressed in this SFES. NRC staff concludes impacts associated with operation of WBN Unit 2 on groundwater quality, public services, noise, transportation infrastructure, cultural and historical resources, greenhouse gas emissions, and severe accidents would be SMALL. In addition, staff concludes that operation of the WBN Unit 2 would not result in a disproportionately high and adverse human health or environmental effect to any of the minority and low-income communities near the WBN site.

Staff also considered cumulative impacts from past, present, and reasonably foreseeable future actions. The NRC staff concludes that although the cumulative impact for aquatic ecology is LARGE, the incremental impact from operation of WBN Unit 2 would be, in all cases, minor and not noticeable in comparison.

The NRC staff's recommendation to the Commission related to the environmental aspects of the proposed action is that the environmental impacts are not great enough to deny the option of issuing the operating license for WBN Unit 2.

9.7 References

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NRC FORM 335 (12-2010) NRCMD 3.7 — U.S. NUCLEAR REGULATORY COMMISSION **BIBLIOGRAPHIC DATA SHEET** *(See instructions on the reverse)*	1. REPORT NUMBER (Assigned by NRC, Add Vol., Supp., Rev., and Addendum Numbers, if any.) NUREG-0498 Supplement No. 2 Vol. 1
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Docket No. 50-391

11. ABSTRACT (200 words or less)

The U.S. Nuclear Regulatory Commission (NRC) prepared this supplemental final environmental statement related to the operating license in response to its review of the Tennessee Valley Authority's (TVA's) application for a facility operating license submitted on March 4, 2009. The proposed action requested is for the NRC to is sue an operating license for a second light-water nuclear reactor at the Watts Bar Nuclear (WBN) Plant in Rhea County, TN.

The NRC staff evaluated a full scope of environmental topics, including land and water use, air quality and meteorology, terrestrial and aquatic ecology, radiological and nonradiological impacts on humans and the environment, historic and cultural resources, socioeconomics, alternatives, and environmental justice. The alternatives considered were natural gas-fired power generation, and a combination of energy alternatives.

The staffs evaluations are based on (1) the application submitted by TVA, including the environmental report and previous environmental impact statements and historical documents, (2) consultation with other Federal, State, Tribal, and local agencies, (3) the staff's independent review, and (4) the staff's consideration of comments related to the environmental review received during the public scopinq process and received during the public comment period for the draft document.

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