U.S.NRC

United States Nuclear Regulatory Commission

Protecting People and the Environment

NUREG-0498
Supplement 2

Draft Final Environmental Statement

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

Supplement 2

Docket Number 50-391

Tennessee Valley Authority

Draft Report for Comment

Office of Nuclear Reactor Regulation

AVAILABILITY OF REFERENCE MATERIALS IN NRC PUBLICATIONS

NRC Reference Material

As of November 1999, you may electronically access NUREG-series publications and other NRC records at NRC's Public Electronic Reading Room at http://www.nrc.gov/reading-rm.html. Publicly released records include, to name a few, NUREG-series publications; *Federal Register* notices; applicant, licensee, and vendor documents and correspondence; NRC correspondence and internal memoranda; bulletins and information notices; inspection and investigative reports; licensee event reports; and Commission papers and their attachments.

NRC publications in the NUREG series, NRC regulations, and *Title 10, Energy*, in the Code of *Federal Regulations* may also be purchased from one of these two sources.

1. The Superintendent of Documents
   U.S. Government Printing Office
   Mail Stop SSOP
   Washington, DC 20402-0001
   Internet: bookstore.gpo.gov
   Telephone: 202-512-1800
   Fax: 202-512-2250
2. The National Technical Information Service
   Springfield, VA 22161-0002
   www.ntis.gov
   1-800-553-6847 or, locally, 703-605-6000

A single copy of each NRC draft report for comment is available free, to the extent of supply, upon written request as follows:

Address: U.S. Nuclear Regulatory Commission
Office of Administration
Publications Branch
Washington, DC 20555-0001
E-mail: DISTRIBUTION.SERVICES@NRC.GOV
Facsimile: 301-415-2289

Some publications in the NUREG series that are posted at NRC's Web site address http://www.nrc.gov/reading-rm/doc-collections/nuregs are updated periodically and may differ from the last printed version. Although references to material found on a Web site bear the date the material was accessed, the material available on the date cited may subsequently be removed from the site.

Non-NRC Reference Material

Documents available from public and special technical libraries include all open literature items, such as books, journal articles, and transactions, *Federal Register* notices, Federal and State legislation, and congressional reports. Such documents as theses, dissertations, foreign reports and translations, and non-NRC conference proceedings may be purchased from their sponsoring organization.

Copies of industry codes and standards used in a substantive manner in the NRC regulatory process are maintained at—

The NRC Technical Library
Two White Flint North
11545 Rockville Pike
Rockville, MD 20852-2738

These standards are available in the library for reference use by the public. Codes and standards are usually copyrighted and may be purchased from the originating organization or, if they are American National Standards, from—

American National Standards Institute
11 West 42nd Street
New York, NY 10036-8002
www.ansi.org
212-642-4900

Legally binding regulatory requirements are stated only in laws; NRC regulations; licenses, including technical specifications; or orders, not in NUREG-series publications. The views expressed in contractor-prepared publications in this series are not necessarily those of the NRC.

The NUREG series comprises (1) technical and administrative reports and books prepared by the staff (NUREG-XXXX) or agency contractors (NUREG/CR-XXXX), (2) proceedings of conferences (NUREG/CP-XXXX), (3) reports resulting from international agreements (NUREG/IA-XXXX), (4) brochures (NUREG/BR-XXXX), and (5) compilations of legal decisions and orders of the Commission and Atomic and Safety Licensing Boards and of Directors' decisions under Section 2.206 of NRC's regulations (NUREG-0750).

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

NUREG-0498
Supplement 2

Draft Final Environmental Statement

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

Supplement 2

Docket Number 50-391

Tennessee Valley Authority

Draft Report for Comment

Manuscript Completed: September 2011
Date Published: October 2011

ABSTRACT

The U.S. Nuclear Regulatory Commission (NRC) prepared this draft 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. 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, TN.

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. 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 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 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 staff's environmental review. The 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 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 staff's independent review, and (4) the staff's consideration of comments related to the environmental review received during the public scoping process.

CONTENTS

Figures

Tables

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, TN. The NRC published 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. 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, an EIS equivalent) and conduct scoping. On October 6, 2009, the NRC held two scoping meetings in Sweetwater, TN, 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, TN, 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 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 staff's recommendation on the proposed action.

To guide its assessment of the environmental impacts of a proposed action or alternative action, the NRC has established a standard of significance for impacts based on guidance from the Council on Environmental Quality. In addition, NRC guidance has usedinformation in the GEIS [generic environmental impact statement] for license renewal, for example, the impact categorization approach (i.e., SMALL, MODERATE, and LARGE) 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 following impact categories in this draft SFES:

- 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 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 TVA's "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 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 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.

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.

Ground water 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 ground water quality, public services, noise, socioeconomic transportation, cultural and historical resources, greenhouse gas emissions, and severe accidents would be SMALL. In addition, the 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 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 and not noticeable in comparison to the other impacts.

A 75-day comment period will begin on the date of publication of the U.S. Environmental Protection Agency notice of availability for the draft SFES to allow members of the public to comment on the results of the NRC review. A public meeting will take place near the site during the public comment period. During this public meeting, the NRC staff will describe the results of the NRC environmental review, provide members of the public with information to assist them in formulating comments on the draft SFES, respond to questions, and accept comments. After the comment period, the staff will consider all comments. The NRC will address those within the scope of the environmental review in the final SFES.

The NRC's final safety evaluation report, anticipated to be published in 2012, will address the 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
APE	Area of Potential Effect or averted public exposure
AQCR	Air Quality Control Region
B.C.	Before Christ
BMP	best management practice
Bq	becquerel
Btu	British thermal unit(s)
Btu/hr	British thermal unit(s) per hour
CCW	Condenser Circulating Water
CDC	Centers for Disease Control
CDF	core damage frequency
CDWE	condensate demineralizer waste evaporator
CEQ	Council on Environmental Quality
CFR	*Code of Federal Regulations*
cfs	cubic (foot)feet per second
CO_2	carbon dioxide
Ci	curies
cm	centimeter(s)
CORMIX	Cornell Mixing Zone Expert System
CTBD	cooling-tower blowdown
CWS	Circulating Water System
dBA	decibels on the A-weighted scale
DBA	design basis accident
DC	design certification
DOE	U.S. Department of Energy
DSM	demand-side management
EIS	environmental impact statement
EAB	exclusion area boundary
ELF	extremely low frequency
EMF	electromagnetic field
EO	Executive Order

EPA	U.S. Environmental Protection Agency
EPRI	Electric Power Research Institute
ER	Environmental Report
ERCW	Essential Raw Cooling Water
ESRP	Environmental Standard Review Plan
FCC	Federal Communications 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
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)
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
gpm	gallon(s) per minute
gpd	gallon(s) per day
GWPP	Ground Water Protection Program
Gy	gray(s)
ha	hectare(s)
HLW	high-level waste
hr	hour(s)
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
IPS	intake pumping station
ISFSI	independent spent fuel storage installation
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)
LLW	low-level waste
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
MEI	maximally exposed individual
MGD	million gallons per day
mGy	milligray(s)
mGy/yr	milligray(s) per year
MHz	megahertz
mg/L	milligram(s) per liter
mi	mile(s)
mi^2	square mile(s)
MIT	Massachusetts Institute of Technology
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
MW	megawatt(s)
MW(e)	megawatt(s) electric
MW(t)	megawatt(s) thermal
NCRP	National Council on Radiation Protection and Measurements
NEPA	National Environmental Policy Act of 1969, as amended
NESC	National Electrical Safety Code
NHPA	National Historic Preservation Act of 1966, as amended
NPDES	National Pollutant Discharge Elimination System
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
PNNL	Pacific Northwest National Laboratory

ppm	parts per million
PRA	probabilistic risk assessment
PWR	pressurized-water reactor
RAI	Request for Additional Information
RCRA	Resource Conversation and Recovery Act
RCW	Raw Cooling Water
rem	roentgen equivalent man
REMP	radiological environmental monitoring program
ROI	region of influence
ROS	Reservoir Operations Study
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
SCCW	Supplemental Condenser Cooling Water
SEIS	supplemental environmental impact statement
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
SHPO	State Historic Preservation Officer
SPCC plan	Spill, Prevention, Control, and Countermeasure 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
TOSHA	Tennessee Occupational Safety and Health Administration
TN	Tennessee State Route
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)
WBN	Watts Bar Nuclear
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), WBN Units 1 and 2 (TVA 1972).
- 1973 – Atomic Energy Commission (predecessor to the NRC) issued construction permits (CPs) 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 the Supplemental FES (SFES) related to the operation of WBN Units 1 and 2, Supplement No. 1 (1995 SFES-OL-1), NUREG-0498, Docket Nos. 50-390 and 50-391 (NRC 1995).
- 1996 – NRC issued a full power operating license (NPF-90) for Watts Bar 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 staff to use the current licensing basis for 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).

This document supplements NRC's 1978 FES-OL (NRC 1978) and updates the 1995 SFES-OL-1 (NRC 1995). This draft SFES related to the operating license for WBN Unit 2 (SFES-OL-2) 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 draft SFES to address issues not previously considered.

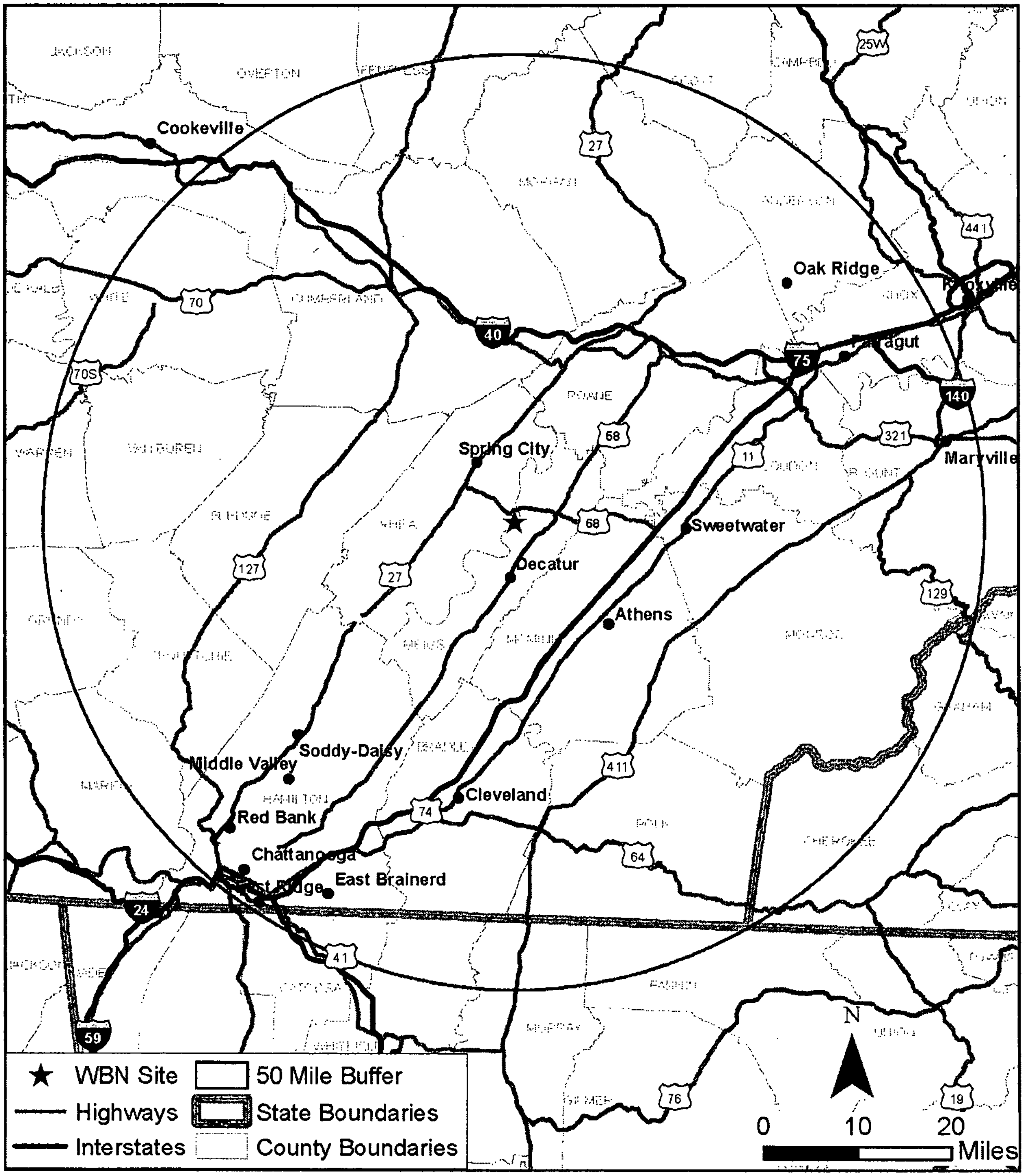
1.1 Background

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 reservation comprises 690 ha (1,700 ac) on the western shore of Chickamauga Reservoir on 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 Watts Bar Fossil Plant, 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 controlled by 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).

The 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 TVA's application, the staff reviewed the 1972 FES-CP, the 1978 FES-OL, the 1995 SFES-OL-1, and the applicant's submittals. The 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.



(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

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) guide 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 TVA's 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 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 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 NRC's standard of significance for impacts was established using the Council on Environmental Quality terminology for "significant". 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 following impact categories in this draft SFES:

> 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 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 preliminary recommendation to the Commission for issuing TVA an operating license for WBN Unit 2.

A 45-day comment period will begin on the date of publication of the U.S. Environmental Protection Agency Notice of Availability of the filing of this draft SFES. A public meeting will be held near the WBN site during the public comment period. During this public meeting, the staff will describe the results of the NRC environmental review, provide members of the public with information to assist them in formulating comments on the SFES, respond to questions, and accept comments. After the comment period, the staff will consider all comments. Those comments within the scope of the environmental review will be addressed in the final SFES.

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 the actual correspondence.

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 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 staff's preliminary 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 Environmental Review Correspondence Related to TVA Application for an Operating License at the WBN Site
- Appendix D – Scoping Meeting Comments and Responses
- Appendix E – Draft Supplemental Final Environmental Statement Comments and Responses (Reserved)
- Appendix F – Key Consultation Correspondence Regarding the WBN Unit 2 Operating License
- Appendix G – List of Authorizations, Permits, and Certifications
- Appendix H – Severe Accident Mitigation 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."

74 FR 20350. May 1, 2009. "Notice of Receipt of Update to Application for Facility Operating License and Notice of Opportunity for Hearing for the Watts Bar Nuclear Plant, Unit 2 and Order Imposing Procedures for Access to Sensitive Unclassified Non-Safeguards Information and Safeguards Information for Contention Preparation." *Federal Register.* U.S. Nuclear Regulatory Commission.

74 FR 46799. September 11, 2009. "Notice of Intent to Prepare a Supplement to the Operating License Final Environmental Statement and Conduct Scoping Process." *Federal Register.* U.S. Nuclear Regulatory Commission.

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

Tennessee Valley Authority (TVA). 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.

Tennessee Valley Authority (TVA). 1998. *Watts Bar Nuclear Plant Supplemental Condenser Cooling Water Project, Environmental Assessment.* Knoxville, Tennessee. Available at http://www.tva.gov/environment/reports/wattsbar2/related/aug_1998.pdf.

Tennessee Valley Authority (TVA). 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.

Tennessee Valley Authority (TVA). 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.

Tennessee Valley Authority (TVA). 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.

Tennessee Valley Authority (TVA). 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.

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

Tennessee Valley Authority (TVA). 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.

U.S. Nuclear Regulatory Commission (NRC). 1978. *Final Environmental Statement Related to Operation of Watts Bar Nuclear Plant Units Nos. 1 and 2.* NUREG-0498, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 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

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

U.S. Nuclear Regulatory Commission (NRC). 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.

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, ecology, socioeconomics, historic and cultural resources, radiological environment, nonradiological human health, and meteorology and air quality. Section 2.9 examines related Federal projects, and references are presented in Section 2.10.

2.1 Land Use

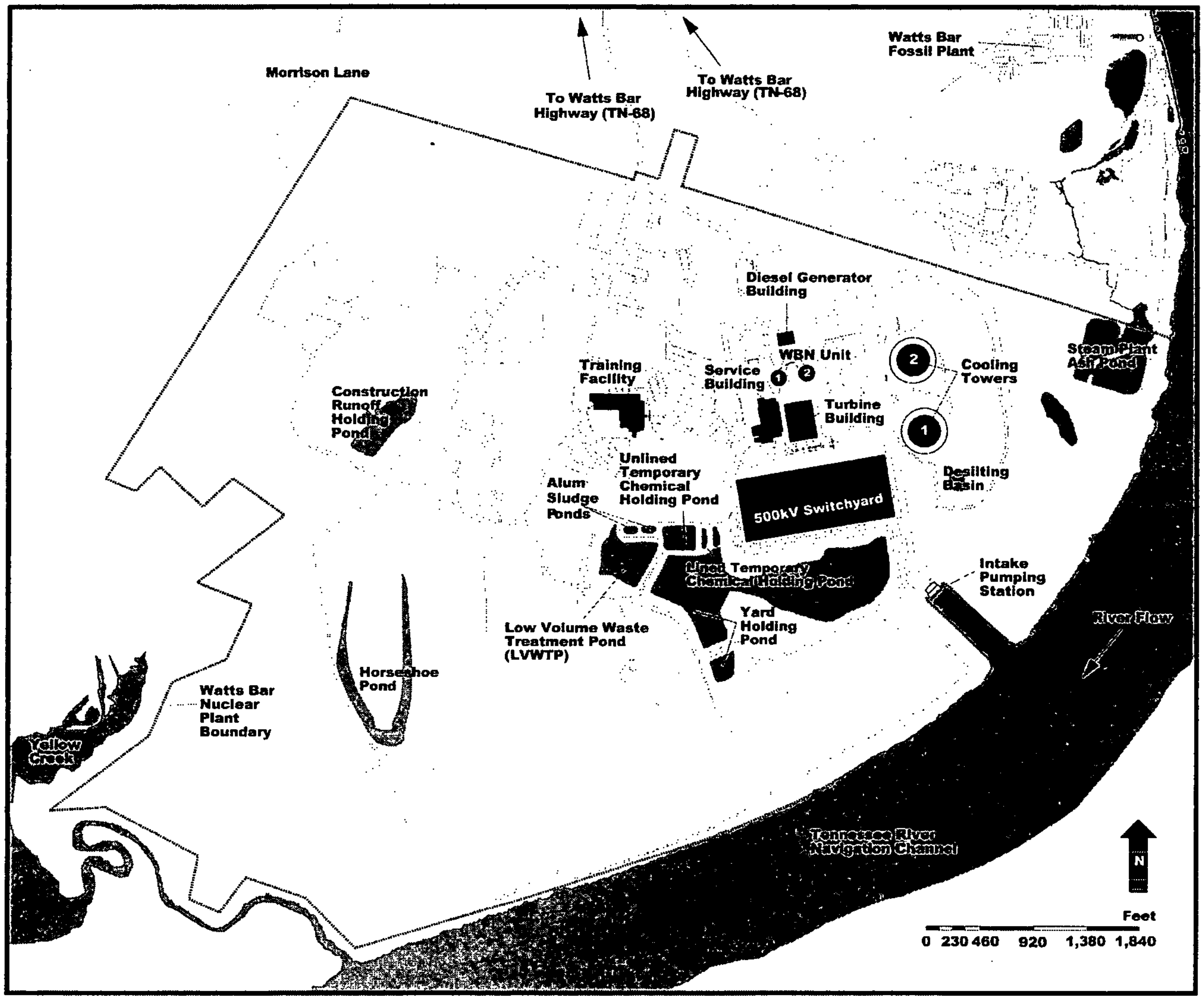
This section describes the WBN site location and land use within and around the WBN site.

2.1.1 Station 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 2,025. The nearest population centers with more than 25,000 residents include Chattanooga, 97 km (60 mi) to the southwest (population 155,554) and Knoxville, about 97 km (60 mi) to the northeast (population 184,802) (USCB 2008a, b, c, d). 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, the TVA Central Maintenance Facility, and the Watts Bar Resort Area (TVA 2008a).

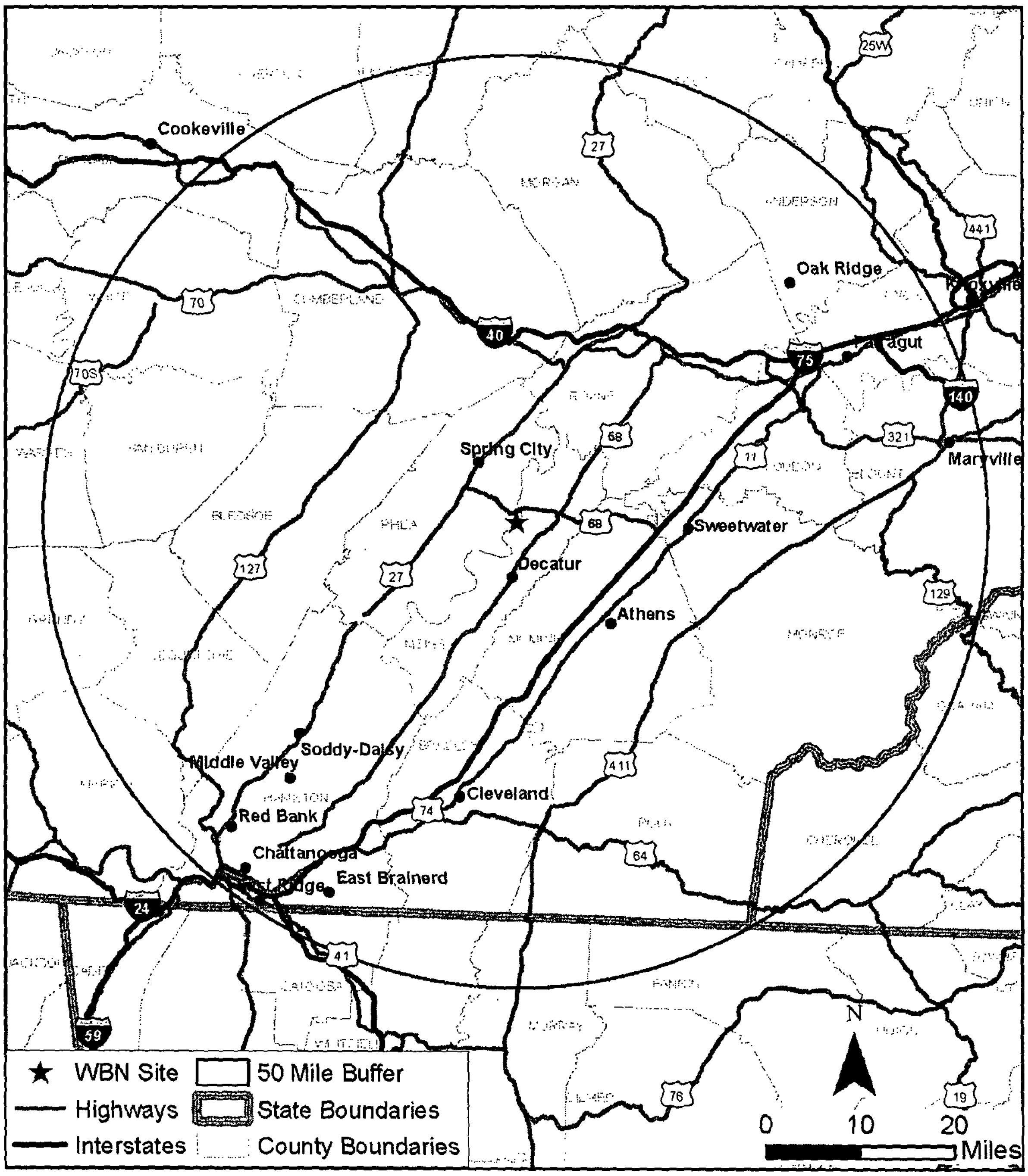
2.1.2 The Site and Vicinity

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 (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

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 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). 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).

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 2005).

2.2 Water

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 m^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 's (NRC's) 1995 SFES-OL-1 (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 1998a). 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).

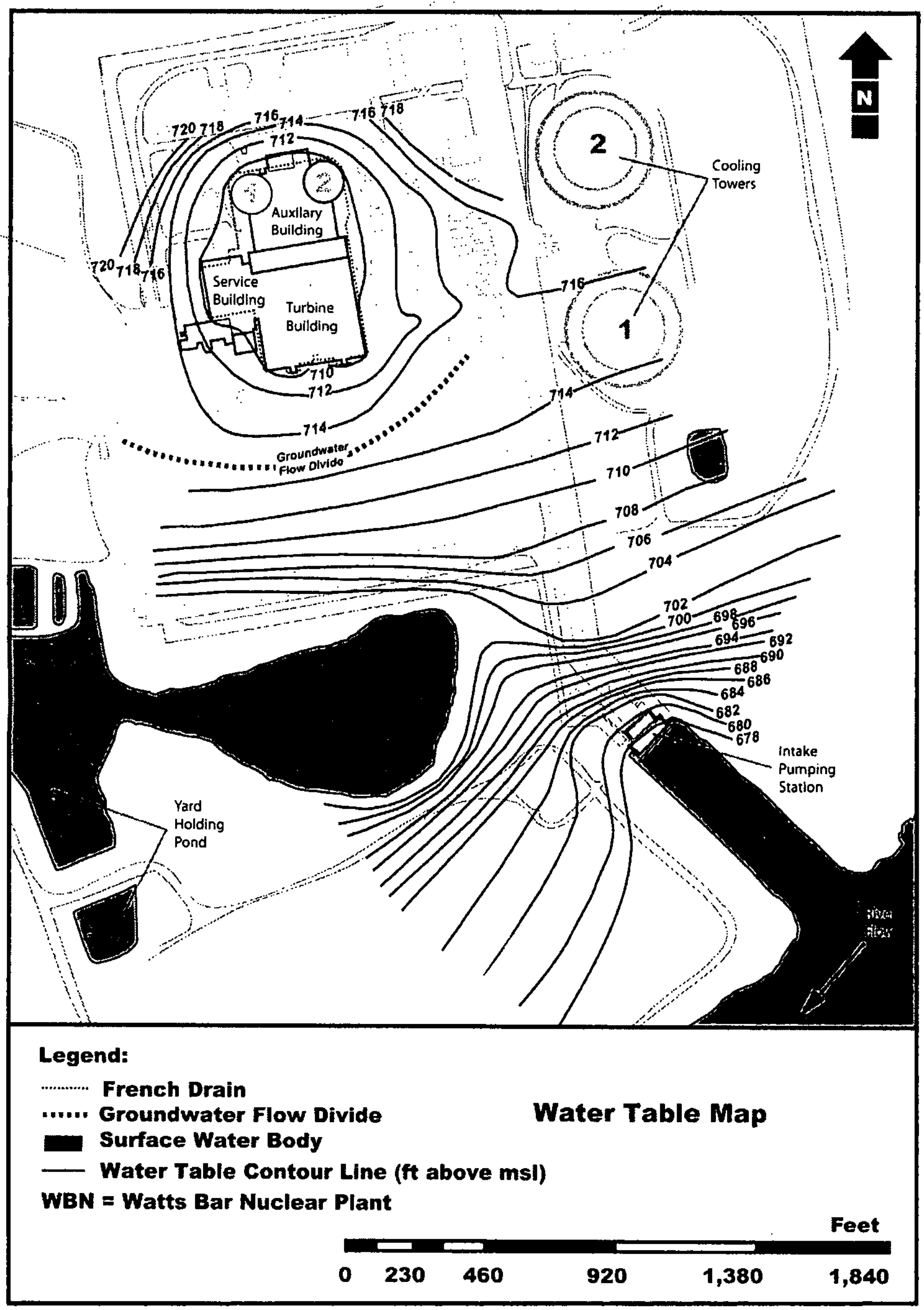
The 1995 SFES-OL-1 (NRC 1995) and the National Pollutant Discharge Elimination System (NPDES) permit renewal application (TVA 2006a) describe surface-water features of the site, including two chemical cleaning holdup ponds (for waste from the turbine generator building), the Yard Holding Pond (YHP), Construction Run Off 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 fairly 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. 2004a; 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) (TVA 2005a).

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
East Side Utility	TRM 473.0
U.S. Army Volunteer Ammunition Plant	TRM 473.0L[b]
Chickamauga Dam	TRM 471.0
Invista-DuPont Company	TRM 469.9R
Tennessee-American Water	TRM 465.3L
BUZZI UNICEM USA	TRM 454.2R
Raccoon Mountain Pump Storage	TRM 444.7L
Signal Mountain Cement	TRM 433.3R
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 down river

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 (TVA 2010a). The shallow 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 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 quality of the water is generally good, with total dissolved solids ranging from 60 to 180 mg/L. 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 identified 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) (TDEC2010a). 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. A summary of results for February and March 2009 for these contaminants in the Emory River indicates concentrations had dropped below applicable water-quality standards (TDEC 2009a). Recent analyses confirm 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 (2860 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 (TVA 1995), 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, 2007a). 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 2007a). 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

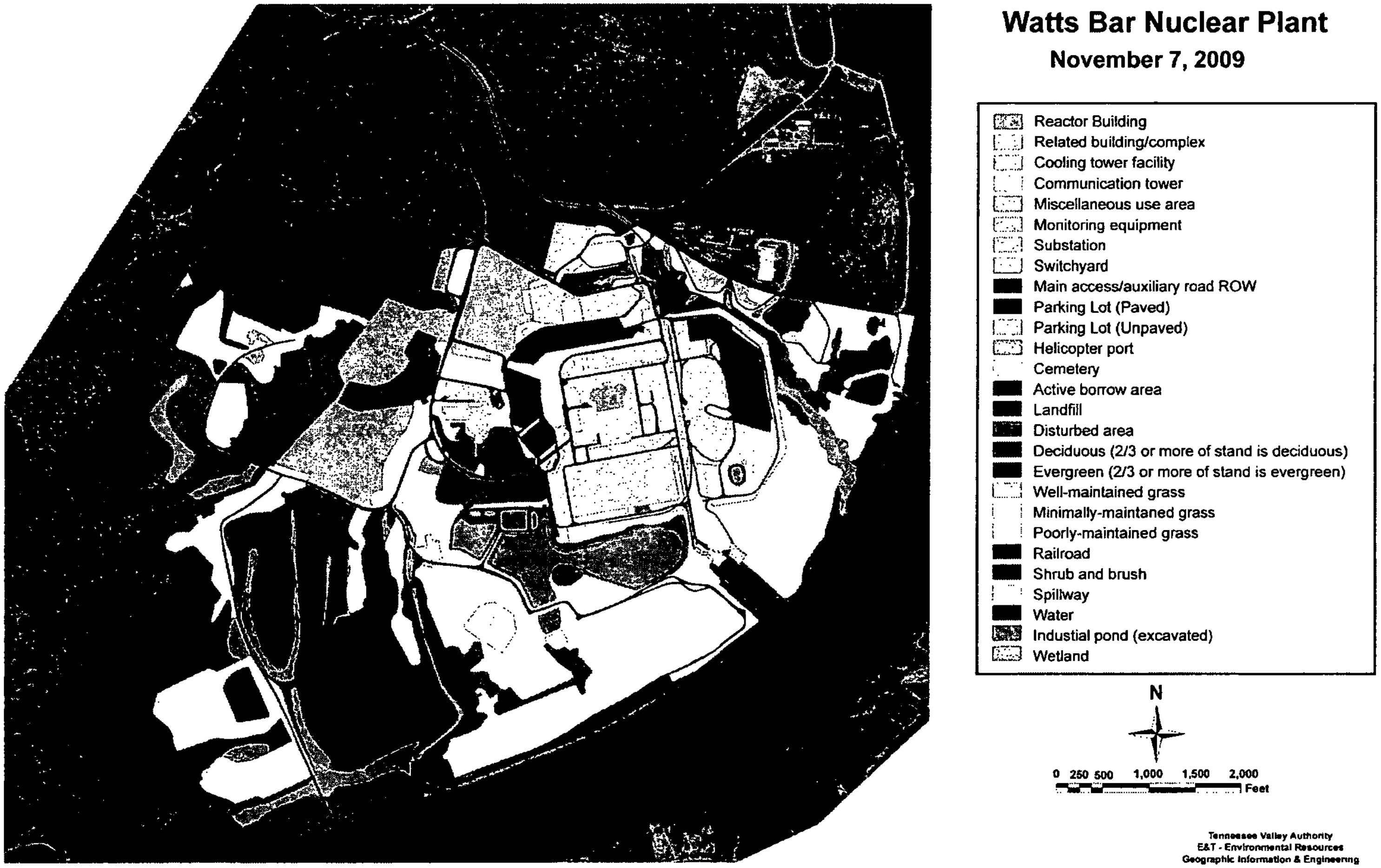
Source: TVA 2010a.

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 2007a). 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

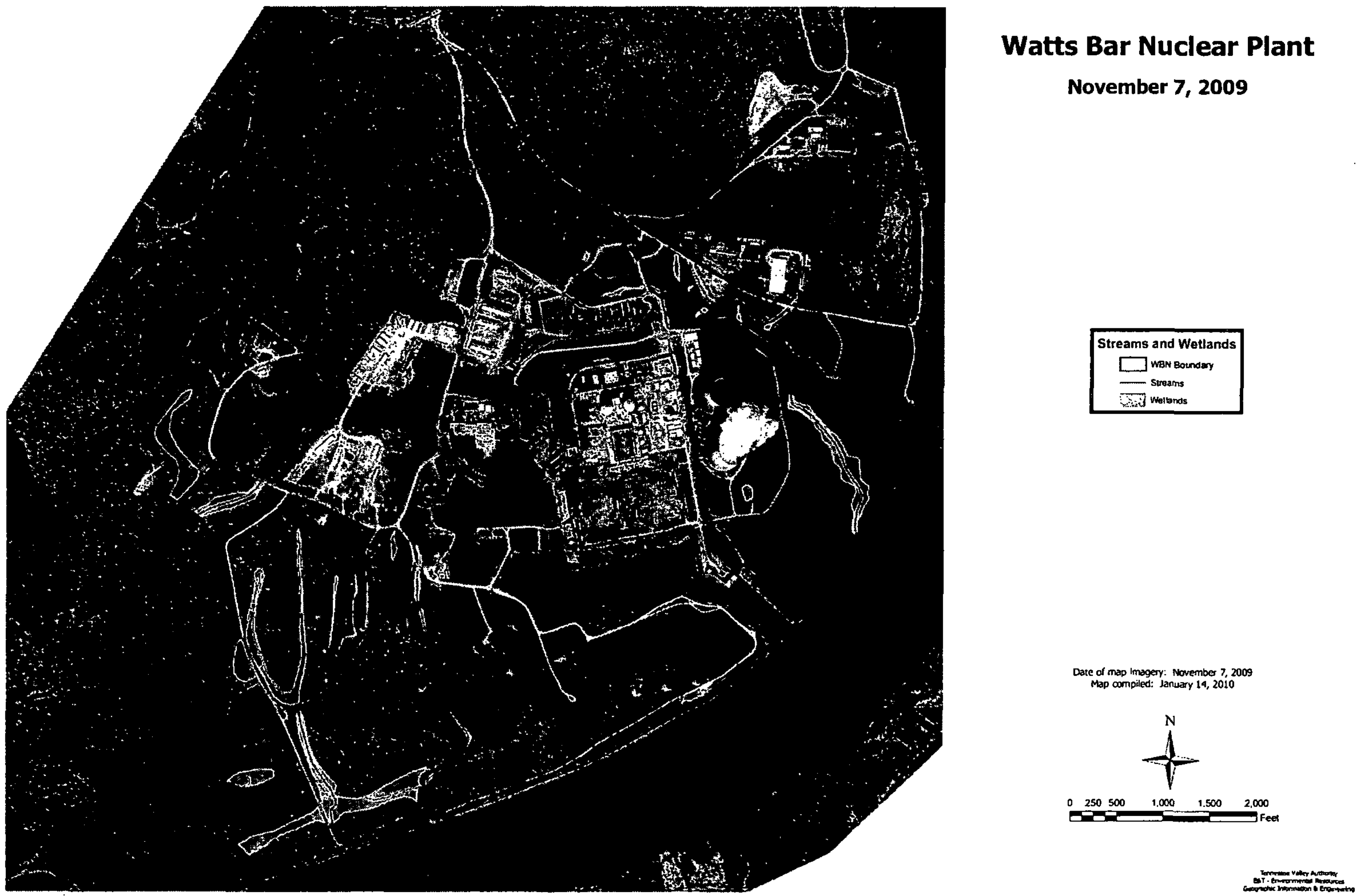
NRC guidance defines important species as rare, economically or recreationally valuable, essential to the maintenance of an important species, playing a critical role in the function of an ecosystem, or serving as biological indicators for environmental change (NRC 1999, 2000). Further, NRC guidance 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).



Date of map imagery: November 7, 2009
Map compiled: January 14, 2010

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

Figure 2-4. Landcover Information for the Watts Bar Nuclear Site (TVA 2010a)



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

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, 2 arthropods, 1 lichen) that were Federally listed as endangered, threatened, or proposed to be listed as endangered or threatened within the Tennessee River Basin (TVA 1995). 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 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). 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 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 1995; 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 2000–2002, 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 2009b). 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 2009b).

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 2009b
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.

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	Watts Bar 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 2009b

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 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 2009c). 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 five 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).

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

Habitats of Importance

The NRC 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.

<u>Set-Aside Lands</u>

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.

<u>State/Federal Priority Protection Habitats</u>

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

<u>Wetlands/Floodplains</u>

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 2007a). 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

The NRC requires discussion of potential impacts on wildlife corridors (NRC 1999, 2000). 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 2004; Spackman and Hughes 1994). 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-Rome 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 1998a).

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. 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), 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.

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 reported in 1968, that were conducted before and after the impoundment of Melton Hill Reservoir 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. These species and their potential effect on the native aquatic biota are discussed in further detail 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. 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 2010). 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 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.

Zooplankton and Phytoplankton

Plankton are small plants or animals that float, drift, or weakly swim in the water column of any body of water (EPA 2010). 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. 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. 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.

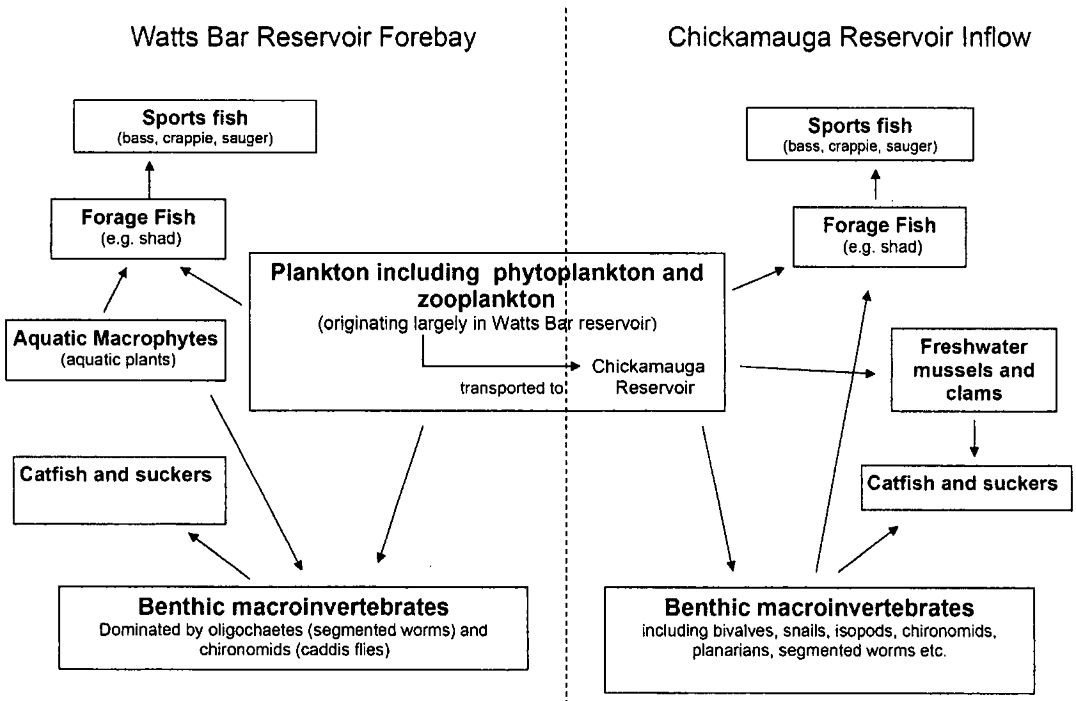


Figure 2-6. Foodweb for Watts Bar Reservoir Forebay and Chickamauga Reservoir Inflow

Periphyton

Periphyton are 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 (Lee 2005). 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, 516, 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. The most abundant species include exotic or non-native species such as Eurasian watermilfoil, spiny leaf naiad, and hydrilla. In addition, alligatorweed (*Alternanthera philoxeroides*), a vascular plant that roots 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 sport-fishing 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 cripsus*).

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.

Benthic Macroinvertebrates Including Freshwater Mussels

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 three sets of studies in the past and in recent years to monitor the presence of benthic macroinvertebrates in the vicinity of the WBN site. The first set of studies monitored the density of benthic macroinvertebrates prior to operation of WBN Unit 1 compared with the 2 years after the start of operations. The second set was a series of monitoring studies upstream of the dam and in the vicinity of the WBN site. The third set of studies looked specifically at freshwater mussels and clams in more detail. These studies are discussed in more detail in the following paragraphs.

First, TVA (1998b) conducted both preoperational (1983 to 1985) and operational (1996 to 1997) studies for WBN Unit 1 and compared preoperational and operational results for each individual sampling station. The results showed the total number of benthic macroinvertebrate taxa collected in the inflow of the Chickamauga Reservoir increased 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 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, three taxa, Asiatic clams; a trichopteran (caddis fly), *Cyrnellus fraternus;* and oligochaeta (segmented worms) composed approximately 85 percent of the total community. 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 (TVA 1998b). Based on a comparison of species composition, occurrence, and densities between the preoperational and operational monitoring periods, TVA (1998b) 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.

Second, TVA conducted studies between 1999 and 2008, collecting benthic macroinvertebrates annually during autumn in the forebay (the deep water above or upstream of the dam) 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). A comparison of the data obtained from the two sampling locations (Table 2-9) during the most recent sampling year (2008) indicates a greater number of species at the downstream sampling location. In contrast, the density of organisms at the upstream sampling location (above the dam) is nearly double that at the downstream sampling location. Oligochaetes (earthworms) 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 at the near the WBN site (Simmons and Baxter 2009).

Third, TVA surveyed the mussel population in the vicinity of the WBN site from 1983 through 2010. As NRC discusses in the 1978 FES-OL and 1995 SFES-OL-1, 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 they are dislodged. Individuals from some species of freshwater mussels are known to live for more than 100 years (Parmalee and Bogan 1998). Native freshwater mussels have a unique reproductive cycle. Sperm are released into the water and carried into the female mussel's body where they fertilize the eggs, which have previously been discharged into tubes in the gills. 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 have been reported to be sexually mature at 4 to 6 years of age (Jirka and Neves 1992), although age of sexual maturity is reported to be 8 to 10 years of age for other species of freshwater mussels (Downing et al. 1993).

Table 2-9. Average Mean Density per Square Meter of Benthic Taxa Collected at Upstream and Downstream Sites near the WBN Site, Autumn 2008

Taxa	Downstream TRM 527.4 (Chickamauga Reservoir)	Upstream TRM 533.3 (Watts Bar Reservoir)
Tubellaria	47	--
Tricladida		
Planariidae		
Oligocheata	15	250
Oligochaetes		
Hirudinea	23	--
Crustacea	3	20
Amphipoda		
Isopoda	20	--
Insecta		
Ephemeroptera		
May flies other than *Hexagenia*	2	--
Chironomidae		
Chironomids	7	70
Gastropoda	10	--
Snails		
Bivalvia	35	--
Veneroida		
Corbicula (≤10 mm)		
Sphaeriidae	2	--
Fingernail clams		
Dressenidae	23	--
Dreissena polymporpha		
Density of organisms per square meters	187	320
Number of areas sampled	10	10
Total areas sampled (square meters)	0.6	0.6

Source: Simmons and Baxter 2009

The numbers of native mussels have been declining since the early 1940s when TVA filled the Chickamauga and Watts Bar reservoirs. As the NRC discusses in its 1995 SFES-OL-1, 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 (A.D. 1) to Late Woodland Mississippian times (approximately 600 A.D. to 1600 A.D.) 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 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 (1999) 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, 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 520.0 to 529.9) (TVA 1998a). 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's 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 furthest 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 (TVA 1998b, 2011c).

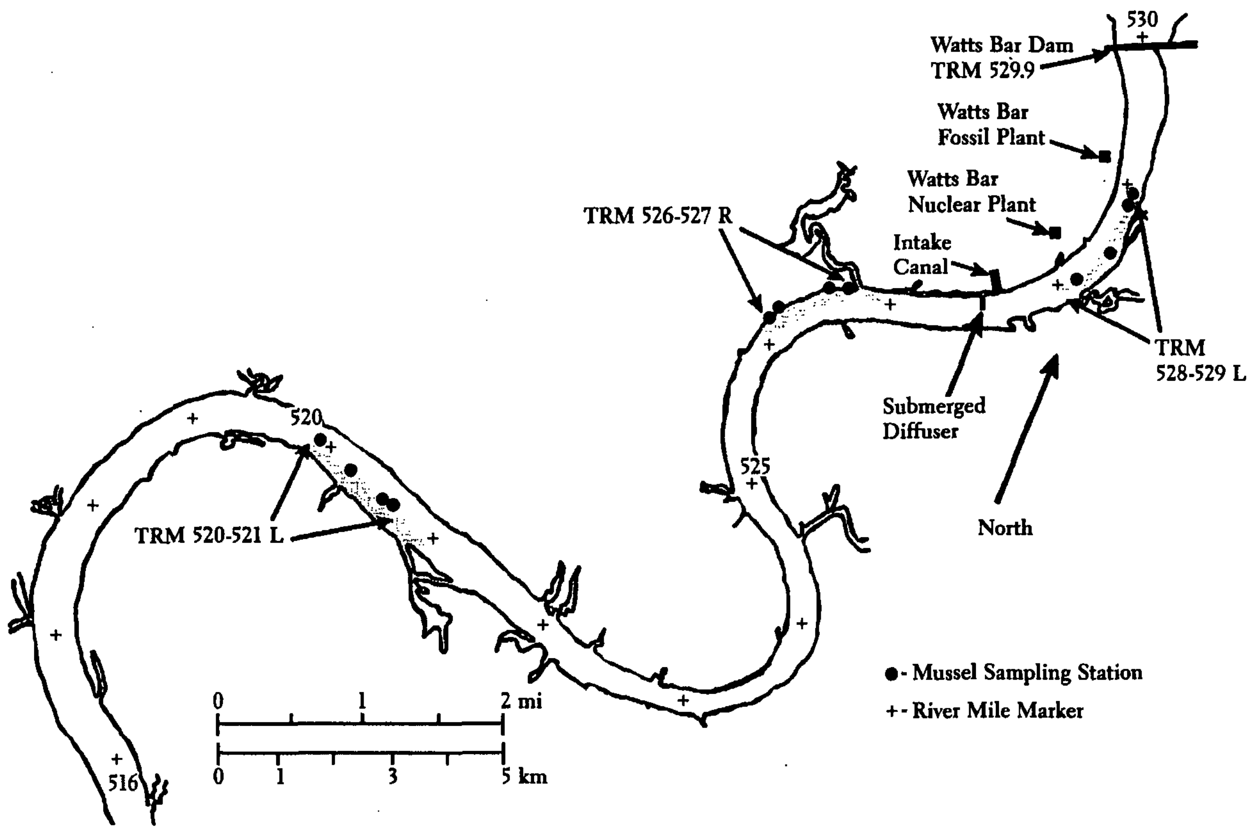


Figure 2-7. Mussel Beds (in gray) and Monitoring Stations (after TVA 1998b)

Although mussel abundance was sampled in 10 different years from 1983 to 2010, the data in Table 2-10 shows the species identified in the years 1983, 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 (TVA 1998b, 2011c). 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 IPS 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 2-11 shows the number of individual mussels and the number of species that were identified in each of the preoperational (1983–1994), operational (1996–1997) and recent (2010) surveys. Between 1983 and 1988 the number of individuals and species remained fairly constant (991–1610 individuals; 18–22 species). In 1992 the number of individuals and species

Table 2-10. Results of 15 Native Mussel Surveys During 1983, 1992, 1997 and 2010 in the Vicinity of the Watts Bar Nuclear 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 1998b, TVA 2010c and TVA 2011c.

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

Year	Number of Individuals	Number of Species	Federally Threatened and Endangered Species/Individuals	Plant Status
1983 (September)	1341	22	4/7	preoperational
1983 (November)	1422	21	3/9	preoperational
1984 (July)	1270	20	2/8	preoperational
1984 (November)	1368	19	2/3	preoperational
1985 (July/August)	1063	20	3/3	preoperational
1985 (October)	1427	20	1/7	preoperational
1986 (July)	1075	18	1/6	preoperational
1986 (October)	1180	20	1 /2	preoperational
1988 (July)	1610	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 1998b, TVA 2011c

started dropping. The largest drop in the number of species and abundance of individuals was observed in 1992, several years before the start of operations of WBN Unit 1, which occurred in 1995. However, the decline appears to have stabilized somewhat and the number of individuals and species found in 2010 is similar to that found in 1992 and 1994, before the start of operations at Unit 2. The surveys conducted in 2010 showed increased abundance for some species compared with the operational surveys conducted in 1996 and 1997 across all of the mussel beds, although the middle bed showed an increase for 11 species between 1997 and 2010, while the downstream bed showed an increase in the population size for 8 species and the upstream bed for only 4 species. Considering the total number of mussels from all three beds, the size 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 1996–1997. 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 (TVA 2011c).

The 2010 surveys found that 62 individuals from 7 species were less than 10 years old. 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*) (TVA 2011c). These data lead to a different interpretation than in the 1995 FES-OL-1 (NRC 1995). The 1995 FES-OL-1 stated 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.

Possible causes of population fluctuations in mussel numbers and species 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 or improvements, may have a negative effect on the population structure. Other changes that were discussed in Section 2.2.1 may have 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 1998a). 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. Mussels were relatively scarce in this area and appeared to be distributed evenly. The freshwater mussels that were in an area of 46 m by 46 m (150 ft 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 (TVA 1999). TVA moved these mussels in an effort to prevent adverse effects from operation of the SCCW system discharge.

In 2000, TVA established four experimental plots of freshwater mussels in a boulder field that is approximately 1 mi (1.6 km) downstream from Watts Bar Dam. 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. 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. 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. This location is along the right (descending) margin of the navigation channel between the loading facility for the Watts Bar Fossil Plant and the WBN intake channel. In 2010, TVA attempted to find the plots in the boulder field (TVA 2011c). 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. Other researchers have tried relocation of mussel species with mixed success (Parmalee and Bogan 1998)

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) (TVA 1998b). 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). Asiatic clams were observed during the mussel surveys conducted in 2010, but the numbers of specimens were not recorded. No zebra mussels were encountered during the surveys.

<u>Fish</u>

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 1997 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).

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. Coves located downstream of the plant (TRM 504 to 509) were sampled using rotenone in the early 1970s (1970, 1972, and 1973) (NRC 1978). Starting in 1977, the sampling was conducted using electrofishing techniques. Because of the differences in rotenone sampling and electrofishing, only the electrofishing results are used for comparison of the fish populations during the years from 1977 to the present.

Two comparisons are made in the following paragraphs. First, the fish species and abundance below the Watts Bar Dam and in the vicinity of the WBN site are compared to the fish species and abundance above the Watts Bar Dam. As discussed further in Chapter 4, fish living above the dam would not be affected by the discharge from WBN Unit 1, but they could be affected by the movement of water into the SCCW intake. Fish below Watts Bar Dam could be affected by the thermal and chemical discharge, as well as the use of the Intake Pumping Station located below the dam. Second, a comparison of fish species and abundance below the Watts Bar Dam is made for discrete periods of time beginning in 1977 and ending in 2007. This comparison provides information about the potential change in species and population size over time, and can be used to provide insight related to the potential effect of operation of WBN Unit 1 on the fish species in the Chickamauga Reservoir in the vicinity of the WBN site, as will discussed in 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 2007 at a location downstream of the Watts Bar Dam (see Section 5.5.2 for a discussion of the sampling studies during these years). This is new information that was not reported in the 1978 FES-OL or the 1995 SFES-OL-1. TVA identified 45 species (including the hybrid sunfish) from 10 different families. Table 2-13 shows the results of electrofishing and gill netting upstream of the WBN site (in Watts Bar Reservoir) for the same time period. The results yielded 46 species (including the hybrid sunfish, hybrid shad, or hybrid bass) from the same 10 families. The bluegill (*Lepomis macrochirus*), gizzard shad (*Dorosoma cepedianum*), and redear sunfish (*Lepomis microlophus*) tended to be consistently numerically dominant in the fish community below the dam. In some years the threadfin shad (*Dorosoma petenense*) also was one of the numerically dominant fish below the dam. Bluegill, gizzard shad, and redear sunfish 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 operational periods (1996 to 1997 and 1999 to 2007) for sampling sites below the Watts Bar Dam. The data from 1996 to 2007 is new information that was not reported 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 43 species from 12 families for the 1977 to 1985 preoperational monitoring period; 40 species from 10 families for the 1990 to 1995 preoperational monitoring period; 36 species from 11 families during the operational monitoring period (1996 to 1997); and 44 species from 10 families during

Table 2-12. Electrofishing Downstream of the Watts Bar Dam for Years 1999 to 2007

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

Table 2-12. (contd)

Species Collected			Percentage Composition of Fish Caught During Electrofishing Downstream of the WBN Site (TRM 529)								
Family	**Scientific Name**	**Common Name**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Cyprinidae	*Cyprinus carpio*	Common carp	0.72	4.1	0.36	0.54	0.58	0.40	0.60	0.11	0.13
	Notropis atherinoides	Emerald shiner	1.1	0.43	5.9	0.16	0.29	0.60	4.4	2.1	0.78
	Pimephales notatus	Bluntnose minnow	0.36	0	0.18	0	0.19	0.07	0	0	0
	Pimephales vigilax	Bullhead minnow	0	0	0	0.47	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
	Cyprinella spiloptera	Spotfin shiner	1.6	2.5	5.5	2.2	1.1	0.73	0.40	4.8	3.5
	Cyprinella whipplei	Steelcolor shiner	0	0	0	0	0.39	0	0	0	0.13
	Luxilus chrysocephalus	Striped shiner	0	0	0	0	0	0	0.20	0	0
	Campostoma oligolepis	Largescale stoneroller	0	0	0	0	0	0.07	0	0	0
Ictaluridae	*Ictalurus furcatus*	Blue catfish	0	0.11	2.0	0	0	0	0.20	0.11	0
	Ictalurus punctatus	Channel catfish	0.72	0.33	2.0	1.7	0.48	0.60	1.5	2.2	1.6
	Pylodictis olivaris	Flathead catfish	1.1	0.54	1.4	0.47	0.48	0.60	1.7	0.76	3.6
Lepisosteidae	*Lepisosteus osseus*	Longnose gar	0.36	0	0	0	0.29	1.2	0.10	0.22	0.13
	Lepisosteus oculatus	Spotted gar	0	0	0.18	0	0	0.07	0	0.22	0
Moronidae	*Morone saxatilis*	Striped bass	0	0.11	0	0.08	0	0	0	0	0.13
	Morone chrysops	White bass	0.54	0.65	0.18	0.70	0.19	2.1	0	0	0
	Morone mississippiensis	Yellow bass	1.1	3.7	0.18	2.7	1.6	1.7	1.3	0.86	0.90
Percidae	*Percina caprodes*	Logperch	3.4	0	0.53	0	0.10	1.2	0.40	2.4	0.65
	Sander canadensis	Sauger	0.18	0	0	0	0	0	0	0	0
	Sander vitreus	Walleye	0	0	0	0	0.10	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

Adapted from Simmons and Baxter 2009

Table 2-13. Electrofishing and Gill Netting Upstream of the Watts Bar Dam for Years 1999 to 2007

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

1 **Table 2-13.** (contd)

			Percentage Composition of Fish Caught During Gillnetting and Electrofishing Upstream of the WBN Site (in Watts Bar Reservoir at TRM 531.0)								
Family	**Scientific Name**	**Common Name**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
	Alosa chrysochloris	Skipjack herring	2.2	0.48	0.23	0	0.19	2.9	0.67	0.14	0.48
	Dorosoma petenense	Threadfin shad	2.8	0.10	0.35	0.15	0.57	0.09	0.37	0.42	0.72
Cyprinidae	*Pimephales notatus*	Bluntnose minnow	0	0.86	0.35	0.30	0.19	0	0.07	1.5	0.12
	Pimephales vigilax	Bullhead minnow	0	0	0	0	0	0	0	0	0.12
	Cyprinus carpio	Common carp	3.2	1.91	1.2	1.5	1.1	0.69	0.75	0.90	0.10
	Notropis atherinoides	Emerald shiner	1.0	0	0	0	0	0.95	0.15	0	0
	Notemigonus crysoleucas	Golden shiner	0	0.48	0	0	0.57	0	0.07	0	0
	Cyprinella spiloptera	Spotfin shiner	1.0	6.3	11	0.91	4.7	1.4	7.6	6.0	1.9
	Cyprinella whipplei	Steelcolor shiner	0	0.10	3.6	0	0	0	0	0	0
	Luxilus chrysocephalus	Striped shiner	0	0.10	0	0	0	0	0	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
	Ictalurus punctatus	Channel catfish	1.8	0.96	1.3	0.91	0.95	0.87	0.90	0.35	0.72
	Pylodictis olivaris	Flathead catfish	1.5	2.0	1.3	4.3	2.0	0.69	2.1	1.0	2.5
Lepisosteidae	*Lepisosteus osseus*	Longnose gar	0.17	0	0	0.46	0	0.09	0	0	0
	Lepisosteus oculatus	Spotted gar	0	0	0.23	0.15	0.19	0	0.37	0.14	0
Moronidae	*Hybrid morone (chrysops x sax)*	Hybrid striped x white bass	0	0.29	0.12	0.46	0	0	0	0	0
	Morone saxatilis	Striped bass	0.5	0.38	0.46	0.76	0.66	0.26	0.22	0.14	1.1
	Morone chrysops	White bass	1.7	0.19	0.81	2.9	0.76	1.6	1.3	2.2	0.48
	Morone mississippiensis	Yellow bass	7.5	10	8.2	6.4	5.1	0.52	5.7	1.8	5.5
Percidae	*Percina caprodes*	Logperch	0	0	0.46	0	0.19	0	0.22	0.49	0
	Sander canadensis	Sauger	0.33	0.38	0	0	0.09	0.09	0	0	0
	Perca flavescens	Yellow perch	0	0	0.58	0	0	0.43	0.07	0.21	0
Sciaenidae	*Aplodinotus grunniens*	Freshwater drum	4.8	2.2	2.0	2.1	0.57	1.0	1.1	0.49	0.96

Adapted from Simmons and Baxter 2009

Table 2-14. Comparison by Species of Percent Composition of the Catch from Preoperational (1977–1985 and 1990–1995) and Operational (1996–1997) Monitoring Periods and Additional Operational Monitoring Periods (1999–2007)

Family	Scientific Name	Common Name	1975–1985 Preoperational [(a)]	1990–1995 Preoperational [(a)]	1996–1997 Operational [(a)]	1999–2007 Operational (range for all years)[(b)]
Anguillidae	*Anguilla rostrata*	American eel	0[(c)]	-	-	-
Atherinopsidae	*Labidesthes sicculus*	Brook silverside	5.4	1.1	--	0 – 3.4
	Menidia beryllina	Inland silverside	-	-	-	0 – 3.2
Catostomidae	*Carpiodes carpio*	River carpsucker	0.0	--	--	--
	Moxostoma duquesnii	Black redhorse	--	0.2	0.3	0 - 0.90
	Moxostoma erythrurum	Golden redhorse	0.5	0.5	1.2	0.13 – 1.4
	Mosostoma carinatum	River redhorse	0.0	--	0.1	0 – 0.18
	Moxostoma macrolepidotum	Shorthead redhorse	--	--	--	0 – 0.18
	Hypentelium nigricans	Northern hog sucker	0.1	0.1	0.1	0 – 0.72
	Ictiobus bubalus	Smallmouth buffalo	0.0	0.1	--	0 – 0.07
	Minytrema melanops	Spotted sucker	1.2	1.3	2.0	0.27 – 1.6
Centrarchidae	*Pomoxis nigromaculatus*	Black crappie	0.0	0.8	1.8	0 – 4.7
	Ambloplites rupestris	Rock bass	0.0	--	--	0 – 0.13
	Lepomis macrochirus	Bluegill	10.0	32.4	45.1	5.9 – 52
	Lepomis cyanellus	Green sunfish	0.0	0.4	0.3	0.29 – 3.0
	Hybrid Lepomis sp.	Hybrid sunfish	--	0.0	0.2	0 – 0.22
	Micropterus salmoides	Largemouth bass	3.4	7.8	6.9	1.4 – 5.1
	Lepomis megalotis	Longear sunfish	0.2	0.1	0.3	0 – 4.6
	Lepomis auritus	Redbreast sunfish	0.9	1.3	0.4	0.68 – 2.9

Table 2-14. (contd)

Family	Scientific Name	Common Name	1975–1985 Preoperational [(a)]	1990–1995 Preoperational [(a)]	1996–1997 Operational [(a)]	1999–2007 Operational (range for all years)[(b)]
	Lepomis microlophus	Redear sunfish	7.2	13.4	12.5	4.3 – 25
	Micropterus dolomieu	Smallmouth bass	0.3	1.8	3.5	0.36 – 2.5
	Micropterus punctulatus	Spotted bass	1.0	3.1	3.2	2.0 – 5.6
	Lepomis gulosus	Warmouth	0.1	0.7	0.2	0 – 0.98
	Pomoxis annularis	White crappie	0.8	0.2	0.4	0 – 0.40
Clupeidae	*Dorosoma cepedianum*	Gizzard shad	(d)	(d)	(d)	7.8 – 50
	Alosa chrysochloris	Skipjack herring	1.5	0.7	-	--
	Dorosoma petenense	Threadfin shad	(d)	(d)	(d)	0 – 47
Cyprinidae	*Pimephales notatus*	Bluntnose minnow	--	0.1	0.1	0 – 0.36
	Pimephales vigilax	Bullhead minnow	0.0	0.1	--	0 – 0.47
	Cyprinus carpio	Common carp	1.2	1.0	3.8	0.11 – 4.1
	Notropis atherinoides	Emerald shiner	58.6	17.1	1.5	0.16 – 5.9
	Notemigonus crysoleucas	Golden shiner	0.2	0.4	0.1	0 – 1.1
	Macrhybopsis storeriana	Silver chub	0.0	--	--	
	Cyprinella spiloptera	Spotfin shiner	0.1	1.8	0.4	0.4 – 5.5
	Cyprinella whipplei	Steelcolor shiner	--	2.5	--	0 – 0.39
	Luxilus chrysocephalus	Striped shiner	--	0.0	--	0 – 0.20
	Campostoma oligolepis	Largescale stoneroller	--	--	--	0 – 0.07
Hiodontidae	*Hiodon tergisus*	Mooneye	0.2	--	0.1	--
Ictaluridae	*Ictalurus furcatus*	Blue catfish	0.0	0.1	--	0 – 2.0
	Ictalurus punctatus	Channel catfish	0.0	1.6	0.6	0.33 – 2.0
	Pylodictis olivaris	Flathead catfish	0.0	0.6	0.9	0.48 – 3.6

Table 2-14. (contd)

Family	Scientific Name	Common Name	1975–1990 Preoperational	1990–1995 Preoperational	1996–1997 Operational	1999–2007 Operational (range for all years)
Lepisosteidae	*Lepisosteus osseus*	Longnose gar	0.5	0	0.1	0 – 1.2
	Lepisosteus oculatus	Spotted gar	0.01	--	--	0 - 0.22
Moronidae	*Morone saxatilis*	Striped bass	0.1	0.2	0.2	0 – 0.13
	Morone chrysops	White bass	1.3	1.7	1.8	0 – 2.1
	Morone mississippiensis	Yellow bass	4.1	4.3	8.5	0.18 – 3.7
Percidae	*Percina caprodes*	Logperch	0.1	1.5	1.3	0 – 3.4
	Sander canadensis	Sauger	0.1	0.1	0.4	0 – 0.18
	Sander vitreus	Walleye	0.0	-	-	0 – 0.10
	Perca flavescens	Yellow perch	0.4	0.4	0.6	
Pteromyzontidae	*Ichthyomyzon castaneus*	Chestnut lamprey	--	--	0.1	--
Sciaenidae	*Aplodinotus grunniens*	Freshwater drum	0.2	0.6	1.0	0.11 – 2.1
Number of Species			43	40	36	45
Number of Families			12	10	11	10

(a) TVA 1998b
(b) Simmons and Baxter 2009
(c) A "0" means "present" but less than 0.01 percent.
(d) Threadfin and gizzard shad are not included in percent composition but are included in species and family counts.

the reservoir monitoring studies below the dam (1999 to 2007). 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, sampling occurred monthly. In 1990, TVA began sampling annually, in the fall.

As with the mussel community, the fish community may be changing in response to historical changes in land use, river regulation, and other human activities. For example, data taken over the past 35 years indicate that emerald shiners (*Notropis aterinoides*) declined substantially in numerical importance – most obviously in the period from 1977 to 1997. The emerald shiner composed 58.6 percent of the community from 1977 to 1985, 17.1 percent from 1990 to 1995, and only 1.5 percent from 1996 to 1997. During sampling from 1999 to 2007, the emerald shiner composed 0.16 to 5.9 percent of the community. No other species appeared to have declined significantly. Because the decline began before WBN Unit 1 started operating, it is unlikely that operation of WBN Unit 1 is the impetus for the decline. Further, there have been documented cases of dramatic reductions in emerald shiner populations in other locations (Crowder 1980). In several cases this was attributed to competition with another fish species (alewife [*Alosa pseudoharengus*]). Alewife has not been found in the vicinity of the Watts Bar plant, but other cluepids (gizzard shad) are prolific in the reservoir. In other cases, researchers identified a decline in water quality as the impetus for reduced emerald shiner populations (Short et al. 1998).

Bluegill appear to have increased in numerical importance through the preoperational period and the first 2 years following startup of WBN Unit 1. In 1975 to 1990, bluegill composed 10 percent of the population. The percentage of bluegill increased to 32.4 percent 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 in the vicinity of the WBN site. Between 1999 and 2007, the numerical importance of the bluegill has varied from a low of 5.9 percent of the population in 2004 to a high of 54 percent in 2007 below the dam. Above the dam, in Watts Bar Reservoir the numerical importance of bluegill remained about 30 percent starting with sampling year 2000.

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. The two locations are discussed separately in the following paragraphs.

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 conducted additional surveys in 1996 and 1997 after Unit 1 began operating (TVA 1998b; TVA 2010c). TVA conducted the third and most recent sampling study from April through June 2010 in the same sampling locations and using the same procedures as in 1996 and 1997, except that the 2010 samples were collected weekly instead of biweekly (TVA 2011d). The second and third studies are new information that was not reported 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.

In the first study, conducted between 1976 and 1979 and between 1982 and 1985, prior to the start of operations at WBN Unit 1, TVA (1998b, 2010d) reported that overall egg densities were low in the ichthyoplankton samples 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 varied from 31 in 1985 to 1,312 in 1983. During the preoperational surveys, the percentage of eggs that were freshwater drum (*Aplodinotus grunniens*) ranged from 13 percent (1983) to greater than 90 percent (1976, 1979, and 1982). The remainder of the eggs were unidentifiable. During the second set of studies, the surveys conducted in 1996 and 1997, after the start of operations for WBN Unit 1, the total number of fish eggs collected ranged from from 1,605 (1997) to 2,929 (1996) (TVA 1998b, 2010c). During these years it was reported that over 99 percent of the eggs were "mutilated and unidentifiable," (TVA 2011d). The small percentage of identifiable eggs were mostly freshwater drum eggs (TVA 1998b). Freshwater drum eggs also dominate samples commonly observed in other areas of the reservoir, such as near the Sequoyah Nuclear Plant (Baxter and Buchanan 2006).

During the first study, the preoperational surveys (TVA 1998b) that started in 1976, the number of fish larvae collected ranged from 2,565 (1979) to 34,086 (1977) larval fish. 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, the clupeids composed between 48 percent and 95 percent of the larvae. During the second study, operational monitoring of larval fish was conducted in 1996–1997. Researchers in 1996 and 1997 collected 4,929 and 9,851 larval fish, respectively, during the operational monitoring for WBN Unit 1 (TVA 1998b). The clupeid larvae (largely threadfin shad and gizzard shad) represented 82 and 86 percent of the individuals in the larval fish community during operational monitoring, for the years 1997 and 1996, respectively, followed by bass (*Morone* spp.) in 1997 and freshwater drum in 1996 and centrarchids (*Lepomis* spp.). TVA researchers took larval size into account 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 (1998b, 2010c) found 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.

TVA conducted a third sampling study from April through June 2010. TVA (2011d) collected 1,002 fish eggs. The composition of the eggs was centrarchids (*Lepomis* spp.) (55 percent), freshwater drum (38 percent), moronids (yellow or white bass) (4.3 percent), and clupeids (threadfin and gizzard shad) (2.7 percent). Because this sampling study obtained a larger number of intact eggs, the data provide a better understanding of the types of eggs in the vicinity of the WBN site. During larval ichthyoplankton sampling in April through June 2010 (TVA 2011d), TVA collected 6,249 larval fish. Members of the clupeid family again dominated the sample (64 percent), followed by centrarchids (17 percent), moronids (12.4 percent), and freshwater drums (5.1 percent). These data are within the range of that found during preoperational studies.

TVA also conducted three studies related to ichthyoplankton density in the Watts Bar Reservoir near the Watts Bar Dam. The first study (TVA 2009d) was conducted in 1975 when the SCCW system was used as the intake for the Watts Bar Fossil Plant. The second was conducted in the spring of 2000 after the start of operation of the SCCW system. The third was performed during May and August of 2010. The second and third studies are new information that was not reported 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 first sampling study 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 of 19 taxa 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 were obtained 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. 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 variation in the percentage of clupeid larvae are in line with the increased population size of adult bluegill in years 2001, as discussed previously.

The third study (TVA 2011e) also provides insight into the ichthyoplankton residing in the vicinity of the SCCW intake. The purpose of this study, performed during May and August 2010, was to describe the temporal and spatial distribution of fish eggs and larvae with respect to the thermal plume from the SCCW. This study also reported that clupeid larvae (includes threadfin and gizzard shad) dominated the samples above the Watts Bar Dam and in front of the SCCW intake and that centrarchid larvae (includes *Lepomis* larvae) were next in abundance. Very small numbers of eggs were found at either location, and very small numbers of larvae were found in the August samples.

Commercially, Recreationally, and Biologically Important Fish Species. 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). However, commercial fishing in the section of Chickamauga Reservoir near the site is practically nonexistent because current velocities make netting virtually impossible (TVA 2001). Although commercial fishing is allowed in Watts Bar Reservoir, very little actually occurs.

The most recent report on commercial fishing indicates that small numbers of paddlefish (*Polydoton spathula*) were harvested in the Chickamauga Reservoir. Only one paddlefish was reported in Watts Bar Reservoir in 2007 and none were reported in 2008. Commercial fishing summaries for 2008 and 2009 for both roe and non-roe harvest for Chickamauga Reservoir and for Watts Bar Reservoir are given in Table 2-15. Paddlefish were not observed in the sampling in the vicinity of Watts Bar as shown in Table 2-16. The majority of fish being 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*) (TWRA 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. Important recreational species for both reservoirs are shown in Table 2-17 for 2008 and 2009. 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*) (TWRA 2010).

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

Paddlefish	Chickamauga Reservoir			Watts Bar Reservoir		
	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: TWRA 2010
(a) To convert lb to kg multiply by 0.45 kg/lb.

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

Species	Common Name	Chickamauga Reservoir Total Weight (lbs)[a]		Watts Bar Reservoir Total Weight (lbs)[a]	
		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: TWRA 2010
(a) To convert lb to kilograms 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 plant or the Watts Bar Dam.

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

	Species	Common Name	Chickamauga 2007	Chickamauga 2008	Watts Bar 2007	Watts Bar 2008
Polyodontidae	*Polyodon spathula*	Paddlefish[(a)]	137	-	-	-
Amiidae	*Amia calva*	Bowfin[(a)]	-	-	1,016	-
Catostomidae	*Ictiobus* sp.	Buffalo	-	-	1,264	-
Centrarchidae	*Pomoxis nigromaculatus*	Black crappie	20,1365	114,294	69,540	79,619
	Pomoxis annularis	White crappie	54,654	31,070	76,057	85,065
	Pomoxis nigromaculatus	Blacknose crappie[(a)]	662	48	3588	1,380
	Lepomis macrochirus	Bluegill	573,417	490,803	191,921	189,472
	Lepomis microlophus	Redear sunfish	55,673	32,571	184	446
	Micropterus salmoides	Largemouth bass	238,006	223,018	167,471	253,243
	Micropterus dolomieu	Smallmouth bass	18,821	17,921	40,623	36,797
	Micropterus punctulatus	Spotted bass	72,874	69,585	38,260	58,155
	Lepomis gulosus	Warmouth	1,192	609	-	-
Clupeidae	*Alosa chrysochloris*	Skipjack herring	3,812	-	43,463	967
	Alosa pseudoharengus	Alewife[(a)]	185	-	-	-
Cyprinidae	*Cyprinus carpio*	Carp	92	-	183	-
	Carassius auratus	Goldfish[(a)]	-	-	586	-
	Notemigonus crysoleucas	Golden shiner	196	1,340	-	-
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
Esocidae	*Esox masquinongy x lucius*	Tiger muskie[(a)]	100	-	-	-
Lepisosteidae	*Lepisosteus osseus*	Longnose gar	-	92	-	-
Moronidae	*Morone saxatilis*	Striped bass	7,789	18,489	35,120	25,938
	Morone chrysops	White bass	52,626	93,407	153,788	323471
	Morone mississippiensis	Yellow bass	159,219	142,693	60,404	70,918
	Hybrid striped bass x white bass	Cherokee bass[(a)]	40	64	1,701	187
Percidae	*Sander canadensis*	Sauger	1,666	22,784	24,131	36,319
	Sander vitreus	Walleye	-	-	242	-
	Perca flavescens	Yellow perch	-	-	-	187
	Aplodinotus grunniens	Freshwater drum	36,095	65,696	21,438	27,141

Source: TWRA 2010

(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, 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. Bluegills are both a forage fish and a game fish. The young are prolific and provide prey for bass. Bluegills 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) report that bluegill select larger prey items when they are abundant but become less selective as the abundance of their favorite prey decreases. The population of bluegills can affect the largemouth bass population.

- Smallmouth buffalo (*Ictobius 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; Metee et al. 1996). Etnier and Starnes (1993) report that buffalo have a preference to spawn on submerged vegetation, although Metee et al. (1996) found active spawning occurring in the rapids below Lake Tuscaloosa Dam. 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 are territorial after spawning and will 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; Metee et al. 1996).

- Carp (*Cyprinius carpio*). The carp is 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, and plankton (Metee et al. 1996) as well as vascular plants and occasional small fish (Etnier and Starnes 1993). They are considered detrimental to the environment because they 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. 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 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 bluegills, redear sunfish, shad, minnows, crayfish, and amphibians (Metee 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 are schooling and avoid flowing water habitats more so than the white bass (Etnier and Starnes 1993). Spawning occurs in mid-water for both species, although the yellow bass migrate into large streams or tributaries to spawn. The eggs drift to the bottom and the larvae hatch in 2 to 3 days. Larvae of white bass in the Tennessee River drift downstream where they then appear to use low-velocity refugia or hug the bottom. Juveniles eat small invertebrates such as cladocerans, copepods, and midge larvae. Adults are aggressive predators and feed on threadfin and gizzard shad (Metee et al. 1996), as well as silversides 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; Metee et al. 1996)

- 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). 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 (SCCW 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 that is 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 (Metee 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. The fish synchronize their spawning time and spawn as a group activity. Ecologists think this is an important behavior for avoiding predators and rapidly building up populations that may have been depleted during the winter. Shad feed on plankton (Metee 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 (47°F) and death at 4 to 5°C (39°F), although death has been reported at as high as 12°C (55°F) (Etnier and Starnes 1993).

Non-Native Species. The introduction of non-native species has also affected the fish population in the Tennessee River. Non-native aquatic plant species and mollusks were discussed previously. 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 (*Menidia beryllina*), 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 to be 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 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. They were introduced into Tennessee and other states intentionally as a forage fish. The species has been found in parts of Chickamauga Reservoir where it has been identified as part of the commercial catch. In other reservoirs it is believed to 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.

The redbreast sunfish is native to the Atlantic slope drainages and has been introduced intentionally for sport fishing. Redbreast sunfish have been found in the vicinity of the WBN site. This species is believed to 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).

The inland silverside is native to coastal and freshwater habitats from Massachusetts to Mexico. In Tennessee it has invaded the Tennessee River system. The first individuals were collected in the Chickamauga Reservoir in 2004, although they were not seen in the electrofishing sampling data adjacent to Watts Bar until 2006. They were observed in data for Watts Bar

Reservoir electrofishing in 2005. The inland silverside completely replaced the 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). The inland silverside has been found in the vicinity of the WBN site.

The yellow perch has been introduced into many states, including Tennessee, from its 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. It was introduced in the late 1800s for food and sport fishing. Yellow perch are known to compete for food resources with trout but conversely, they have been 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

Table 2-18 shows Federally and State-listed aquatic species that may occur near the WBN site.

State-Listed Species

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

Flame Chub (*Hemitremia flammea*)

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, b). As a result, this SFES will not consider the flame chub further.

Tangerine Darter (*Percina aurantiaca*)

The tangerine darter, one of the larger Tennessee darters, reaches a length of 17.15 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, b), the tangerine darter is not discussed further in this SFES.

Table 2-18. Federally and State-Listed Aquatic Species in Rhea County, 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 cooperianuss	Orange pimpleback	Endangered	Endangered
Pleurobema plenum	Rough pigtoe	Endangered	Endangered
Plethobasus cyphyus	Sheepnose mussel		Proposed
	Fish		
Erimonax monachus	Spotfin chub	Threatened	Threatened
Hemitremia flammea	Flame chub	Deemed in need of management	-
Percina aurantiaca	Tangerine darter	Deemed in need of management	-
Phoxinus saylori	Laurel dace	Endangered	Candidate
Phoxinus tennesseensis	Tennessee dace	Deemed in need of management	-
Percina tanasi	Snail darter	Threatened (Meigs County)	Threatened (Rhea County)
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: U.S. Department of Interior 2009 and TVA 2009b.

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 and is not known to exist in the mainstem of the Tennessee River. As a result, it is not discussed further in this SFES.

<u>Laurel Dace (*Phoxinus saylori*)</u>

The laurel dace is a minnow known from only three independent systems on the Walden Ridge section of the Cumberland Plateau: Soddy Creek, Sale Creek, and Piney River. Although the dace originates in the Tennessee watershed, it is not found in the mainstem of the river and thus would not be affected by WBN Unit 2. In addition it has not been observed in the occurrence data in the vicinity of the site (FWS 2007). Therefore, it is not further discussed in this SFES.

<u>Highfin Carpsucker (*Carpiodes velifer*)</u>

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. 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 further discussed in this SFES.

<u>Eastern Hellbender (*Cryptobranchus alleganiensis alleganiensis*)</u>

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 a riffle area 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. In addition, on January 19, 2011, the FWS proposed listing of the sheepnose mussel (*Plethobasus cyphyus*) as endangered (76 FR 3392). 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 generally considered 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) (TVA 1998a). However, the occurrence data 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, low turbidity, high to moderate gradient streams. 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 in recent studies, 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 (TVA 1998b) or in the survey conducted in 2010 (TVA 2011c). 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(TVA 1998a).

Pink Mucket Mussel (*Lampsilis abrupta*)

The FWS designated the pink mucket mussel as endangered in 1976 (41 FR 24062). Historically, this species was found in the entire reach of the Tennessee River across northern Alabama. Currently, it occurs only in the riverine reaches downstream of Wilson Dam in Tennessee and Guntersville Dam in Alabama. However, FWS considers the species to be 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. A single individual was found at middle site (TRM 526 to 527) in the September 2010 survey (TVA 2011c).

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). TVA has not found the orangefoot pimpleback near the WBN site during any of the mussel surveys conducted from 1983 to 2010 (TVA 1998a, 2011c). 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.

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 (NatureServe 2009d). 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 (TVA 1998a). The rough pigtoe mussel was not observed during the samples conducted in the vicinity of the WBN site in 2010 (TVA 2011c).

Sheepnose Mussel (*Plethobasus cyphyus*)

The FWS does not currently list the sheepnose mussel as endangered, but it was proposed for listing on January 19, 2011 (76 FR 3392). It is found across the Southeast and the Midwest, but has been eliminated from two-thirds of streams where it had been known to occur. The sauger is the only known host for the sheepnose mussel (FWS 2011). 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 (TVA 1998a). In September 2010, TVA found a specimen, judged to be approximately 20 years old, during sampling in the middle bed (TRM 526 to 527) (TVA 2011c).

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 further considered 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 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. No State of Tennessee designated natural areas are located in the vicinity of the WBN site. 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 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	121,622	0.01	62,876	0.02
Bradley	22	96,644	0.02	46,688	0.05
Hamilton	106	332,848	0.03	162,400	0.07
Knox	88	431,072	0.02	226,238	0.04
Loudon	38	46,445	0.08	23,274	0.16
McMinn	88	52,511	0.17	23,236	0.38
Meigs	40	11,790	0.34	5,140	0.78
Monroe	29	45,670	0.06	18,639	0.16
Rhea	155	30,781	0.50	13,101	1.18
Roane	53	53,430	0.10	27,405	0.19
Other	67				

Source: TVA 2010b; USBLS 2008;, USCB 2008a, b, c, d.

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 2008. These patterns are similar to overall population trends in the State of Tennessee (USCB 2008a, b, c, d). 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 2030 (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 2030, the population in Meigs County is projected to increase at a rate greater than neighboring Rhea, McMinn, and Roane counties.

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	24.55	4,591,120	17.0
1990	24,344	0.4	8,033	8.1	42,383	1.2	47,227	-2.47	4,877,185	6.2
2000	28,400	16.7	11,086	38.0	49,015	15.6	51,910	9.92	5,689,283	16.7
2008	***30,781***	***8.4***	***11,790***	***6.4***	***52,511***	***7.1***	***53,430***	***2.93***	***6,214,888***	***9.2***
2010	30,852	--	11,798	--	52,729	--	53,550	--	6,229,564	--
2020	33,862	9.8	12,680	7.5	57,607	9.3	56,776	6.02	6,860,231	10.1
2030	36,670	8.3	15,126	19.3	60,827	5.6	56,604	-0.30	7,397,302	7.8

Source: Years 1970-2008 (USCB 2008a, b, c, d); Years 2010-2030 forecasted by TACIR (2010)
-- = No data available.
(a) Percent growth rate is calculated as total growth over the previous period (in decades from 1970-2000; 2010-2030).

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 2008a, b, c, d). The 2000 and 2008 (estimate) demographic profiles of the four-county ROI population are presented in Table 2-21 and Table 2-22.

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

	McMinn	**Meigs**	**Rhea**	**Roane**
Population	49,015	11,086	28,400	51,910
Race (% of total population)				
White	92.7	97.7	95.4	95.2
Black or African American	4.5	1.2	2.0	2.7
American Indian and Alaska Native	0.3	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	0.7	0.1	0.8	0.2
Two or more races	1.1	0.6	1.1	1.2
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 2008

	McMinn	Meigs	Rhea	Roane
Population (2008 State estimate)	52,511	11,790	30,781	53,430
Race (% of total population)				
White	93.4	97.0	95.7	95.2
Black or African American	4.4	2.0	2.4	2.8
American Indian and Alaska Native	0.3	0.2	0.4	0.2
Asian	0.8	0.2	0.3	0.5
Native Hawaiian and Other Pacific Islander	0.0	0.0	0.0	0.0
Some other race	0.4	0.1	1.2	0.3
Two or more races	1.1	0.6	1.1	1.3
Ethnicity				
Hispanic or Latino (of any race)	1,317	125	875	475
% of total population	2.5	1.1	2.8	0.9
Minority Population (including Hispanic or Latino ethnicity)				
Total minority population	4,656	461	2,116	3,040
% minority	8.9	3.9	6.9	5.7

Source: USCB 2008a, 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 2008

	McMinn County	Meigs County	Rhea County	Roane County
Total housing units	22,530	5,188	13,580	24,402
Occupied units	20,503	4,304	11,718	21,318
Owner occupied	14,879	3,526	8,600	17,047
Renter occupied	5,624	778	3,118	4,271
Vacant units	2,027	884	1,862	3,084
Median value of house	$80,300	$87,200	$76,700	$86,500

Sources: USCB 2008a, 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). Some upgrades and expansions of regional systems are planned, including an expansion of water lines in the Spring City and Watts Bar District and a upgrade and expansion of the Dayton water treatment plant, supported in part by grants from State of Tennessee (STDD 2008).

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: (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: (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 2009e). The high school, one middle school, and three 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 2009c). 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 8,400 students enrolled, and Roane County School District has 18 schools with approximately 7,500 students enrolled (NCES 2009d, f).

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 of 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 of 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 unemployment rates for 2009 and median incomes and percentage of individuals below the poverty line for 2008. Table 2-27 contains county employment by proprietorship and industry (2007) 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

	Labor Force[(a)]	Unemployment Rate (%)	Median Household Income	Below Poverty (%)
McMinn County	24,101	13.9	37,052	18.9
Meigs County	4,944	14.4	29,354	14.5
Rhea County	13,101	14.2	30,418	18.6
Roane County	27,405	8.8	33,226	13.9
Tennessee	3,000,242	10.8	43,662	15.7

Sources: USCB 2008a, b, c, d; USBLS 2008.
(a) Labor Force and Unemployment Rates estimated from February 2009 through March 2010.

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

Industry	McMinn County	Meigs County	Rhea County	Roane County
Total employment	27,408	6,164	14,884	22,245
Wage and salary employment	19,887	1,832	11,671	19,858
Proprietors employment	7,521	4,332	3,213	2,387
Nonfarm proprietor employment	6,394	3,974	2,781	1,819
Farm proprietor employment	1,127	358	432	568
By Industry				
Farm employment	1,246	380	479	604
Construction	2,020	1,093	927	826
Manufacturing	6,479	701	4,377	1,601
Transportation and public utilities	1,001	(D)	347	(D)
Retail trade	3,183	476	1,359	2,162
Finance, insurance, and real estate	849	(D)	259	808
Services	4,666	928	2,455	4,112
Government and government enterprises	2,780	493	2,434	4,203

Source: USBEA 2007
D = Not shown to avoid disclosure of confidential information, but the estimates for this item are included in the totals.

The U.S. Census Bureau reported that in March 2010, unemployment rates in the relatively more rural counties of McMinn, Meigs, and Rhea were slightly higher than the state average, while unemployment rates in nearby Roane County were slightly below the state average. In 2008 the highest estimated rates of poverty were reported in McMinn and Rhea counties, while Meigs County had the lowest median income.

Table 2-27 contains county employment by proprietorship and industry (2007) 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).

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:

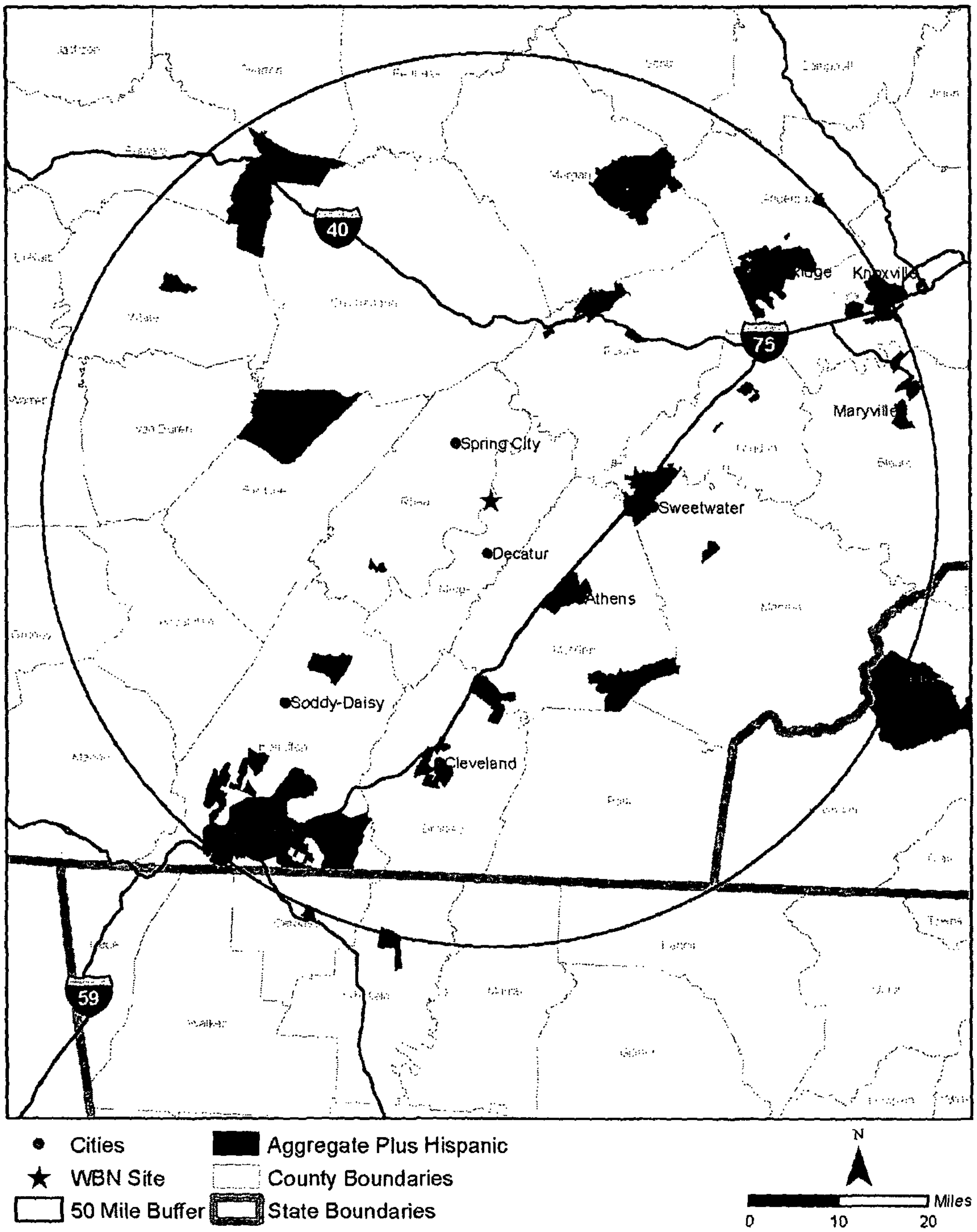
- Minority. Individual(s) who are members of the following population groups: American Indian or Alaskan Native; Asian or Pacific Islander; Black, not of Hispanic origin; or Hispanic.
- Minority populations. Minority populations are identified when (1) the minority population of an affected area exceeds 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 7 percent of the population identified themselves as minorities, with Hispanic or Latino being the largest minority group (2.8 percent) followed by Black or African American (2.4 percent) (USCB 2008c).[a]

Within the 80-km (50-mi) region of the site, approximately 11 percent of the population identified themselves as minority. Approximately 206 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 11 percent of the total population (see Figure 2-8). Of these 206 block groups, 70 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 54 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), Athens (McMinn County), Cleveland (Bradley County), and the City of Chattanooga (Hamilton County). Some more rural concentrations are located in Knox County, Tennessee, and Whitfield County, Georgia. No block groups with high density minority populations were found in Rhea or Meigs County (USCB 2000).

(a) Although many results from the 2010 Census have been released, at the time of the writing of this SFES, a complete set of detailed demographic data by county and block group was not yet available.



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

Figure 2-8. Minority Block Groups (11 percent or more of population) in 2000 Within an 80-km (50-mi) Radius of WBN Unit 2 (USCB 2000)

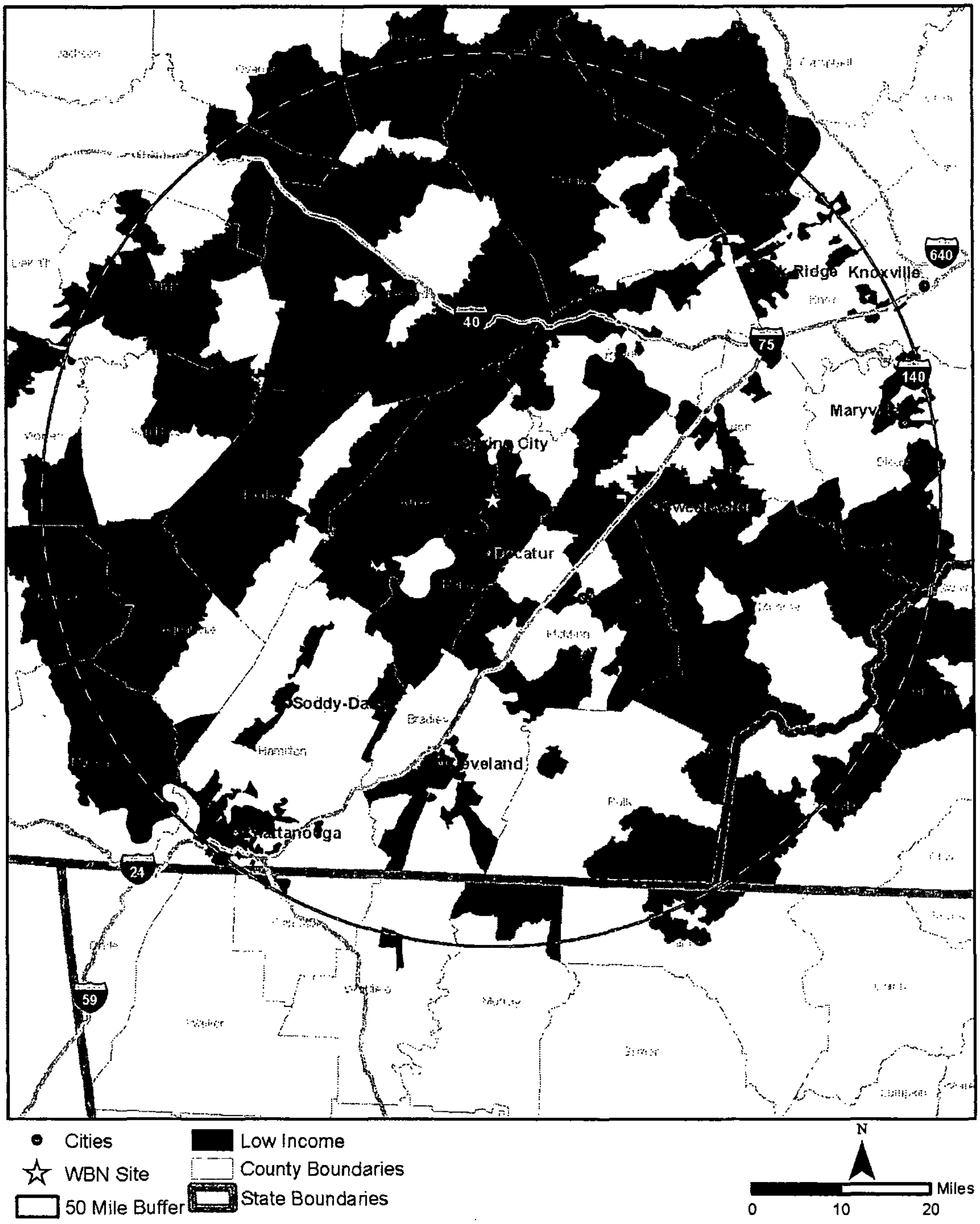
2.4.3.2 Low-Income Populations

According to 2000 census data, approximately 12 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 371 census block groups within the 80-km (50-mi) region of the WBN site (see Figure 2-9) with low-income populations of 12 percent or more (USCB 2000).

According to census data estimates, the median household income for Tennessee in 2008 was $43,662, with 16 percent of the state population living in households below the Federal poverty threshold in 2008 (USCB 2009). Rhea County had a lower median household income average ($37,965) and a higher percentage (17.7) 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 (12 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 2000 Census data, 38 block groups exceeded the 80-km (50-mi) average (12 percent) by 20 percent or more, while only 3 block groups had low-income populations of 50 percent or more. These block groups are distributed throughout the 80-km (50-mi) radius in relatively rural areas of Scott, Morgan, Cumberland, Grundy, Roane, and Knox counties. In addition, some low-income concentrations are found near the town centers of Oak Ridge (Anderson County), Athens (McMinn County), Cleveland (Bradley County), and the City of Chattanooga (Hamilton County). No high-density low-income block groups were found in Rhea and Meigs counties (USCB 2000).

(a) The USCB weighted average Federal Poverty threshold for a family of four was $17,603 (annual) in the year 2000 and $22,025 in 2008 (USCB 2009e, "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 2-9. Low-Income Block Groups (12 percent or more of population) in 2000 Within an 80-km (50-mi) Radius of WBN Unit 2 (USCB 2000)

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 B.C. The record indicates prehistoric occupation of the area was as follows: Paleo-Indian (12,000 to 8000 B.C.), Archaic (8000 to 1200 B.C.), Woodland (1200 B.C. to 1000 A.D.), and Mississippian (1000 to 1500 A.D.) (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 Dennings1984).

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 Watts Bar Nuclear Plant, Units 1 and 2 (NUREG-0498, Supplement No. 1, NRC 1995 and NUREG-0498, NRC 1978).
- The TVA ER – Tennessee Valley Authority (TVA 2008a).
- The TVA Supplemental Environmental Review for Operation of Watts Bar Nuclear Plant (June 1995).
- Tennessee Valley Authority (TVA). 2009. *Final Environmental Impact Statement: Watts Bar Reservoir Land Management Plan for Loudon, Meigs, Rhea, and Roane Counties, Tennessee.* Knoxville, Tennessee (TVA 2009a).
- The NRC Environmental Trip – On October 6 and 7, 2009, the NRC staff conducted an on-the-ground visit at the WBN plant that consisted of an environmental records review.
- NRC meeting with the Tennessee State Historic Preservation Office/Officer (SHPO) – NRC staff met with the Tennessee SHPO to discuss the proposed action and any concerns related to historic and cultural resources on October 8, 2009.
- 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 2006c).

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, TVA's preference is to avoid ground-disturbing activity in this area (TVA 2006c).

TVA did not identify any historic structures in the APE for this operating licensing action. The Watts Bar Fossil Plant located adjacent to the APE is considered eligible for listing in the National Register of Historic Places (PNNL 2009).

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. 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 is in the process of consulting with the Eastern Band of Cherokee Indians regarding the WBN Unit 2 operating license action.

2.6 Radiological Environment

Between December 1976 and December 1995, TVA conducted a pre-operational 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 2003). 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, 2006b, 2007b, 2008b, 2009c, 2010d, 2011b). The staff reviewed historical REMP data from these reports for a 9-year period (2002 through 2010), (TVA 2003b, 2004c, 2005c, 2006d, 2007c, 2008c, 2009e, 2010e, 2011a). Nine years 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, 2003b, 2004b, 2004c, 2005b, 2005c, 2006b, 2006d, 2007b, 2007c, 2008b, 2008c, 2009c, 2009e, 2010d, 2011b). 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 2003a, b; 2004b, c; 2005b, c; 2006b, d; 2007b, c; 2008b, c; 2009c, e; 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 Quality 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 2008). 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°C, 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 waterborne 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, 2007c, 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, c; 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, as well as with operation of the Watts Bar Fossil Plant and Dam. 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 TVA's own 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).

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).

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.

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 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 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 2009f). These data form the basis of the staff's evaluation of current local meteorological conditions. In addition, the staff reviewed climatological records for Chattanooga and Knoxville for indications of potential regional changes in climate. The 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 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 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 staff does not consider the changes in either wind direction or atmospheric stability to be significant.

In summary, the 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 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 staff estimated realistic (50 percentile) dispersion estimates using meteorological data for 2004 through 2008 provided by TVA (TVA 2009f) 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 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 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 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 environmental report 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, Watts Bar Fossil Plant, TVA Central Maintenance Facility, and Watts Bar Resort Area (TVA 2009b). The dam lies 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. The fossil plant currently is not operating, but could be reactivated in the future. Residents and visitors to the area use the reservoir for boating, fishing, swimming, camping, and other outdoor activities (TVA 2009b, d; NRC 1995).

TVA also owns and operates the Sequoyah Power Plant, which is located approximately 50 km (31 mi) south-southwest of WBN (TVA 2009b). 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 environmental impact statement. During the course of preparing this SFES, NRC consulted with TVA and the FWS. Contact correspondence is included in Appendix C.

2.10 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."

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

50 CFR Part 17. Code of Federal Regulations, Title 50, *Endangered and Threatened Wildlife and Plants*, Part 17, "Wildlife and Fisheries."

41 FR 17736. April 28, 1976. "Determination that Two Species of Butterflies are Threatened Species and Two Species of Mammals are Endangered Species; 41 FR 17742 17747 (Schaus swallowtail; Bahama swallowtail; Mexican wolf, *Canis lupus baileyi*; gray bat, *Myotis grisescens*)." *Federal Register.* U.S. Department of the Interior.

41 FR 24062. June 14, 1976. "Endangered Status for 159 Taxa of Animals." *Federal Register.* U.S. Department of the Interior.

55 FR 25591. June 21, 1990. "Endangered and Threatened Wildlife and Plants; Designation of the Freshwater Mussel, the Fanshell as an Endangered Species." *Federal Register.* U.S. Department of the Interior.

59 FR 7629. February 16, 1994. "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, Executive Order 12898." *Federal Register.* Office of the President.

60 FR 6381. February 1, 1995. "Amendment to Executive Order No. 12898." *Federal Register.* Office of the President.

67 FR 1662. January 14, 2002. "Endangered and Threatened Wildlife and Plants; Reclassification of *Scutellaria montant* (Large-Flowered Skullcap) from Endangered to Threatened." *Federal Register.* U.S. Department of the Interior.

69 FR 52040. August 24, 2004. "Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions." *Federal Register.* U.S. Nuclear Regulatory Commission.

72 FR 37346. July 9, 2007. "Endangered and Threatened Wildlife and Plants; Removing the Bald Eagle in the Lower 48 States from the List of Endangered and Threatened Wildlife." *Federal Register.* U.S. Department of Interior.

74 FR 31972. July 6, 2009. "Endangered and Threatened Wildlife and Plants; 5-Year Status Reviews of 23 Southeastern Species." *Federal Register.* U.S. Department of the Interior.

76 FR 3392. January 19, 2011. "Endangered and Threatened Wildlife and Plants; Endangered Status for the Sheepnose and Spectaclecase Mussels. Proposed Rule." *Federal Register.* U.S. Department of the Interior.

Advisory Group on Non-Ionising Radiation (AGNIR). 2006. *Power Frequency Electromagnetic Fields, Melatonin and Risk of Breast Cancer: Report of an Independent Advisory Group on Non-Ionising Radiation.* Documents of the Health Protection Agency, Series B: Radiation, Chemical and Environmental Hazards, RCE-1, Health Protection Agency, Didcot, United Kingdom.

Agency for Toxic Substances and Disease Registry (ATSDR). 1996. *Health Consultation – Lower Watts Bar Reservoir Operable Unit US DOE Oak Ridge Reservation, Oak Ridge, Tennessee.* Atlanta, Georgia. Available at http://www.atsdr.cdc.gov/hac/pha/pha.asp?docid=1361&pg=0.

Aserkoff, B.S., A. Schroeder, and P.S. Brachman. 1970. "Salmonellosis in the U.S.- A Five Year Review." *American Journal of Epidemiology* 92:13-24. Atwood, T.C., H.P. Weeks, and T.M. Gehring. 2004. "Spatial Ecology of Coyotes Along a Suburban-to-Rural Gradient." *Journal of Wildlife Management* 68(4):1000-1009.

Bald and Golden Eagle Protection Act of 1940. 16 USC 688-668c.

Baxter D.C. and J.P. Buchanan. 2006. *Entrainment Monitoring at Sequoyah Nuclear Plant 2004.* Tennessee Valley Authority. Accession No. ML063210325

Baxter, D.S., K.D. Gardner, and G.D. Hickman. 2001. *Watts Bar Nuclear Plant Supplemental Condenser Cooling Water System Fish Monitoring Program.* Tennessee Valley Authority, Nashville, Tennessee. Accession No. ML073510313

Bohac, C.E. and M.J. McCall. 2008. *Water Use in the Tennessee Valley for 2005 and Projected Use in 2030.* Tennessee Valley Authority prepared in cooperation with the U.S. Geological Survey. Accessed March 4, 2011 at www.tva.gov/river/watersupply/watersupply_report_to_2030.pdf

Brady, J., T. Kunz, M.D. Tuttle, and D. Wilson. 1982. *Gray Bat Recovery Plan.* Fish and Wildlife Reference Service, Denver, Colorado. Accessed March 4, 2011 at http:/www.fws.gov/Asheville/htmls/listedspecies/gray_bat.html.

Cadenasso, M.L. and S.T.A. Pickett. 2000. "Linking Forest Edge Structure to Edge Function: Mediation of Herbivore Damage." *Journal of Ecology* 88:31-44.

Calabrese, F.A. 1976. *Excavations at 40RH6, Watts Bar Area, Rhea County, Tennessee.* University of Tennessee at Chattanooga. Tennessee Valley Authority, Knoxville, Tennessee. Available at http://larc.tn.gov:8080/?config=tslaysm#section=resource&resourceid=47667&currentIndex=0&tab=detailViewDescriptionTab. Accession No. ML073510357.

Centers for Disease Control and Prevention (CDC). 1997. "Summary of Notifiable Diseases, United States 1996." Morbidity and Mortality Weekly Report, Vol. 45, No. 53. October 31, 1997. Atlanta, Georgia.

Centers for Disease Control and Prevention (CDC). 1998a. "Summary of Notifiable Diseases, United States 1997." Morbidity and Mortality Weekly Report, Vol. 46, No. 54. November 20, 1998. Atlanta, Georgia.

Centers for Disease Control and Prevention (CDC). 1998b. "Surveillance for Waterborne-Disease Outbreaks — United States, 1995–1996." Morbidity and Mortality Weekly Report, Vol. 47 (SS-5). December 11, 1998. Atlanta, Georgia.

Centers for Disease Control and Prevention (CDC). 1999. " Summary of Notifiable Diseases, United States 1998." Morbidity and Mortality Weekly Report, Vol. 47, No. 53. December 31, 1999. Atlanta, Georgia.

Centers for Disease Control and Prevention (CDC). 2000. "Surveillance for Waterborne-Disease Outbreaks — United States, 1997–1998." Morbidity and Mortality Weekly Report, Vol. 49 (SS04). May 26, 2000. Atlanta, Georgia.

Centers for Disease Control and Prevention (CDC). 2001. "Summary of Notifiable Diseases, United States 1999." Morbidity and Mortality Weekly Report, Vol. 48, No. 53. April 6, 2001. Atlanta, Georgia.

Centers for Disease Control and Prevention (CDC). 2002a. "Summary of Notifiable Diseases — United States, 2000." Morbidity and Mortality Weekly Report, Vol. 49, No. 53. June 14, 2002. Atlanta, Georgia.

Centers for Disease Control and Prevention (CDC). 2002b. "Surveillance for Waterborne-Disease Outbreaks — United States, 1999–2000. Morbidity and Mortality Weekly Report, Vol. 51, No. SS-8." November 22, 2002. Atlanta, Georgia.

Centers for Disease Control and Prevention (CDC). 2003. "Summary of Notifiable Diseases — United States, 2001." Morbidity and Mortality Weekly Report, Vol. 50, No. 53. May 2, 2003. Atlanta, Georgia.

Centers for Disease Control and Prevention (CDC). 2004a. "Summary of Notifiable Diseases — United States, 2002." Morbidity and Mortality Weekly Report, Vol. 51, No. 53. April 30, 2004. Atlanta, Georgia.

Centers for Disease Control and Prevention (CDC). 2004b. "Surveillance for Waterborne Disease and Outbreaks Associated with Recreational Water — United States, 2001–2002; and Surveillance for Waterborne Disease and Outbreaks Associated with Drinking Water and Water not Intended for Drinking — United States, 2001–2002." Morbidity and Mortality Weekly Report, Vol. 53, No. SS-8. October 22, 2004. Atlanta, Georgia.

Centers for Disease Control and Prevention (CDC). 2005. "Summary of Notifiable Diseases — United States, 2003." Morbidity and Mortality Weekly Report, Vol. 52, No. 54. April 22, 2005. Atlanta, Georgia.

Centers for Disease Control and Prevention (CDC). 2006a. "Summary of Notifiable Diseases — United States, 2004." Morbidity and Mortality Weekly Report, Vol. 53, No. 53. June 16, 2006. Atlanta, Georgia.

Centers for Disease Control and Prevention (CDC). 2006b. "Surveillance for Waterborne Disease and Outbreaks Associated with Recreational Water — United States, 2003–2004; and Surveillance for Waterborne Disease and Outbreaks Associated with Drinking Water and Water not Intended for Drinking — United States, 2003–2004." Morbidity and Mortality Weekly Report, Vol. 55, No. SS-12. December 22, 2006. Atlanta, Georgia.

Centers for Disease Control and Prevention (CDC). 2007. "Summary of Notifiable Diseases — United States, 2005." Morbidity and Mortality Weekly Report, Vol. 54, No. 53. March 30, 2007. Atlanta, Georgia.

Centers for Disease Control and Prevention (CDC). 2008a. "Patient Facts: Learn More about Legionnaires' Disease." Accessed June 1, 2010 at http://www.cdc.gov/legionella/patient_facts.htm

Centers for Disease Control and Prevention (CDC). 2008b. "Salmonellosis". Accessed June 1, 2010 at: http://www.cdc.gov/nczved/divisions/dfbmd/diseases/salmonellosis/

Centers for Disease Control and Prevention (CDC). 2008c. "Surveillance for Waterborne Disease and Outbreaks Associated with Recreational Use and Other Aquatic Facility-Associated Health Events — United States, 2005–2006; and Surveillance for Waterborne Disease and Outbreaks Associated with Drinking Water and Water not Intended for Drinking — United States, 2005–2006." Morbidity and Mortality Weekly Report, Vol. 57, No. SS-9. September 12, 2008. Atlanta, Georgia.

Centers for Disease Control and Prevention (CDC). 2008d. "Summary of Notifiable Diseases — United States, 2006." Morbidity and Mortality Weekly Report, Vol. 55, No. 53. March 21, 2008. Atlanta, Georgia.

Council on Environmental Quality (CEQ). 1997. *Environmental Justice Guidance Under the National Environmental Policy Act.* December 10, 1997. Executive Office of the President, Washington, D.C.

Crowder, L.B. 1980. "Alewife, rainbow smelt and native fishes in Lake Michigan: competition or predation?" *Environmental Biology of Fishes* 5(3):225-233.

Downing, J.A, Y. Rochon, M Perusse, H. Harvey. 1993. "*Spatial Aggregation, Body Size, and Reproductive Success in the Freshwater Mussel* Elliptio complanata."*Journal of the North American Benthological Society.*12(2):148-156.

Dunning, J.B. 2006. "Bachman's Sparrow (*Aimophila aestivalis*)." The Birds of North America Online. A. Poole, Ed. Cornell Laboratory of Ornithology.

Eastern Band of Cherokee Indians. 2009. Letter from the Tyler Howe (Tribal Historical Preservation Specialist, Eastern Band of Cherokee Indians) to the U.S. Nuclear Regulatory Commission dated September 29, 2009, "Comments Concerning the Watts Bar Nuclear Plant Unit 2 Operating License Application Environmental Review." Cherokee, North Carolina. Accession No. ML092860591.

Endangered Species Act. 16 USC 1531 et seq.

Electric Power Research Institute (EPRI). 2007. *Ground Water Protection Guidelines for Nuclear Power Plants.* EPRI TR-1015118. Palo Alto, California. Accessed March 4 2011 at mydocs.epri.com/docs/public/000000000001016099.pdf.

Etnier, D.A., WC Starnes and BH Bauer. 1979. "Whatever Happened to the Silvery Minnow (*Hybognathus nuchalis*) in the Tennessee River?" *Southeastern Fishes Council Proceedings* 2(3).

Etnier, D.A. and W.C. Starnes. 1993. *The Fishes of Tennessee.* University of Tennessee Press. Knoxville, Tennessee.

Frey, S.N. and M.R. Conover. 2006. "Habitat Use by Meso-Predators in a Corridor Environment." *The Journal of Wildlife Management* 70(4):1111-1118

Harvey, M.J. and E.R. Britzke. 2002. *Distribution and Status of Endangered Bats in Tennessee.* Final Report Prepared for the Tennessee Wildlife Resources Agency.

Garrow, P.H., R.J. Frymnan, and J.L. Holland. 1992. *Phase 1 Investigations at the Watts Bar Dam and Lock, Meigs County.* Tennessee, Garrow & Associates, Atlanta, Georgia. Not for public disclosure per Section 304 of the National Historic Preservation Act. Accession No. ML101180044.

Golden, J., R.P. Ouellette, S.Saari, and P.N. Cheremisinoff. 1980. *Environmental Impact Data Book.* Ann Arbor Science Publishers, Ann Arbor, Michigan.

Hevel, K.W. and G.D. Hickman. 1991. *Population Survey of Sauger in Chickamauga Reservoir 1990-1991.* Tennessee Valley Authority. Accession No. ML073510353.

Hutson, S.S., M.C. Koroa, and C.M. Murphree. 2004. *Estimated Use of Water in the Tennessee River Watershed in 2000 and Projections of Water Use to 2030.* Water-Resources Investigations Report 03-4302. U.S. Geological Survey and Tennessee Valley Authority, Nashville, Tennessee.

Jirka, K.J. and R.J. Neves. 1992. "Reproductive Biology of Four Species of Freshwater Mussels (Mollusca: Unionidae) in the New River, Virginia and West Virginia." *Journal of Freshwater Ecology* 7(1):35-44.

Johnson, L.R. and J.K. Dennings. 1984. *The Watts Bar Reservoir Area: It's Enigmatic History*, Clio Research Company, Knoxville, Tennessee.

Joklik, W.K. and D.T. Smith. 1972. *Zinsser Microbiology.* Appleton-Century-Croft, New York, N.Y.

Joklik, W. K, and H.P. Willet. 1976. *Zinsser Microbiology*, 16th ed. Appleton-Century-Croft, New York, N.Y.

Lake, R., A. Hudson, and P. Cressey. 2002. *Risk Profile: Salmonella (Non Typhoid) in Poultry (Whole and Pieces).* Institute of Environmental Science & Research Limited, Christchurch Science Centre, Christchurch, New Zealand. Accession No. ML042790521

McCoy, J.W. 1980. *Microbiology of Cooling Water.* Chemical Publishing Company, New York, N.Y.

Mayasich, J., D. Grandmaison, and C. Philips. 2003. *Eastern Hellbender Status Assessment Report.* NRR/TR-2003/09. U.S. Fish and Wildlife Service.

Mettee, M.F., P.E. O'Neil and J.M. Pierson. 1996. *Fishes of Alabama and the Mobile Basin.* Oxmoor House, Inc., Birmingham, Alabama.

Mirarchi, R., J. Garner, M. Mettee, and P. O'Neil, eds. 2004. *Alabama Wildlife, Volume 2, Imperiled Aquatic Mollusks and Fishes.* University of Alabama Press,Tuscaloosa, Alabama.

National Center for Educational Statistics (NACE). 2009a. "Hamilton County School District." *Search for Public Schools.* Accessed September 29, 2009 at http://nces.ed.gov/ccd/schoolsearch/index.asp.

National Center for Educational Statistics (NACE). 2009b. "Louden County School District." *Search for Public Schools.* Accessed September 29, 2009 at http://nces.ed.gov/ccd/schoolsearch/index.asp.

National Center for Educational Statistics (NACE). 2009c. "Meigs County School District." *Search for Public Schools.* Accessed September 29, 2009 at http://nces.ed.gov/ccd/schoolsearch/index.asp.

National Center for Educational Statistics (NACE). 2009d. "McMinn County School District." *Search for Public Schools.* Accessed September 29, 2009 at http://nces.ed.gov/ccd/schoolsearch/index.asp.

National Center for Educational Statistics (NACE). 2009e. "Rhea County School District." *Search for Public Schools.* Accessed September 29, 2009 at http://nces.ed.gov/ccd/schoolsearch/index.asp.

National Center for Educational Statistics (NACE). 2009f. "Roane County School District." *Search for Public Schools.* Accessed September 29, 2009 at http://nces.ed.gov/ccd/schoolsearch/index.asp.

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

National Historic Preservation Act of 1969 (NHPA), as amended. 42 USC 4321, et seq.

National Institute of Environmental Health Sciences (NIEHS). 1999. *NIEHS Report on Health Effects from Exposure to Power-Line Frequency Electric and Magnetic Fields.* NIH Publication No. 99-4493, Research Triangle Park, North Carolina.

NatureServe. 2009a. "*Sylvilagus Floridanus.*" NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. Arlington, Virginia. Available at http://www.natureserve.org/explorer.

NatureServe. 2009b. "*Didelphis virginiana.*" NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. Arlington, Virginia. Available at http://www.natureserve.org/explorer.

NatureServe. 2009c. "*Procyon lotor.*" NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. Arlington, Virginia. Available at http://www.natureserve.org/explorer.

NatureServe. 2009f. "*Pleurobema plenum* (Updated Oct 2009). " NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. Arlington, Virginia. Available at http://www.natureserve.org/explorer.

Neves, R. J., and P. L. Angermeier. 1990. "Habitat alteration and its effects on native fishes in the upper Tennessee River system, east-central U.S.A." *Journal of Fish Biology* 37:45–52.

New Jersey Division of Fish and Wildlife. 2009. *Status Assessment of the Northern Pine Snake (*Pituophis m. melanoleucus*) in New Jersey: An Evaluation of Trends and Threats.* New Jersey Department of Environmental Protection. Trenton, New Jersey. Accessed March 4, 2011 at http://www.state.nj.us/dep/fgw/ensp/literature.htm

Nuclear Energy Institute (NEI). 2007. *NEI 07-07, Industry Ground Water Protection Initiative - Final Guidance Document.* Washington, D.C.

Pacific Northwest National Laboratory. 2009. Letter from JA Stegen (Pacific Northwest National Laboratory) to U.S. Nuclear Regulatory Commission dated November 12, 2009. "Final Watts Bar Site Audit Trip Report for JCN J-4261, 'Technical Assistance for Operating License Environmental Review – Watts Bar Unit 2 Reactivation.'" Accession No. ML100220022.

Parmalee, P.W., W.E. Klippel, and A.E. Bogan. 1982. "Aboriginal and Modern Freshwater Mussel Assemblages (Pelecypoda: Unionidae) from the Chickamauga Reservoir, Tennessee." *Brimleyana* 8:75–90.

Parmalee, P.W. and A.E. Bogan. 1998. *Freshwater Mussels of Tennessee.* University of Tennessee Press, Knoxville, Tennessee.

Ramsdell Jr., J.V. and J.P. Rishel. 2007. *Tornado Climatology of the Contiguous United States.* NUREG/CR-4461, Rev. 2, Washington, D.C. Accession No. ML070810400.

Rhea County. 2009. "Welcome to Rhea County Tennessee, Government." Available at http://www.rheacountyetc.com/government.php

Rhea County Schools. 2009. Phone call from Katherine Cort (Pacific Northwest National Laboratory) to Jerry Levengood (Superintendent of Rhea County School System) on November 2, 2009, "Re: Bar Nuclear Plant Impact on Regional School System. " Accession No. ML101520416.

Sagendorf, J. F., J. T. Goll, and W. F. Sandusky. 1982. *XOQDOQ: Computer Program for the Meterological Evaluation of Routine Effluent Releases at Nuclear Power Stations.* NUREG/CR-2929, U.S. Nuclear Regulatory Commssion, Washington, D.C.

Southeast Tennessee Development District (STDD). 2008. *Comprehensive Economic Development Strategy Progress Report, 2008.* Chattanooga, Tennessee.

Schloesser, D.W, J.L. Metcalfe-Smith, W.P. Kovalak, G.D. Longton, and R.D. Smithee et al. 2006. "Extirpation of Freshwater Mussels (Bivalvia: Unionidae) following the Invasion of Dreissenid Mussels in an Interconnecting River of the Laurentian Great Lakes." *The American Midland Naturalist* 155:307-320.

Short, P., M. Bozek and F.A. Copes. 1998. *Enhancing Domestic Baitfish Production: Developing Techniques for Culturing Emerald Shiners (*Notropis aterinoides*).* Stevens Point, Wiscounsin.

Simmons, J.W. and D.S. Baxter. 2009. *Biological Monitoring of the Tennessee River Near Watts Bar Nuclear Plant Discharge, 2008.* Tennessee Valley Authority, Aquatic Monitoring and Management, Chattanooga, Tennessee. Accession No. ML093510802.

Spackman, S.C. and J.W. Hughes. 1994. "Assessment of Minimum Stream Corridor Width for Biological Conservation: Species Richness and Distribution Along Mid-Order Streams in Vermont, USA." *Biological Conservation* 71(3):325-332.

Tennessee Department of Education (TDOE). 2005. *Local Consolidated District Plan FY 2004-2005.* Nashville, Tennessee. Accessed March 4, 2011 at http://www.meigscounty.net/artman/publish/about/index.shtml

Tennessee Advisory Commission on Intergovernmental Relations (TACIR). 2010. *Population Projections of the State of Tennessee.* Nashville, Tennessee. Accessed March 4, 2011 at http://www.state.tn.us/tacir/population.html

Tennessee Department of Environment & Conservation (TDEC). 1999. Letter from Ashley A. Holt (Division of Solid Waste Management, TDEC) to George Vickery (Tennessee Valley Authority) dated August 18, 1999, "RE: Watts Bar Nuclear Plant." Accession No. ML093510802.

Tennessee Department of Environment & Conservation (TDEC). 2005. *Lower Tennessee River Watershed (06020001) of the Tennessee River Basin Watershed Water Quality Management Plan.* Accessed on May 25, 2009 at http://www.tennessee.gov/environment/watersheds/three/lowertn/.

Tennessee Department of Environment and Conservation (TDEC). 2008. *Final Year 2008 303(d) List.* Available at http://tn.gov/environment/wpc/publications/pdf/2008_303d.pdf.

Tennessee Department of Environment & Conservation (TDEC). 2009a. *Summary of TDEC's January Surface Water Quality Data.* Accessed 3/12/2010 at http://www.tennessee.gov/environment/kingston/pdf/surface_water/wqsummary_jan09.pdf.

Tennessee Department of Environment & Conservation (TDEC). 2009b. *A Guide to the Rare Animals of Tennessee.* Nashville, Tennessee.

Tennessee Department of Environment & Conservation (TDEC). 2009c. *Tennessee Natural Heritage Program Rare Species Observations for Tennessee Counties.* Nashville, Tennessee. Available at http://tn.gov/environment/na/species/watershed.shtml.

Tennessee Department of Environment & Conservation (TDEC). 2010a. *Ash Slide at TVA Kingston Fossil Plant.* Accessed March 13, 2010 at http://www.tennessee.gov/environment/kingston/.

Tennessee Department of Environment & Conservation (TDEC). 2010b. *State of Tennessee Department of Health Environmental Laboratories Results for February Water Samples, TVA Ash Spill Project.* Accessed March 13, 2010 at http://www.tennessee.gov/environment/kingston/pdf/surface_water/02_23_2010.pdf.

Tennessee Department of Environment & Conservation (TDEC). 2010c. *Year 2010 303(d) List Draft Version.* Accessed August 26, 2011 at http://www.state.tn.us/environment/wpc/publications/pdf/2010draft303dlist.pdf

Tennessee Department of Labor and Workforce Development (TDLWD). 2010. *Noise.* Accessed June 1, 2010 at http://tennessee.gov/labor-wfd/tosha_noise.html.

Tennessee Department of Transportation (TDOT). 2008. *Total Road Mileage and Vehicle Miles of Travel in Tennessee* (also known as the 2008 AADT Book). Nashville, Tennessee. Available at http://www.tdot.state.tn.us/projectplanning/adt/2008ADTBOOK.pdf.

Tennessee Department of Transportation (TDOT). 2009. Phone call from Katherine Cort (Pacific Northwest National Laboratory) to Steve Allen (TDOT Engineer, Station 18) on October 22, 2009, "Re: Watts Bar Nuclear Plant Impact on Regional Road Network." Accession No. ML101520367.

Tennessee Historical Commission (THC). 2009. Letter from the Tennessee Historical Commission to the U.S. Nuclear Regulatory Commission dated September 22, 2009. "NRC, Watts Bar Nuclear Plant #2, Unincorporated, Rhea County. Nashville, Tennessee." Accession No. ML093510985.

Tennessee Historical Commission (THC). 2010. Letter from E. Patrick McIntyre, Jr. (State Historic Preservation Officer) to Joel S. Wiebe (Watts Bar Special Projects Branch, Nuclear Regulatory Commission) dated March 5, 2010, "Re: NRC, Watts Bar Nuclear/Unit 2 License, Unincorporated, Rhea County." Accession No. ML100770290.

Tennessee Valley Authority (TVA). 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.

Tennessee Valley Authority (TVA). 1986. *Preoperational Assessment of Water Quality and Biological Resources of Chickamauga Reservoir, Watts Bar Nuclear Plant, 1973-1985.* TVA/ONRED/WRF-87/1a. Knoxville, Tennessee. Accession No. ML073510313.

Tennessee Valley Authority (TVA). 1993. *Tennessee Valley Authority Review of Final Environmental Impact Statement, Watts Bar Nuclear Plant Units 1 & 2.* Knoxville, Tennessee. Accession No. ML073510303.

Tennessee Valley Authority (TVA). 1995. *Energy Vision 2020 - An Integrated Resource Plan and Programmatic Environmental Impact Statement.* Chattanooga, Tennessee. Accessed March 4, 2011 at http://www.tva.gov/enironment/reports/energyvision2020/ev2020_vol1fm.pdf

Tennessee Valley Authority (TVA). 1998a. *Watts Bar Nuclear Plant Supplemental Condenser Cooling Water Project, Environmental Assessment.* Knoxville, Tennessee. Accessed March 4, 2011 at http://www.tva.gov/environment/reports/wattsbar2/related/aug_1998.pdf

Tennessee Valley Authority (TVA). 1998b. *Aquatic Environmental Conditions in the Vicinity of Watts Bar Nuclear Plant During Two Years of Operation, 1996-1997.* Norris, Tennessee. Revised June 7, 2010.

Tennessee Valley Authority (TVA). 1999. *July 1999 Verification Study of Thermal Discharge for Watts Bar Nuclear Plant Supplemental Condenser Cooling Water System.* WR99-2-85-143. Norris, Tennessee.

Tennessee Valley Authority (TVA). 2001. *Tennessee Valley Authority Resource Stewardship. Aquatic Ecological Health Determinations for TVA Reservoirs –2000.* Nashville, Tennessee. Accession Nos. ML042790465, ML042790470.

Tennessee Valley Authority (TVA). 2003a. *Watts Bar Nuclear Plant Unit 1 and 2 - Annual Environmental Radiological Operating Report - 2002.* Knoxville, Tennessee. Accession No. ML031400811.

Tennessee Valley Authority (TVA). 2003b. *Watts Bar Nuclear Plant – Unit 1 – 2002 Annual Radioactive Effluent Release Report.* Knoxville, Tennessee. Accession No. ML031250152.

Tennessee Valley Authority (TVA). 2004a. *Reservoir Operations Study Final Programmatic Environmental Impact Statement.* Tennessee Valley Authority In cooperation with U.S. Army Corps of Engineers and U.S. Fish and Wildlife Service. Accession Nos. ML041100586, ML041100585, ML041100590, ML041100588.

Tennessee Valley Authority (TVA). 2004b. *Watts Bar Nuclear Plant Unit 1 and 2 – Annual Radiological Environmental Operating Report –2003.* Knoxville, Tennessee. Accession No. ML041390218.

Tennessee Valley Authority (TVA). 2004c. *Watts Bar Nuclear Plant – Unit 1 – 2003 Annual Radioactive Effluent Release Report.* Knoxville, Tennessee. Accession No. ML041310349.

Tennessee Valley Authority (TVA). 2005a. Letter from Betsy M. Eiford (Tennessee Valley Authority, Environmental Support Manager) to Ed Polk (Tennessee Department of Environmental Conservation, Manager) dated July 22, 2005, "Tennessee Valley Authority (TVA) - Watts Bar Nuclear Plant (WBN) - NPDES Permit No. TN0020168 - Phase 11 316(b) Rule for Existing Facilities - Proposal for Information Collection for Supplemental Condenser Cooling Water (SCCW) System." Accession No. ML052150033.

Tennessee Valley Authority (TVA). 2005b. *Watts Bar Nuclear Plant Units 1 and 2 - Annual Radiological Environmental Operating Report - 2004.* Knoxville, Tennessee. Accession No. ML051380366.

Tennessee Valley Authority (TVA). 2005c. *Watts Bar Nuclear Plant – Unit 1 – Annual Radioactive Effluent Release Report - 2004.* Knoxville, Tennessee. Accession No. ML051250623.

Tennessee Valley Authority (TVA). 2006a. Letter J.D. Smith (Manager, Site Licensing and Industry Affairs (Acting), Tennessee Valley Authority) to U.S. Nuclear Regulatory Commission dated December 19, 2006. "Watts Bar Nuclear Plant (WBN) Unit 1 – Notification of National Pollution Discharge Elimination (NPDES) Permit Renewal. Accession No. ML063560378.

Tennessee Valley Authority (TVA). 2006b. *Watts Bar Nuclear Plant Unit 1 - Annual Radiological Environmental Operating Report - 2005.* Knoxville, Tennessee. Accession No. ML061290369.

Tennessee Valley Authority (TVA). 2006c. Letter from Thomas Maher (Tennessee Valley Authority) to Richard Tune (Tennessee Historical Commission) dated December 28, 2006. "TVA, Watts Bar Nuclear Plant Unit 2 Completion, Cultural Resources Assessment, Rhea County". Accession No. ML101180044.

Tennessee Valley Authority (TVA). 2006d. *Watts Bar Nuclear Plant Unit 1 – 2005 Annual Radioactive Effluent Release Report.* Knoxville, Tennessee. Accession No. ML061220258.

Tennessee Valley Authority (TVA). 2007a. *Final Supplemental Environmental Impact Statement; Completion and Operation of Watts Bar Nuclear Plant Unit 2, Rhea County, Tennessee.* Project Number 2006-124, Knoxville, Tennessee. Accession No. ML080510469.

Tennessee Valley Authority (TVA). 2007b. *Watts Bar Nuclear Plant Unit 1 - Annual Environmental Radiological Operating Report - 2006.* Knoxville, Tennessee. Accession No. ML071280378.

Tennessee Valley Authority (TVA). 2007c. *Watts Bar Nuclear Plant – Unit 1 – 2006 Annual Radioactive Effluent Release Report.* Knoxville, Tennessee. Accession No. ML071230082.

Tennessee Valley Authority (TVA). 2008a. *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.

Tennessee Valley Authority (TVA). 2008b. *Watts Bar Nuclear Plant Unit 1 – Annual Radiological Environmental Operating Report – 2007.* Knoxville, Tennessee. Accession No. ML081430029

Tennessee Valley Authority (TVA). 2008c. *Watts Bar Nuclear Plant – Unit 1 – 2007 Annual Radioactive Effluent Release Report.* Knoxville, Tennessee. Accession No. ML081300025.
Tennessee Valley Authority (TVA). 2008d. *Fleet Ground Water Protection Program.* NPG Standard Program and Processes, SPP-5.15. Rev 0000. Nashville, Tennessee. Accession No. ML073510313.

Tennessee Valley Authority (TVA). 2009a. *Final Environmental Impact Statement: Watts Barr Reservoir Land Management Plan for Loudon, Meigs, Rhea, and Roane Counties, Tennessee.* Includes 2010 errata. Knoxville, Tennessee. Accessed July 8, 2011 at http://www.tva.gov/environment/reports/wattsbar/summary.pdf.

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

Tennessee Valley Authority (TVA). 2009c. Letter from Masoud Bajestani (Watts Bar Unit 2, Vice President) to U.S. Nuclear Regulatory Commission dated December 23, 2009 in response to NRC letter dated December 3, 2009 and TVA letters dated February 15, 2008, July 2, 2008, and January 27, 2009, "Watts Bar Nuclear Plant (WBN) Unit 2 – Additional Information Regarding Environmental Review (TAC No. MD8203)." Accession No. ML100210350.

Tennessee Valley Authority (TVA). 2009d. *Cultural Resources.* Accessed December 18, 2009, at http://www.tva.gov/river/landandshore/culturalresources/index.htm.

Tennessee Valley Authority (TVA). 2009e. *Watts Bar Nuclear Plant – Unit 1 – 2008 Annual Radioactive Effluent Release Report.* Knoxville, Tennessee. Accession No. ML091260371.

Tennessee Valley Authority (TVA). 2009f. Letter from Masoud Bajestani (Watts Bar Unit 2, Vice President) to U.S. Nuclear Regulatory Commission dated October 22, 2009 in response to TVA letters dated February 15, 2008, July 2, 2008, and January 27, 2009, "Additional Information in Support of TVA Final Supplemental Environmental Impact Statement (FSEIS) (TAC MD8303)." Accession No. ML093510802.

Tennessee Valley Authority (TVA). 2010a. Letter from Masoud Bajestani (Watts Bar Unit 2, Vice President) to U.S. Nuclear Regulatory Commission dated February 25, 2010 in response to NRC letter dated December 3, 2009 and TVA letters dated July 2, 2008, January 27, 2009, and December 23, 2009, "Watts Bar Nuclear Plant (WBN) Unit 2 – Additional Information Regarding Environmental Review (TAC No. MD8203)." Accession No. ML100630115.

Tennessee Valley Authority (TVA). 2010b. Letter from Masoud Bajestani (Watts Bar Unit 2, Vice President) to U.S. Nuclear Regulatory Commission dated April 9, 2010 in response to NRC letter dated December 3, 2009 and TVA letters dated February 15, 2008, July 2, 2008, January 27, 2009, December 23, 2009, and February 25, 2010, "Watts Bar Nuclear Plant (WBN) Unit 2 – Response to U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information Regarding Environmental Review." Accession No. ML101130393.

Tennessee Valley Authority (TVA). 2010c. Letter from Masoud Bajestani (Watts Bar Unit 2, Vice President) to U.S. Nuclear Regulatory Commission, dated July 2, 2010. Watts Bar, Unit 2 – Submittal of Additional Information Requested during May 12, 2010, Request for Additional Information (RAI) Clarification Teleconference Regarding Environmental Review. Accession No. ML101930470.

Tennessee Valley Authority (TVA). 2010d. *Annual Environmental Radiological Operating Report Watts Bar Nuclear Plant 2009.* Knoxville, Tennessee. Accession No. ML101380296.

Tennessee Valley Authority (TVA). 2010e. *Watts Bar Nuclear Plant,2009 Annual Radioactive Effluent Release Report.* Knoxville, Tennessee. Accession No. ML102080384.

Tennessee Valley Authority (TVA). 2011a. *Watts Bar Nuclear Plant– 2010 Annual Radioactive Effluent Release Report.* Knoxville, Tennessee. Accession No. ML111126A180.

Tennessee Valley Authority (TVA). 2011b. *Watts Bar Nuclear Plant Unit 1 – Annual Radiological Environmental Operating Report - 2010.* Accession No. ML1137A122.

Tennessee Valley Authority (TVA). 2011c. Letter from Edwin E. Freeman (Watts Bar Unit 2, Engineering) to U.S. Nuclear Regulatory Commission dated January 4, 2011, "Watts Bar Nuclear Plant (WBN) Unit 2 – Additional Information Related to U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) Regarding Environmental Review." Accession No. ML110060510.

Tennessee Valley Authority (TVA). 2011d. Letter from David Stinson (Watts Bar Unit 2, Vice President) to U.S. Nuclear Regulatory Commission dated March 24, 2011, "Watts Bar Nuclear Plant (WBN) Unit 2 – Additional Information Related to U.S. Nuclear Regulatory Commission (NRC) Regarding Environmental Review." Accession No. ML110871475.

Tennessee Valley Authority (TVA). 2011e. Letter from Marie Gillman (Watts Bar Unit 2, Vice President, Acting) to U.S. Nuclear Regulatory Commission dated February 7, 2011, "Submittal of 'Hydrothermal Effects on the Ichthyoplankton from the Watts Bar Nuclear Plant Supplemental Condenser Cooling Water outfall in Upper Chickamauga Reservoir' Report." Accession Nos. ML110400383, ML110400384.

Tennessee Wildlife Resources Agency (TWRA). 2006. *Hiwasse Wildlife Refuge, Chickamauga Wildlife Management Area, Yuchi Refuge at Smith Bend & Environs.* Accessed December 18, 2009 at http://www.tnbirds.org/IBA/SitePages/Hiwasee.htm.

Tennessee Wildlife Resources Agency (TWRA). 2007. *Yuchi Refuge at Smith Ben (map).*

Tennessee Wildlife Resources Agency (TWRA). 2008. *Tennessee Aquatic Nuisance Species Management Plan.* Developed by the Tennessee Aquatic Nuisance Species Task Force. Nashville, Tennessee.

Tennessee Wildlife Resources Agency (TWRA). 2009. *Wildlife Management Areas.* Nashville, Tennessee.

Tennessee Wildlife Resource Agency (TWRA). 2010. *Contaminants in Fish.* Accessed May 17, 2010 at http://www.state.tn.us/twra/fish/contaminants.html.

Tipler, P.A. 1982. *Physics.* Worth Publishers, New York.

U.S. Bureau of Economic Analysis (USBEA). 2007. "Local Area Personal Income. Tables CA25N (Using NAICS): Total Employment by Industry." Accessed August 29, 2011 at http://www.bea.gov/regional/reis/default.cfm#step3.

U.S. Bureau of Labor Statistics (USBLS). 2008. "Local Area Unemployment Statistics." Accessed at http://www.bls.gov/lau/.

U.S. Census Bureau (USCB). 2000. "Total Population [1] – Universe: Total Population Dataset. Census 2000 Summary File (SF1) 100-Percent Data." Available at http://factfinder.census.gov/home/saff/main.html?_lang=en.

U.S. Census Bureau (USCB). 2008a. "Meigs County, Tennessee. Fact Sheet." American Fact Finder, 2000 U.S. Census. Available at http://factfinder.census.gov/home/saff/main.html?_lang=en.

U.S. Census Bureau (USCB). 2008b. "McMinn County, Tennessee. Fact Sheet." American Fact Finder, 2000 U.S. Census. Available at http://factfinder.census.gov/home/saff/main.html?_lang=en.

U.S. Census Bureau (USCB). 2008c. "Rhea County, Tennessee. Fact Sheet." American Fact Finder, 2000 U.S. Census.

U.S. Census Bureau (USCB). 2008d. "Roane County, Tennessee. Fact Sheet." American Fact Finder, 2000 U.S. Census. Available at http://factfinder.census.gov/home/saff/main.html?_lang=en.

U.S. Census Bureau (USCB). 2009. "Poverty Thresholds." Available at http://www.census.gov/hhes/www/poverty/data/threshld/index.html.

U.S. Department of Education (NCES). 2009. *National Center for Educational Statistics, Search for Public School Districts*. Accessed February 1, 2009 at http://nces.ed.gov/ccd/districtsearch/. .

U.S. Department of Energy (DOE). 1999. *Final Environmental Impact Statement for the Production of Tritium in a Commercial Light Water Reactor*. DOE/EIS-0288, Washington, D.C.

U.S. Department of the Interior (DOI). 2009. Letter from Mary E. Jennings (Field Supervisor, U.S. Fish and Wildlife Service) to Joel Wiebe (Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission) dated October 9, 2009, "FWS #2009-SL-0885. Watts Bar Nuclear Plant, Unit 2 – Request for list of Protected Species, Rhea County, Tennessee." Accession No. ML0929301820.

U.S. Environmental Protection Agency. 2001. *Economic Analysis of the Final Regulations Addressing Cooling Water Intake Structures for New Facilities.* EPA-821-R-01-035, Washington, D.C.

U.S. Environmental Protection Agency (EPA). 2003. "Appendix G, Aquatic Resources." in *EPA and Hardrock Mining: A Source Book for Industry in the Northwest and Alaska.* Seattle, Washington. Accessed at http://yosemite.epa.gov/R10/WATER.NSF/Sole+Source+Aquifers/hardrockmining.

U.S. Environmental Protection Agency. 2010. *Detroit River – Western Lake Erie Basin Indicator Project.* Accessed May 27, 2010 at http://www.epa.gov/med/grosseile_site/indicators/plankton.html

U.S. Fish and Wildlife Service. 1991. *Large-flowered Skullcap (*Scutellaria montana*) Species Account.* Accessed April 1, 2010 at http://www.fws.gov/cookeville/docs/endspec/sklcapsa.html.

U.S. Fish and Wildlife Service (FWS). 1992. "Species Accounts, Snail Darter (Percina (Imostoma) tanasi)." In *Endangered and Threatened Species of the Southeastern United States: The Red Book.* Accessed December 22, 2009 at http://www.fws.gov/cookeville/docs/endspec/snldtrsa.html.

U.S. Fish and Wildlife Service (FWS). 2007. *2007 Candidate Notice of Review – Southeast Region Summary Information.* December 6, 2007. Available at http://www.fws.gov/southeast/news/2007/r07-119.html.

U.S. Fish and Wildlife Service (FWS). 2009. Letter from Mary E. Jennings (Field Supervisor, U.S. Fish and Wildlife Service) to Joel Wiebe (Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission) dated October 9, 2009, "FWS #2009-SO-0085. Watts Bar Nuclear Plant, Unit 2 -Request for list of Protected Species, Rhea County, Tennessee." Accession No. ML092930182.

U.S. Fish and Wildlife Service (FWS). 2010a. "Dromedary Pearlymussel - *Dromus dromas.*" Accessed May 17, 2010 at http://ecos.fws.gov/docs/life_histories/F00K.html.

U.S. Fish and Wildlife Service (FWS). 2010b. "Species Profile for Spotfin Chub (*Erimonax monachus*). " Accessed December 22, 2009 at http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=E012.

U.S. Fish and Wildlife Service (FWS). 2011. "Sheepnose (a freshwater mussel) – *Plethobasus cyphyus.*" Accessed March 28, 2011 at http://www.fws.gov/midwest/endangered/clams/sheepnose/pdf/SheepnoseFactSheetJan2011.pdf.

U.S. Geological Survey. 2002. *A Tapestry of Time and Terrain.* Reston, Virginia. Available at http://tapestry.usgs.gov/features/06valleyridge.html

U.S. Global Change Research Program (GCRP). 2009. *Global Climate Change Impacts in the United States.* T.R. Karl, J. M. Mellilo, and T.C. Peterson, eds. Cambridge University Press, New York. Available at http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf.

U.S. Nuclear Regulatory Commission (NRC). 1974. *Regulatory Guide 1.4 – Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Pressurized Water Reactors*, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1977. *Regulatory Guide 1.111 – Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors*, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1978. *Final Environmental Statement Related to Operation of Watts Bar Nuclear Plant Units Nos. 1 and 2.* NUREG-0498, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1983. *Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants.* Regulatory Guide 1.145, Rev. 1, Washington, D.C. Accession No. ML003740205.

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

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

U.S. Nuclear Regulatory Commission (NRC). 1999. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Calvert Cliffs Nuclear Power Plant.* NUREG-1437, Supplement 1, Washington, D.C.

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

U.S. Nuclear Regulatory Commission (NRC). 2009. Letter from Joel Wiebe (U.S. Nuclear Regulatory Commission) to Richard Allen (Cherokee Nation) dated September 10, 2009, "Watts Bar Nuclear Plant, Unit 2, Operating License Application Review – Environmental Scoping," U.S. Nuclear Regulatory Commission, Washington, D.C. Accession No. ML092110475

Wastrack, K.G., D.E. Pittman, and J.M. Call. 2008. *Impact of Weather Changes on TVA Nuclear Plant Chi/Q (χ/Q).* Tennessee Valley Authority.

Watters, G.T. 1999. "Freshwater Mussels and Water Quality: A Review of the Effects of Hydrologic and Instream Habitat Alterations." In *Proceedings of the First Freshwater Mollusk Conservation Society Symposium.* Ohio Biological Survey, Columbus, Ohio.

World Health Organization (WHO). 2007a. *Electromagnetic Fields and Public Health. Exposure to Extremely Low Frequency Fields.* Fact Sheet No. 322, Geneva, Switzerland. Available at http://www.who.int/mediacentre/factsheets/fs322/en.

World Health Organization (WHO). 2007b. *Extremely Low Frequency Fields.* Environmental Health Criteria Monograph No. 238, Geneva, Switzerland.

Yoder, J.S., B.A. Eddy, G.S. Visvesvara, L. Capewell and M.J. Beach. 2009. "The epidemiology or primary amoebic meningoencephalitis in the USA, 1962-2008." *Epidemiology and Infection* (first view). DOI: 10.1017/S0950268809991014

3.0 Plant Description

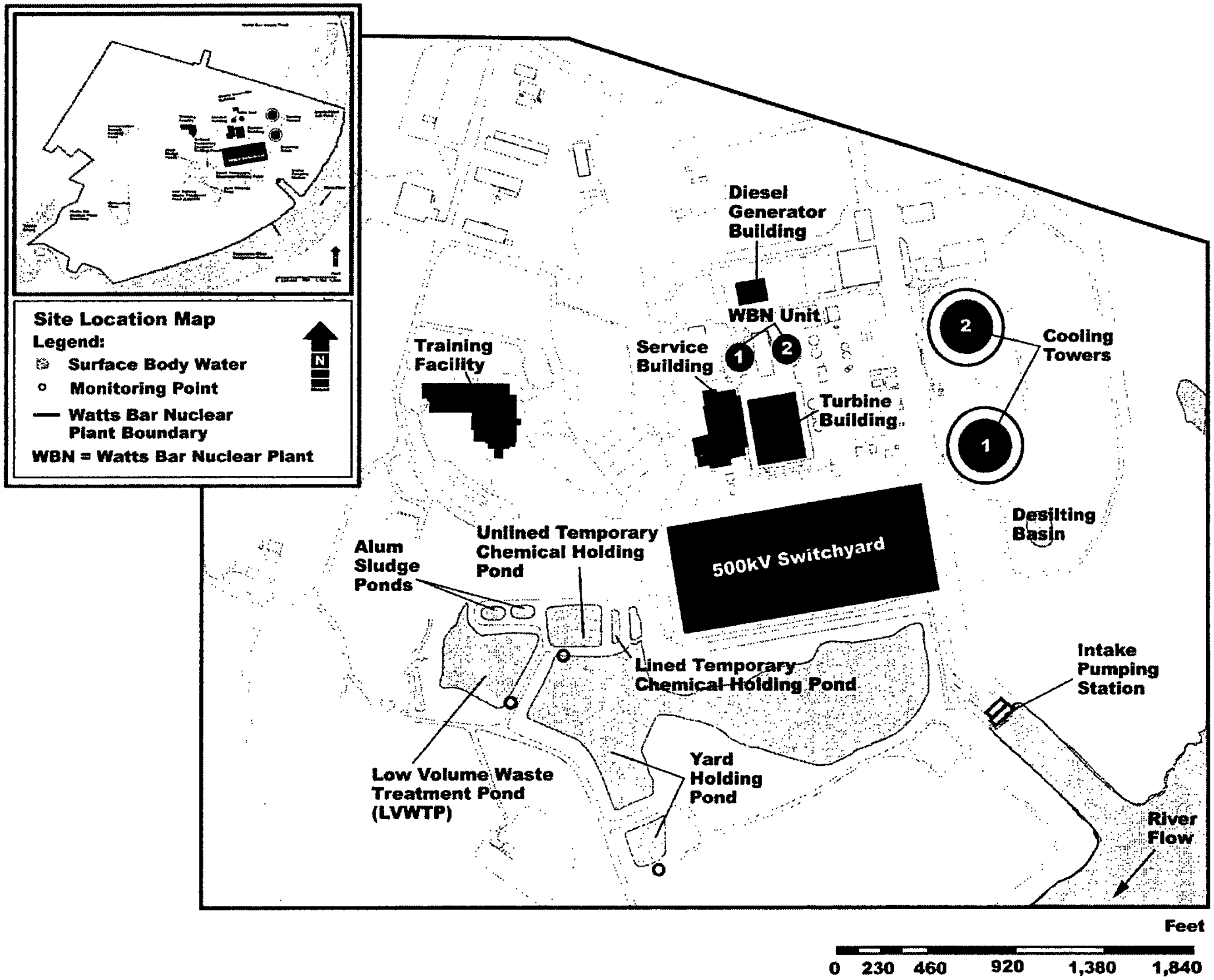
This chapter describes the key physical plant characteristics the U.S. Nuclear Regulatory Commission (NRC) considered in assessing the environmental impacts of the proposed action. The NRC drew on the following documents for the majority of this information: the Tennessee Valley Authority (TVA) Environmental Report (ER) (TVA 2008), the 1995 Supplement No. 1 to the Final Environmental Statement related to the operating license (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 draft 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. 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 (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 Unit 2 operation. Understanding these structures is important in comprehending Chapter 4 of this SFES.

The reactor system includes the reactor, 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 about the WBN Unit 2 reactor system is provided in Section 3.2.1. Additional information about the cooling system at WBN Unit 2 is provided in Section 3.2.2.

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 certain 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 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 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 Circulating 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). Since the SCCW has been operating, elevated total dissolved solids in blowdown water have not been a concern because a large volume of water continually enters and leaves the cooling-tower basins (PNNL 2009). Figure 3-2 shows the major components of the cooling system.

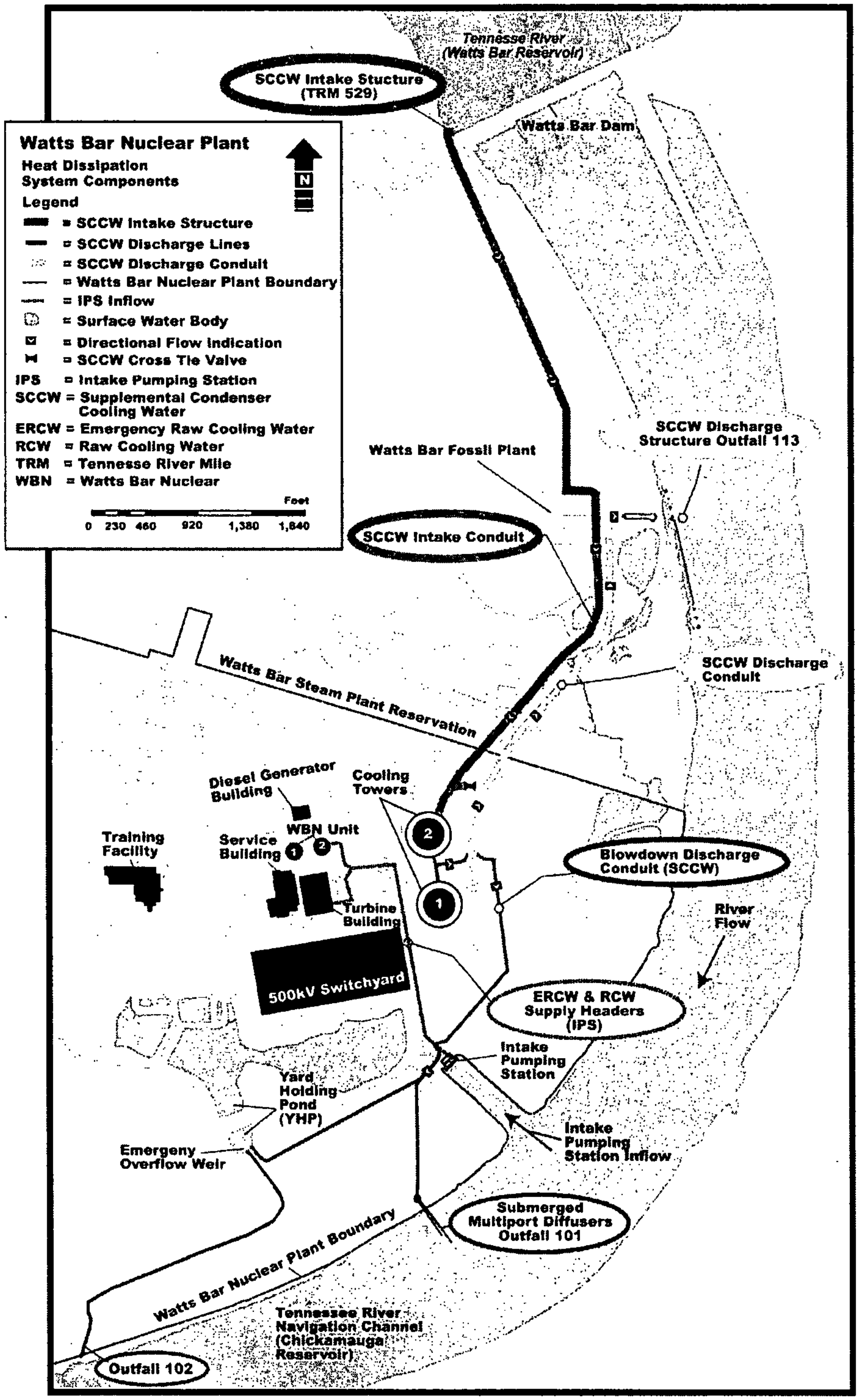
3.2.2.1 Intake Structures

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 2011). 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 35.3 m^2 (380 ft^2) open for the passage of water through the trash racks (TVA 2010a).

Once water flows through the traveling screens, it 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 2011). 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; however, at times four pumps in one side of the IPS may be used (TVA 2011). 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). The IPS also 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 approximately 2.5 m^3/s (88 cfs) of water from the Chickamauga Reservoir for normal operations (TVA 2010a). TVA estimates normal maximum operations for WBN Units 1 and 2 would require withdrawal of 4.93 m^3/s (174 cfs) of water from the Chickamauga Reservoir (TVA 2010a). Normal operations 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 2011). 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 2011).

The withdrawal of 4.93 m^3/s (174 cfs) through the IPS would represent 0.6 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). Withdrawal of 3.79 m^3/s (134 cfs) would represent 0.4 percent of the mean annual flow of the Tennessee River as measured at Watts Bar Dam.

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 9.37 m (30.75 ft) high. This results in an opening of 20.3 m^2 (219.1 ft^2). The traveling screens and their support structures occupy a portion of the opening leaving 9.16 m^2 (98.6 ft^2) open to the passage of water in each bay or a total of 27.48 m^2 (295.8 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 11.5 m^2 (124 ft^2), for a total of 34.6 m^2 (372 ft^2) (TVA 2010a). 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. TVA estimates the average monthly flow through the SCCW intake is approximately 7.31 m^3/s (258 cfs) of water from the Watts Bar Reservoir to Unit 1 when a single unit is in operation (TVA 2010a). TVA estimates the average monthly flow through the SCCW intake for the operation of WBN Units 1 and 2 will be 7.1 m^3/s (250 cfs) of water from the Watts Bar Reservoir (TVA 2010a). The lower flow rate for two units in operation is anticipated because water moves through the system under gravity flow, and the water level in the cooling-tower basin for Unit 2 would be 0.6 m (2 ft) higher when the unit is operating (TVA 2010a). This reduces the water level elevation difference between Watts Bar Reservoir and the cooling-tower basin resulting in a reduction of flow rate.

The normal intake flow rates are higher in the summer months when Watts Bar Reservoir levels are maintained at 225.7 m (740.5 ft). Normal flow rates during summer months with both units operating are expected to be approximately 7.6 m^3/s (270 cfs). This would result in a water velocity through the open areas in the trash racks in the SCCW of 0.22 m/s (0.73 ft/s). The water velocity through the openings in the traveling screens at the SCCW would be 0.28 m/s (0.91 ft/s) under these conditions (TVA 2010a).

TVA provided the following water fluxes for the combined cooling-water system for both units during normal operations (TVA 2010a):

- The normal maximum makeup water-flow rate from the IPS would be 4.93 m^3/s (174 cfs).
- The maximum consumptive water-use rate (evaporation and drift) would be 1.7 m^3/s (61 cfs).
- The normal blowdown rate would be 1.8 m^3/s (64 cfs).
- The normal intake rate for SCCW would be 7.1 m^3/s (250 cfs).
- The normal discharge rate for SCCW would be 8.46 m^3/s (299 cfs).

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

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 for 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

Table 3-1. Anticipated Water Use

Service	Normal Two Unit Operation	Single Unit Operation
Heat discharged	1.5×10^{10} Btu/hr	7.8×10^{9} Btu/hr
CCW		
Evaporation rate	1.7 m^3/s (61 cfs)	0.82 m^3/s (29 cfs)
Drift rate	2.8 L/s (0.1 cfs)[(a)]	2.8 L/s (0.1 cfs)[(a)]
Blowdown rate	1.81 m^3/s (64 cfs)	1.5 m^3/s (53 cfs)
Blowdown rate when diffusers are discharging from cooling towers and YHP	4.81 m^3/s (170 cfs)[(b)]	3.82 m^3/s (135 cfs)[(b)]
IPS makeup flow	4.93 m^3/s (174 cfs)[(c)]	2.5 m^3/s (88 cfs)
SCCW		
Intake flow rate	7.1 m^3/s (250 cfs)	7.31 m^3/s (258 cfs)
Discharge flow rate	8.46 m^3/s (299 cfs)	7.48 m^3/s (264 cfs)
YHP overflow weir[(b)]	0	0

(a) 1972 FES-CP (TVA 1972).
(b) TVA (2008).
(c) 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 2011); maximum normal withdrawal is 4.9 m^3/s (174 cfs) (TVA 2010a).
All other values are from RAI response dated February 25, 2010 (TVA 2010a).

(TDEC 2011). TVA (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 unpaved 1.37-m (4.5-ft)-diameter corrugated steel diffuser pipe at the end of approximately 91 m (297 ft) of paved 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 (TVA 1997).

The upstream leg of the diffuser system consists of 24 m (80 ft) of unpaved 1.07-m (3.5-ft)-diameter corrugated steel diffuser pipe at the end of approximately 136 m (447 ft) of paved 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 (TVA 1997). Figure 3 from TVA's analysis of the SCCW thermal plume (TVA 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).

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 (TDEC 2011). 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 instream 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 (TDEC 2011).

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 that drain away from the site into drainage ditches and creeks.

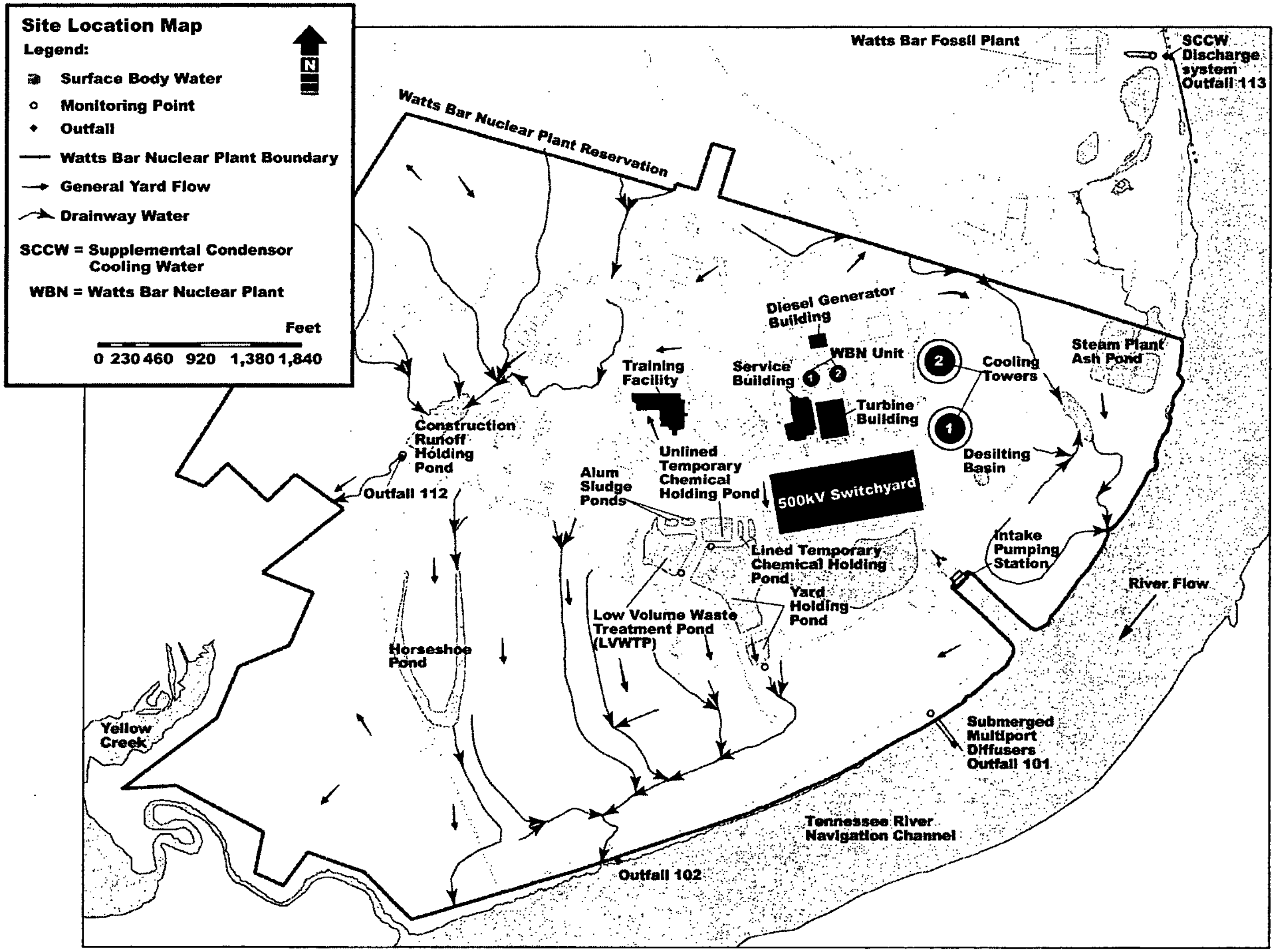
3.2.4 Other Plant Systems

Diesel Generators

TVA installed five diesel generators on the WBN site. Missile and fire barrier-type 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).



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

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

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).

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 Watts Bar Fossil Plant 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 located north of WBN. 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)-wide 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 Intake 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 (TDEC 2011).

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).

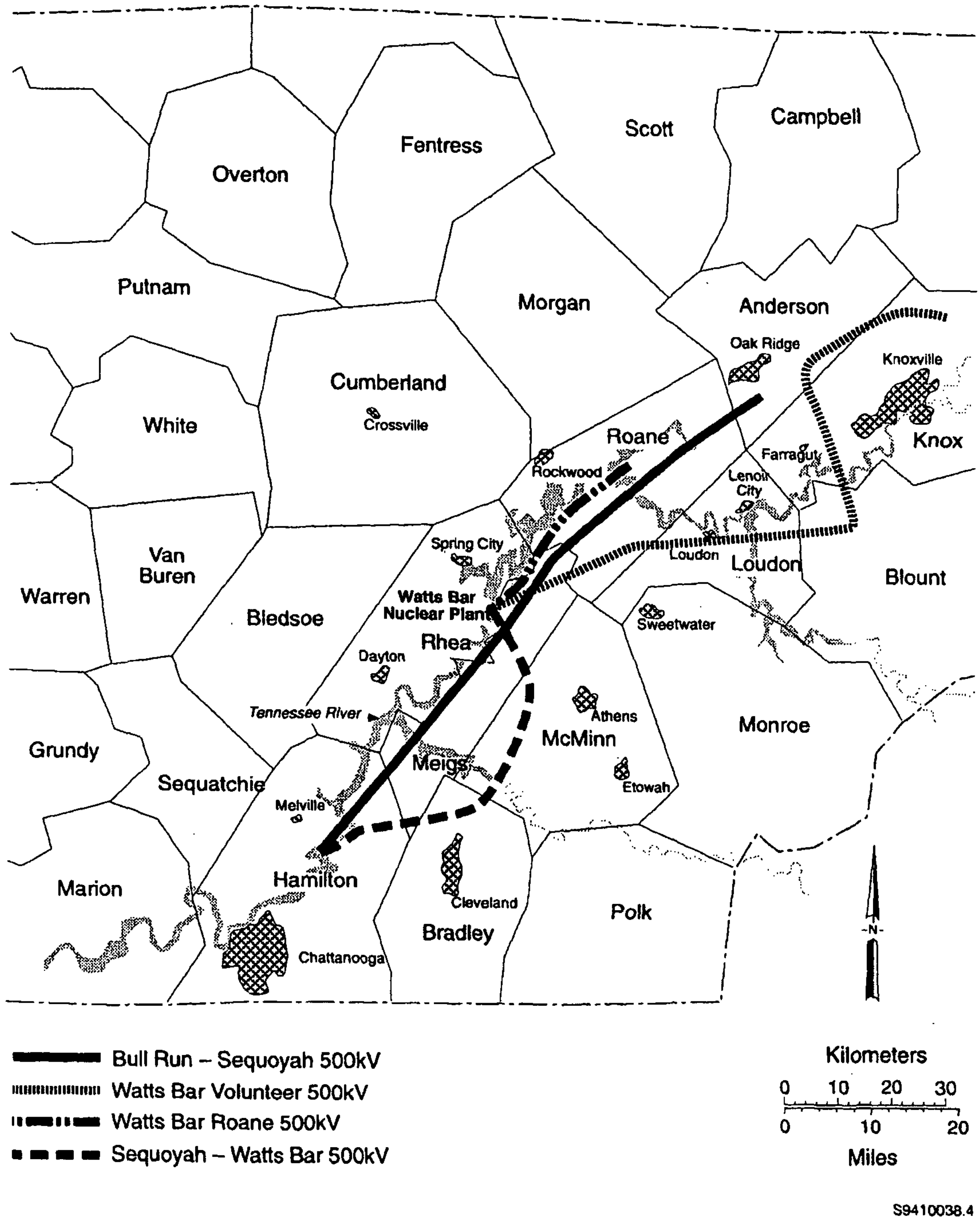


Figure 3-4. WBN Transmission Line Connections (NRC 1995)

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 TDEC-approved Biocide/Corrosion Treatment Plan (B/CTP) (TDEC 2011). WBN's current B/CTP was approved in 2009 (TDEC 2011) based on the list of chemicals included in the NPDES permit modification request submitted by TVA in April 2009 (TVA 2010d). 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)[c]	Dispersant to facilitate iron corrosion inhibition	Continuous	copolymer	< 0.2
Inhibitor AZ8100 (replaces Nalco 1336)[c]	Copper corrosion inhibition	Periodic	sodium tolyltriazole	< 0.25
Sprectrus BD 1500 (replaces Nalco 73551)[c]	Surfactant to facilitate oxidizing biocides	Periodic	nonionic surfactant	< 2.0
Towerbrom 60m (replaces Towerbrom 960)[c]	Oxidizing biocide (chlorination)	Periodic	sodium bromide and sodium dichloroisocyanurate	0.10 chlorine (total residual)
Spectrus OX 1200 (replaces Nalco 901 G)[c]	Oxidizing biocide (chlorination)	Continuous	bromo-chloro, cimethyl hydantoin	0.10 chlorine (total residual)
Spectrus DT 1404 (replaces Nalco CA-35)[c]	De-chlorination	Periodic[d]	sodium bisulfite	< 10
Spectrus CT1300[e] (replaces H150M)[c] 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 (ppm active ingredients)
Spectrus NX1104[4] (replaces Spectrus NX 104)[(c)]	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[(c)]	Detoxification of nonoxidizing biocides	Periodic[(d)]	sodium silicate (bentonite clay)	< 10
Liquid bleach[(c)]	Oxidizing biocide (chlorination)	Continuous	sodium hypochlorite	0.10 chlorine (total residual)
H150M[(f)]	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 (replaces MSW-109, 2010)[(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) SCCW and river flow conditions have a significant impact on these discharge concentrations.

(c) Denotes chemicals previously approved by the division (Tennessee Department of Environment and Conservation, Division of Water Pollution Control).

(d) Dechlorination and detoxification chemicals are applied as needed to ensure the discharge limitations identified in this table are met.

(e) Nonoxidizing biocide treatments are not applied at the same time as oxidizing biocide treatments.

(f) Active ingredient information from TVA 2008

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 (TDEC 2011).

The NPDES permit (TDEC 2011) 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 outfalls 101 and 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's 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 2009d).

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 Conversation 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	2.5 m^3/s (88 cfs)	4.93 m^3/s (174 cfs)[(a)]	2.4 m^3/s (86 cfs)
Consumptive Use			
Evaporation Rate	0.82 m^3/s (29 cfs)	1.7 m^3/s (61 cfs)	0.87 m^3/s (31 cfs)

Table 3-4. (contd)

Item	WBN Unit 1 Current Operations	Anticipated WBN Units 1 and 2	WBN Unit 2 Added Increment
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)	1.8 m^3/s (64 cfs)	0.3 m^3/s (11 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
Intake Flow Rate	7.31 m^3/s (258 cfs)	7.1 m^3/s (250 cfs)	Intake flow rate will decline because elevation of water surface in Unit 2 cooling tower will be higher when plant is in operation.
Discharge Flow Rate	7.48 m^3/s (264 cfs)	8.46 m^3/s (299 cfs)	A portion of the water entering the system through the IPS will be discharged through the SCCW discharge
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
Sanitary Waste Discharge			
Average	49,000 L/d (13,000 gpd) Unit 1 staff 130,000 L/d (34,000 gpd) Unit 1 staff plus Unit 2 construction	68,000 L/d (18,000 gpd)	19,000 L/d (5,000 gpd)
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

(a) Normal withdrawal 3.20 m^3/s (113 cfs) of water in winter and 3.79 m^3/s (134 cfs) of water in summer (TVA 2011) maximum normal withdrawal 4.9 m^3/s (174 cfs) (TVA 2010a).

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

Pacific Northwest National Laboratory. 2009. Letter from J.A. Stegen (Pacific Northwest National Laboratory) to U.S. Nuclear Regulatory Commission dated November 12, 2009. "Final Watts Bar Site Audit Trip Report for JCN J-4261, 'Technical Assistance for Operating License Environmental Review – Watts Bar Unit 2 Reactivation.'" Accession No. ML100220022.

Tennessee Department of Environment and Conservation (TDEC).. 2011. *State of Tennessee NPDES Permit No. TN0020168*. Nashville, Tennessee. Accession No. ML11215A099.

Tennessee Valley Authority (TVA). 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.

Tennessee Valley Authority (TVA). 1977. *Effects of Watts Bar Nuclear Plant and Watts Bar Steam Plant Discharges on Chickamauga Lake Water Temperatures*. WM28-1-85-100, Division of Water Management, Water Systems Branch, Norris, Tennessee.

Tennessee Valley Authority (TVA). 1997. *Watts Bar Nuclear Plant Supplemental Condenser Cooling Water Project, Thermal Plume Modeling*. Norris, Tennessee.

Tennessee Valley Authority (TVA). 1998. *Watts Bar Nuclear Plant Supplemental Condenser Cooling Water Project, Environmental Assessment*. Knoxville, Tennessee. Available at http://tva.gov/environment/reports/wattsbar2/related/aug_1998.pdf.

Tennessee Valley Authority (TVA). 2005a. Letter from Betsy M. Eiford (Tennessee Valley Authority, Environmental Support Manager) to Ed Polk (Tennessee Department of Environmental Conservation, Manager) dated July 22, 2005, "Tennessee Valley Authority (TVA) - Watts Bar Nuclear Plant (WBN) - NPDES Permit No. TN0020168 - Phase 11 316(b) Rule for Existing Facilities - Proposal for Information Collection for Supplemental Condenser Cooling Water (SCCW) System." Accession No. ML052150033.

Tennessee Valley Authority (TVA). 2005b. *Final Environmental Assessment, Watts Bar Nuclear Plant Unit 1, Replacement of Steam Generators, Rhea County, Tennessee.* Chattanooga, Tennessee. Available at www.tva.gov/environment/reports/wattsbarnuc/ea.pdf.

Tennessee Valley Authority (TVA). 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.

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

Tennessee Valley Authority (TVA). 2009b. Letter from Masoud Bajestani (Watts Bar Unit 2, Vice President) to U.S. Nuclear Regulatory Commission dated December 23, 2009 in response to NRC letter dated December 3, 2009 and TVA letters dated February 15, 2008, July 2, 2008, and January 27, 2009, "Watts Bar Nuclear Plant (WBN) Unit 2 – Additional Information Regarding Environmental Review (TAC No. MD8203)." Accession No. ML100210350.

Tennessee Valley Authority (TVA). 2009c. Letter from Masoud Bajestani (Watts Bar Unit 2, Vice President) to U.S. Nuclear Regulatory Commission dated October 22, 2009 in response to TVA letters dated February 15, 2008, July 2, 2008, and January 27, 2009, "Additional Information in Support of TVA Final Supplemental Environmental Impact Statement (FSEIS) (TAC MD8303)." Accession No. ML093510802.

Tennessee Valley Authority (TVA). 2009d. Letter from Darrin Hutchison (Tennessee Valley Authority, Environmental Technical Support Manager) to Vijin Janjic (Tennessee Department of Environment & Conservation, Permit Writer) dated April 15, 2009, "Watts Bar Nuclear Plant (WBN) – National Pollutant Discharge Elimination System (NPDES) Permit No. TN0020168 – Request for Raw Water Treatment Modification." Accession No. ML091190175.

Tennessee Valley Authority (TVA). 2010a. Letter from Masoud Bajestani (Watts Bar Unit 2, Vice President) to U.S. Nuclear Regulatory Commission dated February 25, 2010 in response to NRC letter dated December 3, 2009 and TVA letters dated July 2, 2008, January 27, 2009, and December 23, 2009, "Watts Bar Nuclear Plant (WBN) Unit 2 – Additional Information Regarding Environmental Review (TAC No. MD8203)." Accession No. ML100630115.

Tennessee Valley Authority (TVA). 2010b. Letter from Lindy Johnson (Tennessee Valley Authority, Water Permits and Compliance) to Richard Urban (Tennessee Department of Environment & Conservation) dated August 17, 2010, "Tennessee Valley Authority (TVA) - Watts Bar Nuclear Plant (WBN) – NPDES Permit No. TN0020168 – Permit Modification Request – Addition of Unit 2 Operation."

Tennessee Valley Authority (TVA). 2010c. Letter from Masoud Bajestani (Watts Bar Unit 2, Vice President) to U.S. Nuclear Regulatory Commission dated April 9, 2010 in response to NRC letter dated December 3, 2009 and TVA letters dated February 15, 2008, July 2, 2008, January 27, 2009, December 23, 2009, and February 25, 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.

Tennessee Valley Authority (TVA). 2010d. *2009 Annual Non-Radiological Environmental Operating Report.* Chattanooga, Tennessee. Accession No. ML101310204.

Tennessee Valley Authority (TVA). 2011. Letter from David Stinson (Watts Bar Unit 2) to U.S. Nuclear Regulatory Commission dated May 19, 2011, "Watts Bar Nuclear Plant (WBN) Unit 2 – Intake Pumping Station Water Velocity – Response to Request for Additional Information." Accession No. ML11143A083.

U.S. Nuclear Regulatory Commission (NRC). 1978. *Final Environmental Statement Related to Operation of Watts Bar Nuclear Plant Units Nos. 1 and 2.* NUREG-0498, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 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.

U.S. Nuclear Regulatory Commission (NRC). 2002. *USNRC Nuclear Reactor Concepts Course.* Washington, D.C. Accession No. ML023020519

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 No. 1 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 Unit 2 would not differ from prior land use, either at the plant or along transmission lines. Because TVA built the plant and the transmission lines as planned, 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 would be required, NRC staff identified no additional onsite land-use impacts from operating WBN Unit 2 beyond those experienced with 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 NRC staff expects no land-use impacts beyond those identified in previous analyses. Some 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. However, as discussed in Section 2.1.2, the counties surrounding the WBN site have no restrictive zoning or growth measures. Because TVA had previously disturbed the land for the transmission lines and would disturb no additional land, 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 Tennessee Valley Authority (TVA) maintains the same water-related permits and certifications as any other large industrial facility. These include:

- 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.
- 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 TN002168 on June 30, 2011, effective August 1, 2011 to June 29, 2016 (TDEC 2011). This permit modification includes discharges associated with WBN Unit 2.

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's 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 1.7 m^3/s (61 cfs) during the operation of both units, for an increase of 0.9 m^3/s (32 cfs) associated with the operation of WBN Unit 2. As noted in Section 2.2.1.1, the mean annual flow TVA releases from Watts Bar Dam is 778 m^3/s, or approximately 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 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 TN002168. The State of Tennessee issued the permit on June 30, 2011, effective August 1, 2011 to June 29, 2016 (TDEC 2011).

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, 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. 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. Based on TVA's conformance to NPDES permit requirements and the outcome of its routine outfall water-quality monitoring, the 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 TVA's existing 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. TVA's report, *Discharge Temperature Limit Evaluation for Watts Bar Nuclear Plant* 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 (TVA 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 (TVA 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:

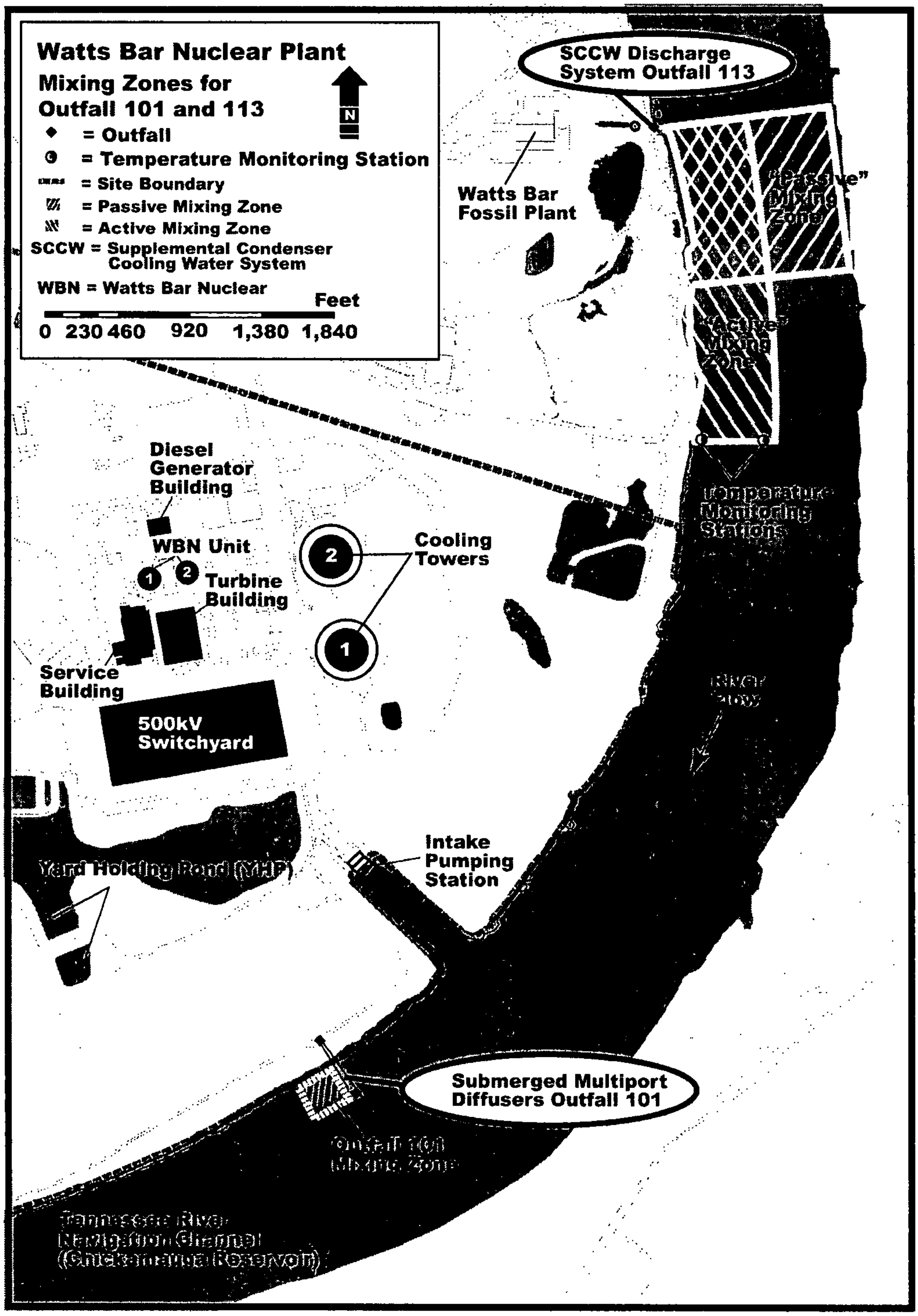
The receiving water shall not exceed (1) a maximum water temperature change of 3°C (5.4°F) relative to an upstream control point, (2) a maximum temperature of 30.5°C (86.9°F), except when upstream (ambient) temperatures approach or exceed this value, and (3) a maximum rate of change of 2°C (3.6°F) per hour outside of a mixing zone."

The current NPDES permit (TDEC 2011) 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 (TVA 2010a).

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 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). The dimensions of the mixing zones have not changed with the addition of WBN Unit 2 to the permit (TDEC 2011). Figure 4-1 illustrates the two mixing zones.

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.

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). 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.



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

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

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/hour)
	In-Stream Temperature Receiving Stream Bottom[(c)]	Max Hourly Avg	33.5°C (92.3°F)

Source: TVA 2010a
(a) Downstream edge of mixing zone.
(b) Upstream ambient to downstream edge of mixing zone.
(c) Mussel relocation zone at SCCW outlet.

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 would increase by approximately 0.3 m^3/s (10 cfs) (for example from 1.25 m^3/s to 1.53 m^3/s [44 cfs to 54 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 2010b).

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. 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 2010b). 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, NRC staff used a river temperature of 7.5°C (45.5°F) for February and a river temperature of 26.2°C (79.1°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 and 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 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. 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 7.5°C Ambient (45.5°F)	August 26.2°C Ambient (79.1°F)
Plume Width	**Normal Operation**	**Normal Operation**
10% of Channel Width	7.8 (14)	2.5 (4.5)
25% of Channel Width	3.9 (7)	1.1 (2)
50% of Channel Width	2.2 (4)	0.6 (1)

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 18.4°C [65.2°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]).

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 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 procedure 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., TVA 2007a, b). Implementation of the TVA procedures (TVA 2010 b) 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 1998a). Temperature monitoring data (TVA 2004a) 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 2010b). Because of this removal, the water table is depressed near the power block (TVA 2010c) (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 4-3). This routing, the plant's large number of impervious surfaces, and TVA's use of surface-water retention basins 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 2010d). 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 TVA's 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 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 Circulating Water System (CWS) increases. The CWS 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. TVA 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 2008b). 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 2-6 may occur close enough to the WBN Unit 2 cooling tower for TDS deposition to affect them, the TVA and NRC do not expect deposition rates of 10 kg/ha/yr (1 lb/ac/mo) to noticeably affect these plant species. TVA's internal modifications to the Unit 1 cooling tower, which also would be made to the Unit 2 tower (TVA 2008a), would not change the NRC'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 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 2-6 may occur close enough to the Unit 2 cooling tower for increased fogging or icing to affect them, the 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's 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 concludes environmental impacts associated with fogging and icing would be minimal.

Species of Ecological Concern

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 2008b) to identify habitats for rare flora and fauna. Although the NRC found none of the important plant species listed in Chapter 2 that are known to occur within WBN Unit 2 transmission corridors, it found many in the vicinity of the transmission corridors. The 1995 SFES-OL-1 (NRC 1995) lists earleaf false-foxglove (*Agalinis auriculata*), tall larkspur (*Delphinium exaltatum*), and prairie goldenrod (*Solidago ptarmicoides*) as species known to occur in open habitats and that could become established within transmission corridors. Regional habitat information also indicates at least six additional plants may occur within open habitats similar to those found within the WBN transmission corridors. University researchers describe most of these plants as herbaceous and unlikely to become a safety issue if established. Although the mountain bush-honeysuckle (*Diervilla sessilifolia* var. *rivularis*) is a shrub, it is low-growing (University of Wisconsin 2010), so TVA would not likely need to remove it for safety reasons. The yellow jessamine (*Gelsemium sempervirens*), another important plant that occurs in open habitats, is a climbing vine. This plant, if established, could become entangled on transmission structures and require removal, thereby limiting any benefit. Routine vegetation removal results in early-successional habitats within transmission corridors. Open habitats maintained as such may benefit from these plant species because maintenance may 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. These plants 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 would affect ecologically sensitive areas such as rock outcrops and wetlands the least, because the sensitive area review process identifies ecologically sensitive areas, and TVA then uses best management practices (BMPs) to limit effects to the extent possible. Maintenance would minimally affect important wetland plants and those that occur in rocky 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 during WBN Unit 1 operations

(NRC 1995). The NRC 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 would be associated with the Tennessee River, and their flight paths would likely remain near enough to the river to avoid collision. Wild turkeys primarily move among habitats while on the ground, and even during flight, the staff does not expect them to collide with the cooling tower. Bald eagles would likely forage near the Tennessee River and may perch or roost on the WBN site. Even with a substantial plume, TVA does not expect eagles to collide with the Unit 2 cooling tower. The plant has not recorded any such collision with the WBN Unit 1 cooling tower. Least bitterns reside exclusively along the river, and the staff does not expect them to collide with the Unit 2 cooling tower. 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. TVA has not recorded or reported any avian mortality for the existing transmission system.

Table 4-4. Watts Bar 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 WBN Dam
Watts Bar-Roane	Tennessee River (backwater)	9.2 TRM upstream of WBN Dam
Watts Bar-Roane	Tennessee River	4.8 km (3 mi) SSW of Kingston, Tennessee
Bull Run-Sequoyah	Tennessee River	8 km (5 mi) SSE 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 forested 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. 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. Maintenance would 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 2008b).

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 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 staff does not expect startling or displacement from intermittent operational noises and ultimate population reduction to destabilize local wildlife populations. The NRC 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 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 2005). These studies found no evidence that EMFs cause any specific types of cancer in rats or mice (Moulder 2005). Therefore, the 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 believes 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 2004b).

Section 4.2.2.1 says 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 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 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. TVA's long-term strategies 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 2008b). 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. Four 500-kV transmission corridors would support WBN Unit 2, and the eight waterway crossings of these lines pose a risk to waterfowl. 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 could benefit wildlife that prefer open habitats, but would also deter 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 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. 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. Road and transmission-line maintenance could affect resources through deposition of sediment, organic debris, chemicals, and increased heat loads into streams and wetlands. TVA uses BMPs, including temporary and permanent erosion barriers, retention of favorable vegetation retention, and good housekeeping to minimize impacts of road maintenance to on the environment.

TVA's use of the sensitive area review process would also limit 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's own 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 aquatic ecosystems and threatened and endangered species from the operation of intake and discharge systems of WBN Unit 2. 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 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 potential impacts on the aquatic biota of the Tennessee River from operating WBN Unit 2 include 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 Consumption

As discussed in Section 3.2.2, the normal makeup water flow rate through the IPS from Chickamauga Reservoir for two units would be 3.2 m^3/s (113 cfs) in the winter and 3.79 m^3/s (134 cfs) in the summer. The summer flow rate would represent 0.4 percent of the mean flow of the Tennessee River at Watts Bar Dam, which is 778 m^3/s (27,500 cfs). The normal intake flow rate through the SCCW intake from above the Watts Bar Dam in the Watts Bar Reservoir would be 7.1 m^3/s (250 cfs), which is slightly below that currently for WBN Unit 1 (see Section 3.2.2.1) and 0.91 percent of the mean flow of the Tennessee River at the dam. Combined, this is 1.3 percent of the mean flow of the Tennessee River at Watts Bar Dam, although 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 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 have a very minor impact, if any, on 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).

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. WBN Unit 2 would also use the IPS, which pulls water into the CCW system. The IPS and associated cooling intake canal are located at Tennessee River Mile (TRM) 528.0, about 3.1 km (1.9 mi) below the dam.

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 has 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 (TDEC 2011). 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. Regardless, the NRC staff believes that compliance with EPA's regulations will afford protection of aquatic organisms at individual, population, community, or ecosystem levels of ecological structure.

SCCW Intake

TVA currently holds an NPDES permit for discharge from the SCCW system and operates the SCCW intake for Unit 1. TVA currently uses the SCCW to operate WBN Unit 1 and plans to continue to use the system for WBN Unit 2. The NRC (1978, 1995) did not previously consider the SCCW system because the system did not begin operating until 1999.

The normal SCCW intake flow rate during operation of both units (Section 3.2.2.1) would be 7.1 m^3/s (250 cfs). This is slightly lower than the intake flow rate that occurs with single-unit operation, 7.31 m^3/s (258 cfs). As discussed previously, the lower flow rate for two units in operation is anticipated because water moves through the system under gravity flow, and the water level in the cooling-tower basin for Unit 2 would be 0.6 m (2 ft) higher when the unit is operating (TVA 2010b). This reduces the difference in water level elevation between Watts Bar Reservoir and the cooling-tower basin, resulting in a reduction of flow rate.

During the summer months when the Watts Bar Reservoir levels are maintained at 225.7 m (740.5 ft), the water velocity through the openings in the traveling screens at the SCCW would be 0.28 m/s (0.91 ft/s) (TVA 2010b), as discussed in Section 3.2.2.1. For the purpose of comparison, this is above the EPA guideline of 0.15 m/s (0.5 ft/s). Through-screen velocities at the SCCW system are variable because this is a gravity-fed system, and the through-screen velocities depend on the depth of the water at the intake.

Entrainment at the SCCW

The SCCW removes less than 1 percent of the average annual flow past the dam. The withdrawal rate is not being increased for operation of the second unit, rather it would decrease slightly for the operations of both WBN Unit 1 and 2 from the flow for Unit 1 as described in Section 3.2.2.1 of this document. Based on this alone, the staff could conclude that the entrainment of aquatic biota from Watts Bar Reservoir would not change as a result of the additional operation of Unit 2. However, because the SCCW system was not operated until 1999, as discussed previously, the staff did not evaluate entrainment at the SCCW intake in either the 1978 FES-OL (NRC 1978) or the 1995 SFES-OL-1 (NRC 1995). The staff has determined that it is appropriate to evaluate the potential for entrainment in this document.

Three studies related to entrainment or ichthyoplankton density on 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). TVA conducted the third study during May and August of 2010 also to look at ichthyoplankton densities (TVA 2011a). The following paragraphs discuss the results of the studies in chronological order. Section 5.5.2 contains a more detailed description of the studies.

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 or 5.23 m^3/s (185 ft^3/s) to 1.11×10^6 m^3/d or 12.8 m^3/s (452 ft^3/s) (TVA 1976), which is almost twice the flow that will be used for both Units 1 and 2. TVA conducted entrainment sampling for the Watts Bar Fossil Plant during 10 sampling periods between March 24 and July 28, 1975 at 5 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 reservoir and intake samples during any sample period. As discussed in Chapter 2, TVA identified fish larvae of 19 taxa 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 (for example, bluegill) had more than 1 percent of the abundance (1.2 percent).

TVA (1976) also estimated water entrained (hydraulic entrainment) during 24-hour periods sampled once every 2 weeks and reported that the 10 biweekly samples ranged from 0 to 1.53 percent of the reservoir flow. TVA's estimates of entrainment of total fish larvae ranged from 0.11 to 0.86 percent of the total population transported through the Watts Bar Dam generators during the 10 sampling periods. TVA estimated total larval fish entrainment for the entire study period (127 days) to be 0.24 percent of the transported population. Because of the low estimate of percent 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.

In its SCCW Environmental Assessment, TVA (1998b) stated that the larval fish entrainment for the WBN Unit 1 would be only 0.12 percent of the transported population because the SCCW system would use only half the water volume originally used for the Watts Bar Fossil Plant. Two ichthyoplankton studies (previously discussed in Chapter 2) indicate changes in the composition of ichthyoplankton in the vicinity of the SCCW system since 1975. Clupeid larvae (includes threadfin and gizzard shad) were still the dominant specie, followed by centrarchid larvae (such as *Lepomis*), although the percentage of the Lepomis larvae was higher than in 1975, which is in line with the with the adult population surveys reported in Chapter 2 for the Watts Bar Reservoir.

The NRC staff believes that no additional impacts on the aquatic biota of Watts Bar Reservoir would result from the additional operation of WBN Unit 2. The levels of entrainment observed in the 1970s were low. The estimated larval entrainment for WBN Unit 1 was estimated to be half of the level of entrainment from operation of the Watts Bar Fossil Plant in the 1970s. As discussed previously a slightly lower flow rate is anticipated during the operation of both units, most likely resulting in even lower rates of entrainment. The composition of the ichthyoplankton entrained in the SCCW system, primarily clupeid larvae and *Lepomis* sp., has remained constant since the studies in the 1970s, although the relative percentages may have changed. Based on the staff's review, entrainment from the SCCW system would likely not destabilize or noticeably alter the aquatic biota of the Watts Bar Reservoir even though the SCCW system operates as a once-through system.

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

The operation of Unit 2 would not modify or change the SCCW system intake, except for the previously discussed flow rate decrease for operation of both units compared to when only Unit 1 was operating. Based on this information alone, the staff can conclude that the additional operation of Unit 2 would not further affect the aquatic biota of Watts Bar Reservoir. However, because the SCCW system was not operated until 1999, as discussed previously, the staff did not evaluate impingement at the SCCW intake in either the 1978 FES-OL (NRC 1978) or the 1995 FES-OL-1 (NRC 1995). The staff has determined that it is appropriate to assess the potential for impingement in this document.

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 2008c). 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.

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, 1999 through September 29, 1999 and March 7, 2000 through April 26, 2000. Further details on the sampling are provided in Section 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). It was estimated that 9,125 fish would be impinged annually by the SCCW system as it was operating for WBN Unit 1.

TVA (2008c) 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, impingement affected only small numbers of fish, with the exception of threadfin shad (*Dorosoma petenense*), of which 5,381,439 (annual estimate) were impinged during 2005–2006.

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 macrochirus*	Bluegill	229	48
	Lepomis gulosus	Warmouth	1	0
	Lepomis megalotis	Longear sunfish	5	0
	Lepomis auritus	Redbreast 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	*Dorosoma cepedianum*	Gizzard shad	1,086	2,957
	Alosa chrysochloris	Skipjack herring	1	1
	Dorosoma petenense	Threadfin shad	768,777	27,164
Cyprinidae	*Pimephales notatus*	Bluntnose minnow	0	2
	Pimephales vigilax	Bullhead minnow	1	7
	Cyprinella spiloptera	Spotfin shiner	0	1
Ictaluridae	*Ictalurus furcatus*	Blue catfish	4	0
	Ictalurus punctatus	Channel catfish	12	3
	Pylodictis ofivaris	Flathead catfish	0	1
Moronidae	*Morone saxatilis*	Striped bass	1	0
	Morone chrysops	White bass	2	1
	Morone mississippiensis	Yellow bass	18	10
Percidae	*Percina aurantiaca*	Tangerine darter	1	0
	Percina caprodes	Logperch	14	1
	Perca flavescens	Yellow perch	2	0
Sciaenidae	*Aplodinotus grunniens*	Freshwater drum	18	2
Total number of fish			770,218	30,202
Total number of species			23	16

Source: TVA 2008c

Table 4-6. Estimated Annual Numbers, Biomass and Percent Composition 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	1603	336	970	40138	8953	24546
Yellow bass	126	70	98	4445	1064	2755
Freshwater drum	126	14	70	10381	483	5432
Largemouth bass	119	7	63	43302	35	21669
Channel catfish	84	21	53	987	266	627
Logperch	98	7	53	1491	84	788
Black crappie	77	0	39	23352	0	11676
Bullhead minnow	7	49	28	04	70	42
Redear sunfish	42	0	21	8512	0	4256
Longear sunfish	35	0	18	4858	0	2429
Redbreast sunfish	35	0	18	2555	0	1278
White crappie	21	14	18	1295	35	665
Blue catfish	28	0	14	3472	0	1736
Brook silverside	14	7	11	56	21	39
White bass	14	7	11	3654	1393	2524
Bluntnose minnow	0	14	7	0	21	11
Skipjack herring	7	7	7	1281	2590	1936
Spotted bass	14	0	7	81	0	42
Yellow perch	14	0	7	1183	0	592
Flathead catfish	0	7	4	0	1344	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	1127	0	564
Total	5,391,526	211,414	2,801,470	10,321,990	352,905	5,337,448

Source: TVA 2008c

To determine whether the number of threadfin shad impinged would have an effect on the aquatic ecosystem in Watts Bar Reservoir, the 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 staff used such an approach for the Cooper Nuclear Station license renewal supplemental environmental impact statement (EIS) (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. As discussed in the previous paragraphs, 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). Furthermore, a comparison with other power facilities in the region also shows that threadfin shad are consistently impinged at rates higher than other fish. Table 4-7 shows the total estimated annual number of fish impinged by species during impingement studies at TVA's Sequoyah Nuclear Plant (2005–2007; TVA 2007c) and TVA's Kingston Fossil Plant (2004–2006; TVA 2007d). 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 4-7. 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	------	2520	2751
Kingston Fossil Plant	185,577	225,197	----	8,337	11,746	

Sources: TVA 2007d, 2007c, and 2008c. 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 2007d), and 91 percent for the Sequoyah Nuclear Plant during 2005 and 2006 (TVA 2007c).

The third line of evidence deals with the biological response shad have to 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 2008 TVA ER (TVA 2008b), 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 ability that might have improved if temperature conditions had improved) 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 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 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 (2010c) 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. However, the population is likely much greater assuming the 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 20 percent of the threadfin shad likely present in Watts Bar Reservoir.

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, indicating the loss of threadfin shad in Watts Bar Reservoir did not noticeably affect species that prey on threadfin shad (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, 1995–2007

Year	Electrofishing Catch Rate (no/hr)	Mean Weight (lb)	% Harvestable	Bass > 4 lb	Bass > 5 lb	Largest Bass (lb)
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 believes that the aquatic biota of Watts Bar Reservoir would not be affected further by impingement from the additional operation of WBN Unit 2 because the intake flow and intake velocity for both units would be either the same as, or less than, that for the current operation of WBN Unit 1, as explained in Section 3.2.2.1. 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 did not destabilize or noticeably alter the aquatic biota of the Watts Bar Reservoir in the following year.

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. NRC (1978) previously considered the use of the IPS for operation of two units.

The flow through the IPS is currently 0.32 percent of the mean annual flow of the Tennessee River as measured at Watts Bar Dam for a single unit. Operation of WBN Unit 2 would increase the flow rate through the IPS, under normal conditions, to approximately 0.4 percent of the mean annual flow of the Tennessee River for normal operation after WBN Unit 2 begins operation as discussed in Section 3.2.2.1.

TVA (1998a,2011b) reports the average velocities in the IPS canal are 0.015 m/s (0.05 ft/s) for the winter pool level and 0.009 m/s (0.03 ft/s) for the summer pool level. The IPS has a flow rate through the openings of the traveling screens of 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 (TVA 2011a). For the purpose of comparison, this 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 1.0 ft/s. EPA indicated that 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 (TVA 1998a; TVA 1998 revised June 7, 2010). TVA conducted the second entrainment study from April through June 2010 (TVA 2011c). 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 (TVA 1998a). Section 5.5.2 contains a more detailed description of the studies.

In first entrainment study (1996 and 1997) for the IPS, TVA (1998a; TVA 2010e) estimated the average the densities of fish eggs and larvae (ichthyoplankton) from a transect located at TRM 528 (just upstream of the intake channel), and multiplied by the corresponding 24-hour flow past the plant. This provided an estimate of the fraction of ichthyoplankton transported 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. 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 0.29 percent and 0.57 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 percent and 0.22 percent, respectively.

TVA conducted the second entrainment study from April through June 2010 using the same procedures as in 1996 and 1997 (TVA 2011c). TVA indicated that the purpose of this study was to "update and verify historical monitoring conducted in 1996 and 1997." TVA reported that the study resulted in an annual entrainment rate of fish eggs and larvae (that would otherwise have been transported past the site) to be 0.14 percent and 0.38 percent respectively for the season. This entrainment rate is within the range reported for 1996 and 1997. However, during one sampling period on May 17, when the Watts Bar Dam had no turbine flow, the density of fish eggs in the intake sample was higher and resulted in an estimated entrainment of 3.5 percent. Similarly, the densities of fish larvae during samples taken between May 24 and June 21 were higher from the intake samples compared to the river samples. The highest percent entrained occurred in samples taken on June 14 (2.65 percent) and June 21 (8.65 percent) (TVA 2011c).

In addition to estimating the entrainment rate, TVA identified the fish larvae obtained in the samples from the intake channel during the 1996 and 1997 studies and compared them to the results of previous sampling from the preoperational (1984 and 1985) studies (TVA 1998a; TVA 2010e). During preoperational and operational studies, the clupeid (threadfin shad and gizzard shad [*Dorosoma cepedianum*]) larvae made up 84 percent (1997) or 91 percent (1996) of the larvae in the intake channel, with the sunfish the next most abundant (7.6 percent and 8.1 percent) (Table 4-9). TVA postulated (TVA 1998, 2010e) that the higher composition of centrarchid or sunfish (*Lepomis*) larvae in the intake channel compared to in the river (where it ranked third or fourth in combined percent) was a result of resident populations using the intake channel as habitat for spawning and nursery (as discussed in Section 2.3.2.1). TVA did not report the identification of the larvae in the intake channel from the 2010 study separately from the larvae that were obtained from the reservoir transect. For this reason, Table 4-9 does not contain the percent composition of fish larvae collected in the intake channel during the 2010 study.

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

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

Source: TVA 1998a, 2010e

Based on the low amounts of entrainment, the staff determined that the operation of the IPS, 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 staff does not anticipate that the additional water withdrawal and subsequent entrainment from the additional operation of Unit 2 would be noticeable or destabilizing to the aquatic ecology.

Impingement at the IPS

TVA conducted two impingement studies at the IPS. The first occurred before WBN Unit 1 started producing commercial power (TVA 1998a, 2010e). TVA conducted an additional impingement studies at the IPS between March 26, 2010 and March 17, 2011 (TVA 2011b). Section 5.4.2 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, 20 fish representing 9 species were collected during sampling. The study found the total annual estimated number of fish impinged during 1996 and 1997 to be 162.2 and 40.8, respectively (TVA 1998a, 2010e). 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 (TVA 1998a, 2010e).

Table 4-10. Actual and Estimated Numbers of Fish Impinged at Watts Bar Nuclear Plant During Sample Periods from March 1996 Through October 7, 1997 and During March 2010 Through March 2011

	March 1996 – October 1997			March 2010 – March 2011		
Common Name	Actual Number Impinged	Total Annual Estimated Number	Composition (%)	Actual Number Impinged	Total Annual Estimated Number	Percent Composition
Gizzard shad	4	40.6	20%	1,172	8,204	60.4%
Threadfin shad	2	20.3	10%	766	5,362	39.5%
Freshwater drum	6	61	30%	0	0	0%
Channel catfish	1	10.1	5%	0	0	0%
Flathead catfish	1	10.1	5%	0	0	0%
Bluegill	2	20.3	10%	0	0	0%
Redear sunfish	1	10.1	5%	0	0	0%
White crappie	2	20.3	10%	0	0	0%
Log perch	1	10.2	5%	0	10.2	0%
Inland silverside	0	0	0%	1	7	0.1%
Total	20	203	100%	1,939	13,573	100%

Source: TVA 1998a; TVA 2010e; TVA 2011b

TVA conducted additional impingement studies at the IPS between March 26, 2010 and March 17, 2011 (TVA 2011b). 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 2011b). It is likely that the increased number of gizzard and threadfin shad in the 2010 to 2011 impingement studies and the timing of the impingement (January through March) is 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, however, the thermal discharges from WBN Unit 1 would have provided a thermal refugia. However, it is also possible that some of the shad that were impinged 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 both Watts Bar and Chickamauga reservoirs and the number of shad impinged in the 2010–2011 study is small compared to the entire population.

The NRC staff believes that impingement at the IPS, even with the operation of both units, would be too low to be readily detected in the populations and would not destabilize, or noticeably alter, the aquatic biota of the Chickamauga Reservoir. The staff bases this decision on the 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 temperature of the heat source (in this case the Tennessee River) and can also cause cold shock when aquatic organisms that are acclimated to warm water are exposed to a sudden decrease in temperature. The effects of the raised temperatures for each of the three thermal outfalls are discussed, 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 is occurring during operation of WBN Unit 1. It will continue with the addition of WBN Unit 2. Thermal discharges will continue to occur via the same three outfalls as described in Section 4.2.2.1 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 indicated that the thermal discharges during the combined operation of both units would remain within the existing NPDES permit limits (TVA 2008a). The NPDES permit issued by the State of Tennessee for Unit 1 specifies limits on the amount of thermal effluents the plant may discharge into the Tennessee River. Table 4-1 shows the current NPDES temperature limits for the three outfalls used during operation for Unit 1. As Section 4.2.2.1 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. TVA used a physical hydrothermal model test of the discharge to determine the mixing zone dimensions for the outfall to the SCCW (Outfall 113) as discussed in Section 4.2.2.2. It has confirmed the model output with actual measurements (TVA 2005, 2006b, 2007e, 2007f). 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 (TVA 2004a). 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 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. 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 (2011d) has characterized the attributes of the SCCW thermal plume 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. Results of the ichthyoplankton studies are discussed in Section 2.3.2. The study showed that the plume remained near the surface and spread across the river. During periods of normal release from Watts Bar Dam, the plume remains near the right descending bank. 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), respectively, which is below the maximum seasonal temperatures that were established by the Tennessee State Water Quality Criteria (30.5°C (86.9°F) for the protection of aquatic resources. However, no ichthyoplankton were collected below the SCCW discharge during August, suggesting that ichthyoplankton are not exposed to the thermal effluent during the peak seasonal temperatures. Based on the ichthyoplankton taxa collected, thermal tolerance data, river temperatures, and exposure times, TVA concluded "there is essentially no risk of thermal damage to ichthyoplankton during no-flow conditions" from the dam (TVA 2011d).

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 a ramp on the invert of the SCCW outfall to deflect the discharge upward, and away from the bottom of the river (TVA 2004a). The analysis of in-stream data collected by TVA for Outfall 113 showed that heat from the SCCW effluent does not reach the bottom in significant amounts (TVA 2004a).

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 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. However, as indicated, the diffuser's plume angles upward at 45 degrees above horizontal in the downstream direction, the plume is buoyant because the water is warmer, and as a result, the plume would 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 occur less frequently if WBN Unit 2 starts operation. Cold shock is also less of a factor at plants like WBN because the water discharges to a river or reservoir where the volume of discharge in comparison to the flow of the river is very small.

Summary

The staff believes 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 determination results from the incremental rise in thermal discharge anticipated from Outfalls 101, 102, and 113 from operation of both WBN Units 1 and 2, the modeling of the thermal plume, requirements in the current NPDES permit limits for thermal discharge during operation of both units, and data obtained from TVA's hydrothermal studies of ichthyoplankton and their exposure to the SCCW thermal plume. It is also based on the lack of an observed impact on the aquatic biota from current operations of WBN Unit 1.

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 1998b). 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. The NRC staff believes that physical changes 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 2009c). The type and quantity of chemicals the plant would discharge are the same as those specified in the current NPDES permit and in TVA's request for the revised permit for WBN Unit 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. 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. Based on the results of these tests and the unchanged quantity of chemicals that would be discharged, the NRC staff believes 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 pearly mussel (*Cyprogenia stegaria*), the dromedary pearly mussel (*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 were heavily represented in either entrainment or impingement studies and, as a result, the staff considers it unlikely that entrainment or impingment 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. Except for the logperch (*Percina caprodes*), which is a host for the Eastern fanshell, 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. The temperatures in this area 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 (TVA 2004a). 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 staff believes 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 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.

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. 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 level of operations employment, while larger than originally expected in the 1978 FES-OL, would be less than current total 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 1.7 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 2-24). 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 2010c, 1987). This influx of students would represent a 1 percent increase in the total number of enrolled students in the four-county ROI (approximately 22,000 students in 2008) (NCES 2009c, d, e, f). 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 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's 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 2009d).

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.

4.4.3 Environmental Justice Impacts

The NRC 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 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 performed an independent analysis using the LADTAP II computer program. 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 confirmed these results using the GASPAR II computer program (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 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 that are integrated into the NRCDOSE program. 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 has 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 has 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 2006a).

This section provides the NRC's 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 2006a). 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 2006a). TVA will restrict all new construction to the existing previously built portion of WBN Units 1 and 2.

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

TVA determined in a letter dated December 28, 2006, that operating WBN Unit 2 does not have the potential to affect historic structures, including the adjacent Watts Bar Fossil Plant (TVA 2006a). 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 received a letter from the Tennessee Historical Commission 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 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 is consulting with the Eastern Band of Cherokee Indians regarding operating WBN Unit 2 on the WBN site.

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 2009e).

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.

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

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

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).

For the evaluation of the potential radiological impacts to the public, the staff reviewed the exposure pathways the TVA ER 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. The 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 staff during this evaluation (TVA 2011e and TVA 2011f), 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 staff determined that direct radiation from WBN Unit 2 does not warrant consideration in the dose to the public.

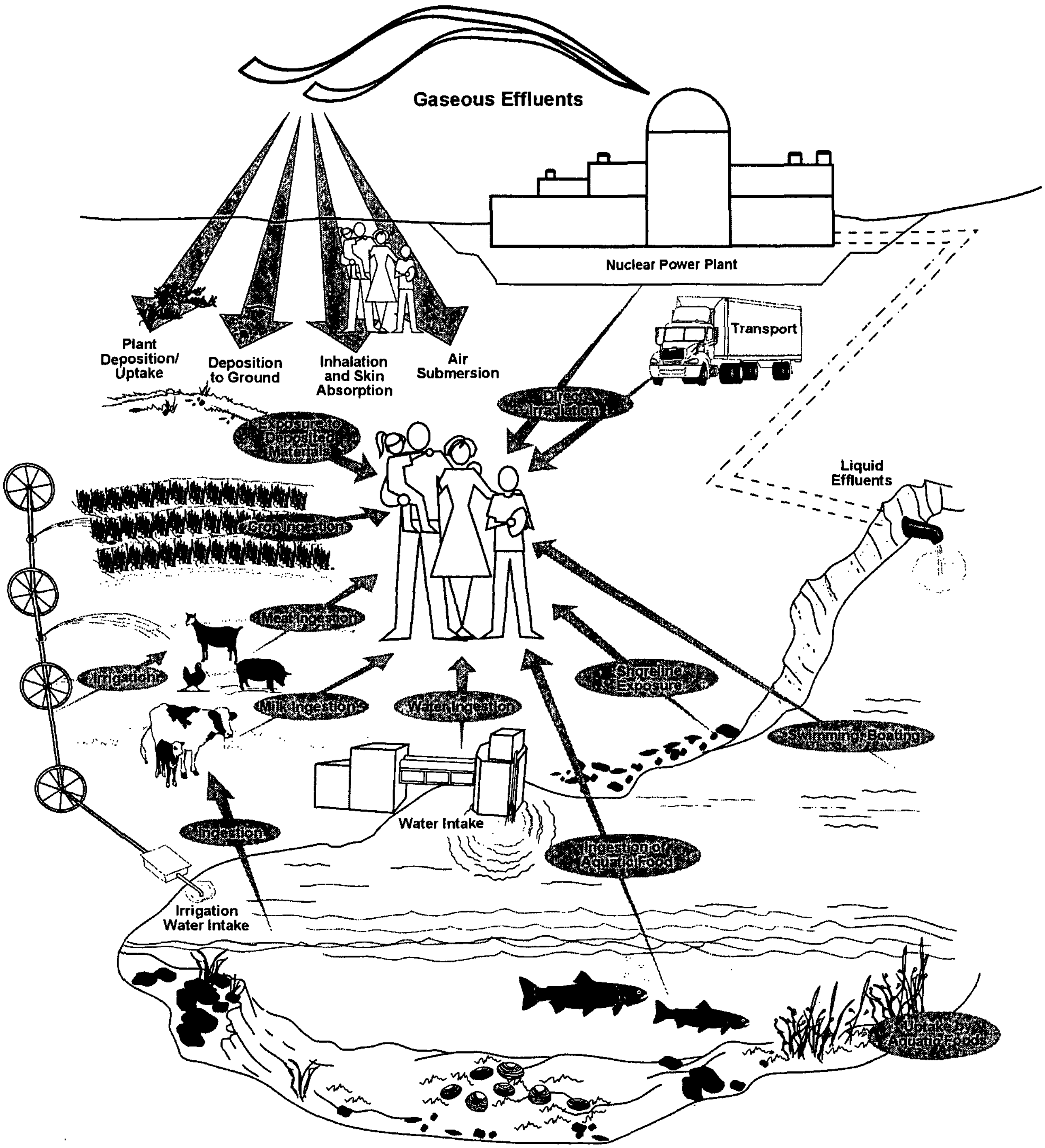


Figure 4-2. Exposure Pathways to Man (adapted from Soldat et al. 1974)

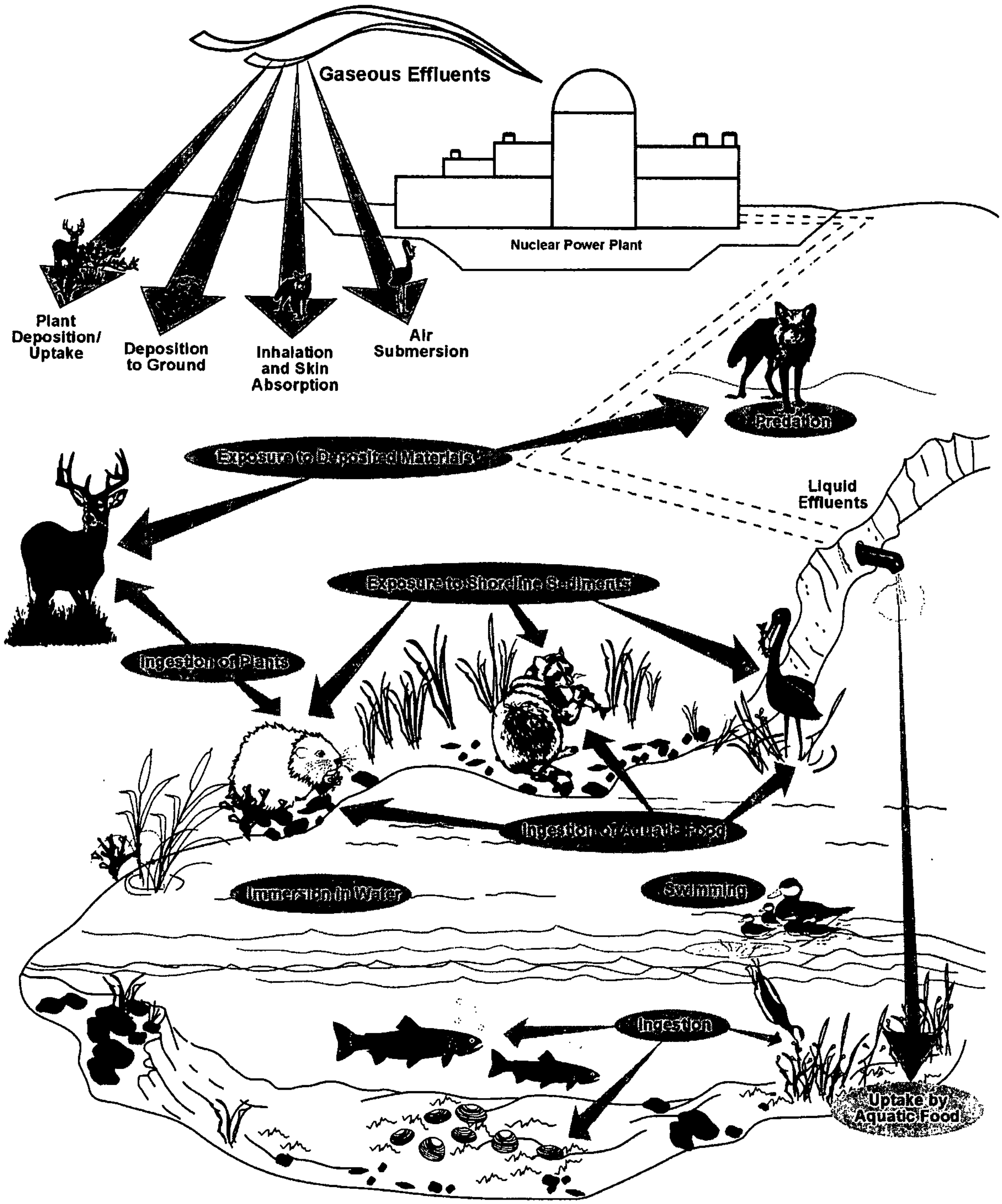


Figure 4-3. Exposure Pathways to Biota Other Than Man (adapted from Soldat et al. 1974)

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 2011g,h) and Final Safety Analysis Report (TVA 2008a, 2009b). 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.

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

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

The 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.

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

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 (2011g) 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 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 staff reviewed the input parameters and values TVA used and concluded that the assumed input parameters and values TVA used were generally appropriate. The 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 staff's analysis in the 1995 SFES-OL-1, and the staff's current analysis do not differ significantly.

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 TVA's dose estimates for WBN Unit 2 to the Appendix I design objectives. The 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 2011g. 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 TVA's 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 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 2011g 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 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 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 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. Appendix I of this SFES shows TVA and 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 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 [1754 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 (1754 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 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's own independent evaluation, the 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 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 2009V). To evaluate the potential radiological impacts to biota, the 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 maximally exposed individual 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 integrated into NRCDose Version 2.3.10 (Chesapeake Nuclear Services, Inc. 2006). 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 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 staff (see the complete analysis in Appendix I), the 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 considers low flow in a river to be less than 2,800 m^3/s (100,000 ft^3/s) (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 ft^3/s). 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 would be used most frequently, 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 2010a). 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 relate 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 95°F, which is below the optimal growth temperatures for the above-mentioned organisms, and TVA has stated it would comply with those requirements (see Table 4-1)(TVA 2010a). 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. 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.

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 (Section 3.2.2). TVA's 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 2008d).

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, as well as with operation of the Watts Bar Fossil Plant and Dam.

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's 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 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 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 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 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 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 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 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 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 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 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 staff's independent review of information since the 1978 FES-OL, the staff concludes that the impact on the atmosphere from heat dissipation resulting from operating WBN Unit 2 would be SMALL.

Operating Watts Bar 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 2011), 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 forseeable 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. The plant would generate air emissions primarily from vehicles, diesel generators, and combustion generators.

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 for the condenser cooling system and the SCCW the Chickamauga Reservoir through Outfalls 101 and 113, respectively. 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 to the Chickamauga Reservoir through Outfalls 101 and 113. 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 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 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 will 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 staff compared TVA's fuel characteristics 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 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 burn-up levels and enrichment to fuel cycle operations since the original publication of Table S–3. NUREG-1437 concluded that increased fuel burn-up levels to 62,000 MWD/MTU and 5.0 fuel enrichment in fuel cycle operation would not change the impacts described in Table S–3. With the exception of radiological waste, the 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. The NRC staff anticipates that TVA would temporarily store Class B and C LLW onsite until offsite disposal locations become available. In addition, TVA also stores 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.

The safety and environmental effects of spent fuel storage have been evaluated by the NRC and, as set forth in the Waste Confidence Rule (10 CFR 51.23), the Commission has made a generic determination that, if necessary, spent fuel generated in any reactor can be stored safely and without significant environmental impacts for at least 60 years beyond the licensed life of operation (which may include the term of a revised or renewed license) of that reactor at its spent fuel storage basin or at either onsite or offsite independent spent fuel storage installations (ISFSIs).

As described in 10 CFR 51.23 "Temporary storage of spent fuel after cessation of reactor operation--generic determination of no significant environmental impact," the Commission has made a generic determination that, if necessary, spent fuel generated in any reactor can be stored safely and without significant environmental impacts for at least 60 years beyond the licensed life for operation (which may include the term of a revised or renewed license) of that reactor in a combination of storage in its spent fuel storage basin and at either onsite or offsite independent spent fuel storage installations. Furthermore, the Commission believes there is reasonable assurance that sufficient mined geologic repository capacity will be available to dispose of the commercial high-level radioactive waste and spent fuel generated in any reactor when necessary. Accordingly, as provided in 51.23(b), this SFES contains no discussion of any environmental impact of spent fuel storage in reactor facility storage pools or ISFSIs for the period following the term of the requested reactor operating license.

This section does not alter any requirements to consider the environmental impacts of spent fuel storage during the term of a reactor operating license. Based on the staff's independent review of information since the 1978 FES-OL, the staff concludes that the environmental impacts of radioactive waste storage and disposal associated with WBN Unit 2 would be SMALL. Similarly, the staff concludes that the environmental impacts of spent fuel storage during the term of a reactor operating license would be SMALL.

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 2011) 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 gas 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 Decomissioning

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)(l) 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 staff relies on the bases established in GEIS-DECOM and concludes the following:

1. Doses to the public would be well below applicable regulatory standards regardless of which decommissioning method TVA uses.

2. Occupational doses would be well below applicable regulatory standards during the license term.

3. 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.
4. Air quality impacts of decommissioning are expected to be negligible at the end of the operating term.
5. 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.
6. Ecological impacts of decommissioning are expected to be negligible.
7. 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 2011), 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 TVAs 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 low level waste, 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 low level waste 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 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 staff evaluated information in the WBN Unit 2 FSAR 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 (TVA2009a).

The 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 burn-up 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 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 relied on TVA's 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 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 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 Requests for Additional Information, 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 inform the cumulative analysis, the staff researched EPA databases for recent EISs within the State, used an EPA database for permits for water discharges in the geographic area to identify water-use projects, and used the www.recovery.gov website to identify projects in the geographic area funded by the American Recovery and Reinvestment Act of 2009 (Public Law 111-5). The staff reviewed major projects near the WBN site considered relevant in the cumulative analysis and used the information to perform an independent evaluation of the direct and cumulative impacts of the action.

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.

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 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.

NRC 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, NRC considers the geographic area of interest to be Rhea County in the Eastern Tennessee-Southwestern Virginia Interstate Air Quality Control Regiondefined 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 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 NRC's 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 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 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 2004b). 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 2004b). 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 TVA's Integrated Resource Plan (TVA 2011i) *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 433 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 1860 m^3s (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 (1170 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 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. 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 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 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 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 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 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 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 2010b). 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 2010d). 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 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 staff concludes that the cumulative surface-water-quality impacts would be MODERATE. Based on TVA's 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 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 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 2010b) and the operation of WBN 2 would not result in an increase in water withdrawn on the site because WNB 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 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 2011). 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 (2860 pCi/L) in 2010 (TVA 2011). Current concentrations in groundwater are well below the EPA drinking water standard of 20,000 pCi/L (TVA 2011). 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 2011). 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 TVA's spill prevention and control plans, 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 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 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 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 NRC's own 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 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. In its ER, TVA (2008a) discussed cumulative aqutic impacts primarily in terms of summary indices meant to communicate the current,gener environmental health of the river and reservoir system. By combining and amalgamating information, such indices produce a general picture at the expense of finer detail. Here the NRCstaff 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 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). Other past actions that have changed the aquatic fauna in the geographical region include introduction of non-native species, over fishing 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.

WBN Unit 1 is collocated with WBN Unit 2. The two units share the same intakes and discharges. As discussed in Section 3.2, the makeup flow rate through the IPS would be almost twice that for the single unit operation. The intake flow rate of the SCCW system when both units are operating would be less than that for a single unit of operation. As discussed previously, the lower flow rate for two units in operation is anticipated because water moves through the system under gravity flow, and the water level in the cooling-tower basin for Unit 2 would be 0.6 m (2 ft) higher when the unit is operating (TVA 2010b). This reduces the difference in water level elevation between Watts Bar Reservoir and the cooling-tower basin resulting in a reduction of flow rate.

The total flow through the two units operating (includes withdrawals from both the SCCW system and the IPS) under maximum normal withdrawals would be 12 m^3/s (424 cfs), which is approximately 1.5 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 1.7 m^3/s (61 cfs), which is approximately 0.2 percent of the mean annual flow past the WBN site.

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 the decades worth 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. The discussions in Section 4.3.2 also take into account the cumulative impact of operating both units. As a result, the staff also 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 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 significantly adversely affect aquatic ecology in the vicinity of the WBN site. Watters (1999) 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).

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 2007c). 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 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 also performed 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. 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 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. TVA attributed the seasonal larval drum entrainment at Sequoyah Nuclear Plant primarily to a sample taken on May 18, 2004, when peak density occurred simultaneously with peak hydraulic entrainment (11 percent) (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 2007d).

Historical entrainment studies 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. NRC 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 also examined 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 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 2010). 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's own 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 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's construction of (1) WBN Units 1 and 2 and associated infrastructure, (2) the adjacent Watts Bar Fossil Plant, and (3) 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 2006a). 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 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 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 maximally exposed individual (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 consideredwithin 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 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 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 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 (TDEQ 2010). NRC also reviewed studies of waterborne 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, the possil plant, and the dam would be expected to be attenuated to below the level the NRC 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 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 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 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.

TVA's current 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 (Tennessee Code Annotated 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 staff does not expect any

(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.

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 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 staff concludes that the cumulative impacts on socioeconomics and environmental justice related to operating WBN Unit 2 would be SMALL. 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 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 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 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. Tables 6-4 and 6-5 in Section 6.2 provide comparisons 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 nuclear power plant gets smaller as the distance increases. The combined risk at any location within 80 km (50 mi) of the Watts Bar 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

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

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

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

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."

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

53 FR 30355. August 11, 1988. "Carolina Power & Light Co. et al. Shearon Harris Nuclear Power Plant, Unit 1; Environmental Assessment and Finding of No Significant Impact." *Federal Register.* U.S. Nuclear Regulatory Commission.

56 FR 23360. May 21, 1991. "Standards for Protection Against Radiation." *Federal Register.* U.S. Nuclear Regulatory Commission.

59 FR 7629. February 16, 1994. "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, Executive Order 12898." *Federal Register.* U.S. Office of the President.

60 FR 6381. February 1, 1995. "Amendment to Executive Order No. 12898." *Federal Register.* President of the United States.

66 FR 65256. December 18, 2001. "National Pollutant Discharge Elimination System: Regulations Addressing Cooling Water Intake Structures for New Facilities." *Federal Register.* U.S. Environmental Protection Agency.

69 FR 41576. July 9, 2004. "National Pollutant Discharge Elimination System – Final Regulations to Establish Requirements for Cooling Water Intake Structures at Phase II Existing Facilities." *Federal Register.* U.S. Environmental Protection Agency.

75 FR 31514. June 3, 2010. "Prevention of Significant Deterioration and Title V Greenhouse Gas Tailoring Rule". Federal Register. U.S. Environmental Protection Agency.

Advisory Group on Non-Ionising Radiation (AGNIR). 2006. *Power Frequency Electromagnetic Fields, Melatonin and Risk of Breast Cancer: Report of an independent Advisory Group on Non-Ionising Radiation.* Documents of the Health Protection Agency, Series B: Radiation, Chemical and Environmental Hazards, RCE-1, Health Protection Agency, Didcot, United Kingdom.

Agency for Toxic Substances and Disease Registry. 1996. *Health Consultation – Lower Watts Bar Reservoir Operable Unit US DOE Oak Ridge Reservation, Oak Ridge, Tennessee.* Atlanta, Georgia. Accessed January 14, 2010 at http://www.atsdr.cdc.gov/HAC/PHA/efork3/hc_p1.html.

American Recovery and Reinvestment Act of 2009 (ARRA). Public Law 111-5.

Atomic Energy Act of 1954. 2 USC 2011 et seq.

Avian Power Line Interaction Committee (APLIC). 2006. *Suggested Practices for Avian Protection on Power Lines: The State of the Art in 2006.* Edison Electrical Institute, APLIC, and the California Energy Commission. Washington, D.C. and Sacramento, California.

Baxter, D.S. and J.P. Buchanan. 2006. *Entrainment Monitoring at Sequoyah Nuclear Plant 2004.* Tennessee Valley Authority. Accession No. ML093510802.

Baxter, D.S., K.D. Gardner, and G.D. Hickman. 2001. *Watts Bar Nuclear Plant Supplemental Condenser Cooling Water System Fish Monitoring Program.* Tennessee Valley Authority, Nashville, Tennessee. Accession No. ML093510802.

Baxter, D.S. and L.K. Kay. 2002. *Sequoyah Nuclear Plant 316(B) Monitoring Program – Effects of Impingement on the Aquatic Populations in Chickamauga Reservoir.* Tennessee Valley Authority Resource Stewardship. Accession No. ML093510802.

Best, T.L. and J.B. Jennings. 1997. "Mammalian Species-*Myotis leibii.*" *American Society of Mammalogists 547:1-6.*

Bohac, C.E. and M.J. McCall. 2008. *Water Use in the Tennessee Valley for 2005 and Projected Use in 2030.* Tennessee Valley Authority prepared in cooperation with the U.S. Geological Survey. Available at www.tva.gov/river/watersupply/watersupply_report_to_2030.pdf.

Brady, J., T. Kunz, M.D. Tuttle, and D. Wilson. 1982. *Gray Bat Recovery Plan.* Fish and Wildlife Reference Service, Denver, Colorado. Accessed March 7, 2011 at http://www.fws.gov/asheville/htmls/listedspecies/gray_bat.html.

Cada, G.F. 1991. *Effects of Hydroelectric Turbine Passage on Fish Early Life Stages. CONF-910778—2.* Information Bridge. Accessed September 13, 2011 at http://www.osti.gov/bridge/purl.cover.jsp?purl=/5879350-POieLN/.

Calabrese, F.A. 1976. *Excavations at 40RH6, Watts Bar Area, Rhea County, Tennessee.* University of Tennessee at Chattanooga. Tennessee Valley Authority, Knoxville, Tennessee. Available at http://larc.tn.gov:8080/?config=tslaysm#section=resource&resourceid=47667&currentIndex=0&tab=detailViewDescriptionTab. Accession No. ML073510357

Chesapeake Nuclear Services, Inc. 2006. *NRCDOSE for Windows.* Radiation Safety Information Computational Center, Oak Ridge, Tennessee.

Clean Water Act. 33 USC 1251 et seq. (also referred to as the Federal Water Pollution Control Act [FWPCA]).

Cohn, J.P. 2008. "White-nose Syndrome Threatens Bats." *BioScience* 58(11):1098.

Council on Environmental Quality (CEQ). 2010. "Draft NEPA Guidance on Consideration of the Effects of Climate Change and Greenhouse Gas Emissions." In *Memorandum For Heads of Federal Departments and Agencies*. February 18, 2010. Available at http://www.whitehouse.gov/administration/eop/ceq/initiatives/nepa.

Doneker, R.L. and G.H. Jirka. 2007. *CORMIX User Manual: A Hydrodynamic Mixing Zone Model and Decision Support System for Pollutant Discharges into Surface Waters*. EPA-823-K-07-001.

Electric Power Research Institute (EPRI). 1993. *Proceedings: Avian Interactions with Utility Structure, International Workshop, September 13-16, 1992, Miami, Florida*. EPRI TR-103268, Palo Alto, California.

Etnier, D.A. and W.C. Starnes. 1993. *The Fishes of Tennessee*. University of Tennessee Press. Knoxville, Tennessee.

Federal Communications Commission (FCC). 2004. *Notice of Inquiry Comment Review Avian/Communication Tower Collisions*. Prepared by Avatar Environmental, LLC, Wester Chester, Pennsylvania, EDM International, Inc., Fort Collins, Colorado, and Pandion Systems, Inc., Gainesville, Florida. Available at http://wireless.fcc.gov/reports/documents/avatar-migratory-bird-report10104.pdf.

Hutson, S.S., M.C. Koroa, and C.M. Murphree. 2004. *Estimated Use of Water in the Tennessee River Watershed in 2000 and Projections of Water Use to 2030*. Water-Resources Investigations Report 03-4302. U.S. Geological Survey and Tennessee Valley Authority, Nashville, Tennessee.

International Atomic Energy Agency (IAEA). 1992. *Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards*. Technical Report Series No. 332, Vienna, Austria.

International Commission on Radiological Protection (ICRP). 1977. *Recommendations of the International Commission on Radiological Protection: Adopted January 17, 1977*. Pergamon Press, New York.

International Commission on Radiological Protection (ICRP). 1991. *1990 Recommendations of the International Commission on Radiological Protection*. ICRP Publication 60, Pergamon Press, New York.

International Commission on Radiological Protection (ICRP). 2007. "The 2007 Recommendations of the International Commission on Radiological Protection." ICRP Publication 103, *Annals of the ICRP* 37(2-4):1-332.

Johnson, J.B., J.E. Gates, and W.M. Ford. 2009. *Notes on Foraging Activity of Female Myotis leibii in Maryland.* United States Department of Agriculture Forest Service Research Paper NRS-8. U.S. Forest Northern Research Station, Newtown Square, Pennsylvania.

Kaseloo, P.A. and K.O. Tyson. 2004. *Synthesis of Noise Effects on Wildlife Populations.* Report No. FHWA-HEP-06-016. Office of Research and Technology Services, McLean, Virginia.

Loar, J.M., J.S. Griffith, and K.D. Kumar. 1978. *An Analysis of Factors Influencing the Impingement of Threadfin Shad (*Dorosoma petenense*) at Power Plants in the Southeastern United States.* Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge Tennessee. Accessed March 10, 2011 at http://www.osti.gov/bridge/purl.cover.jsp;jsessionid=96DE038BBAF747EC272B2CFCBA05A2DF?purl=/5066519-vRrj7d/.

MapMuse. 2010. *Online Cellular Tower Search Tool.* Accessed January 19, 2010 at http://find.mapmuse.com/re1/map_brand_mm2.php?brandID=CELL_TOWERS&init=35.9391,-85.8794,7&tlist=CELL_TOWERS,&ltp=Tennessee.

McLean, R.B., J.S. Griffith and M.V. McGee. 1985. "Threadfin shad, *Dorosoma pentenese* Günther, mortaility: causes and ecological implications in a South-eastern United States reservoir." *Journal of Fish Biology* 27:1-12.

Miller, B.A., V. Alaviany, M.D. Benderz, D.J. Benton, P. Ostrowski Jr., J.A. Parslyzz and M.C. Shiaox. 1992. "Integrated Assessment of Temperature Change Impacts on the TVA Reservoir and Power Supply Systems." In *Hydraulic Engineering: Saving a Threatened Resource—In Search of Solutions: Proceedings of the Hydraulic Engineering sessions at Water Forum '92.* Baltimore, Maryland, August 2–6, 1992. American Society of Civil Engineers.

Moulder, J. 2005. *Powerlines & Cancer FAQs.* Available at http://www.faqs.org/faqs/medicine/powerlines-cancer-faq/.

National Center for Educational Statistics (NACE). 2009a. "Hamilton County School District." *Search for Public Schools.* Accessed September 29, 2009 at http://nces.ed.gov/ccd/schoolsearch/index.asp.

National Center for Educational Statistics (NACE). 2009b. "Louden County School District." *Search for Public Schools.* Accessed September 29, 2009 at http://nces.ed.gov/ccd/schoolsearch/index.asp.

National Center for Educational Statistics (NACE). 2009c. "Miegs County School District." *Search for Public Schools.* Accessed September 29, 2009 at http://nces.ed.gov/ccd/schoolsearch/index.asp.

National Center for Educational Statistics (NACE). 2009d. "McMinn County School District." *Search for Public Schools.* Accessed September 29, 2009 at http://nces.ed.gov/ccd/schoolsearch/index.asp.

National Center for Educational Statistics (NACE). 2009e. "Rhea County School District." *Search for Public Schools.* Accessed September 29, 2009 at http://nces.ed.gov/ccd/schoolsearch/index.asp.

National Center for Educational Statistics (NACE). 2009f. "Roane County School District." *Search for Public Schools.* Accessed September 29, 2009 at http://nces.ed.gov/ccd/schoolsearch/index.asp.

National Council on Radiation Protection and Measurements (NCRP). 1991. *Effects of Ionizing Radiation on Aquatic Organisms.* NCRP Report No. 109, Bethesda, Maryland.

National Council on Radiation Protection and Measurements (NCRP). 1995. *Principles and Application of Collective Dose in Radiation Protection.* NCRP Report No. 121, NCRP Publications, Bethesda, Maryland.

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

National Historic Preservation Act of 1969, as amended (NHPA). 16 USC 470 et seq.

National Institute of Environmental Health Sciences (NIEHS). 1999. *NIEHS Report on Health Effects from Exposure to Power-Line Frequency Electric and Magnetic Fields.* NIH Publication No. 99-4493, Research Triangle Park, North Carolina.

National Research Council. 2006. *Health Risks for Exposure to Low Levels of Ionizing Radiation: BEIR VII - Phase 2.* National Academies Press, Washington, D.C.

Neves, R.J. and P.L. Angermeier. 1990. "Habitat alteration and its effects on native fishes in the upper Tennessee River System, east-central U.S.A." *Journal of Fish Biology* 37:45-52.

Pacific Northwest National Laboratory. 2009. Letter from JA Stegen (Pacific Northwest National Laboratory) to U.S. Nuclear Regulatory Commission dated November 12, 2009. "Final Watts Bar Site Audit Trip Report for JCN J-4261, 'Technical Assistance for Operating License Environmental Review – Watts Bar Unit 2 Reactivation.'" Accession No. ML100220022.

Ramsdell, J.V., Jr., C.E. Beyer, D.D. Lanning, U.P. Jenquin, R.A. Schwarz, D.L. Strenge, P.M. Daling, R.T. Dahowski, and T.J. Kenyon. 2001. *Environmental Effects of Extending Fuel Burnup Above 60 GWd/MTU.* NUREG/CR-6703, PNNL-13257. Washington, D.C.

Resource Conservation and Recovery Act (RCRA). 42 USC 6901 et seq.

Rhea County Schools. 2009. Phone call from Katherine Cort (Pacific Northwest National Laboratory) to Jerry Levengood (Superintendent of Rhea County School System) on November 2, 2009, "Re: Bar Nuclear Plant Impact on Regional School System." Accession No. ML101520416.

Schneider, R.W. and J.D. Tuberville. 1980. *Kingston Steam Plant 316 Permit Renewal report – 1980.* Tennessee Valley Authority Office of Natural Resources. Norris, Tennessee. Accession No. ML093510802.

Simmons, J.W. and D.S. Baxter. 2009. *Biological Monitoring of the Tennessee River Near Watts Bar Nuclear Plant Discharge, 2008.* Tennessee Valley Authority, Aquatic Monitoring and Management, Knoxville, Tennessee. Accession No. ML093510802.

Soldat, J.K., N.M. Robinson, and D.A. Baker. 1974. *Models and Computer Codes for Evaluating Environmental Radiation Doses.* BNWL--1754. Richland, Washington.

Stout, J. and G.W. Cornwell. 1976. "Nonhunting Mortality of Fledged North American Waterfowl." *The Journal of Wildlife Management* 40(4):681-693.

Strenge, D.L., R.A. Peloquin, and G. Whelan. 1986. *Ladtap II- Technical Reference and User Guide.* NUREG/CR-4013, U.S. Nuclear Regulatory Commission, Washington, D.C.

Tennessee Code Annotated (TCA). 67-9-101. 2009. "Tennessee Valley Authority (Tennessee State Revenue Sharing Act)." *Tennessee Code Annotated.*

Tennessee Department of Health. 2009. *Public Health Assessment – Public Comment Release.* Tennessee Valley Authority (TVA) Kingston Fossil Plant Coal Ash Release. December 9, 2009.

Tennessee Department of Environment and Conservation (TDEC). 2010. *State of Tennessee Department of Health Environmental Laboratories results for February Water Samples, TVA Ash Spill Project.* Accessed March 13, 2010 at http://www.tennessee.gov/environment/kingston/pdf/surface_water/02_23_2010.pdf.

Tennessee Department of Environment and Conservation (TDEC). 2011. *State of Tennessee NPDES Permit No. TN0020168.* Accession No. ML11215A099.

Tennessee Department of Labor and Workforce Development (TDLWD). 2010. *Noise.* Accessed June 1, 2010 at http://tennessee.gov/labor-wfd/tosha_noise.html.

Tennessee Historical Commission (THC). 2007. Letter from the Tennessee Historical Commission to the Tennessee Valley Authority dated January 4, 2007. "TVA, Watts Bar Nuclear Plant 21, Unincorporated, Rhea County. Nashville, Tennessee." Accession No. ML101180044.

Tennessee Valley Authority (TVA). 1972. *Final Environmental Statement, Watts Bar Nuclear Plant Units 1, 2, and 3.* TVA-OHES-EIS-72-9, Office of Health and Environmental Science, Chattanooga, Tennessee. Accession No. ML073470580.

Tennessee Valley Authority (TVA). 1976. *Estimates of Entrainment of Fish Eggs and Larvae by Watts Bar Steam Plant, 1975, and Assessment of the Impact on the Fisheries Resource of Watts Bar Reservoir.* Fisheries and Waterfowl Resources Branch, Tennessee Valley Authority, Norris, Tennessee. Accession No. ML093510802.

Tennessee Valley Authority (TVA). 1987. *Watts Bar Nuclear Plant Construction and Operation Employee Survey: July 1, 1986.* January, 1987. Knoxville, Tennessee.

Tennessee Valley Authority (TVA). 1992. *A Guide for Environmental Protection and Best Management Practices for Tennessee Valley Authority Transmission Construction and Maintenance Activities.* Technical Note TVA/LR/NRM 92/1. Chattanooga, Tennessee. Accession No. ML042790355.

Tennessee Valley Authority (TVA). 1993. *Discharge Temperature Limit Evaluation for Watts Bar Nuclear Plant.* Norris, Tennessee. Accession No. ML073510351.

Tennessee Valley Authority (TVA). 1994. *Tennessee Valley Reservoir and Stream Quality – 1993 Summary Of Vital Signs And Use Suitability Monitoring.* Chattanooga, Tennessee. Accession Nos. ML093510810, ML042800078.

Tennessee Valley Authority (TVA). 1998a. *Aquatic Environmental Conditions in the Vicinity of Watts Bar Nuclear Plant During Two Years of Operation, 1996-1997.* Norris, Tennessee. Accession No. ML093510802.

Tennessee Valley Authority (TVA). 1998b. *Watts Bar Nuclear Plant Supplemental Condenser Cooling Water Project, Environmental Assessment.* Knoxville, Tennessee. Available at http://www.tva.gov/environment/reports/wattsbar2/related/aug_1998.pdf.

Tennessee Valley Authority (TVA). 2004a. *Proposed Modifications to Water Temperature Effluent Requirements for Watts Bar Nuclear Plant Outfall 113.* WR2004-3-85-149. Knoxville, Tennessee. Accession No. ML093510802.

Tennessee Valley Authority (TVA). 2004b. *Reservoir Operations Study Final Programmatic Environmental Impact Statement.* Tennessee Valley Authority In cooperation with U.S. Army Corps of Engineers and U.S. Fish and Wildlife Service. Accession Nos. ML041100586, ML041100585, ML041100590, ML041100588.

Tennessee Valley Authority (TVA). 2005. *Winter 2005 Compliance Survey for Watts Bar Nuclear Plant Outfall 113 Passive Mixing Zone.* WR2005-2-85-151. Knoxville, Tennessee. Accession No. ML093510802.

Tennessee Valley Authority (TVA). 2006a. Letter from Thomas Maher (Tennessee Valley Authority) to Richard Tune (Tennessee Historical Commission) dated December 28, 2006, "TVA, Watts Bar Nuclear Plant Unit 2 Completion, Cultural Resources Assessment, Rhea County." Knoxville, Tennessee. Accession No. ML093510802.

Tennessee Valley Authority (TVA). 2006b. *Summer 2005 Compliance Survey for Watts Bar Nuclear Plant Outfall 113 Passive Mixing Zone.* WR2005-85-152. Knoxville, Tennessee. Accession No. ML093510802.

Tennessee Valley Authority (TVA). 2007a. *Summer 2006 Compliance Survey for Watts Bar Nuclear Plant Outfall 113 Passive Mixing Zone.* Knoxville, Tennessee. Accession No. ML093510802.

Tennessee Valley Authority (TVA). 2007b. *Winter 2006 Compliance Survey for Watts Bar Nuclear Plant Outfall 113 Passive Mixing Zone.* Knoxville, Tennessee. Accession No. ML093510807.

Tennessee Valley Authority (TVA). 2007c. *Tennessee Valley Authority Sequoyah Nuclear Plant. NPDES Permit No. TN0026450.* 316(b) Monitoring Program, Fish Impingement at Sequoyah Nuclear Plant During 2005 through 2007. Accession No. ML073580266.

Tennessee Valley Authority (TVA). 2007d. *Kingston Fossil Plant NPDES Permit No. TN0005452.* 316(b) monitoring program. Fish impingement at Kingston fossil plant during 2004 through 2006. Accession No. ML093510802.

Tennessee Valley Authority (TVA). 2008a. *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.

Tennessee Valley Authority (TVA). 2008b. "Appendix D: Sensitive Area Review – SAR." In *Final Supplemental Environmental Impact Statement-Single Nuclear Unity at the Bellefonte Plant Site.* Tennessee Valley Authority, Jackson County, Alabama. Accessed June 21, 2010 at http://www.tva.gov/environment/reports/blnp/index.htm.

Tennessee Valley Authority (TVA). 2008c. Letter from Masoud Bajestani (Watts Bar Unit 2, Vice President) to U.S. Nuclear Regulatory Commission dated July 2, 2008 in response to NRC letter dated June 3, 2008 and TVA letters February 15, 2008 and June 16, 2008, "Watts Bar Nuclear Plant (WBN) – Unit 2 – Final Supplemental Environmental Impact Statement – Request for Additional Information (TAC MD8203)." Accession No. ML081850460.

Tennessee Valley Authority (TVA). 2008d. Letter from Jack A. Bailey (Tennessee Valley Authority, Vice President, Nuclear Generation Development) to U.S. Nuclear Regulatory Commission dated July 25, 2008 in response to NRC letter dated July 11, 2008, "Subject: Bellefonte Combined License Application – Response to Environmental Report Request for Additional Information – Thermophilic Microorganisms." Accession No. ML082100395.

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

Tennessee Valley Authority (TVA). 2009b. Letter from Darrin Hutchison (Tennessee Valley Authority, Environmental Technical Support Manager) to Vijin Janjic (Tennessee Department of Environment & Conservation, Permit Writer) dated April 15, 2009, "Watts Bar Nuclear Plant (WBN) – National Pollutant Discharge Elimination System (NPDES) Permit No. TN0020168 – Request for Raw Water Treatment Modification." Accession No. ML091190175.

Tennessee Valley Authority (TVA). 2009c. Letter from Masoud Bajestani (Watts Bar Unit 2, Vice President) to U.S. Nuclear Regulatory Commission dated December 23, 2009 in response to NRC letter dated December 3, 2009 and TVA letters dated February 15, 2008, July 2, 2008, and January 27, 2009, "Watts Bar Nuclear Plant (WBN) Unit 2 – Additional Information Regarding Environmental Review (TAC No. MD8203)." Accession No. ML100210350.

Tennessee Valley Authority (TVA). 2009d. Letter from Masoud Bajestani (Watts Bar Unit 2, Vice President) to U.S. Nuclear Regulatory Commission dated October 22, 2009 in response to TVA letters dated February 15, 2008, July 2, 2008, and January 27, 2009, "Additional Information in Support of TVA Final Supplemental Environmental Impact Statement (FSEIS) (TAC MD8303)." Accession No. ML093510802.

Tennessee Valley Authority (TVA). 2009e. *Cultural Resources*. Accessed December 18, 2009 at http://www.tva.gov/river/landandshore/culturalresources/index.htm.

Tennessee Valley Authority (TVA). 2010a. Letter from R.M. Krich (Nuclear Licensing, Tennessee Valley Authority) to U.S. Nuclear Regulatory Commission dated July 6, 2010, "Notification of National Pollutant Discharge Elimination System Permit Renewal." Accession No. ML 101890069.

Tennessee Valley Authority (TVA). 2010b. Letter from Lindy Johnson (Tennessee Valley Authority, Water Permits and Compliance) to Richard Urban (Tennessee Department of Environment & Conservation) dated August 17, 2010, "Tennessee Valley Authority (TVA) - Watts Bar Nuclear Plant (WBN) – NPDES Permit No. TN0020168 – Permit Modification Request – Addition of Unit 2 Operation."

Tennessee Valley Authority (TVA). 2010c. Letter from Masoud Bajestani (Watts Bar Unit 2, Vice President) to U.S. Nuclear Regulatory Commission dated February 25, 2010 in response to NRC letter dated December 3, 2009 and TVA letters dated July 2, 2008, January 27, 2009, and December 23, 2009, "Watts Bar Nuclear Plant (WBN) Unit 2 – Additional Information Regarding Environmental Review (TAC No. MD8203)." Accession No. ML100630115.

Tennessee Valley Authority (TVA). 2010d. Letter from Masoud Bajestani (Watts Bar Unit 2, Vice President) to U.S. Nuclear Regulatory Commission dated April 9, 2010 in response to NRC letter dated December 3, 2009 and TVA letters dated February 15, 2008, July 2, 2008, January 27, 2009, December 23, 2009, and February 25, 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.

Tennessee Valley Authority (TVA). 2010e. Letter from Masoud Bajestani (Watts Bar Unit 2, Vice President) to U.S. Nuclear Regulatory Commission dated July 2, 2010, "Watts Bar, Unit 2 – Submittal of Additional Information Requested during May 12, 2010, Request for Additional Information (RAI) Clarification Teleconference Regarding Environmental Review." Accession No. ML101930470.

Tennessee Valley Authority (TVA). 2011a. Letter from David Stinson (Watts Bar Unit 2) to U.S. Nuclear Regulatory Commission dated May 19, 2011, "Watts Bar Nuclear Plant (WBN) Unit 2 – Intake Pumping Station Water Velocity – Response to Request for Additional Information." Accession No. ML11143A083.

Tennessee Valley Authority (TVA). 2011b. Letter from Edwin E. Freeman (Watts Bar Unit 2 Engineering Manager) to U.S. Nuclear Regulatory Commission dated March 28, 2011, "Watts Bar Nuclear Plant (WBN) Unit 2 – Additional Information Related to U.S. Nuclear Regulatory commission (NRC) Environmental Review." Accession No. ML110890472.

Tennessee Valley Authority (TVA). 2011c. "Comparison of 2010 Peak Spawning Seasonal Densities of Ichthyoplankton at Watts Bar Nuclear Plant at Tennessee River 528 with Historical Densities during1996 and 1997." April 2011. In letter from David Stinson (Watts Bar Unit 2 Vice President) to U.S. Nuclear Regulatory Commission dated March 24, 2011. "Watts Bar Nuclear Plant (WBN) Unit 2 – Additional Information Related to U.S. Nuclear Regulatory Commission (NRC) Environmental Review." Accession No. ML110871475.

Tennessee Valley Authority (TVA). 2011d. Letter from Marie Gillman (Watts Bar Unit 2, Vice President, Acting) to U.S. Nuclear Regulatory Commission dated February 7, 2011, "Submittal of 'Hydrothermal Effects on the Ichthyoplankton from the Watts Bar Nuclear Plant Supplemental condenser Cooling Water outfall in Upper Chickamauga Reservoir' Report." Accession Nos. ML110400383, ML110400384.

Tennessee Valley Authority (TVA). 2011e. *Watts Bar Nuclear Plant Unit 1 – Annual Radiological Environmental Operating Report - 2010.* Accession No. ML11137A122.

Tennessee Valley Authority (TVA). 2011f. *Watts Bar Nuclear Plant – Unit 1 – 2010 Annual Radioactive Effluent Release Report.* Knoxville, Tennessee. Accession No. ML111126A180.

Tennessee Valley Authority (TVA). 2011g. Letter from Dave Stinson (TVA, Watts Bar Unit 2 Vice President) to U.S. Nuclear Regulatory Commission dated May 20, 2011, in response to NRC letter dated April 13, 2011, TVA letters dated February 15, 2008, December 17, 2010, February 25, 2011, and an e-mail from Justin C. Poole to William D. Crouch dated March 4, 2011, "Watts Bar Nuclear Plant (WBN) Unit 2 – Response to Final Safety Analysis Report (FSAR), Chapter 11 and Final Supplemental Environmental Impact Statement (FEIS) Request for Additional Information." Accession No. ML11146A044.

Tennessee Valley Authority (TVA). 2011h. Letter from Dave Stinson (TVA, Watts Bar Unit 2 Vice President) to U.S. Nuclear Regulatory Commission dated May 26, 2011, in response to an e-mail from Justin C. Poole to William D. Crouch dated March 4, 2011 and TVA letter dated May 20, 2011, "Watts Bar Nuclear Plant (WBN) Unit 2 – Response to Request for Additional Information from Public Meeting on May 11, 2011." Accession No. ML11152A160.

Tennessee Valley Authority (TVA). 2011i. *Integrated Resource Plan: TVA's Environmental & Energy Future.* March 2011. Accessed March 2011 at http://www.tva.gov/environment/reports/irp/index.htm.

Tennessee Valley Authority Act of 1933. 16 USC 831 et seq.

U.S. Environmental Protection Agency (EPA). 1976. *Development Document for Best Technology Available for the Location, Design, Construction and Capacity of Cooling Water Intake Structures for Minimizing Adverse Environmental Impact.* Effluent Guidelines Division, Office of Water and Hazardous Materials. Washington, D.C.

U.S. Environmental Protection Agency (EPA). 2001. *Economic Analysis of the Final Regulations Addressing Cooling Water Intake Structures for New Facilities.* EPA-821-R-01-035. Washington, D.C.

U.S. Environmental Protection Agency (EPA). 2009. *Global Greenhouse Gas Data.* Accessed December 15, 2009 at http://www.epa.gov/climatechange/emissions/globalghg.html.

U.S. Fish and Wildlife Service (FWS). 2010a. *White-Nose Syndrome.* Online Resource. Accessed May 26, 2010 at http://www.fws.gov/WhiteNoseSyndrome/about.html.

U.S. Fish and Wildlife Service (FWS). 2010b. *The White-nose Syndrome Mystery-Something is Killing Our Bats.* Online fact sheet available at http://www.fws.gov/WhiteNoseSyndrome/pdf/White-nose_mystery.pdf.

U.S. Geological Survey (USGS). 1998. *National Water-Quality Assessment Program, Lower Tennessee River Basin.* Accessed August 25, 2011 at http://www.google.com/url?q=http://tn.water.usgs.gov/lten/lten-fs.pdf&sa=U&ei=bnxWTomUI8XniALZ7v2UCQ&ved=0CBMQFjAA&usg=AFQjCNFL3hWebY13C5iav_p35ADhoqlwbw

U.S. Global Change Research Program (GCRP). 2009. *Global Climate Change Impacts in the United States.* T. R. Karl, J. M. Melillo, and T. C. Peterson, eds. Cambridge University Press, New York.

U.S. Nuclear Regulatory Commission (NRC). 1977. *Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I.* Regulatory Guide 1.109, Washington, D.C. Accession No. ML003740384.

U.S. Nuclear Regulatory Commission (NRC). 1978. Final Environmental Statement Related to Operation of Watts Bar Nuclear Plant Units Nos. 1 and 2. NUREG-0498, Washington, D.C.

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

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

U.S. Nuclear Regulatory Commission (NRC). 1999. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Main Report, Section 6.3 – Transportation, Table 9.1, Summary of Findings on NEPA Issues for License Renewal of Nuclear Power Plants, Final Report.* NUREG-1437, Addendum 1, Washington, D.C.

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

U.S. Nuclear Regulatory Commission (NRC). 2002. *Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities Regarding the Decommissioning of Nuclear Power Reactors.* NUREG-0586, Supplement 1, Vols. 1 and 2, Washington, D.C.

U.S Nuclear Regulatory Commission (NRC). 2009. Memorandum to R.W. Borchardt from Annette L.Vietti-Cook dated April 2, 2009. "Staff Requirements – SECY-08-0197 – Options to Revise Radiation Protection Regulations and Guidance with Respect to the 2007 Recommendations of the International Commission on Radiological Protection." Accession No. ML090920103.

U.S. Nuclear Regulatory Commission (NRC). 2010. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants.* NUREG-1437, Supplement 41. Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 2011. "Carbon Dioxide Footprint Estimates for a 1000-MW(e) Reference Reactor." Appendix L in *Environmental Impact Statement for the Combined License (COL) for Calvert Cliffs Nuclear Power Plant Unit 3.* NUREG-1936, Vol. 2, Washington, D.C.

University of Wisconsin. 2010. Diervilla lonicera *Plant Details Page*. UW-Stevens Point Freckmann Herbarium Online. Accessed 13 January, 2010 at http://wisplants.uwsp.edu/scripts/detail.asp?SpCode=DIELON.

Watters, G.T. 2000. "Freshwater Mussels and Water Quality: A Review of the Effects of Hydro geologic and in Stream Habitat Alterations." In *Proceedings of the First Freshwater Mollusk Conservation Society Symposium, 1999.* Ohio Biological Survey, Columbus, Ohio.

World Health Organization (WHO). 2007. *Electromagnetic Fields and Public Health. Exposure to Extremely Low Frequency Fields.* Fact sheet No. 322. Available at http://www.who.int/mediacentre/factsheets/fs322/en.