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NUREG–2226, Vol. 1

Environmental Impact Statement for an Early Site Permit (ESP) at the Clinch River Nuclear Site

Draft Report for Comment

Chapters 1 to 12

U.S. Nuclear Regulatory Commission
Office of New Reactors
Washington, DC 20555-0001

U.S. Army Corps of Engineers
Nashville District
Nashville, Tennessee 37203

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Mail comments to: May Ma, Division of Administrative Services, Office of Administration, Mail Stop:TWFN-07-A60, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001.

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ABSTRACT

This draft environmental impact statement (EIS) has been prepared in response to an application submitted to the U.S. Nuclear Regulatory Commission (NRC) by the Tennessee Valley Authority (TVA) for an early site permit (ESP) for a site in Oak Ridge, Roane County, Tennessee, for new nuclear power units demonstrating small modular reactor (SMR) technology. The proposed action related to the TVA application is the issuance of an ESP for the Clinch River Nuclear (CRN) Site approving the site as suitable for the future demonstration of the construction and operation of two or more SMRs with characteristics presented in the application. The Nashville District, Regulatory Division, U.S. Army Corps of Engineers (USACE) is a cooperating agency with the NRC to verify that the information presented in this draft EIS is adequate to support a Department of the Army permit application, should TVA submit a Department of the Army permit application at a future date. The USACE is cooperating in the preparation of this draft EIS to streamline regulatory review processes, avoid unnecessary duplication of effort, and ensure issues and concerns related to impacts on waters of the United States and navigable waters of the United States are identified and addressed early in the NRC's review process. The NRC, its contractors, and USACE make up the review team.

This draft EIS documents the review team's preliminary analysis, which considers and weighs the environmental impacts of building and operating two or more SMRs at the CRN Site and at alternative sites, including measures potentially available for reducing or avoiding adverse impacts. This draft EIS also addresses Federally listed species, cultural resources, and plant cooling system design alternatives.

This draft EIS includes the evaluation of the proposed action's impacts on waters of the United States pursuant to Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Appropriation Act of 1899. Upon receipt of an application, the USACE will conduct a public interest review in accordance with the guidelines promulgated by the U.S. Environmental Protection Agency under the authority of Section 404(b) of the Clean Water Act. The public interest review, which will be addressed in the USACE permit decision document, will include an alternatives analysis to determine the least environmentally damaging practicable alternative.

After considering the environmental aspects of the proposed action before the NRC, the NRC staff's preliminary recommendation to the Commission is that the ESP be issued as proposed. This recommendation is based on (1) the application, including the Environmental Report (ER), and supplemental information submitted by TVA; (2) consultation with Federal, State, Tribal, and local agencies; (3) the review team's independent review; (4) the consideration of public scoping comments received as part of the environmental review process; and (5) the assessments summarized in this draft EIS, including the potential mitigation measures identified in the ER and this draft EIS.

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EXECUTIVE SUMMARY

This draft environmental impact statement (EIS) presents the results of a U.S. Nuclear Regulatory Commission (NRC) environmental review of an application by the Tennessee Valley Authority (TVA) for an early site permit (ESP) at the Clinch River Nuclear (CRN) Site in Oak Ridge, Roane County, Tennessee, for a new nuclear power plant demonstrating small modular reactor (SMR) technology. The Nashville District, Regulatory Division, U.S. Army Corps of Engineers (USACE) is a cooperating agency with the NRC to verify that the information presented in this draft EIS is adequate to support a Department of the Army permit application if TVA submits a Department of the Army permit application at a future date. The USACE is cooperating in the preparation of this draft EIS to streamline regulatory review processes, avoid unnecessary duplication of effort, and ensure issues and concerns related to impacts on waters of the United States and navigable waters of the United States are identified and addressed early in the NRC's review process. The NRC, its contractors, and USACE make up the review team.

Background

On May 16, 2016, TVA submitted an application to the NRC for an ESP at the CRN Site. TVA subsequently provided supplemental information in support of the application. The staff determined that the application (with the subsequent submittals) was sufficient for docketing and issued a *Federal Register* (82 FR 3812) notice notifying the public of the NRC's acceptance of the CRN Site ESP application on January 12, 2017. On December 15, 2017, 2017, TVA submitted Revision 1 of its application, including the Environmental Report (ER) to the NRC.

Upon acceptance of TVA's application, the NRC review team began the environmental review process as described in Title 10 of the *Code of Federal Regulations* Part 52 (10 CFR Part 52) by publishing a Notice of Intent to prepare an EIS and conduct scoping in the *Federal Register* on April 13, 2017 (82 FR 17885). As part of this environmental review, the review team did the following:

- considered comments received during a 60-day scoping process that began on April 13, 2017 and ended on June 12, 2017, and conducted related public scoping meetings on May 15, 2017 in Oak Ridge, Tennessee
- reviewed TVA's ER, as supplemented by TVA, and conducted a full scope environmental audit in May 2017
- conducted visits to the proposed CRN Site and alternative sites in May 2017
- consulted with Tribal Nations and other agencies such as the U.S. Fish and Wildlife Service, Advisory Council on Historic Preservation, Tennessee Historical Commission, Tennessee Department of Environment and Conservation, Tennessee Wildlife Resource Agency, and Alabama Department of Conservation and Natural Resources.

Proposed Action

The proposed action related to the TVA application is the issuance of an ESP for the CRN Site approving the site as suitable for the future demonstration of the construction and operation of two or more SMRs with characteristics presented in the application.

Purpose and Need for Action

The purpose of the proposed NRC action, issuance of the ESP, is to provide for early resolution of site safety and environmental issues, which provides stability in the licensing process. The NRC's purpose and need is further informed by the applicant's purpose and need. TVA's application provides TVA's analyses of the environmental impacts that could result from building and operating two or more SMRs with a maximum total electrical output of 800 MW(e) to demonstrate the capability of SMR technology.

The objective of the USACE review is to streamline its regulatory review process, avoid unnecessary duplication of effort, and ensure issues and concerns related to impacts on waters of the United States and navigable waters of the United States are identified and addressed early in the NRC's review process.

Public Involvement

A 60-day scoping period was held from April 13, 2017 to June 12, 2017. On May 15, 2017, the NRC held public scoping meetings in Oak Ridge, Tennessee. The review team received oral comments during the public meetings and a total of 74 pieces of scoping correspondence about topics such as surface-water hydrology, ecology, socioeconomics, and historic and cultural resources. The review team's responses to the in-scope public comments can be found in Appendix D of this draft EIS. The Scoping Summary Report (Agencywide Documents Access and Management System Accession Package No. ML17242A061) contains all of the comments and responses, including those considered out-of-scope.

Affected Environment

The CRN Site is located in Oak Ridge, Roane County, Tennessee (Figure ES-1). The CRN Site is located on the Clinch River arm of the Watts Bar Reservoir, adjacent to the existing U.S. Department of Energy's Oak Ridge Reservation. The CRN Site is situated in the southwestern part of the city limits of Oak Ridge approximately 10 mi south of the Oak Ridge urban center; 16 mi west of Knoxville, Tennessee; and 7 mi east of Kingston, Tennessee. The primary source of cooling water would be the Clinch River. The ultimate heat sink for the CRN SMRs would be the atmosphere, using mechanical draft cooling towers.

Evaluation of Environmental Impacts

This draft EIS evaluates the potential environmental impacts of the construction and operation of two or more SMRs at the CRN Site related to the following resource areas:

- land use
- air quality
- aquatic ecology
- terrestrial ecology
- surface water and groundwater
- waste
- human health (radiological and nonradiological)
- socioeconomics
- environmental justice
- cultural resources
- fuel cycle, decommissioning, and transportation.

The impacts are designated as SMALL, MODERATE, or LARGE. The incremental impacts related to the construction and operations activities requiring NRC authorization are described

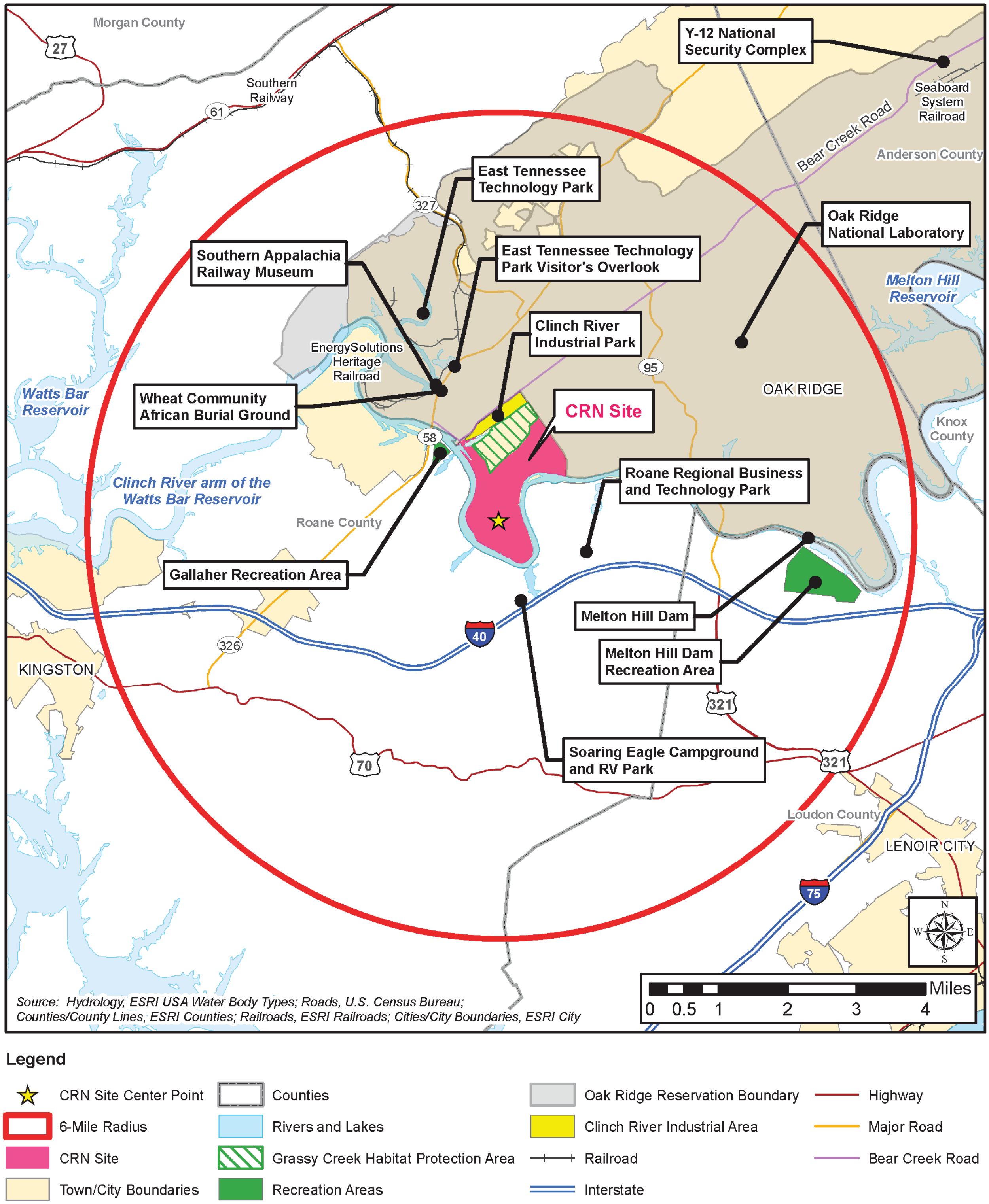


Figure ES-1. The CRN Site and Vicinity

and characterized, as are the cumulative impacts resulting from the proposed action when the effects are added to, or interact with, other past, present, and reasonably foreseeable future effects on the same resources. The construction and operation impacts are outlined in Table ES-1. Table ES-2 summarizes the review team's assessment of cumulative impacts. The review team's detailed analysis, which supports the impact assessment of the proposed new units, can be found in Chapters 4, 5, 6, and 7.

> **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.

Table ES-1. Environmental Impact Levels at the CRN Site

Resource Category	Construction and Preconstruction	Operation
Land Use		
Site and Vicinity	MODERATE	SMALL
Water-Related		
Water Use – Surface Water	SMALL	SMALL
Water Use – Groundwater Use	SMALL	SMALL
Water Quality – Surface Water	SMALL	SMALL
Water Quality – Groundwater	SMALL	SMALL
Ecology		
Terrestrial Ecosystems	MODERATE	SMALL
Aquatic Ecosystems	SMALL	SMALL
Socioeconomic		
Physical Impacts	SMALL to MODERATE	SMALL to MODERATE (aesthetics)
Demography	SMALL	SMALL
Economic Impacts on the Community	SMALL (beneficial to the region)	SMALL (beneficial to the region)
Infrastructure and Community Services	SMALL (for all categories except traffic) and MODERATE to LARGE (for traffic)	SMALL to MODERATE (recreation)
Environmental Justice	NONE[(a)]	NONE[(a)]
Historic and Cultural Resources		
Onsite Direct and Indirect Effects Area of Potential Affect	MODERATE to LARGE	SMALL
Air Quality	SMALL	SMALL
Nonradiological Health	SMALL to MODERATE	SMALL to MODERATE
Radiological Health	SMALL	SMALL
Nonradioactive Waste	SMALL	SMALL
Postulated Accidents	NA	SMALL
Fuel Cycle, Transportation, and Decommissioning	NA	SMALL

(a) A determination of "NONE" for Environmental Justice analyses does not mean there are no adverse impacts on minority or low-income populations from the proposed project. Instead, an indication of "NONE" means that while adverse impacts do exist, they do not affect minority or low-income populations in any disproportionate manner relative to the general population.

Table ES-2. Cumulative Impacts on Environmental Resources, Including the Impacts of Proposed Action

Resource Category	Impact Level
Land Use	MODERATE
Water-Related	
Water Use – Surface Water	MODERATE
Water Use – Groundwater Use	SMALL
Water Quality – Surface Water	MODERATE
Water Quality – Groundwater	MODERATE
Ecology	
Terrestrial Ecosystems	MODERATE
Aquatic Ecosystems	LARGE
Socioeconomic	
Physical Impacts	SMALL to MODERATE
Demography	SMALL
Taxes and Economy	SMALL
Infrastructure and Community Services	MODERATE to LARGE
Environmental Justice	NONE[(a)]
Historic and Cultural Resources	MODERATE to LARGE
Air Quality	SMALL for criteria pollutants and MODERATE for GHGs
Nonradiological Health	SMALL to MODERATE
Nonradioactive Waste	SMALL
Radiological Health	SMALL
Postulated Accidents	SMALL
Fuel Cycle, Transportation, and Decommissioning	SMALL

(a) A determination of "NONE" for Environmental Justice analyses does not mean there are no adverse impacts on minority or low-income populations from the proposed project. Instead, an indication of "NONE" means that while adverse impacts do exist, they do not affect minority or low-income populations in any disproportionate manner relative to the general population.

Alternatives

The review team considered the environmental impacts associated with alternatives to issuing an ESP for the CRN Site. These alternatives included a no-action alternative (i.e., not issuing the ESP), siting locations, and system designs. The applicant's ER is not required to include a discussion of the alternative energy sources for an ESP (10 CFR 51.50(b)(2)).

The no-action alternative would result if NRC does not grant the ESP. If an ESP is not granted, construction and operation of new units at the CRN Site in accordance with the 10 CFR Part 52 (TN251) process referencing an approved ESP would not occur, nor would any benefits intended by an approved ESP be realized.

After comparing the cumulative effects of building and operating two or more SMRs at the proposed site against those at the alternative sites, the NRC staff concluded that none of the alternative sites would be environmentally preferable to the proposed site for building and operating two or more SMRs (Table ES-3). The alternatives sites selected were as follows (Figure ES-2 and ES-3):

- Oak Ridge Reservation (ORR) Site 2, in Oak Ridge, Tennessee
- ORR Site 8, in Oak Ridge, Tennessee
- Redstone Arsenal Site 12, in Huntsville, Alabama.

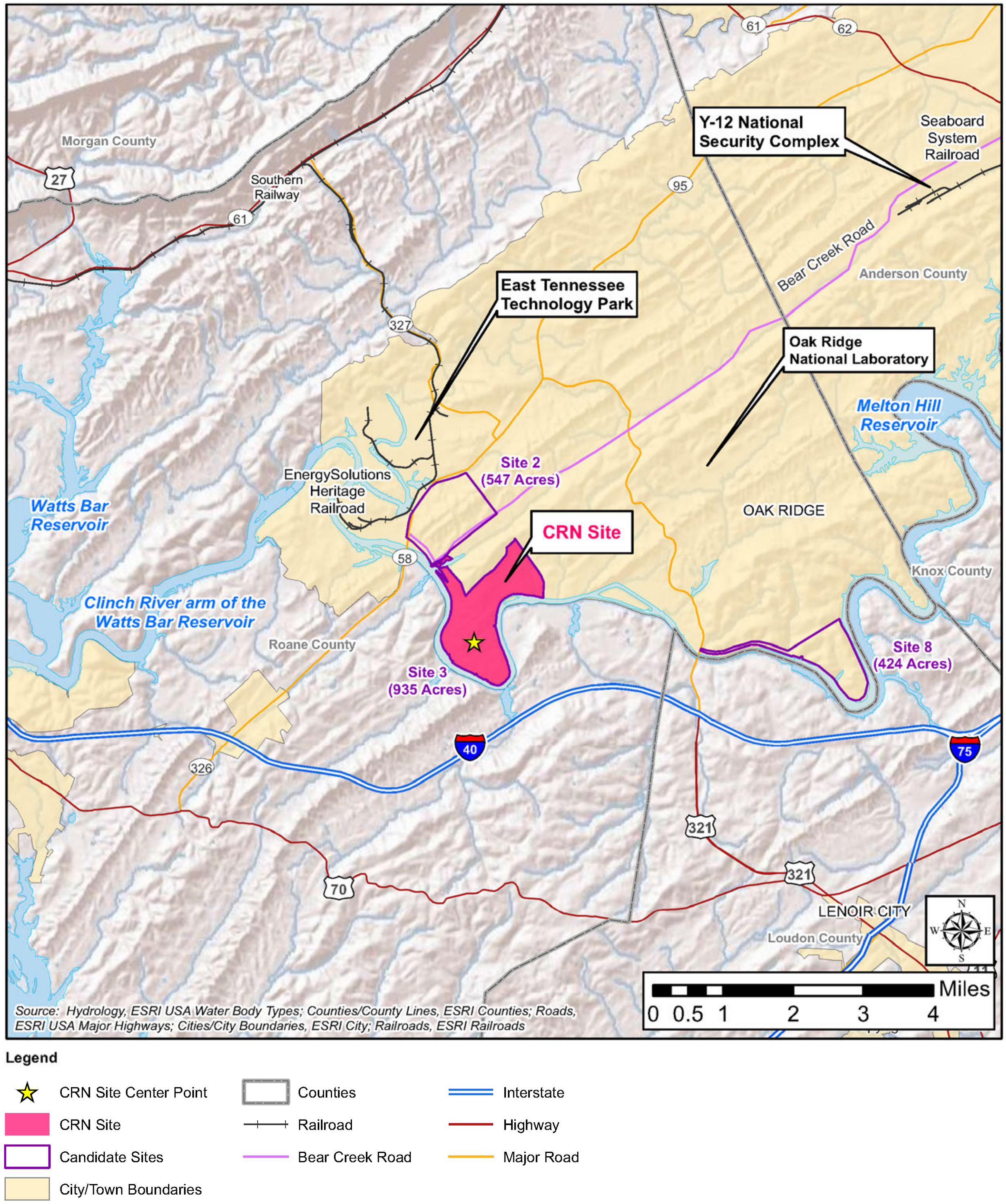


Figure ES-2. CRN Site (Site 3) and Alternative Sites 2 and 8 at Oak Ridge Reservation

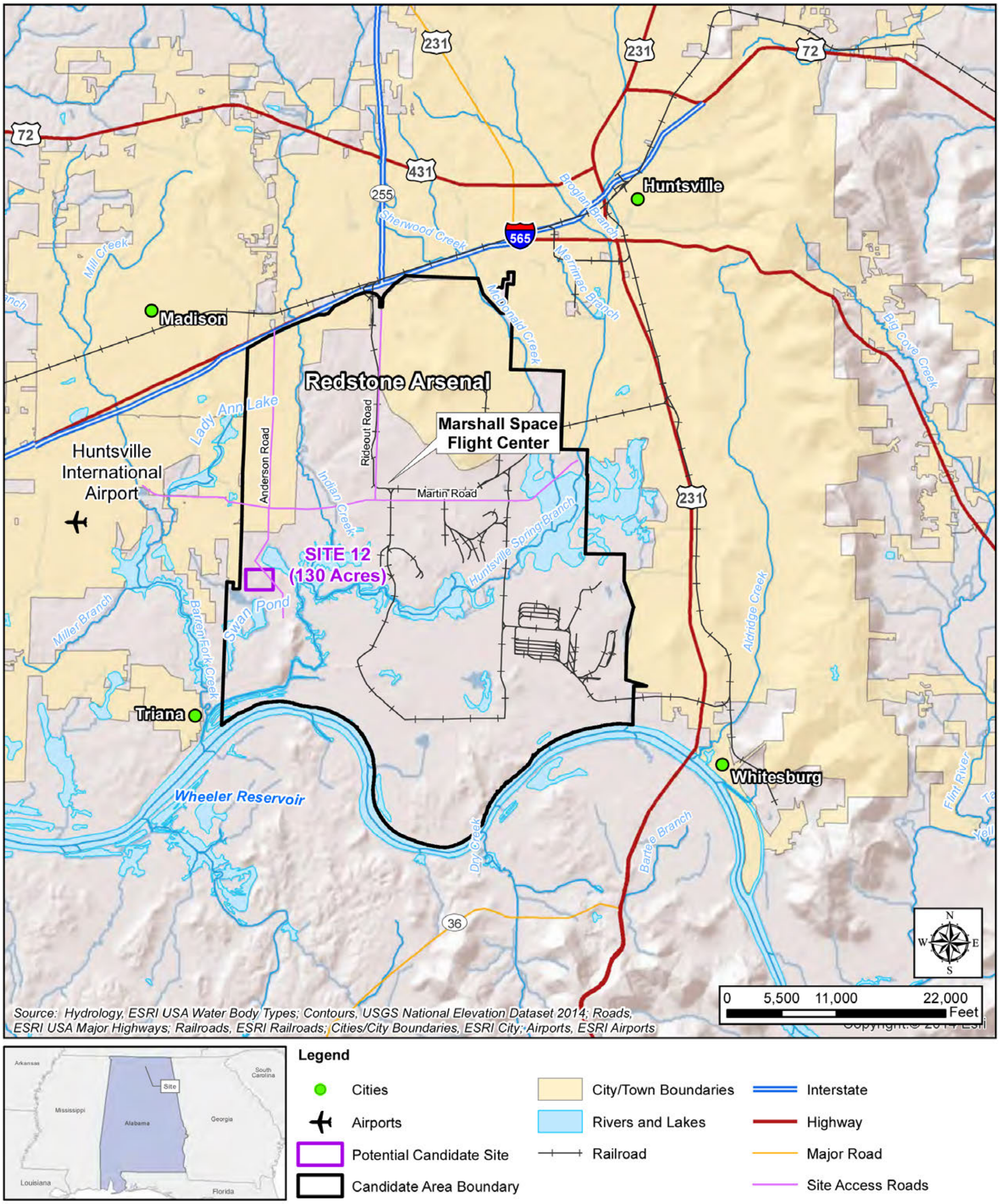


Figure ES-3. Alternative Site at Redstone Arsenal Site 12

Table ES-3. Comparison of Cumulative Impacts at the CRN Site and Alternative Sites

Resource Category	CRN Site (Site 3)[(a)]	ORR Site 2[(a)]	ORR Site 8[(b)]	Redstone Arsenal Site 12[(b)]
Land Use	MODERATE	MODERATE	MODERATE	MODERATE
Water-Related				
Surface-water use	MODERATE	MODERATE	MODERATE	MODERATE
Groundwater use	SMALL	SMALL	SMALL	MODERATE
Surface-water quality	MODERATE	MODERATE	MODERATE	MODERATE
Groundwater quality	MODERATE	MODERATE	MODERATE	MODERATE
Ecology				
Terrestrial ecosystems	MODERATE	LARGE	LARGE	MODERATE
Aquatic ecosystems	LARGE	LARGE	LARGE	LARGE
Socioeconomics				
Physical impacts	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE
Demography	SMALL	SMALL	SMALL	SMALL
Taxes and Economy	SMALL (beneficial)	SMALL (beneficial)	SMALL (beneficial)	SMALL (beneficial)
Infrastructure and community services	MODERATE to LARGE	MODERATE to LARGE	MODERATE to LARGE	MODERTE to LARGE
Environmental Justice	None[(c)]	None[(c)]	None[(c)]	None[(c)]
Historic and Cultural Resources	MODERATE to LARGE	MODERATE to LARGE	MODERATE to LARGE	MODERATE to LARGE
Air Quality				
Criteria pollutants	SMALL	SMALL	SMALL	SMALL
Greenhouse gas emissions	MODERATE	MODERATE	MODERATE	MODERATE
Nonradiological Health	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE
Nonradioactive Waste	SMALL	SMALL	SMALL	SMALL
Radiological Health	SMALL	SMALL	SMALL	SMALL
Postulated Accidents	SMALL	SMALL	SMALL	SMALL

(a) Impact levels for all alternatives are for construction and operation but do not reflect cumulative impacts. Thus, the nuclear impacts identified here may differ from those used to compare the proposed site to the alternative sites, which reflect cumulative impacts.
(b) Impacts are from draft EIS Table 9-14. These conclusions for energy alternatives should be compared to NRC-authorized activities reflected in Chapters 4 and 5 and Sections 6.1 and 6.2.
(c) A determination of "NONE" for Environmental Justice analyses does not mean there are no adverse impacts on minority or low-income populations from the proposed project. Instead, an indication of "NONE" means that while adverse impacts do exist, they do not affect minority or low-income populations in any disproportionate manner, relative to the general population.

Table ES-3 provides a summary of the cumulative impacts for the proposed and alternative sites. The NRC staff concluded that all of the sites were generally comparable, and it would be difficult to state that one site is preferable to another from an environmental perspective. In such a case, the proposed site prevails because none of the alternatives is environmentally preferable to the proposed site.

The NRC staff considered various alternative system designs, including alternative heat-dissipation systems and multiple alternative intake, discharge, and water-supply systems. The review team identified no alternatives that were environmentally preferable to the proposed CRN SMR system design.

Benefits and Costs

TVA did not address the balance of benefits and costs in its ESP application for the CRN Site, because such an assessment is not required for an ESP application per 10 CFR 51.50, Section (b)(2) (TN250). Should the NRC ultimately determine to issue an ESP for the CRN site, and a CP or COL application that references such an ESP is docketed, these matters will be considered in the EIS prepared in connection with the review of that CP or COL application.

Recommendation

The NRC staff's preliminary recommendation to the Commission related to the environmental aspects of the proposed action is that the ESP should be issued.

This recommendation is based on the following:

- the application, including the ER and supplemental information submitted by TVA
- consultation with Federal, State, Tribes, and local agencies
- information gathered during the environmental audit and visits to the site and alternative sites
- consideration of public comments received during the environmental review
- the review team's independent review and assessment summarized in this draft EIS.

ABBREVIATIONS AND ACRONYMS

°C	degree(s) Celsius
°F	degree(s) Fahrenheit
µg	microgram(s)
µg/L	micrograms per liter
µm	micrometer(s)
µSv/cm	microsievert(s) per centimeter
χ/Q	atmospheric dispersion factor(s)
7Q10	7-day, 10-year low flow (i.e., the lowest flow for 7 consecutive days, expected to occur once per decade)
^{235}U	uranium-235
ac	acre(s)
AC	alternating current
ac-ft	acre-feet
ACHP	Advisory Council on Historic Preservation
ACS	American Community Survey
AD	Anno Domini
ADAMS	Agencywide Documents Access and Management System
AECOM	AECOM Technical Services Inc.
ALARA	as low as is reasonably achievable
APE	area of potential effect
ARPA	Archaeological Resources Protection Act
BA	biological assessment
BC	Before Christ
BEIR	Biological Effects of Ionizing Radiation
bgs	below ground surface
BMP	best management practice
BSR	biodiversity significance rank
BTA	barge/traffic area
Btu	British thermal unit(s)
CDC	Centers for Disease Control and Prevention
CDF	core damage frequency
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act (Superfund)
CFR	*Code of Federal Regulations*
cfs	cubic feet per second
CH_4	methane
Ci	curie(s)
cm	centimeter(s)

CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	CO_2 equivalent
COL	combined construction permit and operating license or combined license
COLA	combined license application
CP	construction permit
CR	Clinch River
CRBR	Clinch River Breeder Reactor
CRBRP	Clinch River Breeder Reactor Project
CRM	Clinch River mile
CRN	Clinch River Nuclear
CWA	Clean Water Act (aka Federal Water Pollution Control Act)
CWS	circulating water system
d	day
D/Q	deposition factor(s)
DASU	data acquisition switch unit
dB	decibel(s)
dBA	decibel(s) on the A-weighted scale
DBA	design basis accident
DCD	Design Control Document
DCG	derived concentration guide
DNL	day-night average sound level
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EAB	exclusion area boundary
EIS	environmental impact statement
ELF	extremely low frequency
EMF	electromagnetic field
EO	Executive Order
EPA	U.S. Environmental Protection Agency
EPRI	Electric Power Research Institute
EPZ	Emergency Planning Zone
ER	Environmental Report
ESA	Endangered Species Act of 1973, as amended
ESP	early site permit
ESPA	early site permit application
ESRP	Environmental Standard Review Plan (NUREG–1555)
ETTP	East Tennessee Technology Park
FE	Federally Endangered
fps	feet per second

FR	*Federal Register*
ft	foot or feet
FT	Federally Threatened
ft^2	square foot or feet
ft^3	cubic foot or feet
FTE	full-time equivalent employee
FWS	U.S. Fish and Wildlife Service
g	gram(s)
GAI	geographic area of interest
gal	gallon(s)
GBq	gigabecquerel
GCRP	U.S. Global Change Research Program
GDNR	Georgia Department of Natural Resources
GEIS	*Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (NUREG–1437)
GEIS-DECOM	GEIS-Decommissioning of Nuclear Facilities (NUREG–0586)
GHG	greenhouse gas
GI-LLI	gastrointestinal lining of lower intestine
gpd	gallon(s) per day
gpm	gallon(s) per minute
GWD	gigawatt day(s)
Gy	gray(s)
ha	hectare(s)
HLW	high-level waste
hr	hour(s)
Hz	hertz
IAEA	International Atomic Energy Agency
IBA	Important Bird Area
ICRP	International Commission on Radiological Protection
in.	inch(es)
IPPP	Integrated Pollution Prevention Plan
ISFSI	independent spent fuel storage installation
kg	kilogram(s)
kHz	kilohertz
km	kilometer(s)
km/hr	kilometer(s) per hour
km^2	square kilometer(s)
KSNPC	Kentucky State Nature Preserves Commission
kV	kilovolt(s)
kW	kilowatt(s)
kW(e)	kilowatt(s) (electrical)

kWh	kilowatt-hour(s)
kWp	kilowatt peak
L	liter(s)
lb	pound(s)
Ldn	day-night average sound level
L_{eq}	equivalent continuous sound level
LLC	Limited Liability Company
LLW	low-level waste
LOCA	loss of coolant accident
LOI	letter of interpretation
LOS	level of service
LPZ	low-population zone
LULC	land use and land cover
LWA	Limited Work Authorization
LWCF	Land and Water Conservation Fund
LWR	light water reactor
m	meter(s)
m/s	meter(s) per second
m^2	square meter(s)
m^3	cubic meter(s)
m^3/s	cubic meter(s) per second
MACCS2	Melcor Accident Consequence Code System Version 1.12
MEI	maximally exposed individual
mg	milligram(s)
Mgd	million gallon(s) per day
mGy	milligray(s)
mi	mile(s)
mi^2	square mile(s)
MIMS	Manifest Information Management System
min	minute(s)
MKAA	Metropolitan Knoxville Airport Authority
mL	milliliter(s)
mm	millimeter(s)
M	million
mo	month(s)
mph	mile(s) per hour
mrad	millirad(s)
mrem	millirem(s)
Mscf	thousand standard cubic feet
MSL	mean sea level
mSv	millisievert(s)

MT	metric ton(nes)
MTU	metric ton(nes) uranium
MW	megawatt(s)
MW(e)	megawatt(s) (electrical)
MW(t)	megawatt(s) (thermal)
MWd	megawatt-day(s)
MWd/MTU	megawatt-day(s) per metric ton of uranium
MWh	megawatt-hour(s)
N_2O	nitrous oxide
NA	not applicable
NAGPRA	Native American Graves Protection and Repatriation Act
NAVD	North American Vertical Datum (sea level reference point used in surveying)
NAVD88	North American Vertical Datum of 1988
NCRP	National Council on Radiation Protection and Measurements
NEI	Nuclear Electric Institute
NEPA	National Environmental Policy Act of 1969, as amended
NERP	National Environmental Research Park
NESC	National Electric Safety Code
NGVD29	National Geodetic Vertical Datum of 1929
NHPA	National Historic Preservation Act
NIEHS	National Institute of Environmental Health Sciences
NLEB	northern long-eared bat
NMFS	National Marine Fisheries Service
NO_2	nitrogen dioxide
NO_x	oxides of nitrogen
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
NRHP	National Register of Historic Places
NSA	Naval Support Activity
NTU	nephelometric turbidity unit(s)
NUREG	U.S. Nuclear Regulatory Commission technical document
NWS	National Weather Service
O_3	ozone
OL	operating license
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
OSCS	oriented spray cooling system
OSHA	Occupational Safety and Health Administration
PA	Programmatic Agreement
PAM	primary amebic meningoencephalitis

Pb	lead
PCB	polychlorinated biphenyl
pc/L	picocuries per liter
PEP	Plume Exposure Pathway
pH	measure of acidity or basicity in solution
PIR	public interest review
PIRF	public interest review factor
PM	particulate matter
PM_{10}	particulate matter with a mean aerodynamic diameter of 10 μm or less
$PM_{2.5}$	particulate matter with a mean aerodynamic diameter of 2.5 μm or less
PNNL	Pacific Northwest National Laboratory
ppb	part(s) per billion
PPE	plant parameter envelope
ppm	part(s) per million
ppt	part(s) per thousand
PRA	probabilistic risk assessment
psi	pound(s) per square inch
rad	radiation absorbed dose
RCRA	Resource Conservation and Recovery Act of 1976, as amended
rem	Roentgen equivalent man (a unit of radiation dose)
REMP	radiological environmental monitoring program
RG	Regulatory Guide
RHA	Rivers and Harbors Appropriation Act
ROI	region of interest
ROS	River Operations Study
Ryr	reactor-year(s)
s or sec	second(s)
SACTI	Seasonal and Annual Cooling Tower Impact (prediction code)
SAFSTOR	Safe Storage
scf	standard cubic feet
SER	safety evaluation report
SHPO	State Historic Preservation Office
SMR	small modular reactor
SMZ	streamside management zone
SO_2	sulfur dioxide
SOARCA	State-of-the-Art Reactor Consequence Analysis
SO_x	oxides of sulfur
SSAR	Site Safety Analysis Report
Sv	sievert
SWPPP	stormwater pollution prevention plan
SWS	service water system

T	ton(s)
TDEC	Tennessee Department of Environment and Conservation
TDHS	Tennessee Department of Human Resources
TDS	total dissolved solids
TEDE	total effective dose equivalent
THC	Tennessee Historical Commission
TIA	traffic impact analysis
TNHP	Tennessee Natural Heritage Program
TRAGIS	Transportation Routing Analysis Geographic Information System
TRM	Tennessee River Mile
TVA	Tennessee Valley Authority
TWh	terawatt-hour(s)
TWRA	Tennessee Wildlife Resources Agency
UPF	Uranium Processing Facility
U.S.	United States
UMTRI	University of Michigan Transportation Research Institute
USACE	U.S. Army Corps of Engineers
U.S.C.	United States Code
USCB	U.S. Census Bureau
USGS	U.S. Geological Survey
V	volt
VOC	volatile organic compound
WBN	Watts Bar Nuclear
WNS	white-nose syndrome
Y-12	Y-12 National Security Complex
yd	yard(s)
yd^3	cubic yard(s)
yr	year(s)
yr^{-1}	per year

1.0 INTRODUCTION

By letter dated May 12, 2016, the U.S. Nuclear Regulatory Commission (NRC) received an application pursuant to Title 10 of the *Code of Federal Regulations* Part 52 (10 CFR Part 52) (TN251), from the Tennessee Valley Authority (TVA), for an early site permit (ESP) for a site in Oak Ridge, Roane County, Tennessee, for new nuclear power units demonstrating small modular reactor (SMR) technology (TVA 2016-TN5002). Under the NRC regulations in 10 CFR Part 52 (TN251) and in accordance with the applicable provisions of 10 CFR Part 51 (TN250), which are the NRC regulations implementing the National Environmental Policy Act of 1969, as amended (NEPA) (42 U.S.C. § 4321 *et seq*.-TN661), the NRC is required to prepare an environmental impact statement (EIS) as part of its review of an ESP application. TVA's 2016 application included an Environmental Report (ER) (TVA 2016-TN4637). On December 15, 2017, TVA submitted Revision 1 of its application to the NRC, including a revised ER. Unless stated otherwise, any reference in this draft EIS to the ER refers to Revision 1 (TVA 2017-TN4921).

Light water SMRs are defined in NRC Interim Staff Guidance COL/ESP-ISG-27, *Specific Environmental Guidance for Light Water Small Modular Reactor Reviews*, as light water reactor units with a nominal output of 300 megawatts electric (MW(e)) or less and are able to be factory fabricated and transported to the site for assembly of components and operation (NRC 2014-TN3774). In this draft EIS, the terms "unit", "reactor", and "SMR" are used interchangeably.

The NRC's proposed action related to the TVA application is the issuance of an ESP for the Clinch River Nuclear (CRN) Site approving the site as suitable for the future demonstration of the construction and operation of two or more SMRs with characteristics presented in the application (designated as the plant parameter envelope or PPE). TVA's application provides TVA's analyses of the environmental impacts that could result from building and operating two or more SMRs with a maximum total electrical output of 800 MW(e) to demonstrate the capability of SMR technology.

The Nashville District, Regulatory Division, U.S. Army Corps of Engineers (USACE) is a cooperating agency with the NRC to verify that the information presented in this draft EIS is adequate to support a Department of the Army (DA) permit application, if TVA submits a DA permit application at a future date. Under Section 10 of the Rivers and Harbors Act of 1899 (RHA; 33 U.S.C. § 401 et seq.-TN660), a Section 10 DA permit is normally required for work or structures in or affecting navigable waters of the United States. Under Section 404 of the Clean Water Act (CWA) (33 U.S.C. § 1344-TN1019), a DA permit is normally required for the discharge of dredged or fill material (e.g., fill, excavation, or mechanized land clearing) into waters of the U.S., including wetlands and navigable waters of the U.S. The USACE is a cooperating agency to streamline regulatory review processes, avoid unnecessary duplication of effort, and ensure issues and concerns related to impacts on waters of the U.S. and navigable waters of the U.S. are identified and addressed early in the NRC's review process.

1.1 Background

An ESP is a Commission approval of a site for one or more nuclear power facilities. Issuance of an ESP is a process separate from the issuance of a construction permit (CP), an operating license (OL), or a combined construction permit and operating license (combined license or COL) for such a facility. The ESP application and review process make it possible to evaluate and resolve safety and environmental issues related to siting before the applicant makes a large commitment of resources. If an ESP is approved, the applicant can “bank” the site for up to 20 years for future reactor siting. An ESP does not, however, authorize construction and operation of a nuclear power plant. To construct and operate a nuclear power facility, an ESP holder must obtain a CP and an OL, or a COL, which are separate major Federal actions that require their own environmental reviews in accordance with 10 CFR Part 51 (TN250).

As part of its evaluation of the environmental aspects of the action proposed in an ESP application, the NRC prepares an EIS in accordance with 10 CFR 52.18 (TN251) and 10 CFR Part 51 (TN250). Because site suitability encompasses construction and operational parameters, the EIS addresses the impacts of both the construction and operation of reactors and associated facilities. In a review separate from the EIS process, the NRC analyzes the safety characteristics of the proposed site and emergency planning information. These latter two analyses are documented in a separate safety evaluation report (SER) that presents, in accordance with 10 CFR Part 52 (TN251), the conclusions reached by the NRC regarding the following issues:

- whether there is reasonable assurance that a reactor or reactors, having characteristics that fall within the parameters for the site, can be constructed and operated without undue risk to the health and safety of the public;
- whether, if major features of emergency plans are submitted (as TVA has done), those major features meet the applicable requirements of 10 CFR Part 50 (TN249) and its appendices or whether any exemptions to those regulations may be granted such that there is reasonable assurance that adequate protective measures can and will be taken in the event of a radiological emergency; and
- whether site characteristics are such that adequate security plans and measures can be developed.

Part 5 of TVA’s application contains the major features of two emergency plans for two distinct Plume Exposure Pathway (PEP) Emergency Planning Zones (EPZ). Part 5A contains the major features of an emergency plan for a PEP EPZ at the site boundary (TVA 2017-TN5443), and Part 5B contains the major features of an emergency plan PEP EPZ that consists of an area approximately 2 mi in radius from the site center point (TVA 2017-TN5442). If TVA chooses to submit a COL or CP/OL application referencing this ESP, the size of the EPZ selected by TVA will be based on the SMR design referenced in the application.

In Part 6 of its application (as supplemented by letters dated January 22, 2018 and February 20, 2018), TVA presents an exemption request from current NRC regulations that require an EPZ radius of 10 mi (TVA 2017-TN5444, TVA 2018-TN5407, TVA 2018-TN5427). Section 5.11 of this draft EIS presents the staff’s evaluations of environmental impacts from postulated accidents considering two potential EPZ boundaries proposed in TVA’s exemption request (site boundary and 2 mi) in addition to the current NRC regulations requiring a 10 mi EPZ. The results of the staff’s review of the major features of emergency plans presented by TVA and the related exemption requests will be documented as part of the staff’s safety review, not as part of this EIS.

1.1.1 Plant Parameter Envelope

The applicant for an ESP need not provide a detailed design of a reactor or reactors and the associated facilities, but should provide sufficient bounding parameters and characteristics of the reactor or reactors and the associated facilities so that an assessment of site suitability can be made. Consequently, the ESP application may refer to a PPE as a surrogate for a nuclear power plant and its associated facilities.

A PPE is a set of values of plant design parameters that an ESP applicant expects will bound the design characteristics of the reactor or reactors that might be constructed at a given site. The PPE values are a bounding surrogate for actual reactor design information. Analysis of environmental impacts based on a PPE approach permits an ESP applicant to defer the selection of a reactor design until the CP or COL stage.

TVA's application is based on a PPE that the applicant developed to encompass four light water SMRs under development in the United States at the time of the preparation of the ER—the BWXT mPower™ SMR (Generation mPower LLC), Holtec SMR-160 (Holtec SMR, LLC), NuScale SMR (NuScale Power, LLC), and Westinghouse SMR (Westinghouse Electric Company, LLC) (TVA 2016-TN5002). The proposed PPE is discussed in more detail in Section 3.2 and Appendix I of this draft EIS.

1.1.2 NRC ESP Application Review

In accordance with 10 CFR 52.17(a)(2) (TN251), TVA submitted an ER as part of its ESP application (TVA 2017-TN4921). The ER focuses on the environmental effects of the construction and operation of reactors with characteristics that fall within the PPE. The ER also includes an evaluation of alternative sites to determine whether there is an obviously superior alternative to the proposed site. The ER is not required to include an assessment of the benefits of the proposed action (e.g., the need for power) or a discussion of energy alternatives (10 CFR 51.50(b)(2) [TN250]).

The NRC staff conducts its reviews of ESP applications in accordance with guidance set forth in review standard RS-002, *Processing Applications for Early Site Permits* (NRC 2004-TN2219). The review standard draws from the previously published NUREG–0800, *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants* (NRC 2007-TN613) and NUREG–1555, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants: Environmental Standard Review Plan* (ESRP) (NRC 2000-TN614). RS-002 provides guidance for NRC staff reviewers to help ensure a thorough, consistent, and disciplined review of any ESP application. As stated in RS-002, an applicant may elect to use a PPE approach instead of supplying specific design information (NRC 2004-TN2219). The NRC staff's June 23, 2003 responses to comments received on draft RS-002 provide additional insights into the NRC staff's expectations and potential approach to the review of an application using the PPE approach (NRC 2003-TN2064). Specifically, the NRC staff adapted the ESRP review guidance to support the PPE concept. The findings in this draft EIS reflect the adaptation of the ESRP guidance to the PPE approach.

In addition, the NRC staff's review also considered the information and analyses provided in NUREG–1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS) (NRC 1996-TN288, NRC 1999-TN289, NRC 2013-TN2654). Because the GEIS included a review of data from all operating nuclear power plants, some of the information was useful for the environmental review of the proposed action. The NRC staff has identified in the text those areas where this information has been used. Additional guidance on conducting environmental reviews is provided in NRC Interim Staff Guidance COL/ESP-ISG-26, *Interim Staff Guidance on Environmental Issues Associated with New Reactors* (NRC 2014-TN3767), and NRC Interim Staff Guidance COL/ESP-ISG-27, *Interim Staff Guidance on Specific Environmental Guidance for Light Water Small Modular Reactor Reviews* (NRC 2014-TN3774).

Pursuant to 10 CFR 51.75(b) (TN250), an EIS prepared by the NRC staff for an application for an ESP focuses on the environmental effects of construction and operation of a reactor (or reactors) that has design characteristics that fall within the site characteristics and design parameters. Such an EIS must also include an evaluation of alternative sites to determine whether there is any obviously superior alternative to the site proposed. Commission regulations recognize that certain matters need not be resolved at the ESP stage (e.g., an assessment of the benefits, need for power, and energy alternatives) and, thus, may be deferred until an applicant decides to apply for a CP or COL. This draft EIS does not include an assessment of the need for power or energy alternatives.

The TVA ESP application, including its ER (TVA 2017-TN4921), was submitted under oath or affirmation. Applicants use the body of the NRC regulatory guidance (e.g., regulatory guides, review standards, and standard review plans) and can take advantage of approaches and methods acceptable to the NRC to analyze environmental impacts. The NRC staff relied on the ER as a source of basic information about the project description (including plant parameters), the site, the region, and the environment. Subsequent to the acceptance of the application, the NRC staff visited the site; consulted with Federal, State, Tribal, and local agencies; and conducted its own independent review. This draft EIS is the result of the NRC staff's review and properly includes material from various sources, including the ER. Ultimately, the NRC is responsible for the reliability of all the information used in its EIS. If, as part of its independent review, the NRC determines that information presented in the ER is useful and the NRC confirms its accuracy, then the NRC may use the information in its EIS.

If a CP or COL applicant references the ESP, then in accordance with 10 CFR 51.50(c) and 51.92(e) (TN250), the ER for a CP or COL application would contain—and the NRC staff would consider—any new and significant information for issues related to the impacts of construction (and operation for a COL) of the facility that were resolved in the ESP proceeding. Appendix J of this draft EIS contains a list of representations and assumptions used by the NRC staff to assess environmental impacts associated with building and operating a new nuclear power plant. The information in Appendix J is meant to aid the staff and the applicant in identifying new and potentially significant information at the CP or COL stage, but it does not replace the analyses in the EIS. As described above, information that is new and significant is subject to reexamination at the COL or CP stage; however, the alternative site selection process is resolved through the ESP review process and is not addressed in a supplemental EIS.

As provided by 10 CFR 52.39(a)(2) (TN251), the Commission shall treat those matters that are resolved through this EIS as resolved in any later proceeding on an application for a CP or COL referencing the requested TVA ESP. However, as required by 10 CFR 51.50(c) (TN250), a CP or COL applicant must identify whether there is new and significant information regarding these resolved issues. This requirement complements the obligation of a CP or COL applicant referencing an ESP to provide information to resolve any significant environmental issue not considered in the previous proceeding on the ESP. Issuance of either a CP (and OL) or a COL to construct and operate a nuclear power plant is a major Federal action that requires its own environmental review in accordance with 10 CFR Part 51 (TN250). As provided in 10 CFR 52.79 (TN251) and under NEPA (42 U.S.C. § 4321 *et seq*.-TN661), the CP or COL environmental review is informed by the EIS prepared at the ESP stage, and the NRC staff intends to use tiering and incorporation-by-reference whenever it is appropriate to do so. The CP or COL applicant must address any other issue not considered or not resolved in the EIS for the ESP. Moreover, pursuant to 10 CFR 51.70(b) (TN250), the NRC is required to independently evaluate and be responsible for the reliability of all information used in the environmental review for a CP or COL application, and the NRC staff may (1) inquire into the continued validity of information disclosed in an ESP EIS that is referenced in a COL application and (2) look for any new and potentially significant information that may affect the assumptions, analyses, or conclusions reached in an ESP EIS.

In addition, measures and controls to limit any adverse impact are identified and evaluated for feasibility and adequacy in limiting adverse impacts at the ESP stage, where possible, and at the CP or COL stage. As a result of the NRC staff's environmental review of the ESP application, the NRC staff may determine that conditions or limitations on the ESP may be necessary in specific areas, as set forth in 10 CFR 52.24 (TN251). Therefore, the NRC staff identified in this draft EIS when and how assumptions and PPE values limit its conclusions on the environmental impacts to a particular resource (see Appendices I and J in this draft EIS).

To guide its assessment of environmental impacts of a proposed action or alternative actions, the NRC has established a standard of significance for impacts using Council on Environmental Quality (CEQ) guidance (40 CFR 1508.27 [TN428]). Using this approach, the NRC has established three significance levels—SMALL, MODERATE, or LARGE—which are defined as follows:

> 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.

1.1.2.1 Overview of the CRN ESP Application Environmental Review

TVA submitted its ESP application to the NRC by letter dated May 12, 2016 (TVA 2016-TN5002). TVA subsequently provided supplemental information in support of the application. These supplemental submittals provided by TVA are listed in Appendix C of this draft EIS. Consistent with NRC guidance, the NRC staff completed an acceptance review to determine whether the ESP application for the CRN Site, as supplemented, contained sufficient technical information in scope and depth to allow the NRC staff to conduct its detailed technical safety and environmental reviews within a predictable time frame. The staff determined that the application (with the supplemental submittals) was sufficient for docketing and issued a *Federal Register* notice (82 FR 3812-TN5084) notifying the public of the NRC's acceptance of the CRN Site ESP application on January 12, 2017.

On April 13, 2017, the staff issued a Notice of Intent to prepare an EIS and conduct scoping (82 FR 17885 -TN4910). The NRC staff held two public scoping meetings in Oak Ridge, Tennessee, on May 15, 2017 to obtain public input on the scope of the environmental review. The NRC staff also contacted Federal, State, Tribal, regional, and local agencies to solicit comments. Correspondence between the NRC and Federal, State, Tribal, regional, and local agencies is listed in Appendix C of this draft EIS. The NRC staff reviewed the comments received during scoping and wrote responses for each comment. Comments within the scope of the NRC environmental review and their associated responses are included in Appendix D of this draft EIS. The scoping comments and responses are also documented in the *Scoping Process Summary Report for the Clinch River Nuclear Site Early Site Permit Application* (NRC 2017-TN5343).

Collectively, the NRC staff (including its contractor staff at Pacific Northwest National Laboratory) and the USACE staff, who together reviewed the environmental aspects of the application and supporting documentation and decided on impact levels, are referred to as the "review team" throughout the remainder of this draft EIS. To gather information and to become familiar with the sites and their environs, the review team visited the CRN Site in October 2014, March 2015, and May 2017 and visited the alternative sites in July 2015 and May 2017. In addition, a regulatory audit was conducted from May 15 to August 11, 2017, during which time the review team met with TVA staff, Federal, State, and local officials, and local organizations. The outcomes of the review team's audit and the site/alternative sites visits of May 2017 are recorded in the *Clinch River Nuclear Site Early Site Permit Application Environmental Audit Summary Report* (NRC 2018-TN5386). Other documents related to the TVA ESP application were reviewed and are listed as references where appropriate.

This draft EIS presents the review team's analysis that considers and weighs the environmental impacts of the proposed action at the CRN Site, including the environmental impacts associated with construction and operation at the site of two or more SMRs that are bounded by the PPE, the impacts of constructing and operating the proposed project at alternative sites, the no-action alternative to the NRC's granting the ESP, and mitigation measures available for reducing or avoiding adverse environmental effects. It also provides the NRC staff's preliminary recommendation to the Commission regarding the suitability of the CRN Site for construction and operation of SMRs with design characteristics that fall within the PPE.

1.1.3 USACE Review of the TVA ESP Application

The USACE is part of the review team that makes a determination based on the three significance levels established by the NRC. In addition, the USACE could use the information in this EIS to support the review of the DA permit application if TVA submits a DA permit application at a future date. In general, the decision of whether to issue a DA permit would be based on an evaluation of the probable impacts, including cumulative impacts of the activity, on the public interest. That decision would reflect the national concern for both protection and use of important resources. The benefit that reasonably may be expected to accrue from the work must be balanced against its reasonably foreseeable detriments. All factors which may be relevant to the work will be considered, including the cumulative effects thereof; among those are conservation, economics, aesthetics, general environmental concerns, wetlands, cultural values, fish and wildlife values, flood hazards, floodplain values, land use, navigation, shore erosion and accretion, recreation, water supply and conservation, water quality, energy needs, safety, food and fiber production, mineral needs, considerations of property ownership, and, in general, the needs and welfare of the people. The USACE's evaluation of the impact of the activity on the public interest would include application of the guidelines promulgated by the U.S. Environmental Protection Agency, under authority of Section 404(b)(1) of the CWA (40 CFR Part 230-TN427).

1.1.4 Preconstruction Activities

In a final rule dated October 9, 2007, "Limited Work Authorizations (LWAs) for Nuclear Power Plants" (72 FR 57416-TN260), the Commission defined "construction" (10 CFR 50.10 [TN249] and 10 CFR 51.4 [TN250]) to be consistent with the NRC's jurisdiction over activities having a nexus to radiological health and safety and/or common defense and security. Many of the activities required to build a nuclear power plant are not part of any future NRC action to license the plant. Activities associated with building the plant that are not within the purview of the NRC are grouped under the term "preconstruction." Preconstruction activities include clearing and grading, excavating, erection of support buildings and transmission lines, and other associated activities. These preconstruction activities may take place before the application for an ESP, CP, or COL is submitted, during the NRC staff review of an ESP or COL application, or after an ESP or COL is granted. Although preconstruction activities are outside the NRC regulatory authority, nearly all of them are within the regulatory authority of local, State, or other Federal agencies.

To perform construction-related activities that do require NRC authorization (those activities with a nexus to radiological safety), an applicant must first receive either a CP, COL, or LWA from the NRC. TVA's ESP application did not include a request for a LWA. Because the ESP, if granted, would not authorize any activities, a CWA Section 401 certification is not required prior to the issuance of an ESP. Subsequently, if TVA applies for a CP, COL, or LWA, a CWA Section 401 certification from the State of Tennessee would be required, and any conditions of the CWA Section 401 certification would be incorporated into the license pursuant to 10 CFR 50.54(aa) (TN249).

Because the preconstruction activities are not under the purview of the NRC, their impacts are not reviewed as a direct effect of the NRC action. Rather, the impacts of the preconstruction activities are considered in the context of cumulative impacts. Preconstruction activities that would require authorization under RHA Section 10 or CWA Section 404 (33 U.S.C. § 1344-TN1019) would be considered "direct effects" of a USACE Federal action should a DA permit application be received by the USACE. Because the USACE is a cooperating agency on this EIS, preconstruction activities are addressed in Chapter 4 "Construction Impacts."

1.1.5 Cooperating Agencies

NEPA (42 U.S.C. § 4321 *et seq*.-TN661) lays the groundwork for coordination between the lead agency preparing an EIS and other Federal agencies that may have special expertise regarding an environmental issue or jurisdiction by law. These other agencies are referred to as "cooperating agencies." Cooperating agencies have the responsibility to assist the lead agency through early participation in the NEPA process, including scoping; by providing technical input to the environmental analysis; and by making staff support available as needed by the lead agency.

Most proposed nuclear power plants require a permit from the USACE, where impacts are proposed to waters of the U.S., in addition to a license from the NRC. Therefore, the NRC and the USACE decided the most effective and efficient use of Federal resources in the review of nuclear power plant license applications would be achieved by a cooperative agreement. On September 12, 2008, the NRC and the USACE signed a Memorandum of Understanding (MOU) regarding the review of nuclear power plant license applications (USACE and NRC 2008-TN637). On May 2, 2017, the USACE Nashville District agreed by letter (USACE 2017-TN5003) to become a cooperating agency as defined in 10 CFR 51.14 (TN250).

As described in the Memorandum of Understanding, the NRC is the lead Federal agency and the USACE is a cooperating agency in the development of the EIS. Under Federal law, each agency has jurisdiction related to portions of the proposed project as major Federal actions that could significantly affect the quality of the human environment. The goal of this cooperative agreement is the development of a single EIS that serves the needs of the NRC license decision process and the USACE Department of the Army permit decision process. While both agencies must comply with the requirements of NEPA (42 U.S.C. § 4321 *et seq*.-TN661), each also has independent or individual mission requirements that must be met. The NRC makes license decisions under the Atomic Energy Act of 1954, as amended (42 U.S.C. § 2011 *et seq*.-TN663), and the USACE makes permit decisions under the RHA (33 U.S.C. § 401 *et seq*.-TN660) and CWA (33 U.S.C. § 1251 *et seq*.-TN662). The USACE is cooperating with the NRC to ensure that the information presented in the ESP NEPA documentation is adequate to support a DA permit application, should TVA submit a DA permit application at a future date.

As a cooperating agency, the USACE is part of the NRC review team and is involved in all aspects of the environmental review, including scoping, public meetings, public comment resolution, and EIS preparation. The NRC draft EIS public meeting with the USACE serves the purposes of both agencies, with the USACE referring to the NRC-defined public meeting as its public hearing. The USACE district engineer or designee may participate in joint public hearings with other Federal or State agencies in accordance with 33 CFR Part 327 (TN1788) provided the procedures of those hearings meet the requirements of this regulation. In cases in which the other Federal or State agency allows a cross-examination in its public hearing, the district engineer may still participate in the joint public hearing but shall not require cross-examination as a part of his participation.

The USACE refers to public meetings to acquire information or evidence that will be considered when evaluating a proposed DA permit as hearings, but there is no adjudicatory process involved such as the NRC hearings conducted by the Atomic Safety and Licensing Board. For the purposes of assessment of environmental impact under NEPA (42 U.S.C. § 4321 *et seq*.-TN661), the draft EIS uses the SMALL/MODERATE/LARGE criteria discussed in Section 1.1.3; this approach has been vetted by the CEQ.

A cooperating agency may adopt the EIS of a lead Federal agency without recirculating it when the cooperating agency concludes, after an independent review of the EIS, that its comments and suggestions have been satisfied and issues a Record of Decision. The goal of the process is that the USACE will have all the information necessary to make a permit decision when the final EIS is issued. However, in the case of an ESP application for which no final impacts on waters of the U.S. are estimated, the USACE will need information from the applicant to complete the DA permit application—information that the applicant could not make available by the time of final EIS issuance. Also, any conditions required by the USACE, such as compensatory mitigation, will be addressed in the USACE permit application review process. Compensation may only be used after all appropriate and practical steps to avoid and minimize adverse impacts on aquatic resources, including wetlands and streams, have been taken. All remaining unavoidable impacts must be compensated to the extent appropriate and practicable. Upon review of estimated impacts on waters of the U.S. (in a separate DA permit application), the USACE would include special conditions to the effect that TVA must confirm that any wetland compensation efforts have achieved their established goals and requirements in accordance with Compensatory Mitigation for Losses of Aquatic Resources, Final Rule ([73 FR 19594-TN1789] and 33 CFR Parts 325 [TN425] and 332 [TN1472]).

1.1.6 Concurrent NRC Reviews

In reviews that are separate from, but parallel to, the EIS process, the NRC analyzes the safety characteristics of the proposed site and emergency planning information. The NRC's safety evaluation will be documented in a SER, currently scheduled to be published in 2019. The SER will present the conclusions reached by the NRC as described in Section 1.1 of this draft EIS.

1.2 The Proposed Federal Action

The proposed NRC Federal action is the issuance, under the provisions of 10 CFR Part 52 (TN251), of an ESP for approval of the CRN Site as suitable for the future demonstration of the construction and operation of two or more SMRs that fall within the PPE described in the TVA ESP application. This draft EIS provides the review team's analyses of the environmental impacts that could result from building and operating two or more SMRs with a maximum total electrical output of 800 MW(e) to demonstrate the capability of SMR technology.

Although the USACE does not have a proposed Federal action associated with the ESP application, it intends to verify that the information presented in this draft EIS is adequate to support a Department of the Army permit application, if TVA submits a Department of the Army permit application at a future date. While TVA has yet made no decision to build a new nuclear plant, this draft EIS provides the NRC and USACE analyses of the environmental impacts that could result from building and operating a new nuclear power plant at the CRN Site or at one of three alternative sites. These potential impacts will be analyzed by the USACE to determine whether the proposed site is the least environmentally damaging practicable alternative that would meet the project purpose and need to the furthest extent possible without specific proposed impacts on waters of the United States. These impacts are also analyzed by the NRC to determine whether there is an alternative site that is obviously superior to the proposed site.

1.3 The Purpose and Need for the Proposed Action

The primary purpose and need for the NRC proposed action (i.e., ESP issuance) is to provide for early resolution of site safety and environmental issues, which provides stability in the licensing process. The NRC's purpose and need is further informed by the applicant's purpose and need. In its ER purpose and need section (TVA 2017-TN4921), TVA stated:

> TVA proposes to deploy two or more SMRs with a maximum total electrical output of 800 megawatt electric (MWe) for the site, to demonstrate the capability of SMR technology. SMRs provide the benefits of nuclear-generated power in situations where large nuclear units, with an approximate electrical output exceeding 1000 MWe, are not practical, because of transmission system constraints, limited space or water availability, or constraints on the availability of capital for construction and operation.

In addition, TVA provided the following four main objectives of the CRN SMR Project:

- Power generated by SMRs could be used for addressing critical energy security issues. Their use on or immediately adjacent to DoD or DOE [U.S. Department of Defense or U.S. Department of Energy] facilities, using robust transmission (e.g., armored transformers, underground transmission), could address national security needs by providing reliable electric power in the event of a major grid disruption. A more reliable electric power supply could be accomplished by the SMR operation in "power island" mode with robust transmission to critical facilities. In addition, intentional destructive acts (e.g., terrorist attacks) and natural phenomena (e.g., tornadoes, floods, etc.) could disrupt the grid and the ability to restore most generation sources. SMRs can provide reliable energy for extended operation. Because nuclear reactors require fuel replenishment less frequently than other power generation sources (coal, gas, wind and solar), SMRs are less vulnerable to interruptions of fuel supply and delivery systems. TVA could demonstrate this “power islanding” and secure supply concept as part of the CR SMR project by utilizing controls, switching, and transmission capabilities to disconnect the SMR power plant from the electrical grid, while maintaining power from the SMR power plant to a specified DOE facility supplying reliable power that is less vulnerable to disruption from intentional destructive acts and natural phenomena.

- SMR technology can assist Federal facilities with meeting carbon reduction objectives. Energy-related carbon dioxide (CO_2) emissions account for more than 80 percent of greenhouse gas (GHG) emissions in the United States. Studies show that on average coal combustion generates approximately 894–975 grams of CO_2 per kilowatt-hour (g/kWh) of electricity generated. Natural gas generates an estimated 450–519 g/kWh. Nuclear power emission rates have been calculated to range from 6–26 g/kWh. [Citations in ER text omitted.]

- SMR design features include underground containment and inherent safe-shutdown features, longer station blackout coping time without external intervention, and core and spent fuel pool cooling without the need for active heat removal. These key features advance safety by eliminating several design basis accident scenarios. Development of a security-informed design efficiently provides the same or better protection against the threats [operators of] large reactors must consider. Physical security is designed into the SMR plant architecture, incorporating lessons learned from significant shifts in security posture since 2001, and the opportunity to build more inherently secure features into the initial design.

- SMR power generating facilities are designed to be deployed in an incremental fashion to meet the power generation needs of a service area. Generating capacity can be added in increments to match load growth projections. For the CR SMR project, two or more SMRs would be constructed and brought into operation incrementally to achieve [a capacity of] up to 800 MW(e).

The NRC’s purpose and need is informed by the applicant’s objective to use the power generated by SMRs to address critical energy security issues for TVA Federal direct-served customers (which included only DoD or DOE facilities). Their use on or immediately adjacent to DoD or DOE facilities, could address national security needs by providing reliable electric power in the event of a major grid disruption. Objectives that require the evaluation of design-level information, such as power islanding and SMR design and security features, were not considered in this draft EIS. Deploying SMRs in an incremental fashion to meet power generation needs and to assist in meeting carbon reduction goals were not considered in this draft EIS, because the applicant chose to defer the need for power and alternative energy analysis. However, these objectives could be considered in an EIS for a COL application.

1.4 TVA’s Proposed Project

TVA is the applicant and owns the CRN Site. TVA is a corporate agency of the United States providing electricity for business customers and local power distributors. TVA’s mission includes technological innovation (TVA 2017-TN4921). To meet its objective to demonstrate the capability of SMR technology, TVA proposes to build and operate a new plant including two or more SMRs for which a specific design has not been selected. As mentioned in Section 1.1.1 and described more fully in Section 3.2 and Appendix I of this draft EIS, TVA has developed a PPE for use in evaluating potential environmental impacts. In its application TVA presents parameters associated with station appearance and footprint, water use, transmission and other ancillary facilities, and describes anticipated building activities and the associated footprint. Chapter 3 of this draft EIS describes those characteristics of TVA's proposed project that the staff considers in its assessment of environmental impacts.

As previously mentioned, the ESP would not authorize construction and operation of a nuclear power plant. The ESP would not approve TVA's proposed project. Rather, the staff used TVA's description of its proposed project to evaluate the environmental impacts in this draft EIS. The environmental impacts and alternative sites evaluation associated with the NRC's proposed ESP action inform the suitability determination for the CRN Site.

1.5 The Future USACE Permit Action

It is anticipated TVA will require a Department of the Army permit for work needed to prepare the CRN Site for a new nuclear power plant, but a Department of the Army permit application has not been submitted at this time. As part of the evaluation of permit applications subject to CWA Section 404 (33 U.S.C. § 1344-TN1019), the USACE must define the overall project purpose in addition to the basic project purpose. The overall project purpose establishes the scope of the alternatives analysis and is used for evaluating practicable alternatives under the 404(b)(1) Guidelines (40 CFR Part 230-TN427). In accordance with the guidelines and the USACE Headquarters guidance, the overall project purpose must be specific enough to define the applicant's needs but not so narrow and restrictive as to preclude a proper evaluation of alternatives. The USACE is responsible for controlling every aspect of the 404(b)(1) Guidelines (40 CFR Part 230-TN427) analysis. Hence, defining the overall project purpose is the sole responsibility of the USACE. While generally focusing on the applicant's statement, the USACE will, in all cases, exercise independent judgment in defining the purpose of and need for the project from the perspective of the applicant's alternatives and the public (33 CFR Part 325 Appendix B (9)(c)(4) [TN425]—see also 33 CFR Part 230 [TN2273]).

Where the activity associated with a discharge is proposed for a special aquatic site (as defined in the 404(b)(1) Guidelines, 40 CFR Part 230, Subpart E [TN427]) and does not require access or proximity to or siting within these types of areas to fulfill its basic project purpose (i.e., the project is not "water dependent"), practicable alternatives that avoid special aquatic sites are presumed to be available unless clearly demonstrated to be otherwise (404(b)(1) Guidelines, 40 CFR 230.10(a)(3) [TN427]). The basic purpose of the TVA project is to conduct work associated with building a power plant.

Section 230.10(a) of the 404(b)(1) Guidelines (40 CFR Part 230-TN427) requires that "no discharge of dredged or fill material shall be permitted if there is a practicable alternative to the proposed discharge which would have less adverse impact on the aquatic ecosystem, so long as the alternative does not have other significant adverse environmental consequences." Section 230.10(a)(2) of the 404(b)(1) Guidelines states that "an alternative is practicable if it is available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes. If it is otherwise a practicable alternative, an area not presently owned by the applicant that could reasonably be obtained, used, expanded, or managed to fulfill the basic purpose of the proposed activity may be considered." Thus, this analysis is necessary to determine which alternative is the least environmentally damaging practicable alternative that meets the project purpose and need. The overall purpose of the project is to construct an SMR facility.

1.6 Alternatives to the Proposed Actions

NEPA Section 102(2)(C)(iii) (42 U.S.C. § 4321 *et seq*.-TN661) states that EISs will include a detailed statement about alternatives to the proposed action. The NRC regulations for implementing Section 102(2) of NEPA provide for inclusion of a chapter in an EIS that discusses the environmental impacts of the proposed action and the alternatives (10 CFR Part 51, Subpart A, Appendix A [TN250]). Chapter 9 of this draft EIS discusses the environmental impacts of three categories of alternatives: (1) the no-action alternative, (2) alternative sites, and (3) system design alternatives.

In the no-action alternative, the action would not go forward. The NRC could deny the TVA request for an ESP. The no-action or permit denial alternative also is available to the USACE after a permit is submitted to the USACE. The no-action alternative is one that results in no activities requiring a USACE permit. It may be brought by (1) the applicant electing to modify his proposal to eliminate work under the jurisdiction of the USACE or (2) the denial of the permit. If the request and/or permit were denied, the construction and operation of a new nuclear power plant at the proposed CRN Site in accordance with the 10 CFR Part 52 (TN251) process referencing an approved ESP would not occur, nor would any benefits intended by an approved ESP be realized.

The three alternative sites considered in detail in this draft EIS include two sites on the Oak Ridge Reservation on the Clinch River arm of the Watts Bar Reservoir in Roane County, Tennessee, and one site on the Redstone Site in Madison County, Alabama. Chapter 9 includes sections discussing (1) the TVA region of interest for identification of alternative plant sites, (2) the methods used by TVA to select the proposed site and alternative sites, and (3) generic issues that are consistent among the alternative sites. Chapter 9 also compares the environmental impacts at the CRN Site to those at the alternative sites and qualitatively determines whether any of the alternative sites is obviously superior to the proposed site.

System design alternatives include heat-dissipation and circulating-water systems, intake and discharge structures, and water-use and water-treatment systems. Finally, the USACE will continue to review additional efforts to avoid and minimize potential impacts on waters of the United States, including wetlands and cultural and natural resources on the site.

As part of the evaluation of permit applications subject to CWA Section 404 (33 U.S.C. § 1344-TN1019), the USACE is required by regulation to apply the criteria set forth in the 404(b)(1) Guidelines (40 CFR Part 230-TN427). These guidelines establish criteria that must be met for the proposed activities to be permitted pursuant to Section 404. Specifically, the guidelines state, in part, that no discharge of dredged or fill material shall be permitted if there is a practicable alternative to the proposed discharge that would have less adverse impacts on the aquatic ecosystem provided the alternative does not have other significant adverse consequences (40 CFR 230.10(a) [TN427]). If it is otherwise a practicable alternative, an area not presently owned by the applicant that could reasonably be obtained, used, expanded, or managed to fulfill the basic purpose of the proposed activity may be considered.

1.7 Compliance and Consultations

Before construction and operation of a new reactor or reactors, TVA is required to hold certain Federal, State, and local environmental permits and meet relevant Federal and State statutory requirements. In its ER, TVA provided a list of environmental approvals and consultations associated with the ESP. The list is in Appendix H of this draft EIS. Because an ESP is limited to establishing the acceptability of the proposed site for future development of a nuclear power facility, a number of authorizations TVA will need from Federal, State, and local authorities for construction and operation are not yet necessary.

The NRC staff considered the necessary authorizations and consultations. The staff contacted the appropriate Federal, State, and local agencies to identify any compliance, permit, or significant environmental issues of concern to the reviewing agencies that may affect the suitability of the CRN Site for the construction and operation of the reactors that fall within the PPE.

1.8 Report Contents

The subsequent chapters of this draft EIS are organized as follows. Chapter 2 describes the proposed site and discusses the environment that would be affected by the addition of a new nuclear power plant. Chapter 3 examines the power plant characteristics to be used as the basis for evaluation of the environmental impacts. Chapters 4 and 5 examine site suitability by analyzing the environmental impacts of construction (Chapter 4) and operation (Chapter 5) of a new nuclear power plant. Chapter 6 analyzes the environmental impacts of the fuel cycle, transportation of radioactive materials, and decommissioning, while Chapter 7 discusses the cumulative impacts of the proposed action. Chapter 8, the need for power analysis, is not included, because, in accordance with10 CFR 51.75(b) (TN250), the EIS does not need to discuss need for power unless it is discussed in the ER. Chapter 9 discusses alternatives to the proposed action—no-action, alternative sites, and systems design—and compares the proposed action with the alternatives. Chapter 10 summarizes the findings of the preceding chapters and presents the NRC staff's conclusions and recommendations with respect to Commission approval of the proposed site for an ESP based on the NRC staff's evaluation of environmental impacts. Chapter 11 lists the references. An index is presented at end of the document to help readers find information.

The appendices provide the following additional information:

- Appendix A – Contributors to the Environmental Impact Statement
- Appendix B – Organizations Contacted
- Appendix C – Chronology of NRC and USACE Staff Environmental Review Correspondence Related to the TVA Application for an Early Site Permit (ESP) at the CRN Site
- Appendix D – Scoping Comments and Responses
- Appendix E – Draft Environmental Impact Statement Comments and Responses
- Appendix F – Key Consultation Correspondence
- Appendix G – Supporting Information for Radiological Dose Assessments of Routine Operations and Postulated Severe Accidents
- Appendix H – List of Authorizations, Permits, and Certifications
- Appendix I –Clinch River Nuclear Site Characteristics and Plant Parameter Envelope Values
- Appendix J –Representations and Assumptions
- Appendix K – Greenhouse Gas Footprint Estimates for a Reference 1,000-MW(e) Light Water Reactor (LWR)

- Appendix L – The Effect of Climate Change on the Evaluation of Environmental Impacts
- Appendix M – Biological Assessment for the U.S. Fish and Wildlife Service Regarding the Clinch River Small Modular Reactor Early Site Permit Application.

2.0 AFFECTED ENVIRONMENT

The Clinch River Nuclear (CRN) Site proposed by the Tennessee Valley Authority (TVA) for an early site permit (ESP) is located on the Clinch River arm of the Watts Bar Reservoir in Roane County, Tennessee (Figure 2-1). The proposed site location is described in Section 2.1, followed by descriptions of land use, water, ecology, socioeconomics, environmental justice, historic and cultural resources, geology, meteorology and air quality, nonradiological health, and radiological environment in Sections 2.2 through 2.11, respectively. Section 2.12 discusses related Federal projects.

2.1 Site Location

The CRN Site is situated in the southwestern part of the city limits of Oak Ridge approximately 10 mi south of the Oak Ridge urban center; 16 mi west of Knoxville, Tennessee; and 7 mi east of Kingston, Tennessee. Figure 2-1 depicts the location of the CRN Site in relationship to nearby counties and cities within the context of the wider region.

TVA's Clinch River property comprises 1,200 ac of Federal land adjacent to the Clinch River arm of the TVA-managed Watts Bar Reservoir. This tract includes the CRN Site, which is approximately 935 ac, and the Grassy Creek Habitat Protection Area, but not the Clinch River Industrial Park (Figure 2-1). The Grassy Creek Habitat Protection Area, which would not be encroached upon by the proposed project, is located north of the site as shown in Figure 2-1 and Figure 2-2. Figure 2-2 presents the CRN Site Utilization Plan. Figure 2-3 presents an aerial photograph of the existing TVA property and surroundings. The photograph also depicts the barge/traffic area (BTA), a portion of the Oak Ridge Reservation (ORR) immediately north of the CRN Site where TVA proposes to build various road improvements and transportation facilities to serve the new reactors. TVA lists the CRN Site center point in decimal degrees as:

- Latitude: 35.890889 N
- Longitude: 84.380927 W.

The Clinch River arm of the Watts Bar Reservoir borders the western, eastern, and southern sides of the CRN Site. The U.S. Department of Energy's (DOE's) ORR borders the site to the north. The site is bounded by the reservoir from approximately 4 mi downstream of the Melton Hill Dam, extending to approximately 8.5 mi downstream of the dam. This equates to between Clinch River mile (CRM) 14.5 and CRM 19, along the north shore of the Clinch River arm of the Watts Bar Reservoir. The portion of the reservoir adjacent to the site generally ranges between 400 and 700 ft wide.

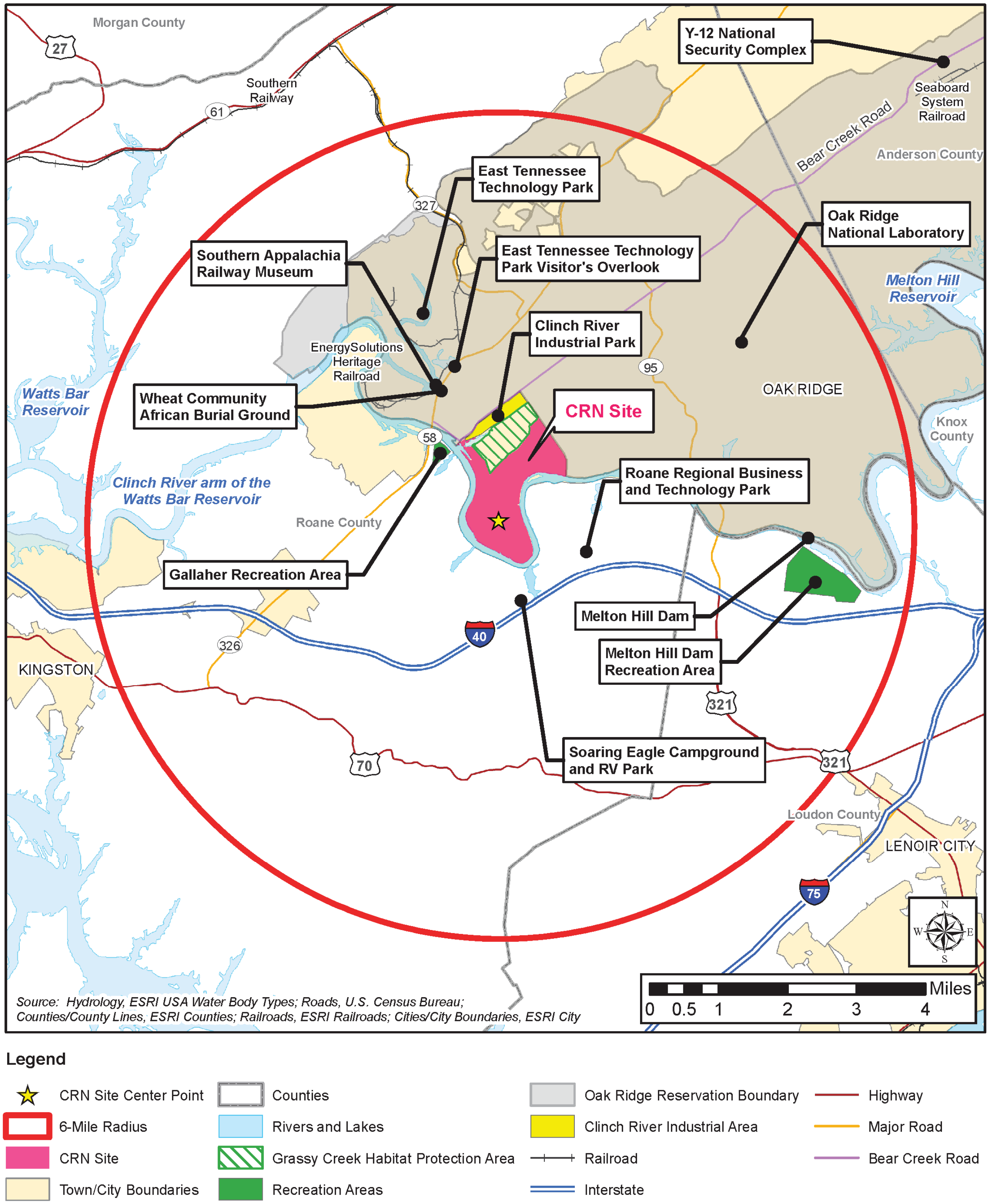


Figure 2-1. Clinch River Nuclear Site and Vicinity (Source: TVA 2017-TN4921)

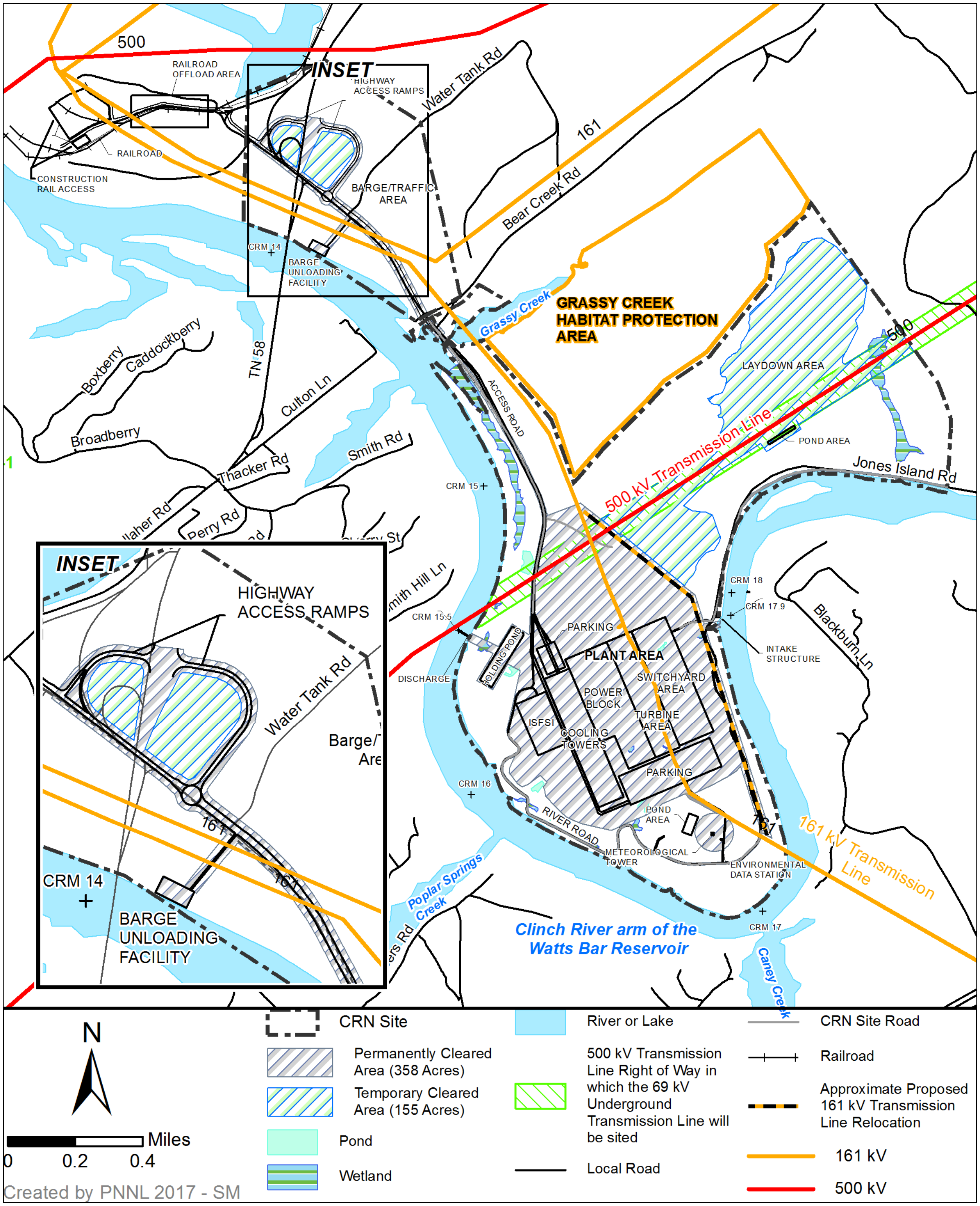


Figure 2-2. Clinch River Nuclear Site Utilization Plan

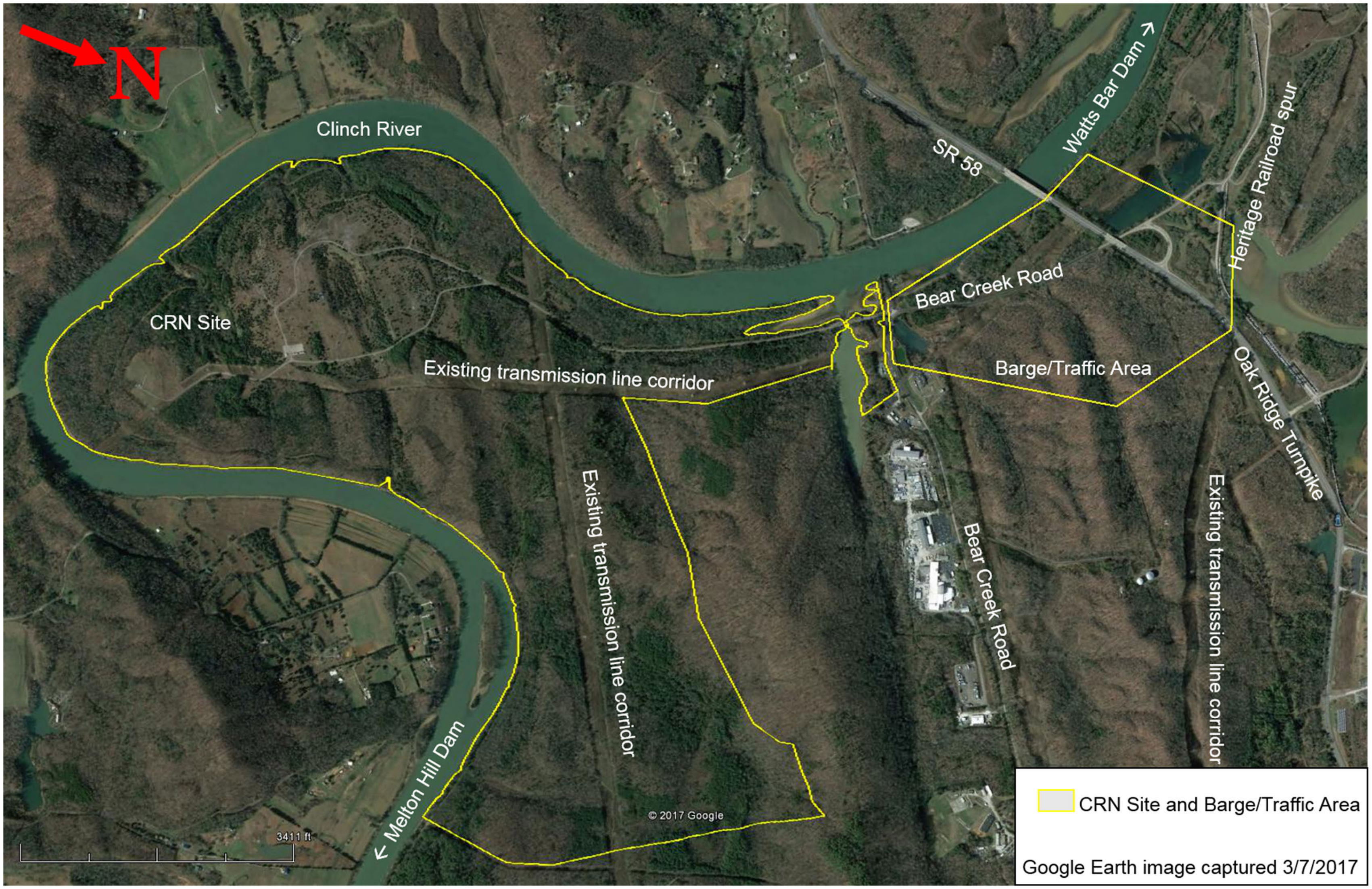


Figure 2-3. Aerial View of the Existing CRN Site and Barge/Traffic Area

2.2 Land Use

This section discusses existing land uses and land-related issues for the CRN Site and other areas potentially affected by the proposed project. Section 2.2.1 describes land use on the site and in the vicinity, which is defined as the area encompassed within a 6-mi radius of the site (NRC 2000-TN614). Section 2.2.2 discusses land uses that may be affected by a series of upgrades identified by TVA as potentially necessary for various segments of its transmission line grid to transmit energy generated by the proposed small modular reactor (SMR) units. These upgrades may consist of transmission line rebuilds, reconductoring, or uprates. Section 2.2.3 discusses land use in the region, which is defined as the area within 50 mi of the site.

2.2.1 Site and Vicinity

The CRN Site is located adjacent to the ORR on existing TVA property in Roane County, Tennessee (Figure 2-4 and Figure 2-5). The site was previously selected and partially developed for the abandoned Clinch River Breeder Reactor Project (CRBRP). CRBRP Site preparation activities began in late 1982 and were nearly complete at the time of project termination at the end of 1983 (TVA 2017-TN4921; BRC 1985-TN5245). Ground disturbance had affected approximately 240 ac by the time of project termination (TVA 2017-TN4921).

The 1,200-ac TVA Clinch River property, including all mineral rights, is owned and managed by TVA. The property includes the 265-ac Grassy Creek Habitat Protection Area and the 935-ac CRN Site (TVA 2017-TN4921). Figure 2-1 illustrates the geographical context of the CRN Site. Figure 2-4 illustrates the land uses and land cover on the site.

The CRN Site is composed of mixed hardwood forests, previously cleared and excavated upland areas, a variety of small or narrow wetlands, and previously excavated stormwater management facilities (e.g., sediment and holding ponds). The site features relatively steep and varied topography and generally ranges from 745 ft above mean sea level (MSL)[(1)] under TVA's current river management policy, as described in TVA's River Operations Study (ROS) (TVA 2004-TN4913) to 940 ft MSL at ridge tops (TVA 2017-TN4921).

The site has not been noticeably disturbed since the termination of the CRBRP in 1983 and subsequent site redress work. CRBRP redress actions included partial filling of a pit excavated for the CRBRP, grading and compacting level areas of the site, reseeding of grass, planting of trees, mulching cleared areas, installation of straw bales in shallow ditches, installation of small berms of riprap in larger ditches, installation of culverts to direct water from steep slopes, and modification of the stormwater-retention ponds for long-term stability. Approximately 240 ac of the current CRN Site were disturbed during site preparation for the CRBRP (TVA 2017-TN4921). Since the completion of CRBRP redress activities, the site has been naturally revegetating back to mixed hardwood forest, upland meadows, and vegetated wetlands (DOE et al. 1984-TN5221).

Access to the site extends via an existing gravel road from Bear Creek Road on the northwestern edge of the TVA property. Bear Creek Road provides access from State Road (SR) 58 to the west and from SR 95 to the north. The existing TVA property can also be accessed from Clinch River via barge facilities at the BTA. Rail access extends to the BTA from the north via a spur of the EnergySolutions Heritage Railroad (TVA 2017-TN4921).

(1) Mean sea level is equivalent to the National Geodetic Vertical Datum of 1929 (NGVD29)

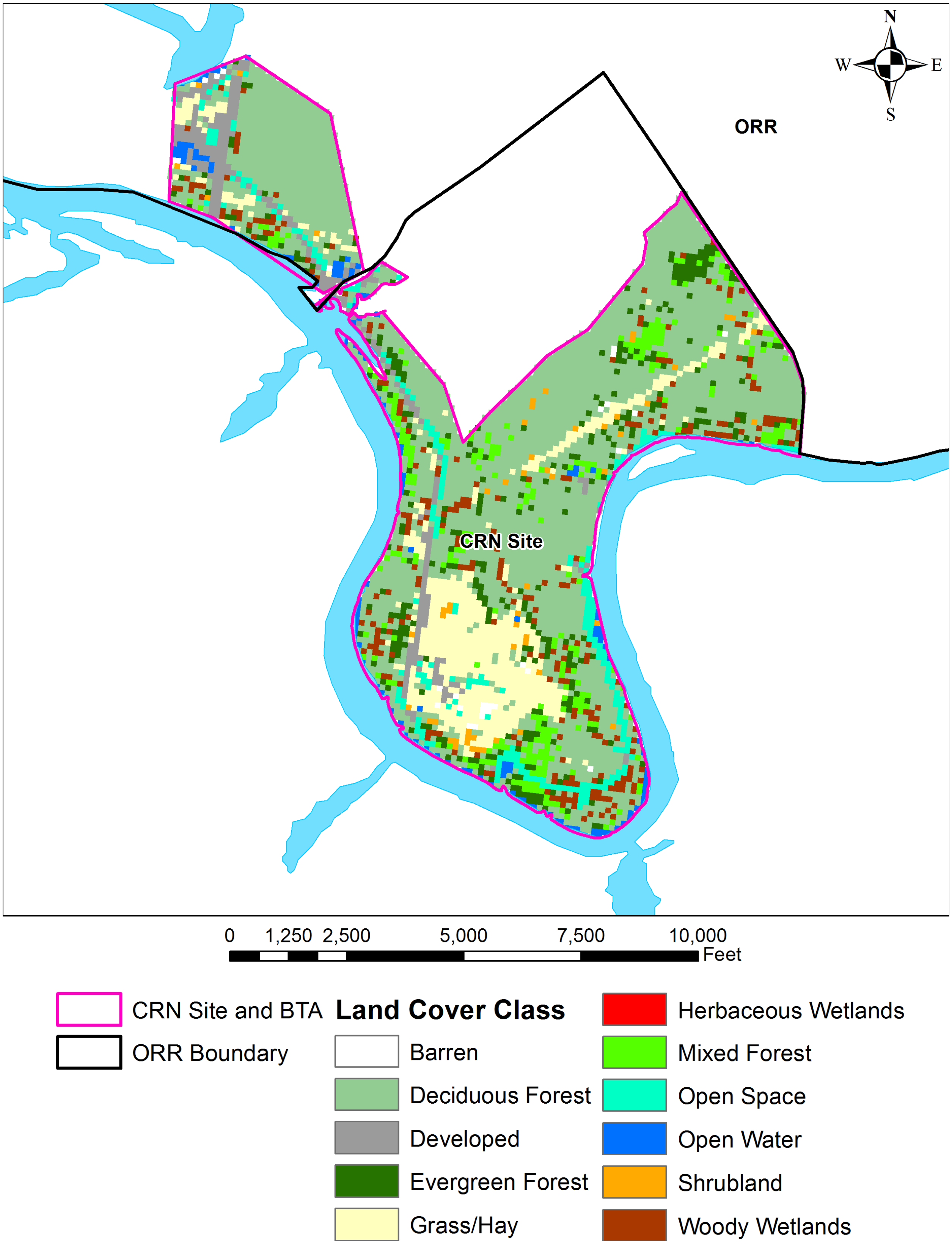


Figure 2-4. Land Use and Land Cover within the CRN Site and BTA (land-use data from NASS 2017-TN5144)

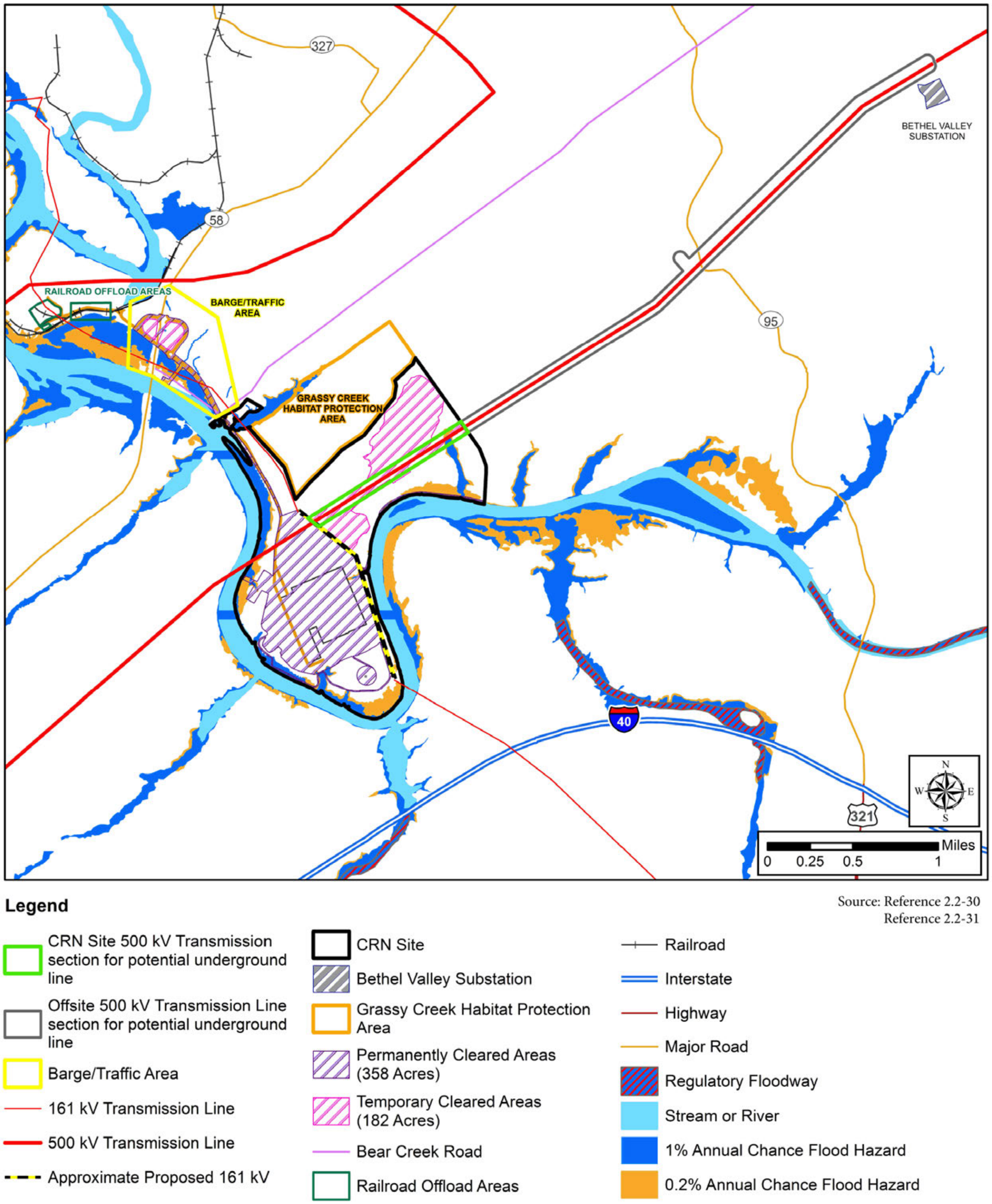


Figure 2-5. Affected Floodplains on the CRN Site (Source: TVA 2017-TN4921)

Currently, two transmission corridors cross the CRN Site (Figure 2-5). The Kingston FP–Ft Loudoun HP 161-kV No.1 transmission line crosses the CRN Site from the southeastern tip of the peninsula (on which the site is located in the Clinch River arm of the Watts Bar Reservoir) to the northwestern corner of the CRN Site near the entrance gate. The Bull Run FP-Watts Bar NP 500-kV transmission line transverses the CRN Site from the northeast to the southwest.

Figure 2-4 illustrates the existing land uses and cover types at the CRN Site. Based on National Agricultural Statistics Service land-cover imagery from 2016 (Table 2-1), forested land (deciduous, evergreen, and mixed forest) covers over 69 percent of the CRN Site (NASS 2017-TN5144). Wetlands (emergent herbaceous and woody wetlands) occupy nearly 6 percent of the CRN Site. Other vegetated undeveloped land (grassland/herbaceous and shrub/scrub) occupies nearly 15 percent of the CRN Site. Open water and barren land occupy more than 3 percent of the CRN Site. Developed areas (high, medium, and low intensity, or open space) occupy approximately 7 percent of the CRN Site.

Land Development Projects are subject to Farmland Protection Policy Act (7 U.S.C. § 4201 *et seq.*-TN708) requirements if they may irreversibly convert farmland (directly or indirectly) to nonagricultural use and are completed by a Federal agency or with assistance from a Federal agency. For the purpose of the Farmland Protection Policy Act, farmland includes prime farmland, unique farmland, and farmland of statewide or local importance (NRCS 2012-TN5238). Figure 2-6 identifies local farmland resources within the vicinity of the CRN Site. Of the entire TVA Clinch River property, 178 ac have been designated as prime and unique farmland by the U.S. Department of Agriculture’s Natural Resources Conservation Service (TVA 2017-TN4921).

The CRN Site and offsite areas include herbaceous and woody wetlands as documented in Section 2.4 of this chapter. The characteristics and jurisdictional status of wetland habitats are discussed in greater detail in Section 2.4.1.6 of this chapter. “Wetlands” as a land-cover category is generally more extensive than formally delineated wetlands.

As part of managing its reservoirs, TVA establishes land-use zones within reservoir management plans. The 2009 Watts Bar Reservoir Land Management Plan (TVA 2009-TN4997) and the 2011 TVA Natural Resource Plan (TVA 2011-TN4998) govern the zones of the reservoir where the CRN Site is located. The majority of the CRN Site is designated as Zone 2 – Project Operations. A strip along the reservoir shoreline is designated Zone 3 – Sensitive Resource Management. The Grassy Creek Habitat Protection Area (adjacent to the CRN Site) is designated Zone 3 – Sensitive Resource Management/Natural Area (TVA 2017-TN4921). TVA indicates that the Oak Ridge Wildlife Management Area, where hunting is allowed, is adjacent to the site, but that hunting access is not allowed on the CRN Site (TVA 2017-TN4921).

Federal lands managed by TVA are not subject to any other local or regional land-use plans. The City of Oak Ridge designates Federally controlled lands within its city limits as “Federal Industry and Research” lands. These lands only become subject to local zoning regulations upon transfer from Federal ownership (City of Oak Ridge 2013-TN4999). The site and surrounding landscape are too far inland to be subject to the Coastal Zone Management Act (16 U.S.C. § 1451 *et seq.*-TN1243).

The only Federal or State public lands on or adjacent to the CRN Site and BTA are owned and managed by TVA and DOE. There are no National or State parks, wildlife refuges, or Tribal lands on or adjacent to the CRN Site or the BTA. The proposed right-of-way for the 69-kV underground transmission line crosses only DOE land once it exits the CRN Site. As shown in Figure 2-5, the only floodplains on the CRN Site or in the BTA are in low-lying lands directly along the reservoir shoreline or in stream valleys where they approach the reservoir. More information about wetlands and floodplains is provided in Section 2.4.1 of this chapter.

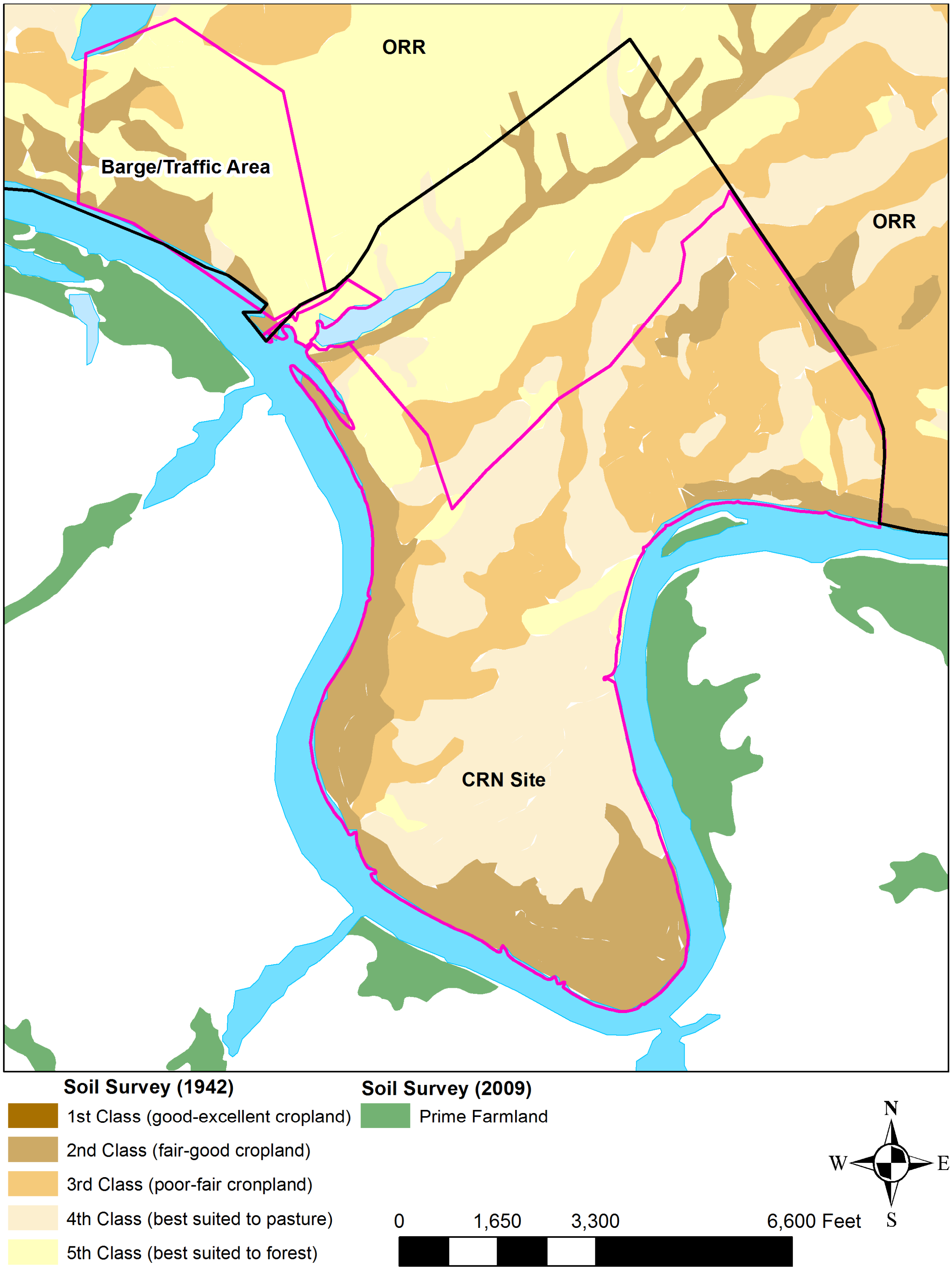


Figure 2-6. Farmland Resources in the Vicinity of the CRN Site (Source: Modified from TVA 2017-TN4921)

Table 2-1. Land Use and Land Cover within the CRN Site and Surrounding Areas

Land Cover	Site (ac)	Percent	BTA (ac)	Percent	6-Mi Vicinity (ac)	Percent	50-Mi Region (ac)	Percent
Deciduous Forest	520	55.6	117	57.7	41,548	57.7	2,851,049	56.9
Evergreen Forest	68	7.2	6	2.8	1,715	2.4	270,128	5.4
Mixed Forest	60	6.5	3	1.3	1,314	1.8	243,710	4.9
Grass/Pasture	116	12.4	14	6.7	12,583	17.5	704,961	14.1
Other Hay/Non-Alfalfa	3	0.3	-	-	600	0.8	84,665	1.7
Other Vegetation and Crops	8	0.8	-	-	76	0.1	67,812	1.4
Shrubland	11	1.2	1	0.5	676	0.9	92,058	1.8
Wetlands	54	5.8	8	4.0	941	1.3	5,083	0.1
Developed/High Intensity	1	0.1	-	-	632	0.9	16,882	0.3
Developed/Open Space	39	4.2	9	4.2	4,931	6.8	327,409	6.5
Developed/Med Intensity	4	0.4	14	7.0	1,444	2.0	55,269	1.1
Developed/Low Intensity	21	2.3	19	9.3	3,043	4.2	142,286	2.8
Open Water	24	2.6	12	5.8	2,389	3.3	142,291	2.8
Barren	5	0.5	1	0.6	167	0.2	10,624	0.2
Total Acres	935	100	203	100	72,059	100	5,014,226	100

Source: NASS 2017-TN5144.

Roane County and Loudon County are the only counties located within the 6-mi vicinity of the CRN Site (Figure 2-7). Most of the land surrounding the site is owned by the Federal government (under DOE control). Lands on the opposite side of Clinch River from the site are privately owned and include farms and rural housing developments.

2.2.1.1 Barge/Traffic Area

The BTA consists of approximately 203 ac of partially developed land that is part of the ORR where TVA anticipates building an access road, barge dock, rail offload, and heavy-haul road to support building and operation of the project at the CRN Site. The existing access road to the CRN Site links the expected construction footprint and laydown areas with the expected barge access and rail access points to the northwest of the site on the opposite side of the Oak Ridge Turnpike/SR 58. Existing land use for this area is visible in Figure 2-7. The BTA lies within the Oak Ridge Wildlife Management Area which is cooperatively managed by Oak Ridge National Laboratory (ORNL) and Tennessee Wildlife Resources Agency (TWRA) for hunting access (TVA 2017-TN4921).

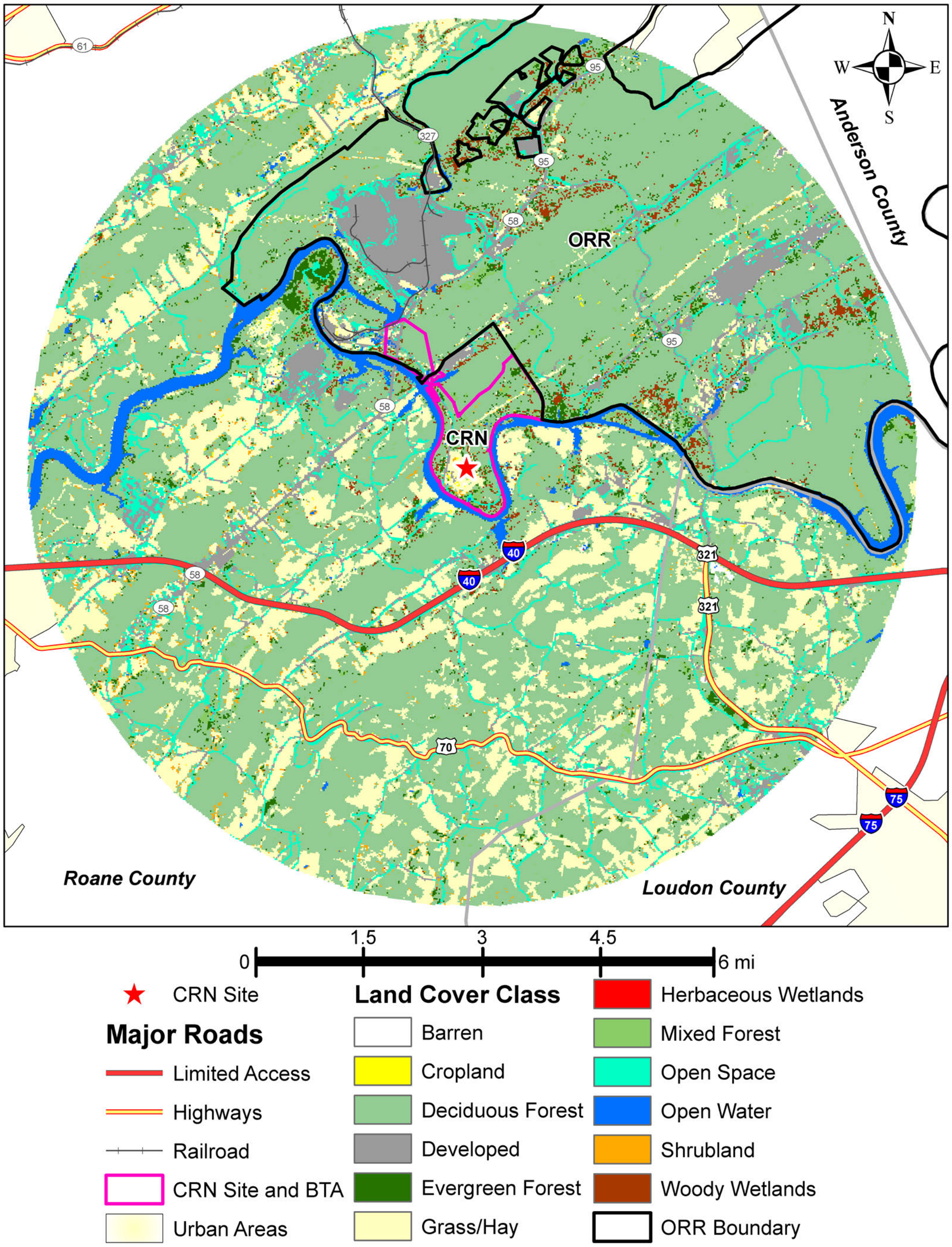


Figure 2-7. Land Use within the Vicinity of the CRN Site (land-use data from NASS 2017-TN5144)

2.2.2 Transmission Lines and Other Offsite Areas

This section describes land use along the existing transmission line corridors from the CRN Site (Section 2.2.2.1), the existing access road corridor and proposed highway alterations for the CRN Site (Section 2.2.2.2), and the proposed use of rail and barge facilities.

2.2.2.1 Existing Transmission Lines

TVA expects to upgrade (reconductor, uprate, or rebuild) multiple offsite transmission lines to receive power from the proposed SMR units. Figure 2-8 illustrates the segments of existing transmission lines TVA expects could be modified. For the purpose of this ESP application review, the review team addressed potential impacts to these segments. However, TVA notes that the exact actions required to modify the transmission system as a result of the proposed reactor units cannot be precisely estimated at the ESP stage (TVA 2017-TN4921). The review team would consider any new information regarding affected transmission line corridors and the associated land-use impacts at the combined construction permit and operating license (combined license or COL) application stage. At the ESP stage, TVA expects all actions related to offsite transmission line modifications would occur within the existing transmission line right-of-ways (TVA 2017-TN4921). Detailed information regarding changes anticipated for the transmission lines, including lengths of individual segments affected, is discussed in Section 3.7 of this draft environmental impact statement (EIS). Table 2-2 provides an overview of the mileage and acreage that could be affected by the proposed upgrades.

TVA has developed a description of existing land uses along the transmission lines based on an analysis of U.S. Geological Survey (USGS) land-use and land-cover (LULC) data (TVA 2017-TN4921). Table 2-2 summarizes the affected mileage and acreage in these previously cleared existing corridors.

Table 2-2. Mileage and Acreage of Affected Transmission Line Corridors

Activity	Total Line Mileage	Total Corridor Acres
Rebuild	13	152
Reconductor	212	2,566
Uprate	215	2,608
Total, all activities	439	5,327

Totals are affected by rounding.

Source: TVA 2017-TN4920.

2.2.2.2 Rail Offloading Area and Rail Spur

TVA has stated that an existing rail spur would be reconditioned to provide delivery of large components to the site. The spur terminates at the rail offloading area to the northwest of the BTA. Energy Solutions, LLC operates the Heritage Railroad spur line that connects with the Norfolk Southern line 11.5 mi from the East Tennessee Technology Park (ETTP; formerly the K-25 Area). The spur terminus is located northwest of SR 58, approximately 2.5 mi north-northwest of the center point of the CRN Site, as shown in Figure 2-5.

2.2.2.3 Offsite Borrow Pits

TVA indicated that existing borrow pits currently used for other TVA purposes likely would be used to support construction activities at the CRN Site. Neither the precise use, nor the specific source, of fill material can be identified at the ESP stage (TVA 2017-TN4921). Figure 2-9 identifies borrow pits currently used by TVA, which could provide construction fill material, if needed. Roadway distances from the CRN Site to the borrow pits range from about 6 mi to over 30 mi.

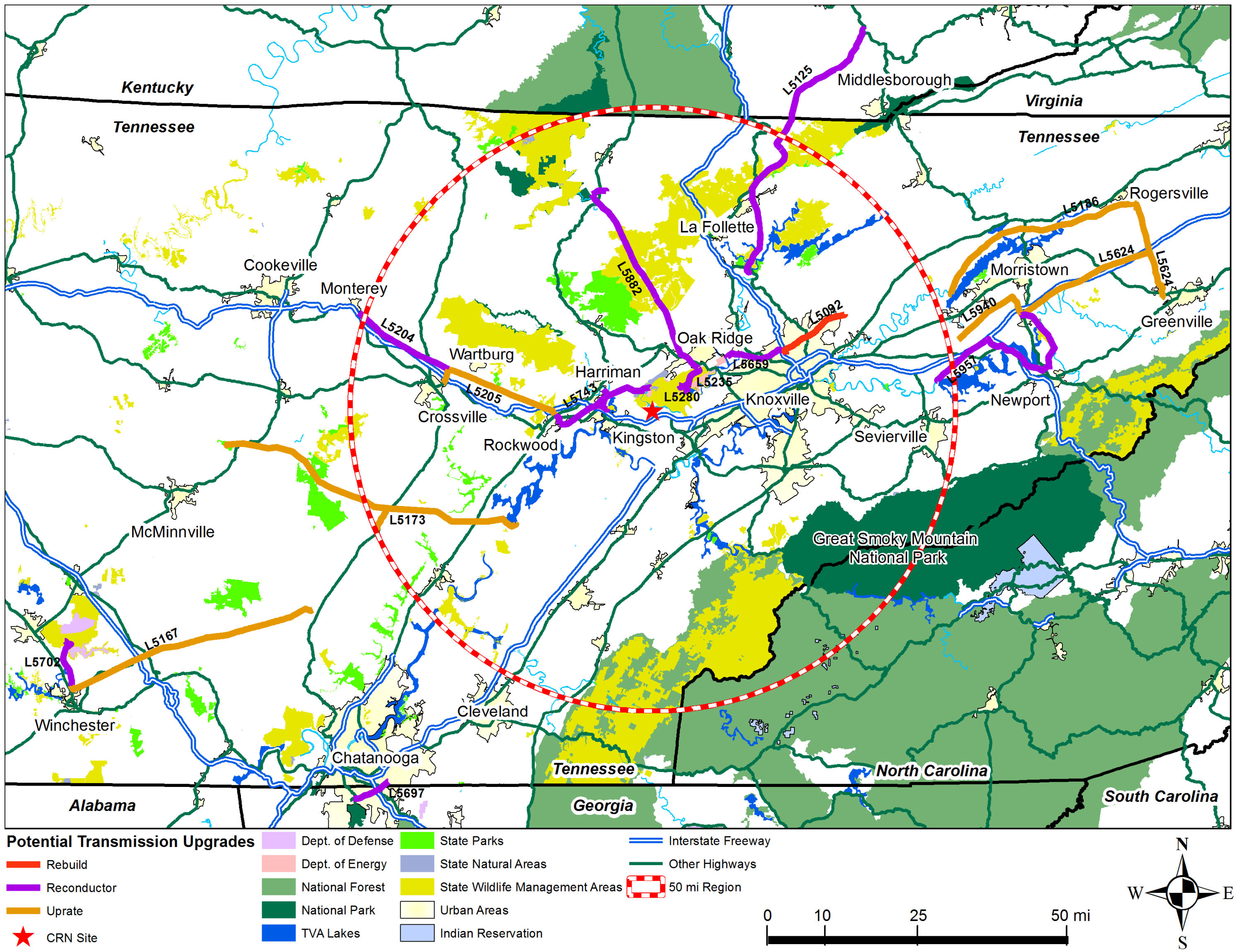


Figure 2-8. Affected TVA Transmission Corridors

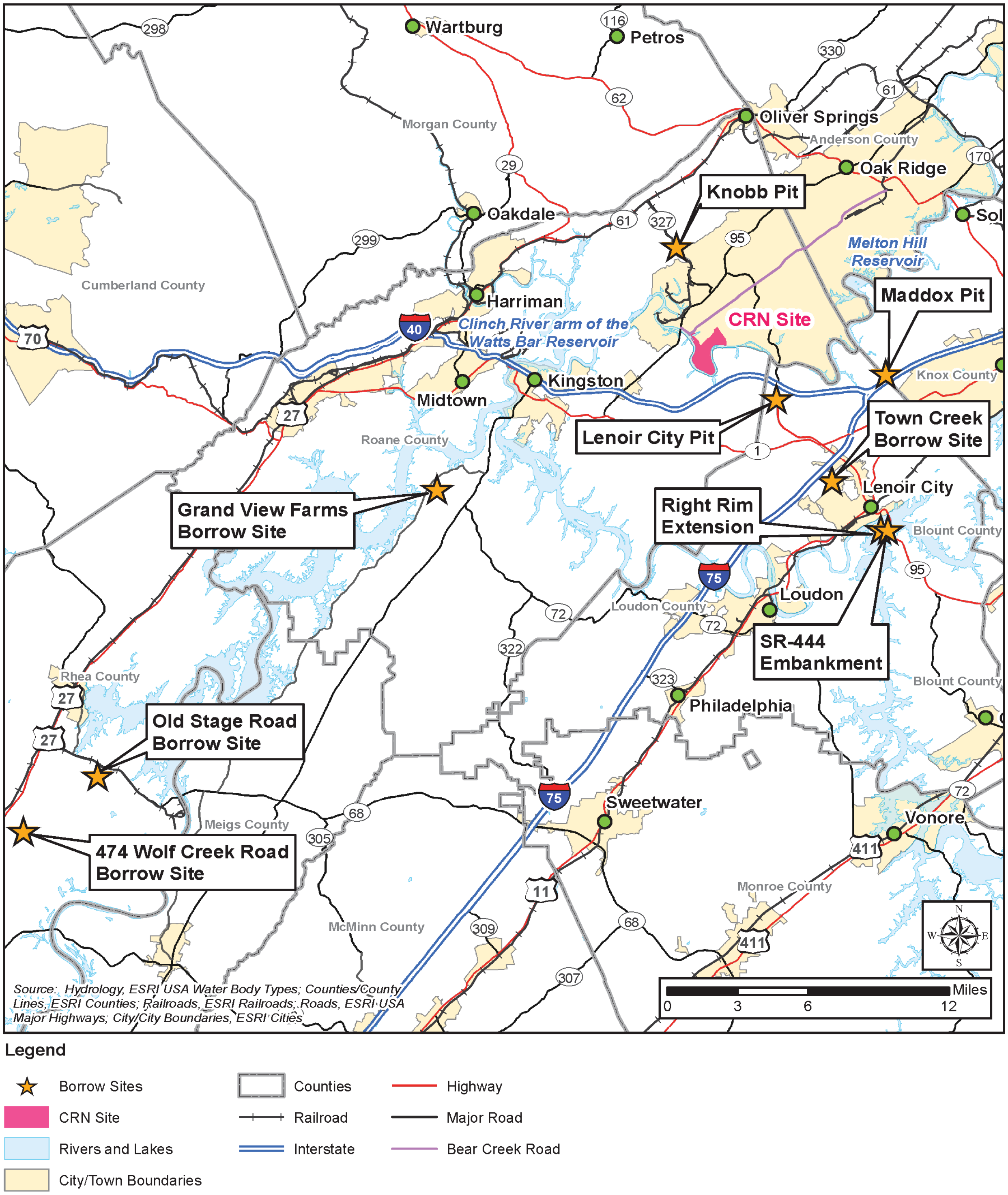


Figure 2-9. Borrow Pits Currently Used by TVA (Source: TVA 2017-TN4921)

2.2.3 The Region

For purposes of environmental review, the U.S. Nuclear Regulatory Commission (NRC) defines the region as the area within a 50-mi radius of the site (NRC 2000-TN614). The region includes all or parts of 33 counties in three states (i.e., three in North Carolina, two in Kentucky, and the rest in Tennessee). The region covers much of the Valley and Ridge Physiographic Province of eastern Tennessee. The Valley and Ridge Physiographic Province is characterized by variable drainage, abundant forests, low topographic elevations, and low-to-moderate relief caused by alternating ridges and valleys running parallel to the Appalachian Mountains.

Land use and land cover in this region are summarized in Table 2-1 and Figure 2-10. The general composition of various land-cover types is generally consistent between the 50-mi region, the 6-mi vicinity, and on the CRN Site (Table 2-1). Deciduous or mixed forests dominate the landscape and are broken up by rural properties, farmlands, waterways, industrial sites, and small cities and towns.

As shown in Figure 2-11, major highways traversing the region include Interstates 40, 75, 140, and 640. State highways include State Routes (SRs) 58, 95, 162, 327, 73, 321, 61, and 62. Bear Creek Road is an important local access route for the CRN Site. The Tennessee River and its tributary, the Clinch River, represent the major waterways within the region and provide navigation access to the Ohio and Mississippi Rivers and the Gulf Coast. Major freight rail lines or rail systems in the area are owned and operated by Norfolk Southern Railway Company (TVA 2017-TN4921).

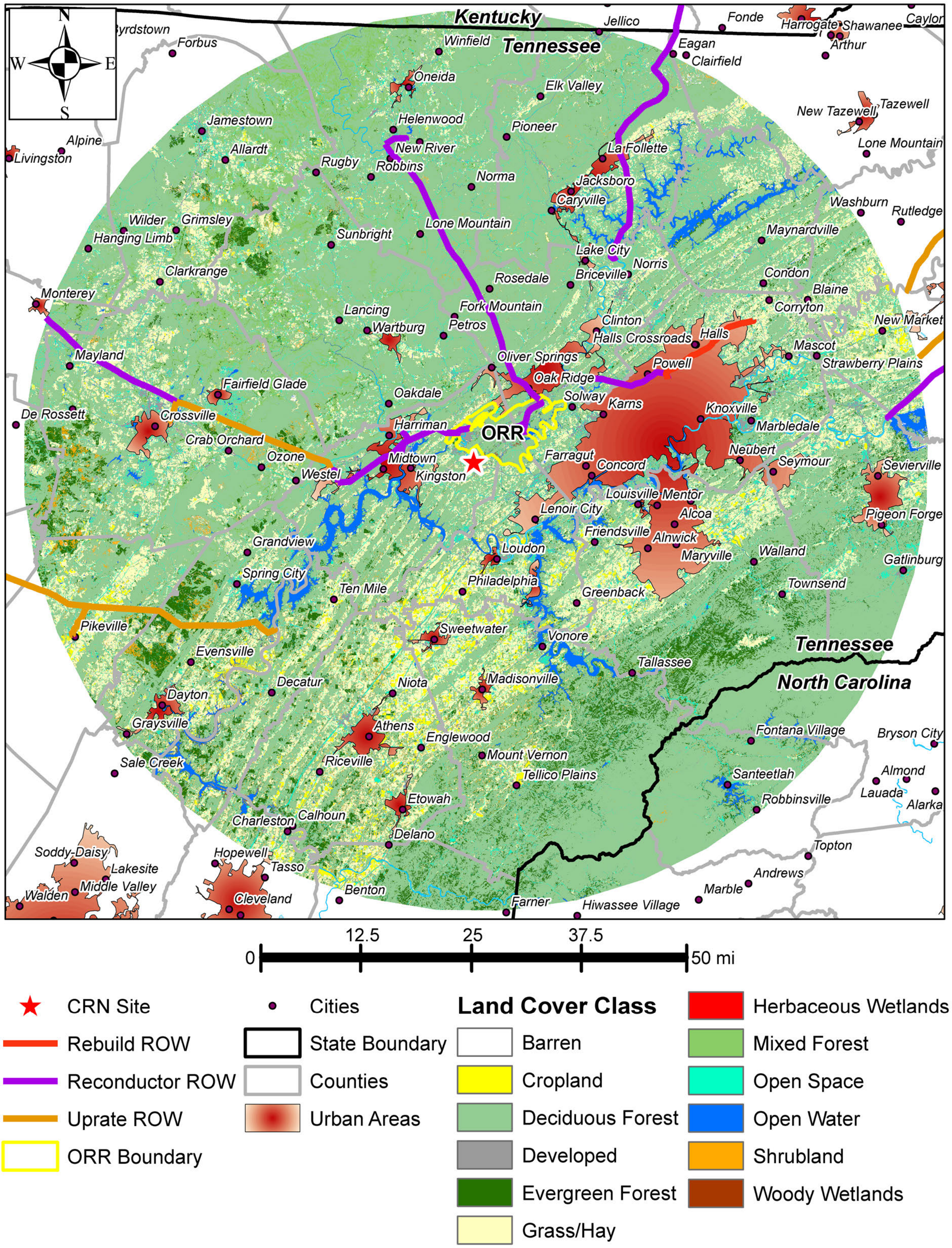


Figure 2-10. Land Use in the CRN Site Region (land-use data from NASS 2017-TN5144)

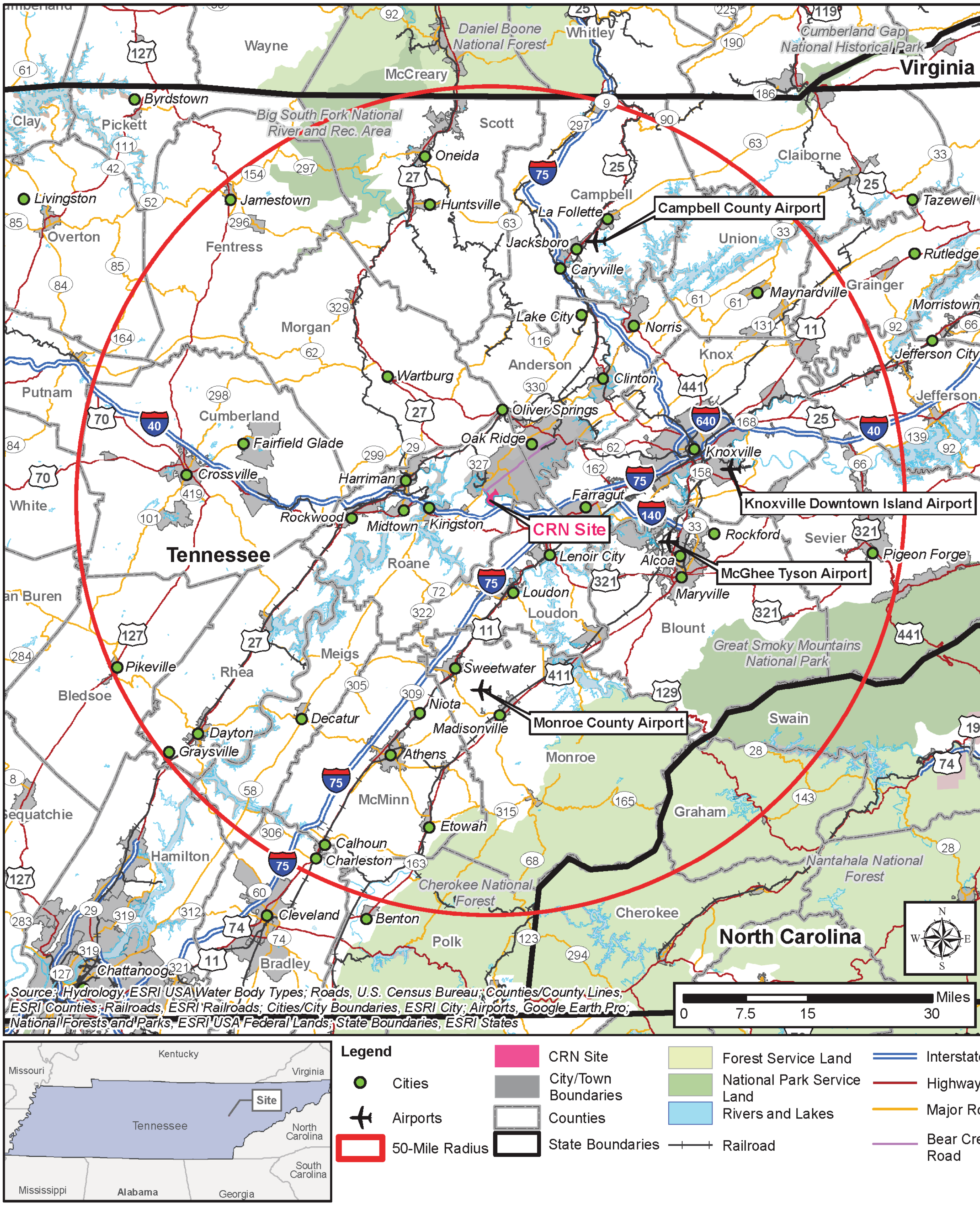


Figure 2-11. Major Transportation Features in the CRN Site Region (Source: TVA 2017-TN4921)

2.3 Water

This section describes the hydrological processes governing the movement and distribution of water in the existing environment at and around the CRN Site. Surface waterbodies (Section 2.3.1.1), groundwater resources (Section 2.3.1.2), existing water uses (Section 2.3.2), and water quality (Section 2.3.3) in the vicinity of the site are described. In addition, water monitoring used to characterize the site hydrology (Section 2.3.4) is described. Descriptions are limited to only those parts of the hydrosphere that may affect or be affected by building and operating two or more SMRs at the CRN Site. Section 2.9.1 provides information about the existing climate at the site, including air temperature and precipitation.

2.3.1 Hydrology

This section describes the site-specific and regional hydrological features of the existing environment that could be altered by building and operating two or more SMRs at the CRN Site. As described in Section 2.2 of this chapter, in 1982 and 1983 the CRN Site was partially developed in preparation for the CRBRP; the present site topography reflects the backfilling and grading done to remediate the site after the CRBRP was cancelled, as well as surface drainage infrastructure, retention ponds, and other ponds that were left in place. A description of the site's current hydrological features is presented in Section 2.4 of the Site Safety Analysis Report (SSAR) (TVA 2017-TN5387), and in Section 2.3.1 of the Environmental Report (ER) (TVA 2017-TN4921). The review team evaluated information in these reports and also gathered additional information during site visits and meetings with local water-resource agencies (NRC 2018-TN5386). The descriptions, presented here, are based on information from these and other sources of publicly available hydrologic information.

A new nuclear power plant at the CRN Site would withdraw most of the water needed for building and operations from the Clinch River arm of the Watts Bar Reservoir. Makeup water for operations would be obtained using a new intake structure. Blowdown from the circulating-water system cooling towers and other effluents would be discharged to the Clinch River using a new discharge structure. Water for potable and sanitary uses would be supplied by the City of Oak Ridge Public Works Department. No groundwater would be used for building or operations of the nuclear plant. Clearing and grading would potentially affect streams, ponds, and wetlands on the site. New transmission lines would also be built from the CRN Site and would cross existing waterbodies. Development of a new plant would result in some building activities in floodplains on the CRN Site, as discussed in EIS Section 4.2.1.1.3.

The environment described in this section includes the following:

- the Clinch River because it would be the source of water withdrawn for building and operating a new nuclear power plant and would be the receiving waterbody for effluent discharge
- the Tennessee River because releases from the Watts Bar and Fort Loudoun Dams affect the flow and the water level of the Clinch River arm of the Watts Bar Reservoir
- tributary streams near the CRN Site because they may potentially affect water quality at the site; and other streams, ponds, and wetlands on and near the CRN Site because they may be affected by site preparation activities, or may receive stormwater runoff during building and operations of the nuclear plant
- the groundwater system in the vicinity of the CRN Site because it may be affected by building activities, or inadvertent releases of contaminants during operations of the nuclear plant.

2.3.1.1 Surface-Water Hydrology

The Clinch River originates in western Virginia and flows generally to the southwest, joining the Tennessee River near Kingston, Tennessee. Along with its tributaries, the Clinch River drains an area of about 4,416 mi^2 in the Upper Tennessee River basin. The drainage pattern in the Clinch River watershed is characterized by both long straight river reaches and frequent sharp bends, which is a consequence of the long parallel ridges and valleys of the Valley and Ridge Physiographic Province through which the Clinch River and its tributary streams flow. The CRN Site is bordered on the east, south, and west by a significant bend in the lower Clinch River, between about CRM 14.5 and CRM 19, which is 14.5 to 19 river miles upstream from the confluence with the Tennessee River (Figure 2-12). The drainage area of the Clinch River watershed above the location of the CRN Site proposed intake is 3,370 mi^2, about 76 percent of the total watershed area.

Two dams, owned and operated by TVA, are located on the Clinch River upstream of the CRN Site: the Melton Hill Dam is located at about CRM 23 and Norris Dam is located just downstream from the confluence with the Powell River at about CRM 80 (Figure 2-13.). Releases from each of these dams influence Clinch River flows at the CRN Site. Norris Dam is operated for flood control and hydroelectric power generation of 110 megawatts electric (MW(e)). The reservoir provides 1,113,000 ac-ft of flood storage and has a water-surface elevation that varies 29 ft from summer to winter during a year with normal rainfall (TVA 2017-TN5239). Melton Hill Dam does not provide significant flood storage, but it does provide 79 MW(e) of hydroelectric power generation, and it includes a navigation lock that allows barge traffic 38 mi upstream to Clinton, Tennessee (TVA 2017-TN5240). Both reservoirs provide significant shoreline and in-water recreational opportunities.

Two dams located on the Tennessee River influence flows in the Clinch River at the CRN Site: Watts Bar Dam and Fort Loudoun Dam, both owned and operated by TVA (Figure 2-13.). Watts Bar Dam is located at Tennessee River mile 530, about 38 mi downstream from the Clinch River confluence and about 52 river miles downstream from the CRN Site. The reach of the Clinch River downstream from Melton Hill Dam, which includes the river adjacent to the CRN Site, is part of the Watts Bar Reservoir and is referred to as the Clinch River arm of the Watts Bar Reservoir. Fort Loudoun Dam is located at Tennessee River mile 602.3, about 35 mi upstream from the Clinch River confluence, and releases water into the Watts Bar Reservoir. Watts Bar and Fort Loudon Dams are operated for hydroelectric power generation, flood control, and navigation. Both reservoirs provide significant shoreline and in-water recreational opportunities. Some characteristics of the reservoirs that influence flows at the CRN Site are listed in Table 2-3.

Because the Clinch and Tennessee Rivers near the CRN Site are regulated by releases from reservoirs operated by TVA, relevant information about the flows adjacent to the CRN Site were obtained from TVA (TVA 2017-TN5387, TVA 2017-TN4921). As described in TVA's ROS (TVA 2004-TN4913), releases from reservoirs are determined by rainfall, runoff, and management objectives (e.g., flood control). Reservoirs are drawn down in the winter to provide flood storage, and minimum elevations are established to maintain a navigation channel. Reservoir elevations are maintained at higher levels during the summer and fall (generally May through October). Significant excursions from the operating guide elevations occur in response to variations in rainfall across the basin, as illustrated in Figure 2-14 for the Watts Bar Reservoir elevations.

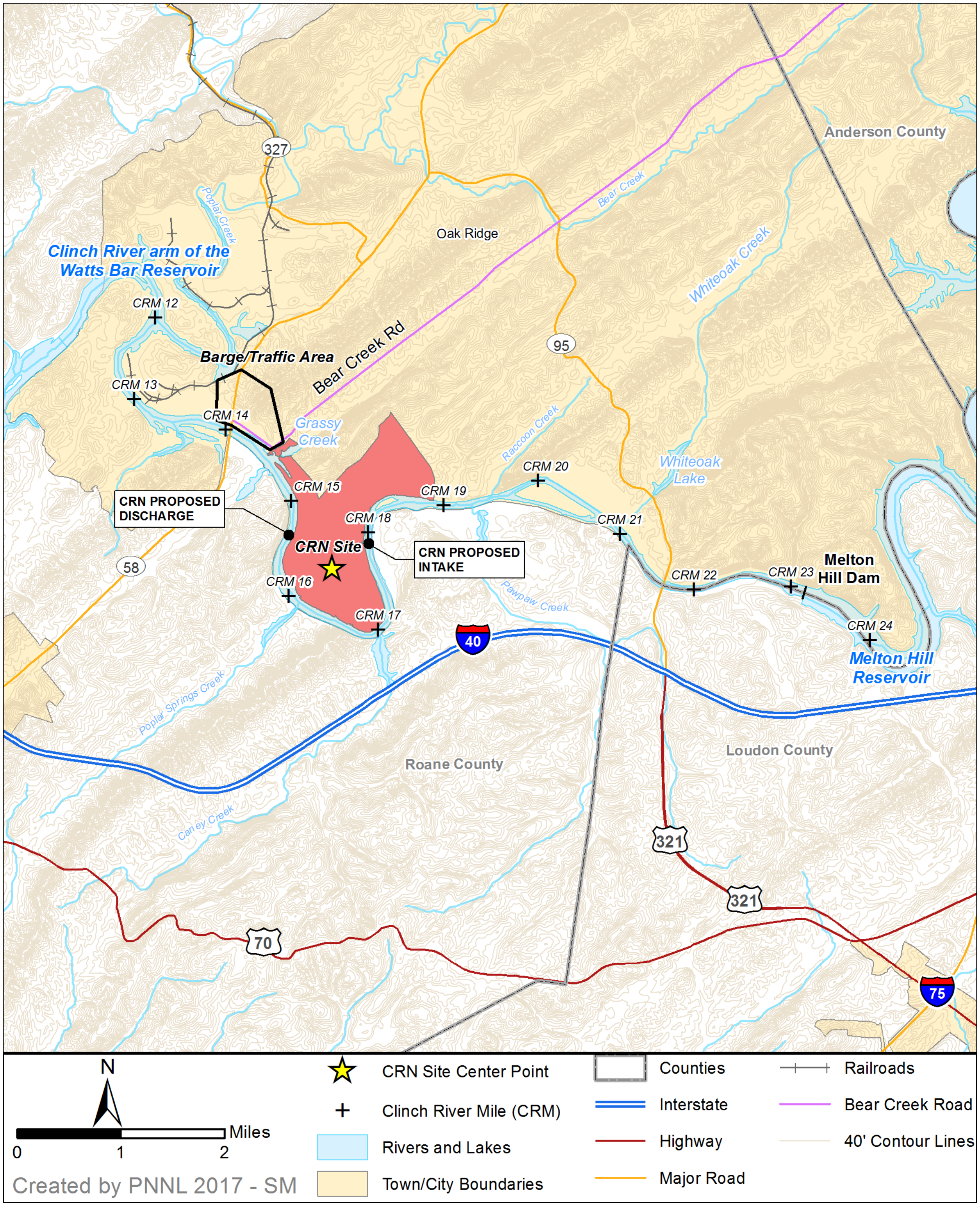


Figure 2-12. Streams and Rivers near the CRN Site

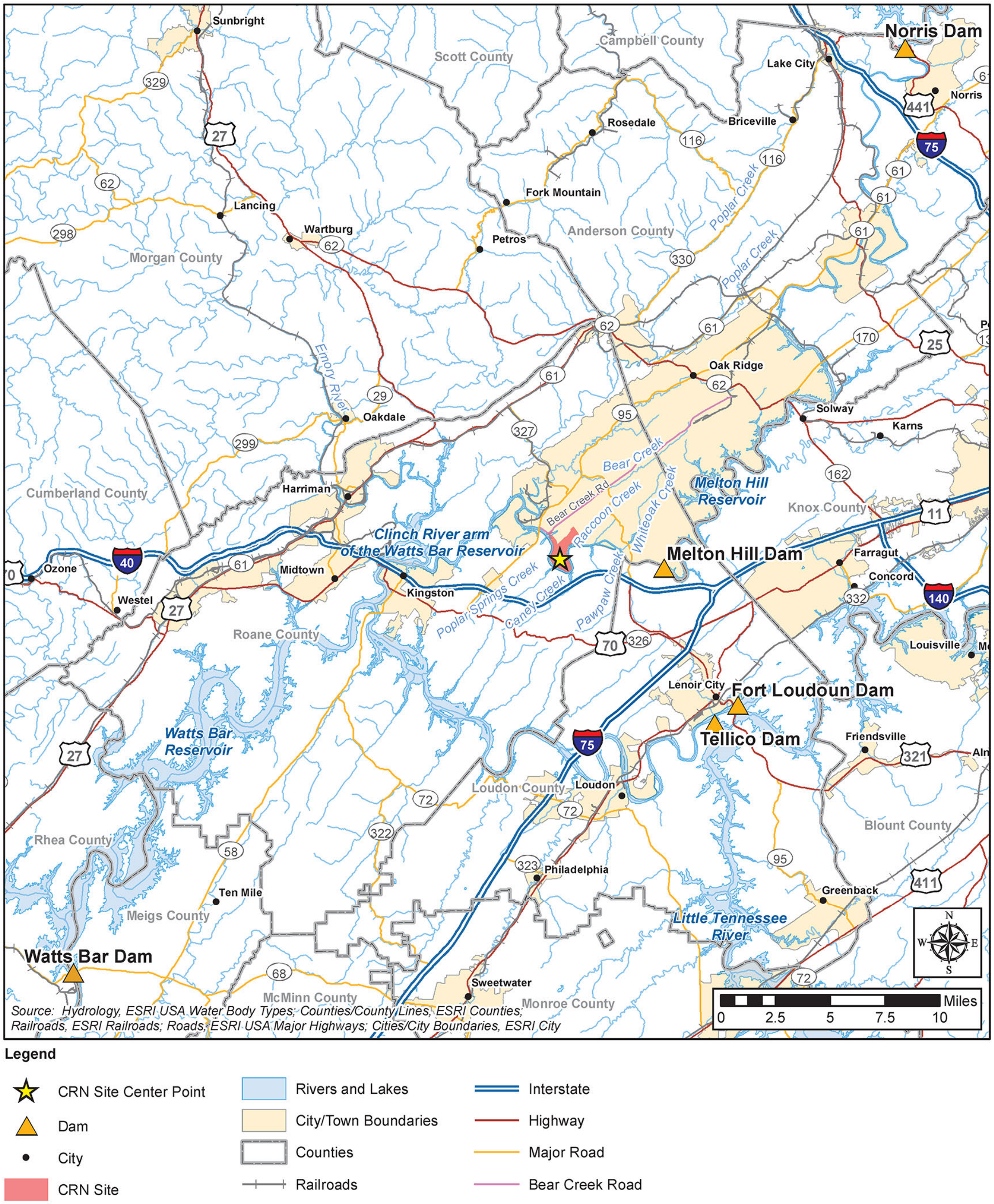


Figure 2-13. Locations of Dams that Influence Flows at the CRN Site (Source: TVA 2017-TN4921)

Table 2-3. Reservoirs that Influence Flows at the CRN Site

Reservoir	Waterbody	Purpose	Flood Storage (ac-ft)[a]	Area (ac)[a]	Operating Guide Elevation Range (ft MSL)[b]	Date Completed[a]
Norris	Clinch & Powell Rivers	Power Generation, Flood Control, Recreation	1,113,000	33,840	992-1,020	1936
Melton Hill	Clinch River	Power Generation, Navigation, Recreation, Water Supply	negligible	5,470	793-795	1963
Watts Bar	Tennessee, Clinch, & Emory Rivers	Power Generation, Flood Control, Navigation, Water Supply, Recreation	379,000	39,090	735-741	1942
Fort Loudoun[c]	Tennessee River	Power Generation, Flood Control, Navigation, Water Supply, Recreation	111,000	14,600	807-812.8	1943

(a) Source: TVA 2017-TN5241.
(b) Source: TVA 2017-TN5242.
(c) Fort Loudoun Reservoir is connected by a canal to Tellico Reservoir on the Little Tennessee River. A regulated spillway on Tellico Dam is used only during extreme flooding (TVA 2017-TN4921).

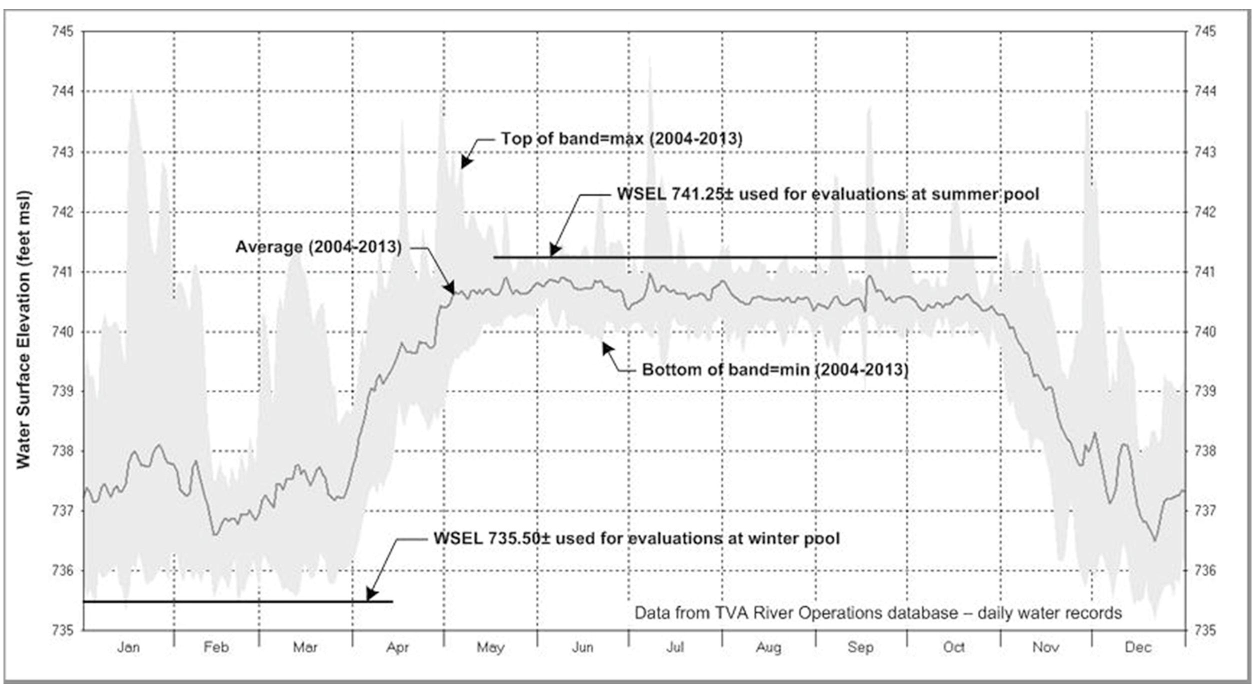


Figure 2-14. Watts Bar Reservoir Elevation at the Dam: Maximum, Minimum, and Average of Daily Midnight Readings for 2004–2013. Operating guide range is 735 to 737 ft in winter and 740 to 741 ft in summer (Source: TVA 2017-TN4921) .

Because the Clinch River adjacent to the CRN Site is part of the Watts Bar Reservoir, water-surface elevations at the CRN Site are closely correlated with the reservoir elevations measured at the Watts Bar Dam, shown in Figure 2-14, but are expected to be locally influenced by releases from the Melton Hill Reservoir. Water-surface elevations at CRM 16.1 observed in 2013 were never more than about 1.5 ft above the water-surface elevations at the Watts Bar Dam (TVA 2017-TN4921). Based on Figure 2-14, water-surface elevations at the CRN Site vary between about 735 and 746 ft MSL[(2)] under TVA's current river management policy, described in TVA's ROS (TVA 2004-TN4913).

Characterization of flows in the Clinch River arm of the Watts Bar Reservoir provided in the ER are largely based on the record during the period from 2004 to 2013. Annual average discharge from Melton Hill Dam during this period varied from 2,010 cfs in 2008 to about 6,760 cfs in 2011, with a mean annual discharge of 4,670 cfs (TVA 2017-TN5387). Discharge was well below average in 2006, 2007, and 2008 and above average in 2004, 2011, and 2013. The long-term, natural variability in streamflow in the Clinch River basin is illustrated by Figure 2-15, which shows the annual discharge from 1920 to 2016 for an unregulated portion of the Clinch River above Norris Reservoir (USGS gage 03528000, Clinch River above Tazewell). This discharge record illustrates that 2013 was a representative high-flow year in the upper Clinch River basin, and that 2008 was a near record-low-flow year. Other years with annual flows less than 50 percent of the long-term average in the upper Clinch River basin were 1941 and 1988. Significant variability in the annual flows can be seen in Figure 2-15, such as the low-flow years of 1999–2002, followed by the high-flow years of 2003-2004, and the 3-year low-flow period of 2006–2008. The longer discharge record from the unregulated portion of the upper Clinch River basin suggests that the regulated discharge from Melton Hill Reservoir during the period from 2004 to 2013 is representative of long-term variability in the lower Clinch River basin.

Monthly releases from Melton Hill Reservoir during the period from 2004 to 2013 show that average discharge peaked during December and January and was relatively low from April to November (Table 2-4). There is significant variability from year to year, but the maximum monthly discharge for individual years occurred between November and March. Minimum monthly discharge occurred mostly in April or June, with the exception of the two lowest annual flow years (2007 and 2008) when the minimum monthly discharge occurred in November (TVA 2017-TN5387).

As noted above, the Melton Hill Reservoir does not provide significant flood storage; as a result, its year-round elevation is held within a relatively narrow range (about 793 to 795 ft). Discharge from Melton Hill Dam, which is governed by TVA's ROS, is the main factor determining Clinch River flows at the CRN Site. There are two hydropower generating units in the Melton Hill Dam powerhouse. With one unit operating at minimum load, water releases to the Clinch River would be 4,000 to 5,000 cfs; with both units operating at maximum load, water releases would be 21,000 to 23,000 cfs (TVA 2017-TN4921). The ROS provides a guideline of 400 cfs for the minimum daily average release from the dam, which can be achieved by running one generating unit for 1 hour of the day. In practice, this means there is often no discharge from the Melton Hill Dam; Figure 2-16 shows that this occurred about half the time from 2004 to 2013. The duration of these events with no releases from the dam was most often 6 or 7 hours, but was commonly 15 to 22 hours, and occasionally more than 30 hours (TVA 2017-TN4921). When water was being released from Melton Hill Dam, discharge was typically between 5,000 and 15,000 cfs, but as much as about 25,000 cfs.

(2) Mean Sea Level, equivalent to the National Geodetic Vertical Datum of 1929 (NGVD29)

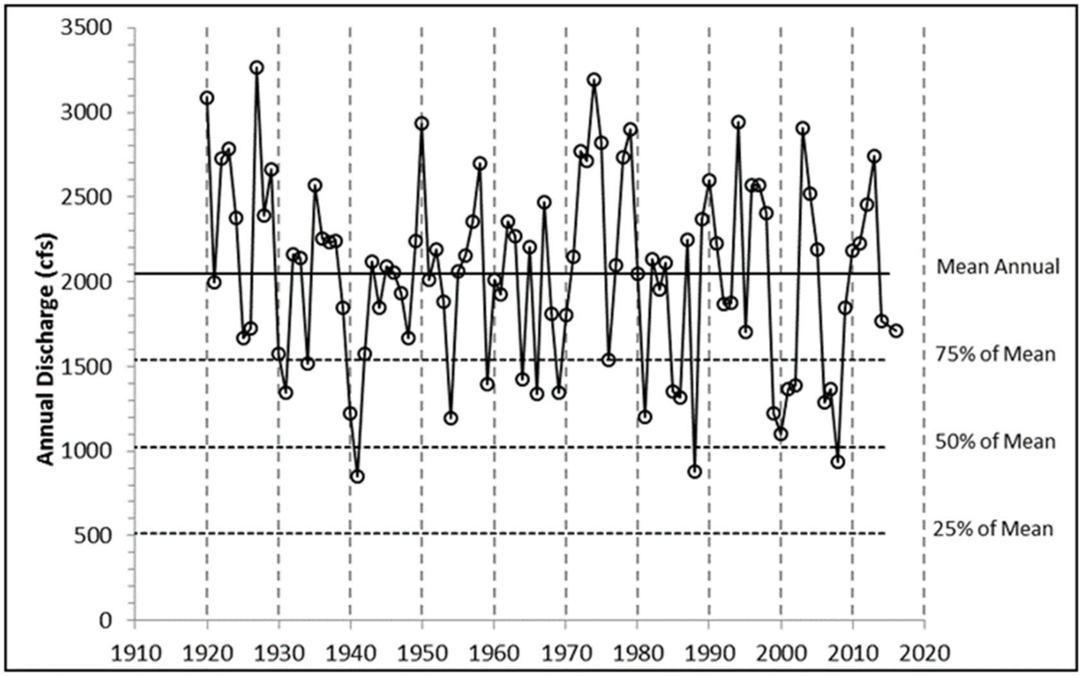
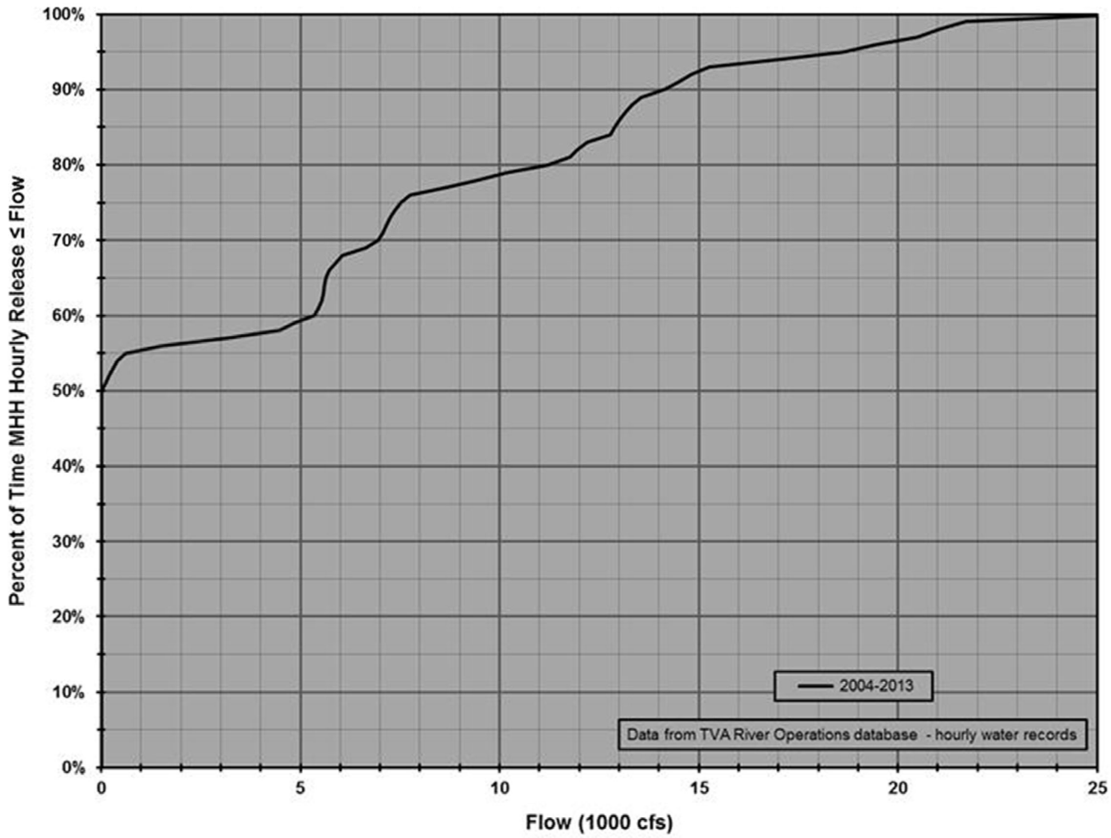


Figure 2-15. Annual Discharge of the Clinch River Upstream of Norris Reservoir, 1920–2016 (USGS 03528000, Clinch River above Tazewell, USGS 2017-TN5286)

Table 2-4. Monthly Mean Statistics for Melton Hill Dam Releases

	Monthly Mean Flow (cfs)		
Month	**Average**	**Minimum (year)**	**Maximum (year)**
October	3,740	719 (2008)	6,330 (2013)
November	436	589 (2008)	7,860 (2011)
December	7,190	865 (2007)	14,900 (2004)
January	7,120	1,090 (2008)	10,800 (2013)
February	6,530	1,510 (2008)	14,500 (2013)
March	5,150	1,640 (2007)	14,800 (2011)
April	2,610	1,050 (2010)	7,540 (2011)
May	3,700	1,260 (2008)	7,340 (2009)
June	3,450	1,530 (2012)	7,580 (2004)
July	3,550	2,240 (2005)	6,190 (2013)
August	5,150	3,120 (2013)	6,450 (2011)
September	3,530	1,540 (2008)	5,050 (2004)

Source: Site Safety Analysis Report Table 2.4.1-4 (TVA 2017-TN5387).



MHH = Melton Hill Hydro Power Plant

Figure 2-16. Frequency of Hourly Discharge from the Melton Hill Dam for 2004–2013 (Source: TVA 2017-TN4921)

Because the river at the site is part of the Clinch River arm of the Watts Bar Reservoir, Clinch River flow velocity at the CRN Site may be low when no water is being released from Melton Hill Dam. In addition, the Clinch River flow direction at the CRN Site may reverse when Melton Hill and Watts Bar Dams abruptly shut down while releasing water from Fort Loudoun Dam (TVA 2017-TN4921).

In the vicinity of the CRN Site, the Clinch River arm of the Watts Bar Reservoir is generally between 400 and 700 ft wide. A bathymetric survey conducted by TVA showed that river bottom elevations at the CRN Site ranged from 709 ft to 743 ft MSL, as shown in Figure 2-17 and Figure 2-18. The survey also identified an elongated mid-channel bar of shallower depths at CRM 15.9 that TVA called a “submerged island” (see Figure 2-18). This feature is also visible in some aerial imagery. The location of the discharge structure was selected to avoid the relatively shallow water around this submerged island.

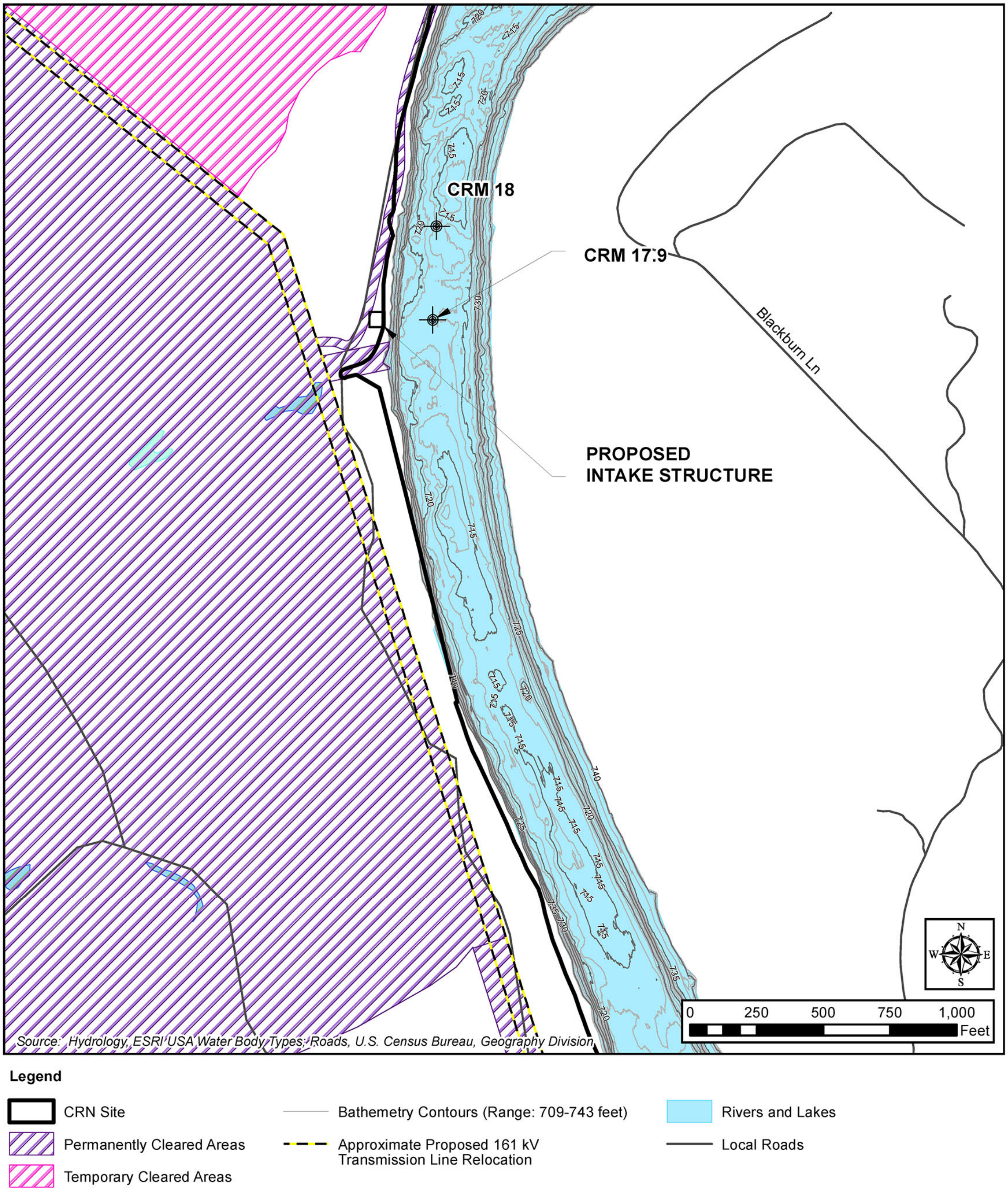


Figure 2-17. Bathymetry of the Clinch River at the CRN Site Intake Location (contours are elevation in feet) (Source: TVA 2017-TN4921)

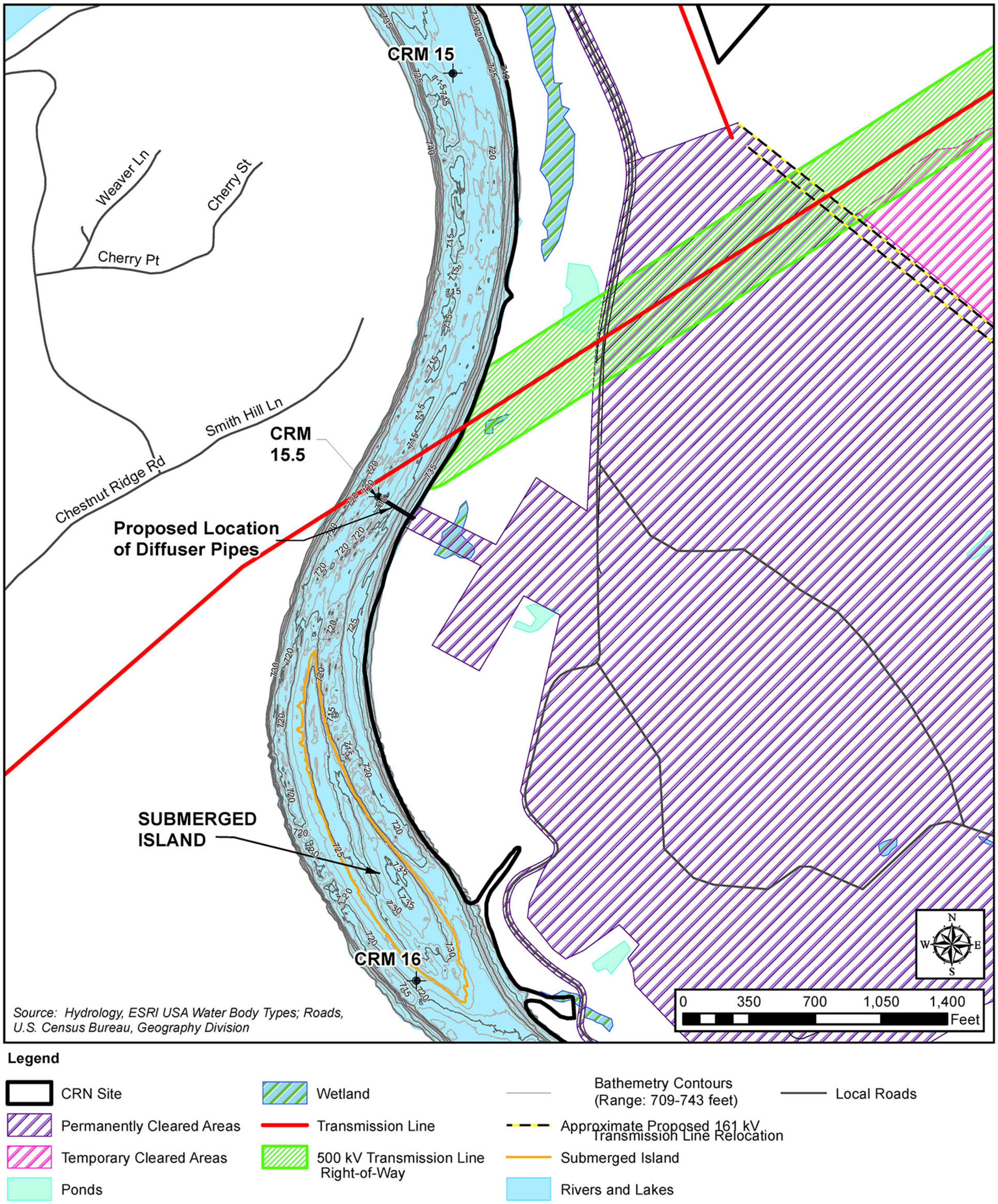


Figure 2-18. Bathymetry of the Clinch River at the CRN Site Discharge Location (contours are elevation in feet) (Source: TVA 2017-TN4921)

Several named tributary streams enter the Clinch River near the CRN Site (Figure 2-12). These include Poplar Creek at CRM 12.0 just downstream of the BTA, Grassy Creek at CRM 14.5 near the main entrance to the CRN Site, Raccoon Creek at CRM 19.5, and White Oak Creek at CRM 21.0. Several more creeks flow in from the south opposite the CRN Site: Poplar Springs Creek at CRM 16.2, Caney Creek at CRM 17.0, and PawPaw Creek at CRM 19.3. The lower parts of these streams are under the influence of the Watts Bar Reservoir, including Grassy Creek, which flows across the northernmost section of the CRN Site. White Oak Creek flows through Melton Valley on the ORR, entering Clinch River about 3 mi upstream from the CRN Site intake location. Melton Valley has been the site of various waste-disposal activities since the early 1950s, including burial of transuranic and low-level wastes, and impoundment and seepage of liquid low-level waste (DOE 2013-TN5075). These activities have resulted in contamination of sediments, groundwater, and White Oak Creek (DOE 2013-TN5075). Two control structures are located on White Oak Creek: White Oak Dam, which forms White Oak Lake, and a sediment retention dam located at the confluence with the Clinch River, which forms the White Oak Creek Embayment.

2.3.1.1.1 Local Drainage (Site and Barge/Traffic Area)

A number of small, unnamed, perennial, intermittent, and ephemeral streams are located on the CRN Site (Figure 2-19). Perennial streams are characterized by year-round flow in a well-defined channel; intermittent streams generally have a defined channel but may be dry part of the year when precipitation and/or groundwater levels drop sufficiently. TVA describes "ephemeral streams/wet-weather conveyances" as depressions that would hold or carry water temporarily in response to heavy precipitation, some of which are natural and some of which were created during development and stabilization of the CRBRP site. Perennial and intermittent streams are designated by an S and ephemeral streams/wet-weather conveyances are designated by a C in Figure 2-19. In addition, several small ponds and a number of wetland areas are located on the CRN Site (designated P and W, respectively, in Figure 2-19). Most of the ponds were constructed as stormwater-retention ponds after the CRBRP was terminated. The surface-water features on the CRN Site are connected to the shallow groundwater and are responsive to rainfall events. Most of these features are located around the edges of the site; drainage is generally toward the Clinch River arm of Watts Bar Reservoir (TVA 2017-TN4921).

TVA identified several perennial and intermittent streams in the BTA (Figure 2-19). There are two ponds, one small (P07) and one large (P08), located on the southeast edge of the BTA (Figure 2-19). Several large wetlands are also located in three low areas near the shore of the Clinch River arm of the Watts Bar Reservoir: in the BTA, south of Grassy Creek parallel to the CRN Site access road, and near the northeast edge of the CRN Site (associated with the cluster of streams). Streams, ponds, and wetlands on the CRN Site and in the BTA are described in detail in Section 2.4 of this chapter.

2.3.1.2 Groundwater Hydrology

The geology of the CRN Site and surrounding area is summarized in Section 2.8 of this chapter and is described in detail in SSAR Section 2.5 (TVA 2017-TN5387). The CRN Site is located in the Valley and Ridge Physiographic Province, which has an extent of about 50 to 100 mi (east to west) in eastern Tennessee and is characterized by a northeast-trending sequence of ridges and valleys resulting from folding and thrust-faulting of the underlying sedimentary rocks (Lloyd and Lyke 1995-TN4988). The CRN Site is located about 6 mi southeast of the western edge of the Valley and Ridge Physiographic Province.

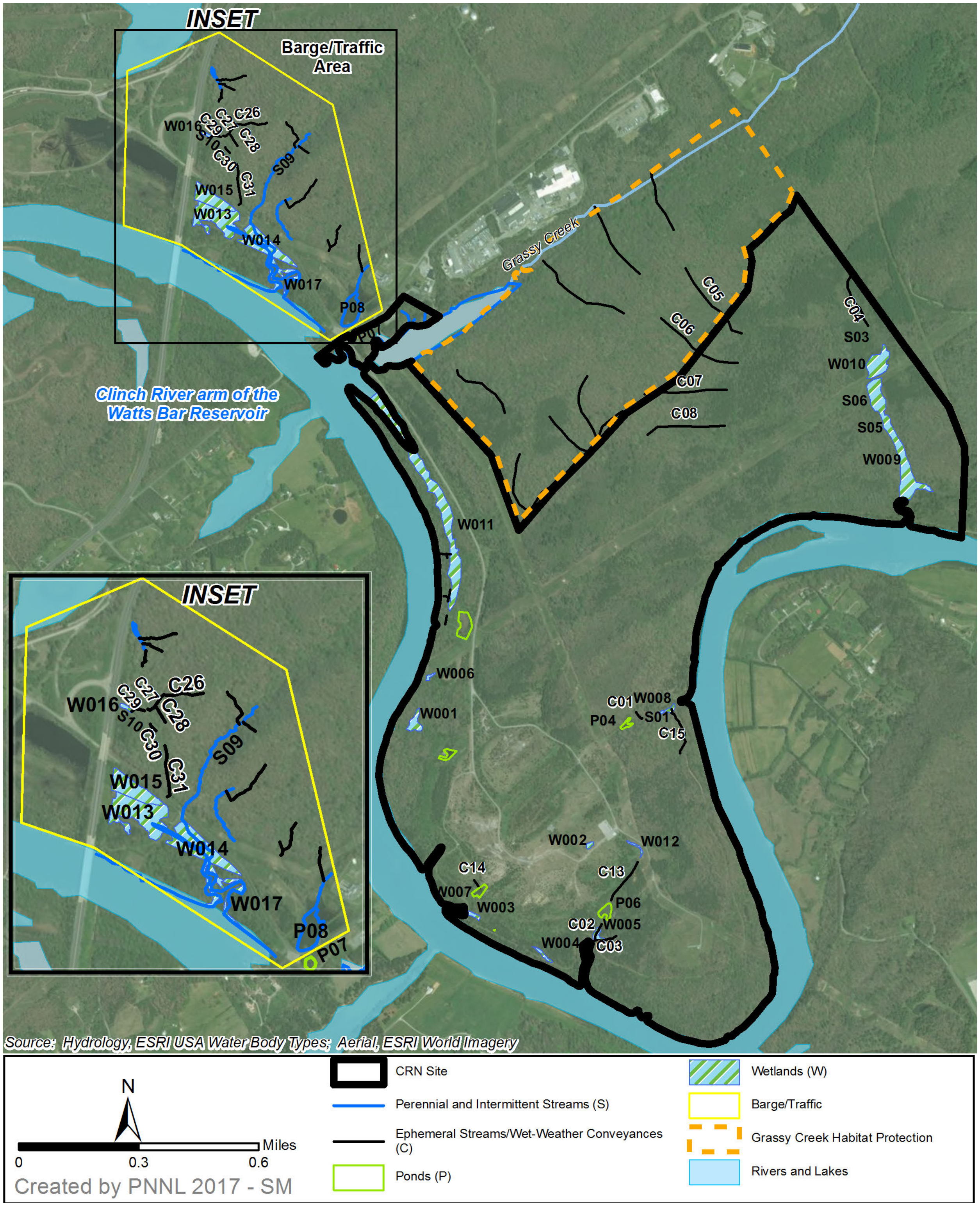


Figure 2-19. Streams, Ponds, and Wetlands on and near the CRN Site

2.3.1.2.1 Regional Groundwater Description

Regional groundwater hydrology is described in ER Section 2.3.1.2 (TVA 2017-TN4921) and SSAR Section 2.4.12 (TVA 2017-TN5387). The hydrogeologic description provided in these documents is consistent with the regional description provided in Segment 10 of the Ground Water Atlas of the United States (Lloyd and Lyke 1995-TN4988), as summarized here. The principal aquifers in the Valley and Ridge Physiographic Province consist of carbonate rocks, and typically occur in the valleys while the ridges serve as areas of recharge. The carbonate-rock aquifers are often directly connected to surface-water features that serve either as groundwater discharge points or as sources of recharge to the aquifers. Most groundwater occurs in and moves through secondary rock porosity features such as fractures and bedding planes, some of which may be enlarged by dissolution (karst development) (Figure 2-20). Little primary porosity occurs in the body of the rocks. Alluvium occurring along stream courses, and residuum (soil and subsoil formed from weathered rock) that overlies much of the rock, may hold groundwater within the primary pore spaces.

Figure 2-20. Road Cut in Valley and Ridge Physiographic Province Illustrating Secondary Porosity Features: Fractures, Bedding Planes, and Dissolution

Groundwater in the Valley and Ridge Physiographic Province is localized by the occurrence of thrust faults, which resulted in a repeated sequence of permeable and less permeable rocks, and by the stream networks (Lloyd and Lyke 1995-TN4988). Groundwater in the Valley and Ridge Physiographic Province generally moves from the ridges toward the valleys where it either discharges to streams running parallel to the valleys, or flows along the geologic strike (down the valleys) toward more distant discharge points (springs or streams). Lloyd and Lyke (TN4988) describe groundwater in the Valley and Ridge Physiographic Province as, “a series of adjacent, isolated, shallow ground-water flow systems,” with most of the flow occurring within 300 ft of the ground surface.

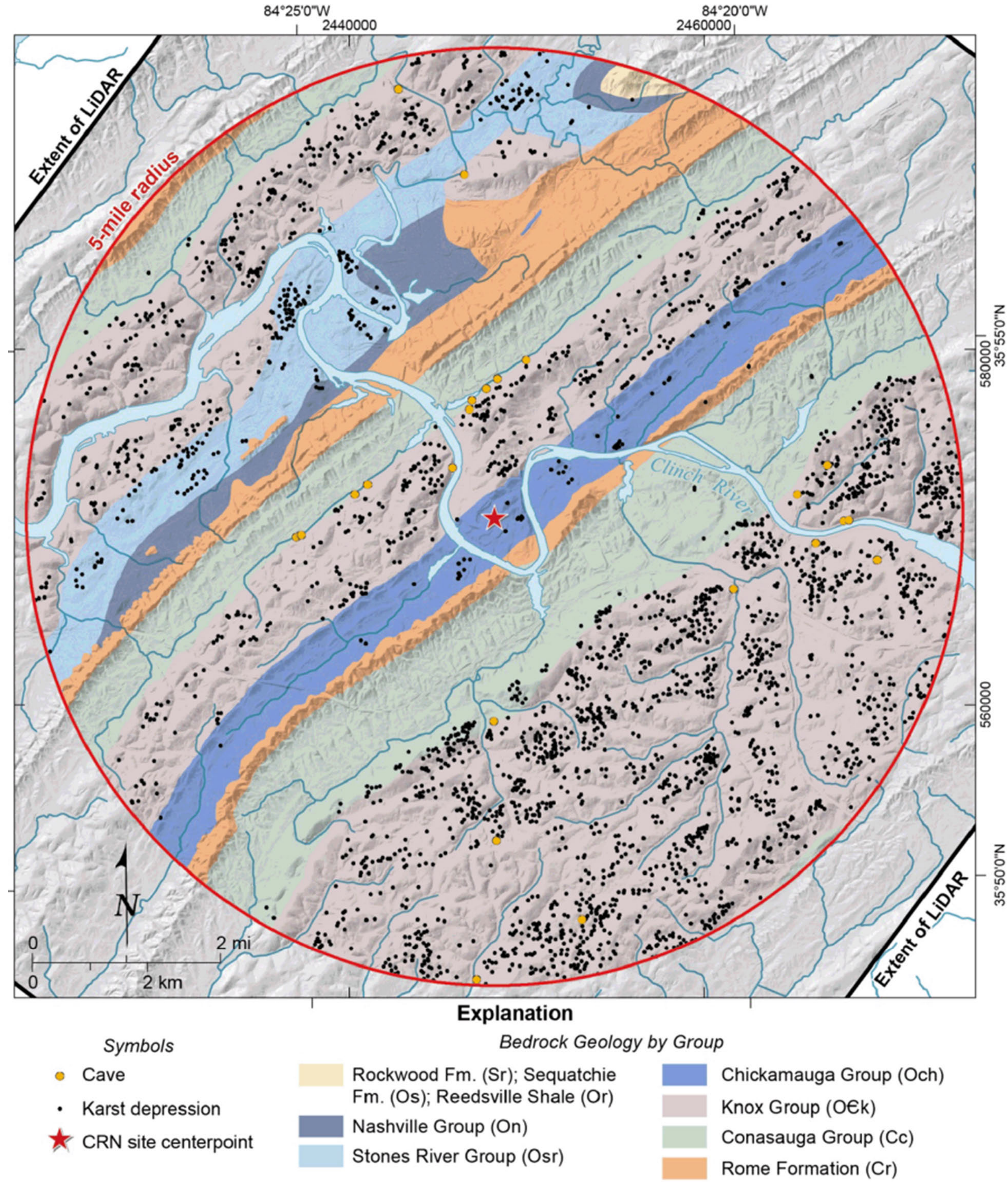
In the CRN Site region, the sequence of Chickamauga Group, Knox Group, Conasauga Group, and Rome Formation geologic units are repeated across the landscape, as described in EIS Section 2.8. On the ORR, two general hydrogeologic settings have been identified (DOE 2013-TN5075). The Rome Formation and the Conasauga Group (excluding the uppermost unit, the Maynardsville Limestone [see Figure 2-21]) are dominated by clastic rocks (primarily shale and siltstone). Well yields in the clastic-dominated setting tend to be low and dissolution of fractures and bedding planes is limited. The Knox Group and the Maynardsville limestone are dominated by carbonate rocks, have higher well yields, and a greater propensity for dissolution and conduit development. The Chickamauga Group includes formations of both types, as described in Section 2.8 of this chapter.

Well yields in the principal aquifers of the Valley and Ridge Physiographic Province range from 1 to 2,500 gpm, with median yields ranging from 11 to 350 gpm (Lloyd and Lyke 1995-TN4988). Discharges from springs emanating from the principal aquifers in the province range from 1 to 5,000 gpm, with median discharges of 20 to 175 gpm. Spring discharge during periods of abundant rainfall is significantly larger (as much as 10 times larger) than the discharge during extended dry periods (Lloyd and Lyke 1995-TN4988), reflecting the relatively shallow groundwater flow. Well yields and spring discharge are highest in the carbonate-dominated areas due to dissolution along groundwater-flow pathways. Mapping of karst features (caves and surface depressions resulting from collapse of dissolution cavities) in the CRN Site region shows that there is minimal karst development in the clastic-dominated hydrogeologic setting, significant karst development in the carbonate-dominated setting, and scattered karst development where the Chickamauga Group outcrops (Figure 2-21).

Dissolved solids concentrations in aquifers in the Valley and Ridge Physiographic Province ranged from 15 to 1,700 mg/L, with a median concentration of 150 mg/L (Lloyd and Lyke 1995-TN4988). Spring discharge dissolved solids concentrations varied from 25 to 300 mg/L, with a median value of 150 mg/L. The concentration of dissolved solids in groundwater is an indicator of the length of time groundwater has been in contact with rocks from which it is dissolving material. Low dissolved solids concentrations suggest rapid groundwater-flow paths, while high concentrations suggest longer groundwater-flow paths. High-density, briny water exists at elevations near sea level across the region of the ORR, limiting the depth of circulation of groundwater (DOE 2013-TN5075). The depth of groundwater circulation is greater in the carbonate-dominated hydrogeologic setting than in the clastic-dominated setting. The presence of groundwater with total dissolved solids concentrations greater than 100,000 mg/L was used to infer low groundwater-flow rates below a depth of about 600 ft below ground surface (bgs) in the Melton and Bethel Valleys on the ORR and below a depth of about 1,000 ft bgs in Bear Creek Valley (Solomon et al. 1992-TN5148).

Average precipitation in the CRN Site region is 51 to 54 in./yr (TVA 2017-TN5387; DOE 2013-TN5075), and about 50 percent of this is estimated to return to the atmosphere as evapotranspiration (DOE 2013-TN5075). Average annual recharge estimates to groundwater beneath the weathered rock for the ORR range from about 1 to 7.5 in./yr (Solomon et al. 1992-TN5148; TVA 2017-TN5387). Recharge occurs sporadically in response to precipitation events and is expected to be greatest in areas that have a prevalence of carbonate-dominated rocks and karst development near the surface.

No sole-source aquifers have been designated by the U.S. Environmental Protection Agency (EPA) in Tennessee. Because all sole-source aquifers are at least 200 mi from the CRN Site, they would not be affected by building and operating a plant at the site.



Fm. = formation

Figure 2-21. Mapped Karst Features in the CRN Site Area (Source: TVA 2017-TN5387)

2.3.1.2.2 Onsite Groundwater Description

To characterize the CRN Site hydrogeology, existing data from the ORR and from the CRBRP were combined with results from 82 geotechnical boreholes and 44 wells completed for the CRN Site ESP application (TVA 2017-TN5387). CRN Site stratigraphy is described in EIS Section 2.8. Figure 2-36 shows a stratigraphic section of the CRN Site based on the geotechnical borings. Borings were concentrated in two areas within the power block envelope of the CRN Site (Locations A and B shown in Figure 2-36 in Section 2.8). Both areas were located to the east of the CRBRP footprint. The maximum depth of the CRN Site investigation boreholes was 540 ft bgs (260 ft NAVD88[(3)] elevation) at borehole MP-101 (shown in Figure 2-36 and located in the southern portion of the CRN Site). The majority of the CRN Site is underlain by rocks of the Chickamauga Group; the Knox Group outcropping is on the northern portion of the site (on the left side of Figure 2-36). The lithology and thickness of the geologic units at the CRN Site are summarized in Section 2.8 of this chapter. These bedded sedimentary rock units dip consistently 32 to 35°SE in the uppermost 400 ft at the CRN Site (TVA 2017-TN4921).

The unconsolidated surface materials at the CRN Site consist of artificial fill from previous excavation and construction activities related to the CRBRP, residuum, colluvium in isolated areas, and alluvium near the Clinch River. The thickness of the artificial fill varied from 0 to 51 ft in the CRN Site boreholes and had an average thickness of 9.1 ft (TVA 2017-TN5387). The thickness of the residuum varied from 0 to 51 ft and had an average thickness of 10.1 ft. Weathered rock of variable thickness overlies the competent rock formations. The thickness of the weathered rock was 0 to 39 ft in the CRN Site boreholes and had an average thickness of 7.3 ft. Plant foundations would be constructed on competent rock of the formations of the lower Chickamauga Group and the upper Knox Group, depending on the final location of the plant (see Figure 2-36). Depth to competent rock varied from 1.8 to 80.7 ft in the CRN Site boreholes (elevation from 720 to 829 ft NAVD88) and the average depth was 26.2 ft (elevation of 779 ft NAVD88) (TVA 2017-TN5387).

Groundwater at the CRN Site was observed in the unconsolidated surface materials; the weathered rock was reported to act as a water table aquifer and depth to groundwater ranged from near surface to 25 ft across the site (TVA 2017-TN5387). The occurrence and movement of groundwater at the CRN Site are dominated by the presence and orientation of rock fractures and the extent of conduits and cavities resulting from dissolution. Chickamauga Group formations are generally thinly bedded (0.5- to 4-in.) limestone/shale interbeds (DOE 2013-TN5075), which tends to reduce the occurrence of connected fractures and dissolution channels. Weathering and dissolution in the Chickamauga Group are more likely to occur in the more limestone-rich units, such as the Witten and Rockdell formations (DOE 2013-TN5075). Evidence from CRN Site borehole logs indicated a zone of pervasive fracturing to a depth of about 100 ft bgs, moderate fracturing to a depth of about 200 ft bgs, and slight fracturing below that (TVA 2017-TN5387). Fractures are generally oriented both parallel and perpendicular to the strike and dip of the rock beds (TVA 2017-TN5387). The frequency and size of cavities at least 0.1 ft in size (open and clay-filled) in CRBRP and CRN Site boreholes decreased with depth; cavities were largest and most numerous in the Rockdell and Eidson formations and appeared to be aligned with bedding planes (TVA 2017-TN5387). The majority of the cavities were observed above the elevation of the bed of the Clinch River (approximately 720 ft

(3) North American Vertical Datum of 1988. Elevation NAVD88 = Elevation NGVD29 – 0.4 ft at the CRN Site (TVA 2017-TN4921)

NAVD88), although a few cavities were observed at lower elevations, as low as 660 ft NAVD88, suggesting that groundwater circulation occurs at deeper depths (TVA 2017-TN5387).

Groundwater monitoring wells on the CRN Site were installed as well clusters, with two or three wells located in close proximity and screened at up to three depths at each cluster location (see Figure 2-22 for locations). Eighteen upper-level wells were screened at depths between 15 and 105 ft bgs, 18 lower-level wells were screened at depths between 89 and 178 ft bgs, and 7 deep wells were screened at depths between 176 and 297 ft bgs (TVA 2017-TN4921). Observation wells were screened in the Bowen, Benbolt, Rockdell, Fleanor, Eidson, and Blackford Chickamauga Group formations and in the upper portion of the Knox Group. Manual measurements of hydraulic head were made during the period from September 2013 to August 2015. Continuous hydraulic head measurements were also made during most of this period in a subset of the monitoring wells. TVA obtained concurrent measurements of precipitation at the CRN Site and water-surface elevations in Watts Bar Reservoir.

The review team evaluated well hydrographs provided in the ER (TVA 2017-TN4921) and determined that the observed fluctuations in the level of the Clinch River arm of the Watts Bar Reservoir did not significantly affect the observed groundwater hydraulic head measurements. No strong seasonal variation in groundwater levels was observed in the data, although some groundwater heads in some wells appeared to be highest in the winter and early spring months. In contrast, groundwater heads in the wells that were continuously measured were observed to fluctuate by as much as 25 ft in response to precipitation events (TVA 2017-TN4921). Figure 2-23 shows groundwater heads measured at well cluster OW-423 (upper, lower, and deep wells). The effect of precipitation on water levels in wells was highly variable with well location, and depended on the hydraulic connection created by secondary porosity features, such as fractures and cavities, between the area of infiltration and the well screen. In the case of well cluster OW-423, the response of groundwater head to precipitation appeared to be greater for the deeper wells than for the upper well.

TVA used the groundwater hydraulic head measurements to infer the vertical and horizontal groundwater-flow directions at the CRN Site. TVA reported an average horizontal hydraulic gradient of 0.07 ft/ft at the CRN Site, with a range from 0.03 to 0.17 ft/ft depending on location, date, and the wells used in the interpretation of hydraulic heads (TVA 2017-TN4921). TVA reported vertical hydraulic gradients ranging from 0.69 ft/ft in the upward direction to 1.03 ft/ft in the downward direction based on hydraulic heads measured in the well clusters (TVA 2017-TN4921). Vertical gradients tended to be in the downward direction in the center (upland areas) of the CRN Site and in the upward direction closer to the Clinch River. TVA stated that this suggests groundwater recharge is occurring in the center of the site and groundwater is discharging to the Clinch River and to other incised drainage features (such as ephemeral streams) (TVA 2017-TN4921). TVA acknowledged that not all head observations conformed to this conceptualization of groundwater flow. For example, well cluster OW-423, shown in Figure 2-23, indicated upward flow at this location although it is in an upland area of the site (see Figure 2-22). TVA attributed the anomalous apparent direction of vertical gradient to the deep well being screened at a much greater depth and in a different geologic unit than the other two wells (TVA 2017-TN4987).

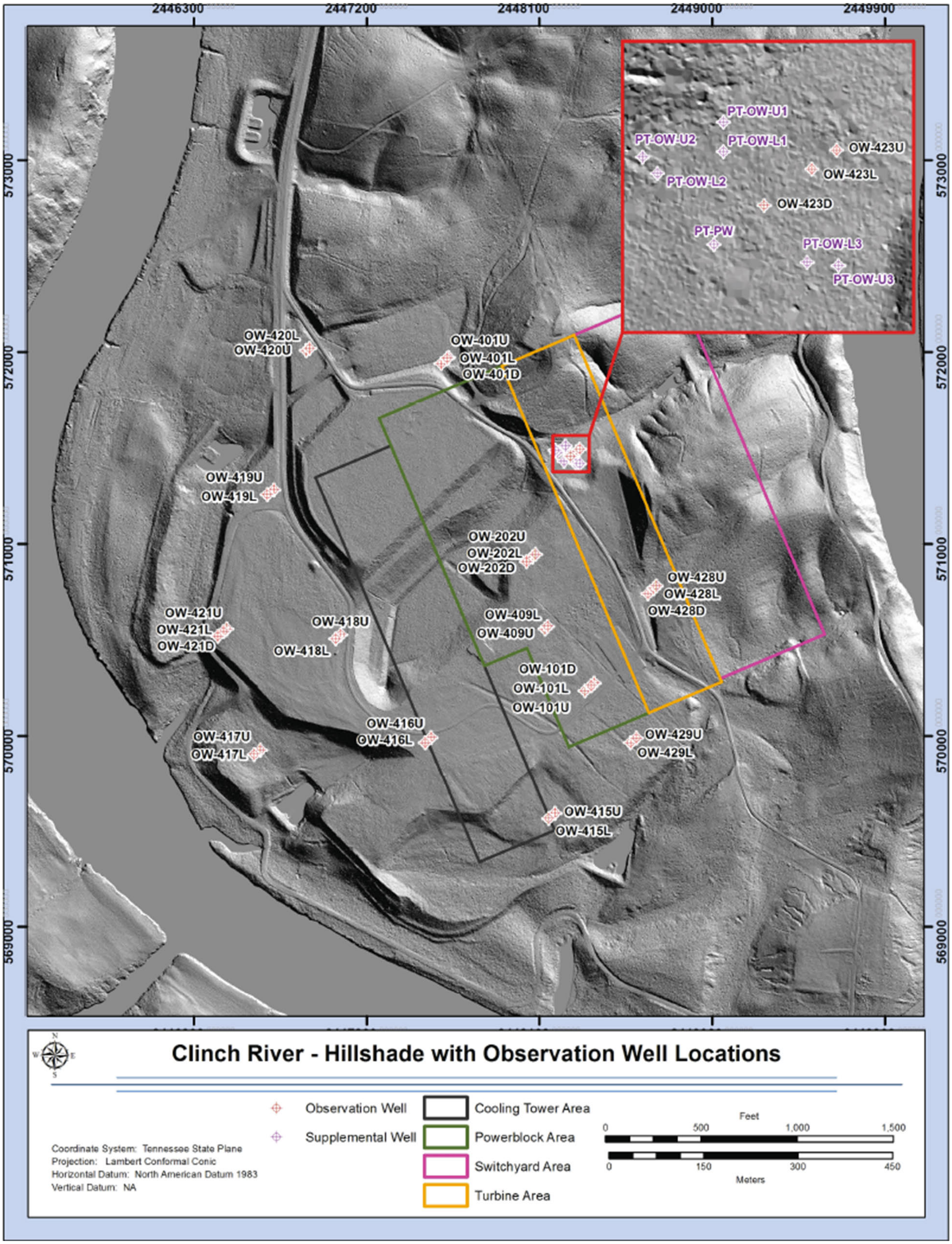


Figure 2-22. CRN Site Topography and Observation Well Locations (Source: TVA 2017-TN4921)

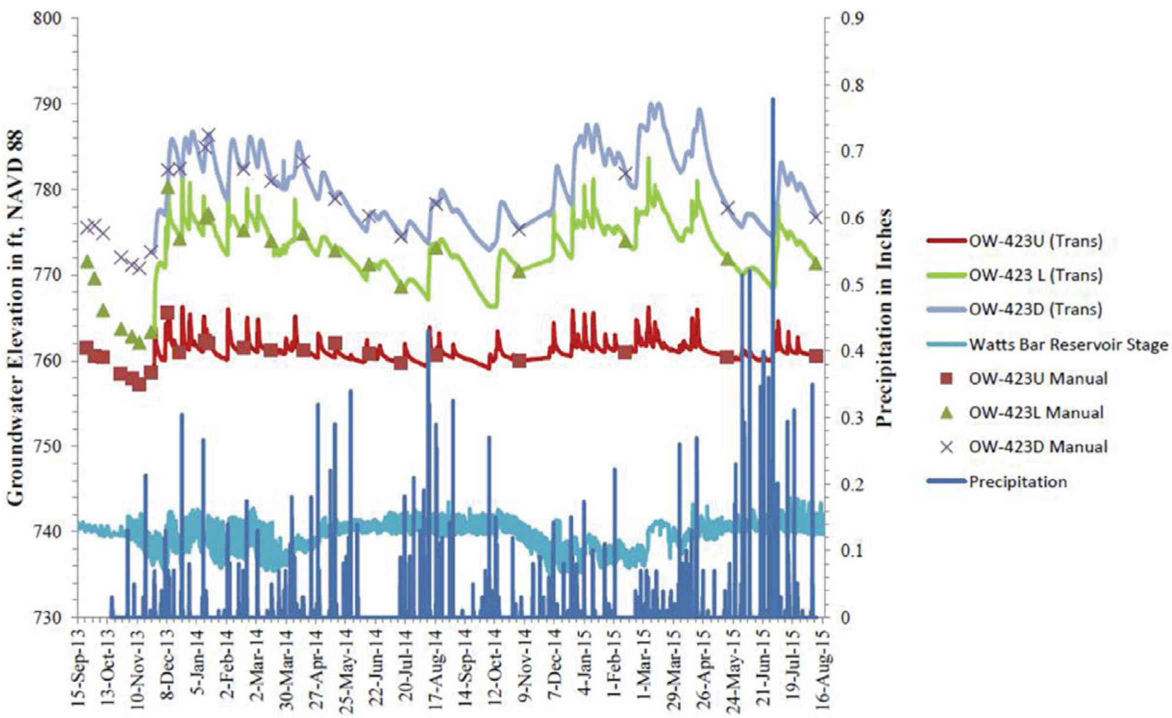


Figure 2-23. Continuous (Trans) and Manual Groundwater Heads Measured at Well Cluster OW-423 (Upper, Lower, and Deep Wells) (Source: TVA 2017-TN4921)

Based on a review of the references cited herein, and on information obtained during the site audit, including examination of road cuts through portions of the Chickamauga and Knox Group formations, the review team determined that groundwater flow at the CRN Site occurs predominantly within the fracture and bedding planes of the rock. As a result, flow over significant distances requires the presence of continuously connected fractures. In the absence of these connections, hydraulic head measurements in wells cannot be interpreted, and the system cannot be evaluated, as if the rocks are an equivalent continuum porous medium (such as would be appropriate for an unconsolidated aquifer). Evidence from the ORR and the observed decrease in fractures with depth indicates that most groundwater flow occurs within the weathered rock and at shallow depths within the competent rock, and that the shallow groundwater discharges to the local streams and rivers. As a result, the review team concludes that the groundwater flow at the CRN Site will largely conform to TVA's conceptualization (as described above), with the majority of groundwater recharge at the site being discharged to the Clinch River after a short time in the aquifer. However, the review team also acknowledges (consistent with DOE 2013-TN5075) that the Clinch River may not be a complete hydraulic barrier to deep groundwater flow in the presence of significant hydraulic forcing and a connected fracture pathway.

2.3.1.2.3 Aquifer Material Properties

TVA evaluated the saturated hydraulic conductivity of the aquifer through analysis of fractures observed in CRN Site boreholes, and through the evaluation of borehole packer tests, slug tests in the observation wells, and an aquifer pump test (TVA 2017-TN5387). Results of the CRN Site tests were compared to results from similar tests from the ORR and from the CRBRP site investigation.

TVA stated that the frequency of observed fractures was pervasive in the uppermost 100 ft of the boreholes and moderate to a depth of about 200 ft bgs (TVA 2017-TN5387). TVA reported that fracture frequency was slight at greater depths; the maximum depth at which a fracture was observed was about 300 ft bgs (TVA 2017-TN5387). TVA characterized groundwater flow at the CRN Site as occurring primarily within about 150 ft of the ground surface with little or no connection to groundwater at greater depths due to the decreasing frequency of observed open fractures with depth (TVA 2017-TN4987).

TVA estimated saturated hydraulic conductivity values from 22 packer tests in 10 boreholes and from 47 slug tests in 26 wells at 13 locations. TVA completed a 72-hour aquifer test using a pump test well and nine observation wells near (and including) well cluster OW-423 (see Figure 2-22). The pumping well was screened from 39 to 169 ft bgs in the Fleanor and Eidson geologic units and pumped at an average rate of about 14.5 gpm (TVA 2017-TN4921). This pumping rate resulted in a maximum drawdown of 12.4 ft in the pumping well (a water level of about 65 ft bgs), and higher pumping rates resulted in significant drawdown and dewatering of the pumping well (TVA 2017-TN4987). Observation wells were screened in the Eidson and Blackford geologic units.

Saturated hydraulic conductivity results for the various tests are provided in Table 2-5. Relatively minor differences are seen between results for the Chickamauga Group formations and for the Knox Group tests. The slug tests provided significantly lower minimum values than the packer tests, likely because the longer test intervals of the slug tests allowed for test results to be obtained when no significant fracture zones were present. Plots of the test results as a function of the depth below ground surface of the test, included in the ER (TVA 2017-TN4921), provided weak evidence that the saturated hydraulic conductivity may decrease with depth.

Table 2-5. Saturated Hydraulic Conductivity Results from CRN Site Tests

	Saturated Hydraulic Conductivity (ft/day)		
Unit/Test	**Geometric Mean**	**Minimum**	**Maximum**
Chickamauga			
Packer	0.54	0.04	5
Slug	0.13	0.004	8
Knox			
Packer	0.44	0.1	2
Slug	0.14	0.00055	12
Pump Test	0.26	0.06	2.6

Source: ER Figure 2.3.1-49 and Table 2.3.1-7, TVA 2017-TN4921.

TVA reported an effective porosity value of 4 to 5 percent (TVA 2017-TN4921, TVA 2017-TN5387). TVA stated that the porosity value was based on porosimetry data from the ORR conducted on rock samples from the Conasauga and Knox Groups, and represents the matrix porosity (NRC 2018-TN5386). The review team determined that, because groundwater flow at the CRN Site occurs primarily in the secondary (fracture) porosity, the porosity value provided by TVA represents a likely upper bound for the CRN Site.

2.3.1.2.4 Groundwater Pathways

As described above, most groundwater flow occurs within the weathered rock and at shallow depths within the fractures of the competent rock. The review team concluded that the shallow groundwater at the CRN Site discharges to the small streams and ponds onsite, or directly to the Clinch River. Based on upward hydraulic head gradients observed in CRN Site and ORR well clusters, the review team concludes that groundwater at the base of the CRN Site excavation (elevation 683 ft NAVD88) falls within the region of shallow groundwater that will discharge to the Clinch River. Groundwater travel time to the Clinch River from the area of the power block is likely to be rapid. TVA used the average horizontal hydraulic gradient (0.07 ft/ft), the maximum saturated hydraulic conductivity from the pump test (2.6 ft/day), and an effective porosity of 0.0467 to estimate a linear groundwater velocity of 3.9 ft/day (TVA 2017-TN5387).

2.3.2 Water Use

The water supplies potentially affected by the building and operating activities at the CRN Site would be those in the lower Clinch River watershed, which includes Melton Hill Reservoir and the Clinch River arm of Watts Bar Reservoir, and local groundwater. TVA conducted several studies that provide the most comprehensive surface-water use information available (Bohac and Bowen 2012-TN5026; Bohac and Bowen 2015-TN5157). Water supply and discharge data for 2010 were compiled from TVA, USGS, and EPA information sources. For the entire Tennessee River basin, over 98 percent of water withdrawn in 2010 was from surface-water sources, while less than 2 percent of water withdrawals were from groundwater (Bohac and Bowen 2012-TN5026). Thermoelectric water use was 84.1 percent of withdrawals, industrial use was 9.6 percent, and public supply was 6 percent. Public supply use was the largest consumptive use in the Tennessee River basin, totaling 310 Mgd in 2010.

2.3.2.1 Surface-Water Use

In the lower Clinch River watershed, more than 99 percent of all water used in 2010 was surface water. Of the annual average surface-water withdrawal rate of 457.6 Mgd, the majority was used for thermoelectric power generation: TVA’s Bull Run Fossil Plant withdrew 430.2 Mgd or 94 percent of the surface water used in the lower Clinch River watershed. Another 26.3 Mgd or 5.8 percent was withdrawn by public water suppliers, the largest of which are the Oak Ridge Department of Public Works, Hallsdale-Powell Utility District, and West Knox Utility District (Bohac and Bowen 2012-TN5026; TDEC 2017-TN5032). Industrial and agricultural uses make up the remaining 1.1 Mgd (0.2 percent) of surface-water use, withdrawing 0.5 and 0.6 Mgd, respectively, in 2010. The Bull Run plant and most of the public water suppliers in the lower Clinch River watershed withdraw their water from Melton Hill Reservoir (Bohac and Bowen 2012-TN5026; Bohac and Bowen 2015-TN5157). The City of Oak Ridge owns a small water-treatment plant that has an intake on the Clinch River arm of the Watts Bar Reservoir (near Bear Creek Road), but this plant is not currently active and would require a major upgrade to be put back into service (NRC 2018-TN5386).

2.3.2.1.1 Consumptive Surface-Water Use

Consumptive use occurs when more water is withdrawn than is returned to the source waterbody, resulting in a decrease in supply downstream of the user. The Bull Run Fossil Plant consumptively uses approximately 0.6 Mgd from Melton Hill Reservoir. Although the public water suppliers represent a small proportion of total surface-water use in the lower Clinch River, these users return less water to the source, consuming about 6.9 Mgd of the water withdrawn (Bohac and Bowen 2012-TN5026). The 0.6 Mgd withdrawn for irrigation is assumed to not be returned, resulting in consumptive use. Industrial users in the vicinity of the lower Clinch River watershed also use water from sources outside the watershed, resulting in a greater return to the watershed than the 0.5 Mgd withdrawal. According to TVA’s water-use report, approximately 8.1 Mgd, or less than 2 percent, of the surface-water use in the lower Clinch River watershed is consumptive use (Bohac and Bowen 2012-TN5026).

2.3.2.1.2 Nonconsumptive Surface-Water Use

Most of the surface-water use in the lower Clinch River watershed is nonconsumptive, meaning either no water is withdrawn, or that the volume withdrawn is returned to the source waterbody and is thus available to downstream users. The Bull Run Fossil Plant returned 429.6 Mgd of the 430.2 Mgd it withdrew in 2010. Of the 28.0 Mgd withdrawn for public water supply in the lower Clinch River watershed (94 percent from surface-water sources and 6 percent from groundwater), 21.1 Mgd was return flow (Bohac and Bowen 2012-TN5026). Other nonconsumptive water uses in the lower Clinch River watershed include hydroelectric power generation at Melton Hill Dam, navigation, aquatic habitat, and recreational activities such as fishing, boating, and swimming. TVA manages releases from Norris Dam on the upper Clinch River, Melton Hill Dam on the lower Clinch River, and Watts Bar Dam on the Tennessee River to protect these nonconsumptive uses (TVA 2017-TN4921).

2.3.2.2 Groundwater Use

Surface water is the dominant water source in the Tennessee River basin. In the lower Clinch River watershed, less than 0.4 percent of total water withdrawals in 2010 were from groundwater (Bohac and Bowen 2012-TN5026). Groundwater withdrawals in the lower Clinch River watershed totaled just 1.72 Mgd in 2010. Of these, 99 percent were for public supply water use, which was about 6 percent of the total public supply withdrawals (Bohac and Bowen 2012-TN5026). EPA's Safe Drinking Water Information System database was searched for water systems near the CRN Site with a primary water source of groundwater; the closest system was a transient non-community water system (a campground) located south of the Clinch River about 2.5 mi from the CRN Site boundary (EPA 2017-TN5147). All other systems using groundwater as a primary water source were much farther from the CRN Site.

Individual groundwater well users within about 1.5 mi of the CRN Site were identified by TVA based on Tennessee Department of Environment and Conservation (TDEC) records (TVA 2017-TN4921). These included 32 residential wells, three commercial wells, and one agricultural well, with locations shown in Figure 2-24. The depths of the wells ranged from 42 to 900 ft bgs, and about 50 percent of the wells were less than 300 ft deep. TVA inferred the geologic unit penetrated by each well based on well locations and regional geologic information. Most of the wells penetrated to the Knox Group and upper Conasauga Group formations. All wells with information about the type of completion were finished as open boreholes. Estimated well yields ranged from 0.5 to 75 gpm, and 50 percent of well yields were less than 7 gpm. Well information provided by TVA was consistent with information provided to the review team by TDEC and DOE staff during the site audit (NRC 2018-TN5386).

TVA stated that no groundwater would be used at the CRN Site during building or operations (TVA 2017-TN4921). Some groundwater would be extracted during building for dewatering of excavations, and this water would be routed to a stormwater-retention pond for eventual infiltration or discharge to the Clinch River as part of the stormwater-management system (TVA 2017-TN4921).

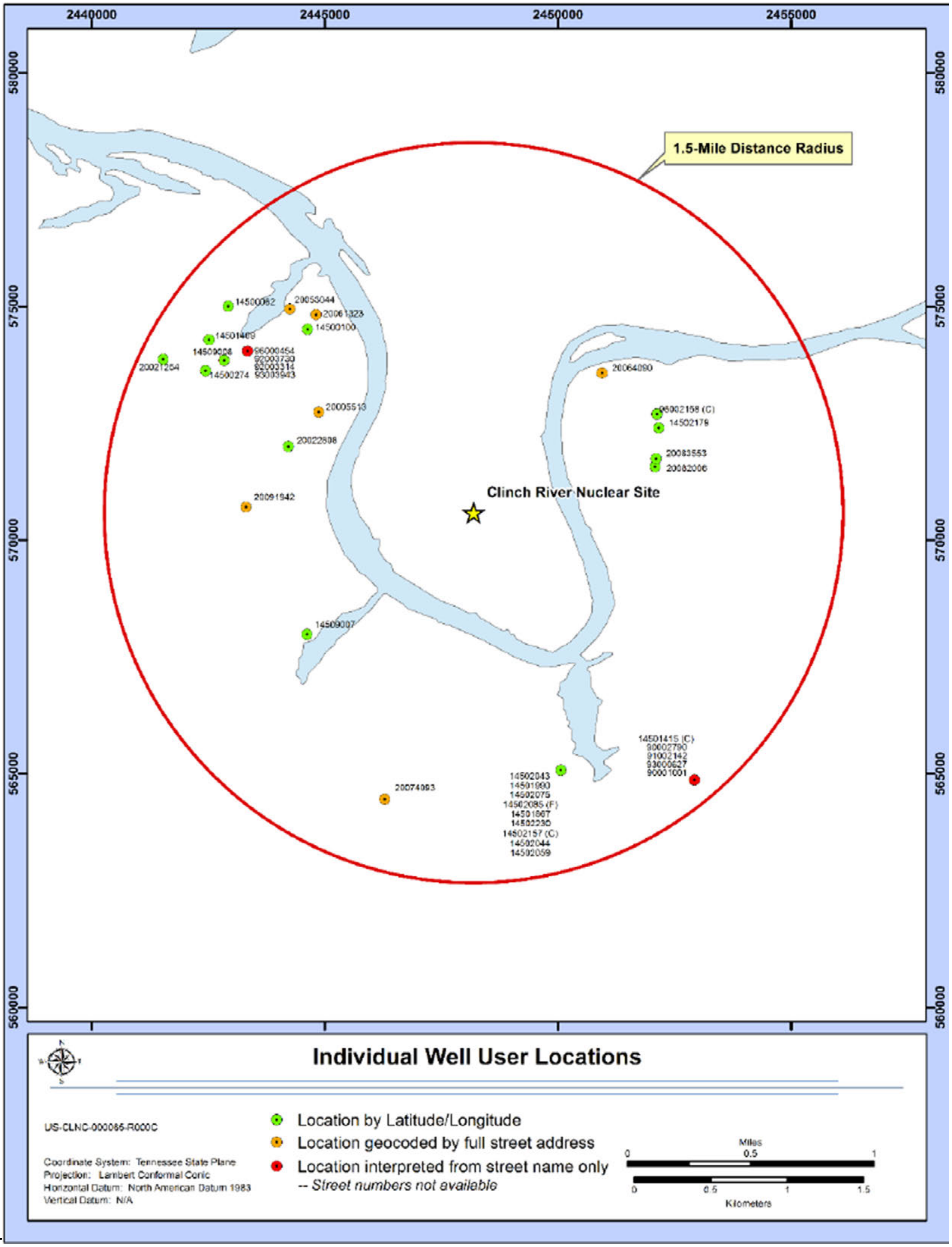


Figure 2-24. Wells Located within 1.5 Mi of the CRN Site (Source: TVA 2017-TN4921)

2.3.3 Water Quality

The primary water supply source for a new nuclear power plant at the CRN Site and the receiving waterbody for plant discharges is the Clinch River arm of the Watts Bar Reservoir. The following sections describe the quality of surface-water and groundwater resources along the Clinch River arm of the Watts Bar Reservoir and in the vicinity of the CRN Site. Tennessee water-quality standards are provided in Rules of the Tennessee Department of Environment and Conservation, Chapter 0400-40-03, "General Water Quality Criteria" (TNSOS 2017-TN5071). Designated uses for the lower Clinch River are domestic and industrial supply, fish and aquatic life, recreation, livestock watering, wildlife, irrigation, and navigation (Rules of the TDEC, Chapter 0400-04-04-.09; TNSOS 2017-TN5071).

2.3.3.1 Surface-Water Quality

TDEC monitors water quality in the Tennessee River basin and produces water-quality reports that satisfy the requirements of Clean Water Act (CWA) Sections 305(b) and 303(d) (TDEC 2014-TN4893; TDEC 2017-TN5060). Waterbodies are assessed for the uses of water supply, fish and aquatic life, recreation (includes fish consumption), and agriculture; TDEC performs watershed assessments on a 5-year cycle. TDEC monitors 12 stations in the Clinch River arm of the Watts Bar Reservoir, 4 of which are between Melton Hill Dam and the CRN Site (a distance of about 5 mi), and 8 of which are between the CRN Site and the Tennessee River (a distance of about 18 mi). The 303(d) list identifies impaired waterbodies that do not meet water-quality standards for one or more of these designated uses. Impairment causes on the lower Clinch River, including the Clinch River arm of the Watts Bar Reservoir, are temperature and flow alterations and sediment-associated pollutants from prior industrial activity (mercury, polychlorinated biphenyls [PCBs], and chlordane). The Clinch River arm of the Watts Bar Reservoir (2,682 ac) and the Melton Hill Reservoir just upstream of it (5,690 ac) are impaired for fish-consumption use because of PCBs; Melton Hill Reservoir is also impaired for fish consumption because of chlordane. About 2.5 mi downstream of the CRN Site, the Poplar Creek embayment of Watts Bar Reservoir is impaired for fish consumption because of mercury and PCBs. Releases from the Melton Hill Dam can cause rapid flow and temperature alterations that result in impairment for fish and aquatic life in the Clinch River arm of the Watts Bar Reservoir (TVA 2017-TN4921; TDEC 2017-TN5060).

TVA monitors water quality in the waterbodies associated with its existing hydroelectric and thermal power plants through an ongoing Reservoir Ecological Health Program. Sites located near the inflow, mid-reservoir, and forebay (area just upstream of the dam) of each reservoir are regularly sampled every other year. However, this program focuses on the reservoirs and did not include the Clinch River arm of the Watts Bar Reservoir in the vicinity of the CRN Site. TVA characterized water quality in the Clinch River arm of the Watts Bar Reservoir near the CRN Site as part of biological monitoring completed in 2011. Standard water-quality parameters were measured monthly from March through December 2011 and total and dissolved metals were measured bimonthly from April through December 2011 at CRM 15.5, CRM 18.5, CRM 19.7, and CRM 22.0 (TVA 2017-TN4921). TVA completed additional surface water quality monitoring between July 2013 and June 2015 as part of a pre-application monitoring program. Four locations on the Clinch River arm of the Watts Bar Reservoir (three near the Barge/Traffic Area and one at about CRM 18.3) were sampled seven times (approximately quarterly). In addition, four stormwater ponds on the CRN Site were sampled four times in the first year of pre-application monitoring. For pre-application monitoring, surface water and stormwater samples were analyzed for standard water-quality parameters (temperature, pH, conventional pollutants), metals, and selected radionuclides.

Water-quality parameter maximum values measured during TVA's pre-application and 2011 biological monitoring programs are compared with State of Tennessee water quality criteria for aquatic life in Table 2-6. Maximum measured values of most reported water-quality parameters satisfied available water-quality standards for aquatic life.

Table 2-6. Maximum Values for Water-Quality Parameters Measured by TVA in the Clinch River Arm of Watts Bar Reservoir

			Clinch River Arm of Watts Bar Reservoir		Stormwater
Parameter	**Units**	**Water-Quality Standard[a]**	**Biological Monitoring Stations CRM 15.5, 18.5, 19.7, and 22.0 (all dates)**	**Pre-Application Monitoring Stations CRS8, CRS9, CRS10, CRS12 (all dates)**	**Pre-Application Monitoring Stations CRS1, CRS2, CRS3, CRS6 (all dates)**
Temperature	°C	30.5	-	26.8	31.3
pH		6.5 to 9.0	-	6.1-7.7	6.7-8.1
Oil and Grease	mg/L		-	<5.0	<5.6
Cyanide	µg/L	5.2	-	<5	<5
Total Phenols	mg/L		-	0.14	0.083
BOD	mg/L		-	8.85	< 5
TSS	mg/L		-	13.4	114
Color	PCU		-	50.0	80.0
Bromide	mg/L		-	0.10	2.0
Surfactants	mg/L		-	0.20	0.16
Total Organic Carbon	mg/L		3.6	18.1	37.0
Sulfide	mg/L		-	< 0.10	< 0.10
Ammonia-N	mg/L	1.24[b]	0.19	0.21	0.13
Nitrate/Nitrite	mg/L		0.7	1.5	0.95
Total Organic Nitrogen	mg/L		-	< 0.50	1.1
Total Kjeldahl Nitrogen	mg/L		0.79	< 0.50	1.1
Total Phosphorus	mg/L		0.048	< 0.10	0.23
COD	mg/L		-	< 25	62.0
Total Fluoride	mg/L		-	< 0.50	0.25
Sulfate	mg/L		-	24.3	130
Alkalinity	mg/L		130	-	-
Suspended Solids	mg/L		11	-	-
Dissolved Solids	mg/L		200	-	-
Hardness, Total (as $CaCO_3$)	mg/L		160	143	324
Phosphate, Ortho	mg/L		<0.025	-	-
Total Organic Carbon	mg/L			-	-
Turbidity	NTU		12	-	-
Metals					
Total Aluminum	µg/L		800	747	2,180
Aluminum, Dissolved	µg/L		150 DT[c]	-	-
Total Magnesium	µg/L		11,000	11,400	33,100

Table 2-6. (contd)

Parameter	Units	Water-Quality Standard[a]	Clinch River Arm of Watts Bar Reservoir: Biological Monitoring Stations CRM 15.5, 18.5, 19.7, and 22.0 (all dates)	Clinch River Arm of Watts Bar Reservoir: Pre-Application Monitoring Stations CRS8, CRS9, CRS10, CRS12 (all dates)	Stormwater: Pre-Application Monitoring Stations CRS1, CRS2, CRS3, CRS6 (all dates)
Magnesium, Dissolved	µg/L		12,000	-	-
Total Calcium	µg/L		38,000	39,100	87,300
Total Iron	µg/L		610	232	2,880
Iron, Dissolved	µg/L		<100	-	-
Total Copper	µg/L		<2.0	1.5	5
Copper, Dissolved	µg/L	9[d]	2.2 DT	-	-
Total Zinc	µg/L		<10	10.0	25.0
Zinc, Dissolved	µg/L	120[d]	<10	-	-
Total Barium	µg/L		-	38.4	81.5
Total Boron	µg/L		-	50	50
Total Cobalt	µg/L		-	1.0	5
Total Manganese	µg/L		58	895	884
Manganese, Dissolved	µg/L		42 DT	-	-
Total Molybdenum	µg/L		-	1.0	1.2
Total Tin	µg/L		-	50	50
Total Titanium	µg/L		-	< 10	36.9
Total Antimony	µg/L		-	1.0	1.0
Total Arsenic	µg/L		1.1	0.0	5.0
Arsenic, Dissolved	µg/L	150	<1.0	-	-
Total Beryllium	µg/L		-	1.0	0.18
Total Cadmium	µg/L		<0.5	0.1	0.10
Cadmium, Dissolved	µg/L	0.25[d]	<0.5	-	-
Total Chromium	µg/L		<2.0	1.4	5
Chromium, Dissolved	µg/L		<2.0	-	-
Total Lead	µg/L		8.6	2.1	3
Lead, Dissolved	µg/L	2.5[d]	1.5 DT	-	-
Total Mercury	µg/L		-	-	1,220
Low-Level Mercury	ng/L		-	5.33	5.64
Total Nickel	µg/L		3.1	1.0	5.0
Nickel, Dissolved	µg/L	52[d]	2.5 DT	-	-
Total Selenium	µg/L	5	<1.0	1.0	5.0
Selenium, Dissolved	µg/L		<1.0	-	-
Total Silver	µg/L	3.2[d,e]	-	< 0.5	0.5
Total Thallium	µg/L		-	1.0	1.0
Radioactivity					
Gross Alpha	pCi/L		-	<MDC[f]	2.39 ± 1.21
Gross Beta	pCi/L		-	2.85 ± 1.05	3.12 ± 1.41

Table 2-6. (contd)

			Clinch River Arm of Watts Bar Reservoir		Stormwater
Parameter	**Units**	**Water-Quality Standard[(a)]**	**Biological Monitoring Stations CRM 15.5, 18.5, 19.7, and 22.0 (all dates)**	**Pre-Application Monitoring Stations CRS8, CRS9, CRS10, CRS12 (all dates)**	**Pre-Application Monitoring Stations CRS1, CRS2, CRS3, CRS6 (all dates)**
Total Alpha Radium	pCi/L		-	<MDC	<MDC
Radium 226	pCi/L		-	0.719 ± 0.217	<MDC
Radium 228	pCi/L		-	<MDC	<MDC

(a) Fish and Aquatic Life Criteria Continuous Concentration from Chapter 0400-40-03, General Water Quality Criteria, Rules of the Tennessee Department of Environment and Conservation, unless otherwise noted.
(b) For pH 8 and 25°C (Chapter 0400-40-03, General Water Quality Criteria, Rules of the Tennessee Department of Environment and Conservation gives formulas for calculating Criteria Maximum Concentration depending on presence/absence of salmonids and pH).
(c) DT= dissolved fraction exceeded the total recoverable metal concentration.
(d) Criteria concentrations are a function of total hardness; values correspond to total hardness of 100 mg/L.
(e) Fish and Aquatic Life Criteria Maximum Concentration for dissolved silver from Chapter 0400-40-03, General Water Quality Criteria, Rules of the Tennessee Department of Environment and Conservation.
(f) MDC = minimum detectable concentration.

Source: Adapted from ER Tables 2.3.3-2, 2.3.3-3, 2.3.3-4, and 2.3.3-5 (TVA 2017-TN4921).

The water temperature in the Clinch River arm of Watts Bar Reservoir varies with meteorological conditions and operation of the upstream Norris and Melton Hill Reservoirs (EIS Section 2.3.1.1). Cold water released from storage in Norris Reservoir flows down to Melton Hill Reservoir where it receives heat from Bull Run Fossil Plant discharge. This contributes to thermal stratification in Melton Hill Reservoir, which affects the temperature of water at the Melton Hill Dam hydroelectric intakes and therefore affects the temperature of the water released downstream to the Clinch River arm of Watts Bar Reservoir. TVA monitors temperature on an hourly basis at several locations up- and downstream of the Melton Hill Dam. Figure 2-25 (TVA 2017-TN4921) shows the results of water-temperature monitoring in the tailwater about 0.5 mi below the dam for 2004 and 2008 through 2013. TVA estimated the seasonal temperature range at this location to be between 39°F (4°C) in winter to 75°F (24°C) in summer. During pre-application thermal monitoring in 2013, TVA found that hourly water temperature at the proposed discharge location 7.65 mi downstream of Melton Hill Dam could be up to 1°F colder and 3°F warmer than the Melton Hill Dam tailwater temperature. As a result, TVA estimated a seasonal water temperature range of 38°F (3°C) in winter to 78°F (26°C) in summer at the discharge location. Because Melton Hill Dam operations are expected to continue in the same manner during building and operating activities at the CRN Site, TVA expects future water-temperature fluctuations and seasonal variability to be similar to those shown in Figure 2-26 (TVA 2017-TN4921).

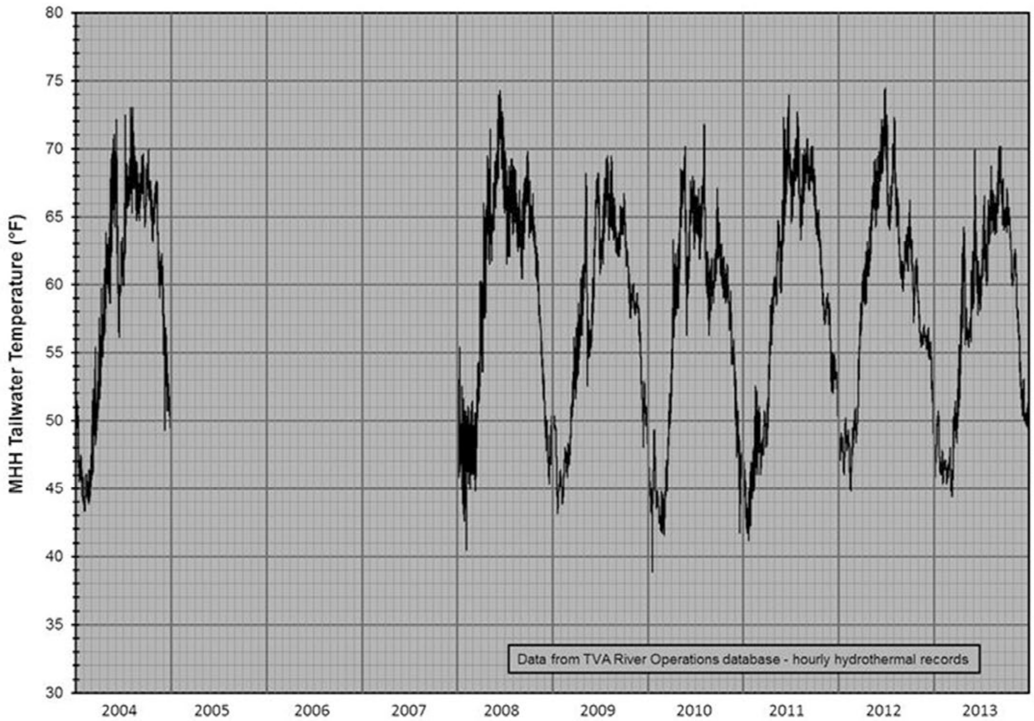


Figure 2-25. Results of Hourly Temperature Monitoring in the Tailwater below Melton Hill Dam, in 2004 and 2008–2013 (Source: TVA 2017-TN4921)

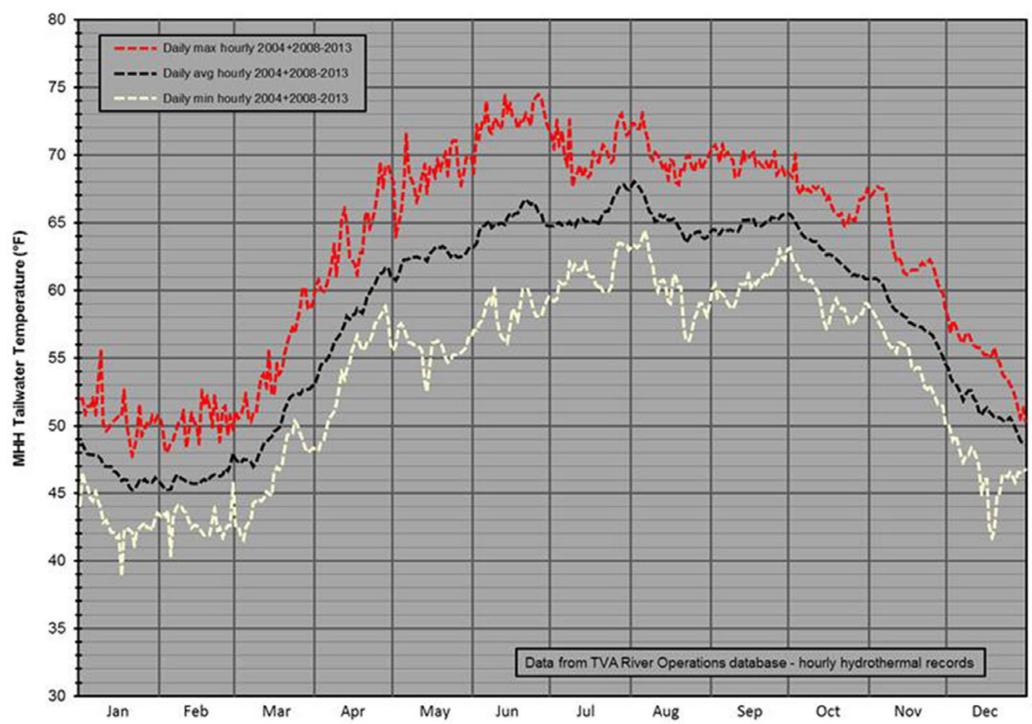


Figure 2-26. Average and Range of Hourly Water Temperature in the Tailwater below Melton Hill Dam by Date (data from 2004 and 2008–2013) (Source: TVA 2017-TN4921)

The Clinch River sediments from CRM 0.0 to CRM 44 are a designated Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) site as the result of hazardous and radioactive contamination from past activities at ORR and other non-DOE municipal and industrial sources (EPA 1997-TN5222). The current remedy includes institutional controls on potential sediment-disturbing activities (i.e., the procedures of the Watts Bar Interagency Working Group), fish-consumption advisories, and monitoring to detect changes in contaminant levels or mobility (EPA 1997-TN5222). The CERCLA investigation concluded that metals and radionuclide contaminants occur in deep-water sediments, the highest concentrations are buried 20–60 cm deep, and little DOE-related contamination is in near-shore sediments (EPA 1997-TN5222). Radionuclides detected in sediment during the CERCLA investigation included Cs-137, Co-60, U-238, U-235, and Tc-99 (EPA 1997-TN5222). DOE completed annual sediment sampling at locations near the CRN Site through 2005, at which point the sampling frequency was reduced to once every 5 years; the closest monitoring location was at about CRM 14.5. The review team examined sediment monitoring data from this location and found that a number of metals and radionuclides have been present at greater than background concentrations (as measured at CRM 44.5-45) (OREIS 2017-TN5225). In 2015, sediment concentrations of aluminum, boron, lithium, potassium, and cesium-137 exceeded background levels. Cesium-137 concentration was very low, at 1.35 pCi/g sediment. PCBs were below detection levels in 2010 at CRM 14.5 (OREIS 2017-TN5225).

2.3.3.2 Groundwater Quality

TVA described the monitoring program used to evaluate CRN Site groundwater quality (Fisher 2015-TN5143), and additional information and results of the evaluation of field and laboratory groundwater samples are provided in ER Section 2.3.3.2 (TVA 2017-TN4921). TVA evaluated basic groundwater geochemistry in November 2013. Sampling was carried out in 15 wells at 12 locations, screened in the Bowen, Benbolt, Rockdell, Fleanor, Eidson, Blackford, and Mascot (Newala) formations (refer to Section 2.8 of this draft EIS for geologic unit descriptions and stratigraphy) at depths from 37 to 160 ft bgs. Results are presented in ER Tables 2.3.3-9 and 2.3.3-10 (TVA 2017-TN4921). Site groundwater was characterized as mostly calcium-bicarbonate to magnesium-bicarbonate, with pH levels between about 7 and 8 and total dissolved solids concentrations ranging from 190 to 520 ppm. Water from one well screened in the Fleanor Shale unit (at a depth of 160 ft bgs—the deepest well sampled) was characterized as having sodium-bicarbonate chemistry with a pH level of 9.6 and total dissolved solids concentration of 1,100 mg/L. These results are more characteristic of deeper water and may have been biased by sampling difficulties (TVA 2017-TN4921). TVA stated that water having a sodium-chloride chemistry with high total dissolved solids concentration occurs at a depth of greater than 300 ft bgs, and was observed at a depth of about 400 ft bgs in a well on the ORR adjacent to the CRN Site (TVA 2017-TN4921).

TVA performed a baseline investigation of the proposed CRN Site groundwater quality between November 2013 and November 2014. Quarterly groundwater sampling was conducted in 21 wells at nine locations; wells were screened in the Bowen, Benbolt, Rockdell, Eidson, Blackford, and Mascot (Newala) formations at depths from 37 to 252 ft bgs (Fisher 2015-TN5143). The results of those analyses are provided in Tables 2.3.3-12 to 2.3.3-16 of the ER (TVA 2017-TN4921). Locations of monitoring wells sampled for the quarterly groundwater-quality characterization were provided by Fisher (2015-TN5143). Minimum and maximum values of selected water-quality parameters from the quarterly sampling are provided in Table 2-7.

Table 2-7. Minimum and Maximum Values for Groundwater-Quality Parameters at the CRN Site

Parameter	Minimum	Maximum
Temperature, ºC	8.4	24.4
Dissolved Oxygen, mg/L	0	13
pH	5.3	9.7
Conductivity, µS/cm	72.4	938.1[(a)]
Turbidity, NTU	0.9	114
Oxidation-Reduction Potential, mV	-19	478
Total Dissolved Solids,[(b)] mg/L	43	563

(a) Excluding well OW-415L, which had a maximum conductance of 4,723 µS/cm.
(b) Approximate, calculated from conductivity using a conversion factor of 0.6.

Source: TVA 2017-TN4921.

Numerous other water-quality parameters were evaluated and compared to established Tennessee and EPA drinking water maximum contaminant levels, including metals, gross alpha and beta radioactivity, selected radionuclides, organic compounds, PCBs, and pesticides. Observed concentrations exceeded maximum contaminant levels for fluoride in five samples from two wells and for lead in one sample.

Past and current activities on the ORR resulted in the release of hazardous and radioactive contaminants, some of which have affected ORR groundwater quality. Since the ORR was placed on the National Priorities List in 1989, extensive efforts have been made to isolate existing contaminant sources and reduce levels of groundwater contamination. DOE currently has a groundwater strategy to identify potential onsite and offsite public health threats from contaminated groundwater and protect and restore to beneficial use the groundwater resources on the ORR (DOE 2013-TN5075). Investigating the potential for offsite contamination via deep groundwater transport is one focus of the groundwater strategy. Radionuclides and some volatile organic compounds have been sporadically detected at low concentrations in offsite wells (DOE 2013-TN5075). Although there have been no specific health concerns from offsite contamination, DOE has worked with the TDEC to provide water connections to residences currently obtaining drinking water from private wells located west of Clinch River across from existing ORR groundwater contaminant plumes. A summary of groundwater contamination on the ORR is provided by DOE in the ORR Groundwater Strategy Report (DOE 2013-TN5075). Current conditions and DOE activities to monitor and reduce contamination are described in the ORR Remediation Effectiveness Report (DOE 2016-TN5072).

Quarterly monitoring at the CRN Site evaluated groundwater at the site for the presence of legacy contaminants associated with ORR activities. Legacy contaminants not detected in CRN Site groundwater included mercury, uranium, trichloroethylene, and 1,1-dichloroethane. Detected legacy contaminants are listed in Table 2-8 along with the maximum observed concentrations and the number of samples with detections. These detections were at low concentrations and do not indicate a direct transport pathway from the ORR. Most existing ORR groundwater plumes are separated from the CRN Site by the region’s geologic structures. Existing groundwater contamination in the Bear Creek and Bethel Valleys on the ORR is more than 2 mi from the CRN Site (DOE 2013-TN5075).

Table 2-8. ORR Legacy Contaminants Detected in CRN Site Groundwater Samples (TVA 2017-TN4921)

Parameter	MCL	Maximum	# of Detections
Nitrite + Nitrate, mg/L	NE[(a)]	2.62	54
Arsenic, µg/L	10	7	1
Barium, µg/L	2000	582	73
Cadmium, µg/L	5	1.2	2
Chromium, µg/L	100	11.6	5
Tritium, pCi/L	NE	847	4
Strontium-90, pCi/L	NE	0.428	5
Technitium-99, pCi/L	NE	8.16	3
Chloroform, µg/L	80	4.02	22
Tetrachloroethylene, µg/L	5	0.499	1

(a) Not established
MCL = maximum contaminant level.

During well completion, petroleum products were detected in a single well on the CRN Site (well OW-422L) (TVA 2017-TN4921). The source of this contamination appeared to be restricted to the area around this well, but no source for the contamination was apparent. The entire OW-422 well cluster (upper, lower, and deep wells) remains in place, but is locked and was not used for groundwater sampling. TVA indicated that they would disposition this well cluster following a determination by TDEC.

2.3.4 Water Monitoring

2.3.4.1 Surface-Water Monitoring

TVA works closely with the USGS and U.S. Army Corps of Engineers (USACE) to maintain a hydrologic monitoring system that continuously measures streamflow and rainfall throughout the Tennessee River watershed. TVA uses these data in real time to manage reservoir inflows and releases in accordance with its river management policy (TVA 2004-TN4913). TVA continuously monitors water temperature as part of its ongoing operational support monitoring program. Fourteen of the temperature monitoring locations are in the Watts Bar and Melton Hill Reservoirs, but most are located immediately up- and/or downstream of an operating hydroelectric or fossil generation plant and only one is located in the Clinch River arm of Watts Bar Reservoir (at CRM 22.6 just below Melton Hill Dam). TVA monitored continuous temperature (hourly) between late November 2012 and early February 2014 at nine stations in the Clinch River arm of Watts Bar Reservoir between CRM 13.5 and CRM 23.5 during its pre-application monitoring program. In addition to the stations in the Clinch River arm of Watts Bar Reservoir, pre-application thermal monitoring stations were also located upstream of the CRN Site: one in the forebay of Melton Hill Reservoir, one at the SR 61 bridge in Clinton, Tennessee, and one at a boat ramp about 3 mi downstream of Norris Dam (TVA 2017-TN4921).

TVA's pre-application monitoring program included the surface-water quality sampling and analysis described in EIS Section 2.3.3, in which four stations in the Clinch River arm of Watts Bar Reservoir were sampled seven times from July 2013 through June 2015 and stormwater was sampled at five stations four times between July 2013 and November 2014. Samples were analyzed for standard water-quality parameters (temperature, pH, conventional pollutants), metals, and selected radionuclides. Prior to the pre-application monitoring, TVA had conducted a biological monitoring program in 2011, during which four stations in the Clinch River arm of

Watts Bar Reservoir were sampled monthly and analyzed for standard water-quality parameters (monthly) and total and dissolved metals (bimonthly) (TVA 2017-TN4921). The maximum reported constituent concentrations from both the biological and pre-application water-quality monitoring programs are provided in Table 2-6.

2.3.4.2 Groundwater Monitoring

TVA installed 44 groundwater monitoring wells (including the aquifer pump test well) on the CRN Site as part of its pre-application monitoring program, as described in EIS Section 2.3.1.2. Wells were installed as clusters—two or three wells located in close proximity, screened at multiple depths. Eighteen upper-level wells were screened at depths between 15 and 105 ft bgs, 18 lower-level wells were screened at depths between 89 and 178 ft bgs, and 7 deep wells were screened at depths between 176 and 297 ft bgs (TVA 2017-TN4921). Observation wells were screened in the Bowen, Benbolt, Rockdell, Fleanor, Eidson, Blackford, and Mascot (Newala), formations (refer to Figure 2-35 and Figure 2-36). Manual and continuous hydraulic head measurements were obtained between September 2013 and August 2015. Concurrent measurements of precipitation and water-surface elevations in Watts Bar Reservoir were used to infer the response of groundwater to rainfall and the groundwater levels in the Clinch River arm of the Watts Bar Reservoir. Monitoring of groundwater hydraulic head was used to infer the vertical and horizontal groundwater-flow directions.

TVA identified 21 wells at 9 locations for quarterly groundwater-quality monitoring completed between December 2013 and November 2014, although not all wells were able to be sampled due to a lack of water (Fisher 2015-TN5143). Field and laboratory water-quality parameters included legacy contaminants from the ORR, as described in the ER (TVA 2017-TN4921) and summarized in EIS Section 2.3.3.2.

2.4 Ecology

This section describes terrestrial and aquatic ecological resources that might be affected by building and operating two or more SMR units on the CRN Site. Section 2.4.1 and Section 2.4.2 provide general descriptions of terrestrial and aquatic resources, respectively. Detailed descriptions are provided where needed to support the analysis of potential environmental impacts.

2.4.1 Terrestrial and Wetland Ecology

The text below characterizes terrestrial and wetland ecological resources that could be affected by the proposed project. It also identifies important terrestrial species and habitats, as defined in NUREG-1555, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants: Environmental Standard Review Plan* (NRC 2000-TN614), that might be affected.

2.4.1.1 Terrestrial Resources – Site and Vicinity

The CRN Site lies in the Ridge and Valley Ecoregion, which extends from the Saint Lawrence Valley in southeastern New York southwest through the Gulf Coastal Plain in Alabama. The ecoregion is about 40 mi wide in eastern Tennessee and is characterized by alternating forested ridges and agricultural valleys that have a variety of geologic materials containing numerous springs and caves (EPA 2013-TN5033; Tucci 1992-TN5034; USGS 2016-TN5035; Woods et al. 1999-TN1805; Woods et al. 2003-TN1806). The greatest land conversion in the Ridge and Valley Ecoregion from 1973 through 2000 was from forested to disturbed land followed by the reversion of disturbed lands back to forest (USGS 2016-TN5035). This pattern of land conversion has likely existed since earlier in the twentieth century. Forest and disturbed land (likely much of it agricultural) are both also being converted to developed land (TNC 2003-TN5036; USGS 2016-TN5035). Three land-cover types dominate the ecoregion: forest (56 percent), agriculture (about 30 percent), and developed areas (about 9 percent) (USGS 2016-TN5035).

The CRN Site spans two subdivisions of the Ridge and Valley Ecoregion: (1) Southern Limestone/Dolomite Valleys and Low Rolling Hills and (2) Southern Dissected Ridges and Knobs (USGS 1998-TN5159). The latter subdivision covers only the southeastern corner of the CRN Site (EPA 2004-TN5158) and is characterized by broken, hummocky ridges with white oak forests (*Quercus alba*), mixed mesophytic forest, and tulip poplar (*Liriodendron tulipifera*) forests on the lower slopes, knobs, and draws (USGS 1998-TN5159). The former subdivision covers the remainder of the CRN Site (EPA 2004-TN5158) and is characterized by low rolling ridges and valleys supporting white oak forests, bottomland oak forests, and American sycamore (*Platanus occidentalis*)-ash (*Fraxinus* spp.)-elm (*Ulmus* spp.) riparian forest with grassland barrens intermixed with cedar-pine glades (USGS 1998-TN5159).

The percentages of land-cover types in the CRN Site vicinity (within 6 mi, as defined in EIS Section 2.2) and region (within 50 mi, as defined in EIS Section 2.2) are provided in Table 2-1. Percentages of land-cover types in the vicinity are generally typical of the region and the Ridge and Valley Ecoregion. Agriculture, harvesting timber, coal mining, and hydropower development have played a key role in shaping upland terrestrial and wetland communities in the region (TNC 2003-TN5036). These rural lifestyles, which generally are prevalent in relatively natural landscapes, largely continue today (EPA 2002-TN5038; LandScope America 2017-TN5039), along with commercial, industrial, and residential land uses (TVA 2017-TN4921), which tend to more fully and permanently convert the landscape to a more artificial state. Conservation in the form of natural areas and habitat protection areas plays a role in maintaining a relatively natural landscape in the region around Clinch River (TVA 2009-TN4997).

TVA's Clinch River property comprises approximately 1,200 ac of Federal land on a peninsula in the Clinch River arm of the Watts Bar Reservoir, managed by TVA. This tract includes the 935-ac CRN Site and the Grassy Creek Habitat Protection Area (Figure 2-27) (TVA 2017-TN4921). The Clinch River arm is regulated upstream by Melton Hill Dam (LandScope America 2017-TN5039). Based on aerial photography provided by TVA in the application, the review team has determined that the CRN Site topography includes a series of roughly parallel ridges with elevations ranging from about 760 ft MSL at the river to about 960 ft MSL in the northern part of the site (TVA 2017-TN4921). Several small drainages extend from the ridges to the Clinch River. The southeastern portion of the peninsula is relatively flat, with a few small hills with elevations of around 780 ft MSL. The northeastern portion of the CRN Site consists of interspersed hills and valleys with elevations ranging from approximately 780 MSL to 940 MSL (TVA 2017-TN4921).

The CRN Site disturbance history that pre-dates TVA's application includes the following. In 1939 aerial photography, some of the low-elevation areas between the ridges onsite appear to have been farmed (TVA 2017-TN4920). As shown in Figure 2-27 and in aerial photography from 1983 (TVA 2017-TN4920), the southern portion of the CRN Site was substantially altered for the CRBRP, starting with site preparation and construction in 1982, when about 240 ac were cleared and grubbed (TVA 2017-TN4920) and about 1.5 million cubic yards of rock were removed and used as structural fill or were spoiled. Construction of the CRBR ceased in 1983 prior to its completion. Redress for future industrial use was implemented; redress to the site's original condition was not viewed as being needed (DOE et al. 1984-TN5221). Redress consisted of reconfiguring rock to make the site self-draining and stabilizing soil and spoils via reseeding. About 66 ac were seeded with herbaceous species for erosion control, and runoff from 95 ac of unstabilized land was directed to five onsite treatment ponds. Some areas were replanted with pine seedlings (DOE 1984-TN5282). Areas of rare plant species were identified beyond the disturbed area and protected from disturbance during redress (DOE 1984-TN5282; DOE et al. 1984-TN5221); these areas are addressed further in EIS Section 2.4.1.3. The CRBRP site is currently in a state of early old-field succession. The CRN Site also supported electricity distribution, as indicated by onsite transmission lines (Figure 3-6) that pre-date TVA's application. Currently, onsite vegetation management consists of maintaining these transmission line corridors.

The Clinch River played a geological role in shaping the surrounding terrestrial and wetland communities prior to the construction of Watts Bar Dam in 1939 and Melton Hill Dam in 1960. The dams regulate downstream flow and have moderated historic flood events and their influence on surrounding terrestrial and wetland communities.

Upland and wetland habitats on the CRN Site and BTA are generally typical of the vicinity, region, and ecoregion and are described in more detail in the following subsections. The approximate coverage by specific upland and wetland terrestrial habitats is quantified in Table 2-9. The acreages in Table 2-9 were calculated based on habitat descriptions from ecological field surveys transcribed onto aerial photography. The habitat acreages derive from general LULC data (TVA 2017-TN5226).

Table 2-9. Extent of Habitat Types on the CRN Site and in the BTA

Habitat Type	CRN Site (ac)[(a)]	BTA (ac)[(b)]
Mixed Evergreen-Deciduous Forest	389	3
Deciduous Forest	279	117
Herbaceous Vegetation	202	--
Evergreen Forest	32	6
Wetlands	16	8
Grass/Pasture	--	14
Roads/Developed Areas	14	42
Ponds/Open Water	3	12
Shrubland	--	1
Barren	--	1
Total	935	204

(a) Habitat types and acreages on the CRN Site are based on aerial photography modified by the results of ecological field surveys (TVA 2017-TN5226).
(b) Habitat types and acreages for the BTA derive from general LULC data in TVA 2017-TN5226.

2.4.1.2 Upland Plant Communities and Habitat Types

Forest cover on the CRN Site and BTA consists mostly of deciduous forest (Table 2-9) (TNC 2003-TN5036). Most forest in Tennessee has undergone one or more timber harvests and is considered second-growth forest. Early successional habitats have been declining in Tennessee over recent decades due in part to farm abandonment and subsequent forest succession, changes in farming practices, urban encroachment, and the suppression of natural disturbances such as fire, and flooding (TWRA 2015-TN5042).

TVA initially estimated the approximate distribution of plant communities across the CRN Site and BTA using aerial photography and subsequently refined the distribution on the CRN Site using habitat descriptions from field surveys conducted in 2011 and 2013 (Cox et al. 2015-TN5193; TVA 2017-TN5226). TVA surveyed plant communities in the BTA in 2015 but did not use survey results to refine the aerial photography (Cox et al. 2015-TN5193; TVA 2017-TN5226). The surveys covered all lands included in the expected footprint of disturbance. Figure 2-27 depicts plant communities across the CRN Site based on aerial photography modified by habitat descriptions from field surveys and plant communities across the BTA based on LULC data.

TVA identified 178 plant species in the field surveys (Cox et al. 2015-TN5193). The more prominent of these species are noted below in the summary descriptions of the plant communities.

2.4.1.3 CRN Site

2.4.1.3.1 Mixed Evergreen-Deciduous Forest

This forest consists of a combination of evergreen and deciduous trees and accounts for approximately 389 ac of the CRN Site. It is dominated by oaks (black [*Q. velutina*] chestnut [*Q. montana*], northern red [*Q. rubra*], southern red [*Q. falcata*], and white [*Q. alba*]); hickories (mockernut [*C. tomentosa*], pignut [*C. glabra*], and shagbark [*C. ovata*]); and Virginia pine (*P. virginianus*) with sparse eastern redcedar (*Juniperus virginiana*). Blackgum (*Nyssa sylvatica*), ironwood (*Carpinus caroliniana*), and sourwood (*Oxydendrum arboreum*) are common understory species with black snakeroot (*Cimicifuga racemosa*), Christmas fern (*Polystichum acrostichoides*), little brown jug (*Hexastylis arifolia*), ebony spleenwort (*Asplenium platyneuron*), pennywort (*Hydrocotyle* sp.), running ground cedar (*Diphasiastrum digitatum*), spotted wintergreen (*Chimaphila maculata*), wood sorrel (*Oxalis* sp.) and yellow giant hyssop (*Agastache nepetoides*) in the groundcover (Cox et al. 2015-TN5193). The oldest forest parcels are likely to occur on ridgetops.

2.4.1.3.2 Deciduous Forest

This forest type consists of deciduous trees and accounts for approximately 279 ac of the CRN Site. Deciduous forest on the CRN Site is dominated by tulip poplar and includes American beech (*Fagus grandifolia*), white oak, and yellow buckeye (*Aesculus flava*). The understory is varied and includes American holly (*Ilex opaca*), Carolina buckthorn (*Rhamnus caroliniana*), flowering dogwood (*Cornus florida*), maple-leaf viburnum (*Viburnum acerifolium*), pawpaw (*Asimina triloba*), sassafras (*Sassafras albidum*), serviceberry (*Amelanchier arborea*), and wild black cherry (*Prunus serotina*). The herbaceous layer includes bishop’s cap (*Mitella diphylla*), blue cohosh (*Caulophyllum thalictroides*), blood root (*Sanguinaria canadensis*), dog-tooth violet (*Erythronium americanum*), foam-flower (*Tiarella cordifolia*), Jack-in-the-pulpit (*Arisaema triphyllum*), maidenhair fern (*Adiantum pedatum*), and Solomon’s seal (*Polygonatum biflorum*) (Cox et al. 2015-TN5193).

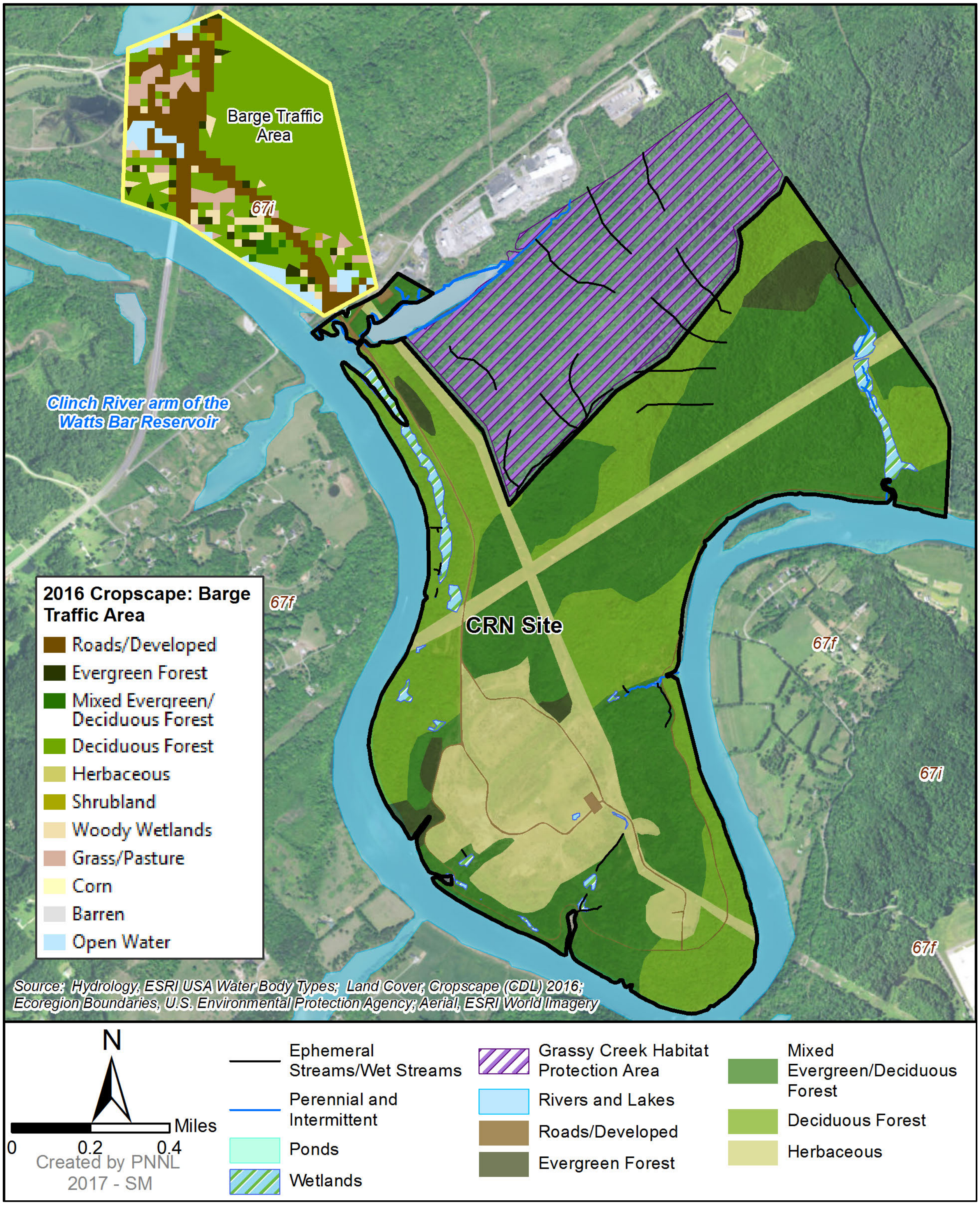


Figure 2-27. Plant Communities and Habitat Types across the CRN Site and BTA. CRN Site plant communities based on aerial photography modified by field mapping (TVA 2017-TN5226). BTA plant communities based on land-use/land-cover data.

A subtype of deciduous forest, calcareous forest, occurs in areas underlain by limestone, mostly in the Grassy Creek Habitat Protection Area and a few mesic slopes on the CRN Site adjacent to the Clinch River. Woody species include bladdernut (*Staphylea trifolia*), eastern redcedar, and eastern redbud (*Cercis canadensis*). Herbaceous species include Appalachian bugbane (*Cimicifuga rubifolia*), glade fern (*Diplazium pycnocarpon*), green violet (*Hybanthus concolor*), harbinger of spring (*Erigenia bulbosa*), Jacob's ladder (*Polemonium reptans*), twin-leaf (*Jeffersonia diphylla*), and walking fern (*Asplenium rhizophyllum*) (Cox et al. 2015-TN5193).

2.4.1.3.3 Old-Field Community

Approximately 240 ac of forest were previously cleared for the CRBRP (Cox et al. 2015-TN5193). Some of this land was revegetated with non-native herbaceous species such as sericea lespedeza (*Lespedeza cuneata*) and tall fescue (*Schedonorus arundinaceus*). These areas are undergoing succession and now support a number of old-field species such as black-eyed Susan (*Rudbeckia hirta*), blunt broom sedge (*Carex tribuloides*), Canada goldenrod (*Solidago missouriensis*), Johnson grass (*Sorghum halepense*), Queen Anne's lace (*Daucus carota*), and tickseed (*Coreopsis* sp.). Eastern redcedar seedlings and saplings are present throughout (Cox et al. 2015-TN5193). Sericea lespedeza sprouts dense stems from rootcrowns that slow forest succession and may remain viable for decades (see local invasive plant species listed in Section 2.4.1.10.2). Revegetation with this species may have contributed to the relatively slow rate of forest regeneration in the area disturbed by the CRBRP. Currently, the herbaceous community type accounts for approximately 202 ac of the CRN Site.

2.4.1.3.4 Evergreen Forest

This forest type consists of remnant loblolly pine (*Pinus taeda*) and white pine (*Pinus strobus*) plantations (Cox et al. 2015-TN5193). This forest type accounts for approximately 32 ac on the CRN Site (Table 2-9).

2.4.1.4 BTA

2.4.1.4.1 Deciduous Forest

Deciduous forest in the BTA is described as dry upland forest. Common overstory species include American beech, black gum (*Nyssa sylvatica*), chestnut oak, mockernut hickory, red maple (*Acer rubrum*), scarlet oak (*Quercus coccinea*), sourwood, umbrella magnolia (*Magnolia tripetala*), and white oak. The understory consists of flowering dogwood, lowbush blueberry (*Vaccinium angustifolium*), and mountain laurel (*Kalmia latifolia*). Herbaceous plants are sparse and include Christmas fern, muscadine grape (*Vitus rotundifolia*), and wild yam (*Dioscorea villosa*) (Dattilo 2015-TN5283). This forest type accounts for approximately 117 ac of the BTA.

2.4.1.4.2 Herbaceous Community

Open fields and transmission line corridors account for most of the herbaceous vegetation in the BTA. Most of these areas are dominated by early successional plants including many non-native species. Common species include Japanese honeysuckle (*Lonicera japonica*), lobed tickseed (*Coreopsis auriculata*), sericea lespedeza, showy goldenrod (*Solidago* sp.), Small's ragwort (*Packera anonyma*), southern blackberry (*Rubus argutus*), and winged sumac (*Rhus copallinum*) (Dattilo 2015-TN5283). The herbaceous community accounts for approximately 14 ac of the land area of the BTA.

2.4.1.5 Underground 69-kV Transmission Line Route

Terrestrial resources within the existing overhead 500-kV transmission line corridor where the proposed 69-kV line would be buried compose a scrub-shrub/grassland community similar to the old-field and herbaceous communities described above for the CRN Site and BTA, respectively (TVA 2017-TN4921, TVA 2016-TN5145). Vegetation is typical of maintained right-of-ways in the region. Terrestrial resources within the expansion area (about 0.33 ac) of the existing Bethel Valley Substation (Figure 2-27) (TVA 2017-TN4921, TVA 2016-TN5145) also consist of a similar scrub-shrub/grassland community.

2.4.1.6 Wetlands

The USACE regulates development activities in wetlands under CWA Section 404 (33 U.S.C. § 1251 *et seq*.-TN662). The State of Tennessee regulates development activities in wetlands under the Water Quality Control Act (T.C.A. § 69-3-101 *et seq*.-TN4914), which is implemented by TDEC. The dredge-and-fill permit program of the CWA and the State water-quality control regulations work together to ensure that all activities in wetlands are regulated.

As indicated in their application (TVA 2017-TN4921), TVA delineated wetlands in 2011 and 2015 using routine USACE procedures (USACE 1987-TN2066, USACE 2010-TN5325), which require documentation of hydrophytic vegetation, hydric soil, and wetland hydrology. TVA used the TVA Rapid Assessment Method to assess wetland condition (Mack 2001-TN5289). The TVA Rapid Assessment Method scores use six criteria to assess wetland condition: wetland area/size; upland buffers and surrounding land use; hydrology; habitat alteration and development; special wetlands (biodiversity); and plant communities, interspersion, and microtopography (surface features of an area on a small scale). These six metrics correspond to wetland indicator functions that can be used to differentiate wetlands based on three condition categories (Pilarski-Hall and Lees 2015-TN5299):

- Category 1 wetlands are “limited quality waters” because they are degraded, have limited potential for restoration, and have relatively low functionality.
- Category 2 includes wetlands of moderate quality that are degraded but exhibit reasonable potential for restoration.
- Category 3 generally includes wetlands of very high quality or of concern regionally and/or statewide, such as wetlands that provide habitat for threatened or endangered species (Pilarski-Hall and Lees 2015-TN5299).

2.4.1.6.1 CRN Site

TVA delineated 12 wetlands (Figure 2-19 and Table 2-10) on the CRN Site between January and May 2011 (Pilarski-Hall and Lees 2015-TN5299). USACE verified this wetland delineation in September 2013 (Pilarski-Hall and Lees 2015-TN5299). Prior to or concurrent with issuing a Department of the Army permit, the USACE will issue a jurisdictional determination verifying which wetlands and other waters are jurisdictional under the CWA.

Most wetland acreage on the CRN Site is forested (Table 2-10). Most forested wetlands occur along the reservoir shoreline and in the riparian areas of tributaries (Figure 2-19). Forested wetlands may be monotypic or occur in combination with scrub/shrub and emergent wetlands. Most forested wetland acreage is part of the deciduous forest complex described above, although forested wetlands are discussed separately here (TVA 2017-TN4921). Wetland forest is generally dominated by woody species such as American sycamore, black willow (*Salix nigra*), buttonbush (*Cephalanthus occidentalis*), silky dogwood (*Cornus amomum*), and tag alder (*Alnus serrulata*). Persimmon (*Diospyros virginiana*), box elder (*Acer negundo*), Chinese privet (*Ligustrum sinense*), false indigo bush (*Amorpha fruticosa*), multiflora rose (*Rosa multiflora*), and silver maple (*Acer saccharinum*) are also common along the reservoir. Herbaceous species such as netted chain fern (*Woodwardia areolata*), jewelweed (*Impatiens capensis*), lizard's tail (*Saururus cernuus*), poison hemlock (*Conium maculatum*), rose mallow (*Hibiscus moscheutos*), water willow (*Decodon verticillatus*), yellow flag (*Iris pseudacorus*), and several species of grasses (family Poaceae), rushes (family Juncaceae), and sedges (family Cyperaceae) are also present (Cox et al. 2015-TN5193).

Emergent wetlands on the CRN Site support a mosaic of monotypic patches of vegetation dominated by squarestem spikerush (*Eleocharis quadrangulata*), broad-leaf cattail (*Typha latifolia*), softstem bulrush (*Schoenoplectus tabernaemontana*), tall fescue, and rushes (*Juncus* spp.). Small black willow trees grow amid the herbaceous vegetation (Pilarski-Hall and Lees 2015-TN5299).

Table 2-10. Type, Condition, and Size of Wetlands on the CRN Site and in the BTA. Adapted from TVA (Pilarski-Hall and Lees 2015-TN5299; Pilarski-Hall and Kennon 2015-TN5290).

Wetland Number	Wetland Type[(a)]	TVA Condition Category[(b)]	Size (ac)
CRN Site			
W001	PF01E	2	0.67
W002	PEM1E	1	0.13
W003	PF01E	2	0.18
W004	PF01E	2	0.24
W005	PF01E	2	0.36
W006	PEM1E/PSS1E	2	0.11
W007	PSS1E/PF01E	2	0.17
W008	PF01E	2	0.23
W009	PEM1E/PSS1E/PFO1E	3	5.66
W010	PEM1E/PSS1E/PFO1E	2	1.79
W011	PF01E	3	5.87
W012	PEM1E	1	0.13
Total			15.54
BTA			
W013	PSS1E/PEM1E	2	3.73
W014	PSS1E/PEM1E	2	3.05
W015	PF01E	2	1.95
W016	PEM1E	2	0.11
W017	PSSHh	3	1.33
Total			10.17

PEM1E = palustrine emergent, persistent vegetation, seasonally flooded/saturated; PFO1E = palustrine forested, broad-leaved deciduous vegetation, seasonally flooded/saturated; PSS1E = palustrine scrub-shrub, broad-leaved deciduous vegetation, seasonally flooded/saturated; PSSHh = palustrine scrub-shrub, broad-leaved deciduous vegetation, permanently flooded, diked/impounded.

Wetlands associated with the reservoir support diverse plant species and communities and provide functions such as shoreline stabilization, retention of sediments, removal or transformation of contaminants, nutrient cycling, provision of fish and wildlife habitat, and flood flow alteration. In its Watts Bar Reservoir Land Management Plan EIS, TVA considers wetlands in the CRBRP footprint area particularly important for provision of the above functions (TVA 2009-TN4997). Most wetlands on the CRN Site are small and of moderate quality (Pilarski-Hall and Lees 2015-TN5299). Two wetlands are considered to be of low quality because they are small and they have been severely degraded (Pilarski-Hall and Lees 2015-TN5299). Wetland Nos. 9 and 11 (Figure 2-19) are considered to be of high quality because of their size, habitat integrity, and plant community diversity (Pilarski-Hall and Lees 2015-TN5299). Wetland Nos. 9 and 11 compose more than two-thirds of the wetland habitat on the CRN Site.

2.4.1.6.2 BTA

TVA delineated and characterized five wetlands in the BTA in April 2015 (Figure 2-19) (Pilarski-Hall and Kennon 2015-TN5290). As for the CRN Site, the USACE has not issued a jurisdictional determination for the BTA (Table 2-10). Before issuing any Department of the Army permit, the USACE would issue a jurisdictional determination verifying which wetlands and other waters of the United States are jurisdictional under the CWA (33 U.S.C. § 1251 *et seq*.-TN662). The type, size, and TVA Rapid Assessment Method condition category of each wetland are provided in Table 2-10.

Most wetland acreage in the BTA supports scrub-shrub vegetation (Table 2-10), situated as narrow strips along streams within pronounced valleys and swales. Some of the scrub-shrub wetland vegetation is located under overhead transmission lines and is maintained by transmission corridor vegetation management practices (Pilarski-Hall and Kennon 2015-TN5290). This wetland vegetation is dominated by saplings such as green ash *(Fraxinus pennsylvanica),* American sycamore, and black willow, with broom panicgrass (*Dicanthelium scoparium),* silky dogwood, giant river cane (*Arundinaria gigantea*), common rush (*Juncus effusus),* swamp rose (*Rosa palustris),* southern blackberry, red maple seedlings, and swamp dock (*Rumex verticillatus*) (Pilarski-Hall and Kennon 2015-TN5290). Forested wetland overstory species include American sycamore, black willow, green ash, red maple, and sweetgum (*Liquidambar styraciflua*) (Pilarski-Hall and Kennon 2015-TN5290). Several small emergent wetlands support native species, including buttonbush, common rush, groundnut (*Apios americana*), jewelweed, lizard's tail (*Saururus cernuus*), shallow sedge (*Carex lurida*), silky dogwood, squarrose sedge (*Carex squarrosa*), and false indigo bush (Pilarski-Hall and Kennon 2015-TN5290).

Most of the wetlands in the BTA are considered to be of moderate quality (Table 2-10) (Pilarski-Hall and Kennon 2015-TN5290). However, wetland No. 17 (Figure 2-19) is considered to be of high quality (Table 2-10) because it exhibits wetland hydrology, hydric soils, and hydrologic connectivity to a navigable waterway (Clinch River Arm of Watts Bar Reservoir) (Pilarski-Hall and Kennon 2015-TN5290).

2.4.1.7 Wetlands Along Underground 69-kV Transmission Line Route

Based on the U.S. Fish and Wildlife Service (FWS) National Wetlands Inventory (FWS 2017-TN5300), within the approximately 350-ft-wide 500-kV corridor where the proposed 69-kV underground line would be installed there is one forested/shrub wetland (PF01A) that extends about 50 ft within the corridor. The corridor also crosses four streams. Each stream is conservatively assumed to support narrow fringe wetlands. TVA does not plan to delineate and further characterize wetlands within the corridor until the COL stage.

2.4.1.8 Floodplains

Watts Bar Reservoir permanently inundates the historic floodplain of the Clinch River at the CRN Site and BTA. Water is released from the lake annually in the fall to create storage capacity during winter runoff for flood control. During this time, generally a narrow (~20 ft) margin of mudflat shoreline becomes exposed, which is up-gradient of the continually submerged historic floodplain. The lake begins to fill during the winter, submerging the exposed narrow shoreline by spring where it remains inundated through the growing season. This narrow margin of shoreline that is exposed and inundated annually does not function biologically as a floodplain.

U.S. Federal Emergency Management Agency maps depict floodplains for the 1 percent and 0.2 percent chance annual flood zones based on current reservoir operations (i.e., they do not include the historic river floodplain) (Figure 2-5) (TVA 2017-TN4922). These floodplains are in low-lying areas along the reservoir shoreline or along connecting streams near their confluence with the reservoir (see EIS Section 2.2.1); they extend beyond the lateral ~20 ft of mudflat that is typically exposed and inundated annually as described above, and appear to be associated with wetlands along the reservoir (Figure 2-19). Portions of the BTA lie within both the 1 percent and 0.2 percent annual flood zones. Flooding potential exists in the immediate vicinity of the CRN Site along the banks of the Clinch River arm of Watts Bar Reservoir at elevations of up to 752 ft NAVD88 (0.2 percent chance annual flood) (TVA 2017-TN4922).

2.4.1.9 Wildlife

TVA conducted a series of wildlife field surveys on the CRN Site in April, May, and July of 2011 and in February, April, July, and October of 2013, and in the BTA in November of 2014 and January, April, and June of 2015 (TVA 2017-TN4921). A variety of detection methods (e.g., visual, acoustic, ultrasonic, traps) were used along transects that covered a variety of habitat types on the CRN Site and the BTA; these methods are detailed by LeGrand et al. (2015-TN5188) and Hamrick (2015-TN5187). A total of 156 bird, mammal, reptile, and amphibian species were visually observed, heard, trapped, or noted based on sign, and/or acoustically detected across one or more seasons using one or more sampling methods on the CRN Site and in the BTA (Hamrick 2015-TN5187; LeGrand et al. 2015-TN5188). Each of these groups of wildlife is discussed below.

2.4.1.9.1 Mammals

Twenty-seven mammal species were observed on the CRN Site and in the BTA. Other than bats, the species include those relatively common in the area in which building and operating activities will occur at the CRN Site and in the State of Tennessee (TNHP 2016-TN5295). The habitat affinities of the species listed below are provided parenthetically:

- beaver (*Castor canadensis*) (streams, rivers, lakes, ponds)
- white-tailed deer (*Odocoileus virginianus*) (general, i.e., species has a broad range of habitat affinities)
- coyote (*Canis latrans*) (general)
- eastern gray squirrel (*Sciurus carolinensis*) (deciduous forest, general)

- eastern chipmunk (*Tamias striatus*) (general)
- eastern cottontail (*Sylvilagus floridanus*) (brush thickets, hedgerows, general)
- raccoon (*Procyon lotor*) (forest, general)
- Virginia opossum (*Didelphis virginiana*) (general)
- red fox (*Vulpes vulpes*) (brush thickets, hedgerows, agricultural lands, old-field)
- short-tailed shrew (*Blarina brevicauda*) (general)
- elk (*Cervus elaphus*) (mosaic of forested and open habitats)
- hispid cotton rat (*Sigmodon hispidus*) (early successional habitats within open woods)
- muskrat (*Ondatra zibethicus*) (swamps, marshes, rivers, ponds, lakes, drainage ditches, and canals)
- deer mouse (*Peromyscus maniculatus*) (general)
- striped skunk (*Mephitis mehphitis*) (general)
- white-footed mouse (*Peromyscus leucopus*) (brushy fields and deciduous forest, general).

Eleven bat species were observed. The general habitat, maternity and day roost, and hibernation preferences of the five relatively common bat species (TNHP 2016-TN5295) are summarized parenthetically in the following list:

- big brown bat (*Eptesicus fuscus*) (deciduous forest, maternity and day roosts in buildings and tree hollows, hibernation in mines, caves, rock crevices, and buildings)
- eastern red bat (*Lasiurus borealis*) (deciduous forest, maternity and day roost and hibernation in tree foliage)
- evening bat (*Nycticeius humeralis*) (maternity and day roosts in buildings or tree cavities or under loose bark, hibernation unknown)
- hoary bat (*Lasiurus cinereus*) (forests, maternity and day roosts and hibernation in tree foliage and cavities)
- silver-haired bat (*Lasionycteris noctivagans*) (mature forests, maternity roosts in tree cavities, day roosts and hibernation under loose bark and in buildings, caves, mines, rock crevices [BCI 2017-TN5294; Menzel et al. 2003-TN5293; TNBWG 2017-TN5043]).

The other six bat species are considered rare and to be of conservation concern by the State of Tennessee (TNHP 2016-TN5295) and/or the FWS and are discussed in EIS Section 2.4.1.11.

2.4.1.9.2 Birds

One hundred six bird species were observed on the CRN Site and in the BTA (Hamrick 2015-TN5187). A general description of each group of avian species using representative species observed is provided below, including a description of forest interior dwelling species.

Four waterfowl species were observed: Canada goose (*Branta canadensis*), mallard duck (*Anas platyrhynchos*), American black duck (*Anas rubripes*), and wood duck (*Aix sponsa*) (Hamrick 2015-TN5187). The wood duck is present year-round while the other three species are present primarily during winter (Cornell 2015-TN4433). The Clinch River arm of Watts Bar Reservoir provides habitat for waterfowl.

Two wading bird species were observed: great blue heron (*Ardea herodias*) and black-crowned night heron (*Nycticorax nycticorax*); and two shorebirds were observed: killdeer (*Charadrius vociferus*) and spotted sandpiper (*Actitis macularius*) (Hamrick 2015-TN5187). The great blue heron and killdeer are present year-round (Cornell 2015-TN4433). The spotted sandpiper is on the southern limit of its breeding range in northeastern Tennessee (Cornell 2015-TN4433). The black-crowned night heron is not typically present in the area but was sighted opportunistically (Hamrick 2015-TN5187).

Other water bird species observed included belted kingfisher (*Megaceryle alcyon*), Bonapart's gull (*Chroicocephalus philadelphia*), and double-crested cormorant (*Phalacrocorax auritus*) (Hamrick 2015-TN5187). Bonapart's gull is a migrant and the double-crested cormorant winters in the area (Cornell 2015-TN4433). Kingfishers are present in the area year-round (Cornell 2015-TN4433).

Four upland game species were observed: wild turkey (*Meleagris gallopavo*), mourning dove (*Zenaida macroura*), rock dove (*Columba livia*), and Eurasian collared dove (*Bonasa umbellus*) (Hamrick 2015-TN5187). All four species are year-round residents (Cornell 2015-TN4433). The rock dove and Eurasian collared dove are introduced species. The wild turkey inhabits forest habitat while the mourning dove, Eurasian collared dove, and rock dove are birds of open areas, fields, and pastures.

Ten birds of prey were observed: black vulture (*Coragips atratus*), Cooper's hawk (*Accipiter cooperii*), red-shouldered hawk (*Buteo lineatus*), red-tailed hawk (*Buteo jamaicensis*), turkey vulture (*Cathartes aura*), osprey (*Pandion haliaetus*), sharp-shinned hawk (*Accipiter striatus*), bald eagle (*Haliaeetus leucocephalus*), and two owl species, great horned owl (*Bubo virginianus*) and barred owl (*Strix varia*) (Hamrick 2015-TN5187). The barred owl and red-shouldered hawk are forest birds. The red-tailed hawk is a bird of open habitats. The black vulture, Cooper's hawk, turkey vulture, and great horned owl are habitat generalists. The osprey is a species that prefers habitat near relatively large waterbodies. All these species occur year-round in the area of the CRN Site (Cornell 2015-TN4433). An osprey nest was observed on a transmission line structure along the right-of-way corridor that crosses the Clinch River property (Hamrick 2015-TN5187). Sharp-shinned hawk and bald eagle are considered to be of conservation concern in the State of Tennessee (TNHP 2016-TN5295) and are discussed in EIS Section 2.4.1.3.

Seven woodpecker species were observed: downy woodpecker (*Picoides pubescens*), hairy woodpecker (*Picoides villosus*), pileated woodpecker (*Dryocopus pileatus*), red-bellied woodpecker (*Melanerpes carolinus*), northern flicker (*Colaptes auratus*), yellow-bellied sapsucker (*Sphyrapicus varius*), and red-headed woodpecker (*Melanerpes erythrocephalus*) (Hamrick 2015-TN5187). All species except the yellow-bellied sapsucker are year-round residents and are assumed to breed in the vicinity (Cornell 2015-TN4433). The yellow-bellied sapsucker is present in winter (Cornell 2015-TN4433). The red-headed woodpecker is currently declining in the eastern United States (Cornell 2015-TN4433).

Roughly two-thirds of the avian species observed were perching birds (or passerines). Perching birds may be resident breeders, stopover migrants that breed further north, or year-long residents. Some of the most common (TNHP 2016-TN5295) perching bird species that may breed in the area of the CRN Site that were not noted above include American crow (*Corvus* *brachyrhynchos*), blue jay (*Cyanocitta cristata*), Carolina chickadee (*Poecile carolinensis*), Carolina wren (*Thryothorus ludovicianus*), tufted titmouse (*Baeolophus bicolor*), ruby-throated hummingbird (*Archilochus colubris*), yellow-billed cuckoo (*Coccyzus americanus*), white-eyed vireo (*Vireo griseus*), chuck-wills-widow (*Antrostomus carolinensis*), and tree swallow (*Tachycineta bicolor*) (Hamrick 2015-TN5187).

Parr et al. (2015-TN5151) defined forest interior habitat for the ORR as consisting of at least 10 ac of interior forest surrounded by a 200-m (660-ft) forest buffer from the nearest forest edge (e.g., road, utility corridor). Edge effects have been observed up to 200 m into the forest from the forest edge on the ORR. The 10 ac plus the 200-m buffer is considered a minimum threshold for the presence of deep forest wildlife species on the ORR, including forest interior birds. The CRN Site completely contains one such forest interior area and overlaps a large part of two other forest interior areas that extend into forest offsite. The BTA neither contains nor overlaps part of forest interior habitat.

Forest interior breeding birds need relatively large contiguous tracts of forest to support viable breeding populations, although they may also breed in less than optimum conditions and may also occur in habitats other than forest interior habitat. Seventeen forest interior breeding birds were documented on the CRN Site: Acadian flycatcher (*Empidonax virescens*), black-and-white warbler (*Mniotilta varia*), black-throated green warbler (*Dendroica virens*), blue-gray gnatcatcher (*Polioptila caerulca*), Canada warbler (*Wilsonia canadensis*), hooded warbler (*Wilsonia citrina*), Kentucky warbler (*Oporomis formosus*), Louisiana waterthrush (*Seiurus motacilla*), northern parula (*Parula americana*), prothonotary warbler (*Protonotaria citrea*), red-eyed vireo (*Vireo olivaceus*), scarlet tanager (*Piranga olivacea*), whip-poor-will (*Caprimulgus vociferous*), wood thrush (*Hylocichla mustelina*), worm-eating warbler (*Helmitheros vermivorus*), yellow-throated vireo (*Vireo flavifrons*), and yellow-throated warbler (*Dendroica dominica*) (Hamrick 2015-TN5187). All these species, except the black-throated green warbler and Canada warbler, are summer residents in the area of the CRN Site. The black-throated green warbler and Canada warbler are present during migration (Cornell 2015-TN4433).

2.4.1.9.3 Amphibians and Reptiles

Observations included 10 amphibian (9 frog and toad and 1 salamander) species and 13 reptile (9 turtle and 4 snake) species (LeGrand et al. 2015-TN5188). Frogs and toads included bullfrog (*Rana catesbeiana*), American toad (*Bufo americanus americanus*), green frog (*Lithobates clamitans*), gray treefrog (*Hyla versicolor*), eastern narrow-mouthed toad (*Gastrophryne carolinensis*), pickerel frog (*Lithobates palustris*), southern leopard frog (*Lithobates sphenocephala utricularia*), northern spring peeper (*Pseudacris crucifer crucifer*), and upland chorus frog (*Pseudacris feriarum*). The habitats of the frogs and toads on the CRN Site range from fully aquatic (e.g., bullfrog) to semi-aquatic (e.g., toad species and treefrogs). All species of frogs and toads observed during the surveys (LeGrand et al. 2015-TN5188) are closely tied to the water habitats where they reproduce (e.g., wetlands, temporary pools, and low-gradient streams and rivers). Further, with the exception of the bullfrog, all make extensive use of adjacent terrestrial habitats (e.g., forest, herbaceous) as juveniles and adults. The eastern red spotted newt (*Notophthalmus viridescens*) is semi-aquatic.

Turtles included northern map turtle (*Graptemys geographica*), snapping turtle (*Chelydra serpentina*), Cumberland slider (*Trachemys scripta troostii*), eastern box turtle (*Terrapene carolina carolina*), Ouachita map turtle (*Graptemys ouachitensis*), painted turtle (*Chrysemys picta*), red-eared slider (*Trachemys scripta elegans*), eastern river cooter (*Pseudemys concinna*), and spiny softshell turtle (*Apalone spinifera*) (LeGrand et al. 2015-TN5188). The habitats of turtles on the CRN Site include aquatic habitats ranging from rivers and streams to stillwater habitats such as wetlands. The lifestyles of these turtles range from semi-aquatic (box turtle) to mostly aquatic (other eight species). All nine turtle species leave the water to nest and to bask. Nesting (egg deposition) is accomplished in soft substrates near water. Hibernation/burrowing during inactive periods may occur in soft soil or in fallen logs/debris, soft substrates underwater, or under rocks or in holes in banks, depending on the species and habitat availability.

Snakes observed include black rat snake (*Pantherophis obsoletus),* corn snake *(Pantherophis guttatus),* eastern worm snake *(Carphophis amoenus amoenus),* and northern water snake (*Nerodia sipedon sipedon) (LeGrand et al. 2015-TN5188).* The snake habitats on the CRN Site range from mostly aquatic (northern watersnake) to entirely terrestrial (corn snake, worm snake). All four snake species spend periods of inactivity underground or in crevices or burrows, and they deposit eggs in soil, litter, debris, or abandoned mammal burrows.

2.4.1.10 Terrestrial Resources – Offsite Areas

2.4.1.10.1 Offsite Transmission Line Corridors

This section describes terrestrial resources within the offsite 161-KV transmission lines where TVA anticipates possible upgrades (uprates, reconductorings, or rebuilds) (Figure 2-8 and Table 2-11). TVA manages vegetation within the right-of-way lands as predominantly scrub-shrub/herbaceous communities consisting of plant and animal species such as those described in EIS Section 2.4.1.1 for similar communities on the CRN Site and the BTA (TVA 2016-TN5145). General categories of terrestrial resources in the transmission line segments that may be uprated, reconductored, or rebuilt are listed in Table 2-11.

Table 2-11. Terrestrial Resources within Transmission Line Segments that May Be Uprated, Reconductored, or Rebuilt

Number/Name	Modification	Resource Description
L5092 Volunteer-N Knoxville No 1	Rebuild	Wetlands (potential and field verified)
L5125 Norris HP–Lafollette-Pineville (Including Sweet Gum Flats)	Reconductor	Wetlands (potential)
		Cumberland Trail State Park
		North Cumberland State Wildlife Management Area (WMA)
		Corrigan WMA, Kentucky
		Kentucky Ridge Forest WMA
L5167 Winchester–Smith Mountain SW STA (Including Pelham, Coalmont)	Uprate	Wetlands (potential)
L5173 Watts Bar HP–Great Falls HP (Including Pikeville)	Uprate	Special botanical occurrence
		Wetlands (potential)
		Bledsoe State Forest
		Fall Creek Falls State Park
		Rock Island State Park

Table 2-11. (contd)

Number/Name	Modification	Resource Description
L5186 John Sevier FP–Cherokee HP No 1	Uprate	Wetlands (potential, field verified 2013) Grainger County Park
L5204 Monterey–Peavine SW STA 161 KV (Including Campbell Junction, Fredonia, Crossville, W Crossville)	Reconductor	Wetlands (potential)
L5205 Rockwood–Peavine SW STA (Including Crossville)	Uprate	Wetlands (potential)
L5205 Rockwood–Peavine SW STA (Including Crossville)	Uprate	Cumberland Trail State Park
L5235 Elza–Spallation Neutron Source	Reconductor	Wetlands (potential) Oak Ridge National Laboratory (ORNL) and Oak Ridge Reservation (ORR)
L5280 Oak Ridge National Laboratory–Spallation Neutron Source 161 KV	Reconductor	Wetland (jurisdictional [field delineated] and potential) ORNL and ORR
L5624 John Sevier FP-White Pine No 2 (Incl Greenville)	Uprate	Wetlands (field verified 2013 and potential)
L5659 Bull Run FP–N Knoxville No 1	Reconductor	Wetlands (potential) Brushy Valley Park Upper Bull Run Bluffs TVA Habitat Protection Area
L5697 Oglethorpe–Concord (Including Cloud Springs)	Reconductor	Wetlands (potential)
L5702 Franklin–Winchester	Reconductor	Wetlands (potential) Woods State Wildlife Management Area Arnold Engineering Development Center Double Powerline Barrens
L5743 Kingston FP–Rockwood-Roane No 1 (Including Harriman, K33)	Reconductor	Heronry Wetlands (potential) ORNL and ORR
L5882 Elza–Huntsville (Including Braytown, Windrock)	Uprate/ Reconductor	Wetlands (potential) Big South Fork National River Recreation Area, National Park Service North Cumberland State WMA ORNL and ORR
L5940 White Pine–Dumplin Valley	Uprate	Wetlands (potential)
L5957 Douglas HP–White Pine (Including Newport)	Reconductor	Bald eagle Wetlands (potential) Rankin Bottoms State WMA & Wildlife Observation Area

The Bethel Valley Substation expansion area would comprise about 0.33 ac at a location that has been previously disturbed (NRC 2018-TN5386). The area is part of a herbaceous community that likely consists of plant and animal species such as those described above for such communities on the CRN Site and in the BTA. The entire expansion would occur in an area that is sloped and would require fill.

2.4.1.10.2 Offsite Borrow Areas

In addition to potentially using borrow material from the CRN Site, TVA indicated that nine existing borrow pits (Figure 2-9) totaling 227 ac may be used to support construction activities. The volume of fill material and selection of the source for fill material would be dependent on the backfill plan and the required material properties identified by analyses performed in support of the COL (TVA 2016-TN5145).

2.4.1.11 Important Species and Habitats

The NRC has defined important species as those that are rare or meet other specific criteria for deserving individualized evaluation (NRC 2000-TN614). The NRC has defined rare species as Federally threatened or endangered species and those proposed or candidates for listing as threatened or endangered (NRC 2000-TN614). The FWS identifies Federally threatened or endangered species in Title 50 of the *Code of Federal Regulations* Part 17 (TN1648), Section 11 (50 CFR 17.11) and 50 CFR 17.12. Rare species also include those listed as threatened, endangered, or of concern by State agencies (NRC 2000-TN614). Thus, in Tennessee, rare (or important) species include those listed as threatened, endangered, in need of management (refers only to non-game wildlife), or of special concern (refers only to plants), or species that are proposed for listing in one of those categories. In Tennessee, rare (or important) species also include those that have a State rank indicating rarity and conservation concern; i.e., extremely rare (S1; having 5 or fewer occurrences in the State), very rare (S2; having 6 to 20 occurrences in the State), or rare and uncommon (S3; rare, having 21 to 100 occurrences in the State). The NRC has also defined important species as those that are commercially or recreationally valuable, essential to the maintenance and survival of other species that are rare (as defined above by NRC and other agencies) or commercially or recreationally valuable, critical to the structure and function of the ecosystem, or biological indicators of environmental change (NRC 2000-TN614).

2.4.1.11.1 Clinch River Nuclear Site and Barge Traffic Area

In a letter dated April 20, 2017, the NRC requested that the FWS Field Office in Cookeville, Tennessee, provide information regarding Federally listed, proposed, and candidate species and critical habitat that may occur in the vicinity of the CRN Site (NRC 2017-TN5089). The FWS provided a response on May 5, 2017 (FWS 2017-TN5090) and an updated response on July 20, 2017 (FWS 2017-TN5091). The updated FWS letter contained a definitive list of species for the CRN Site and vicinity. The FWS requested the review team also consider the little brown bat and tri-colored bat (*Perimyotis subflavus*), species which may be listed under the ESA in the future, in a telephone conference held October 24, 2017 (PNNL 2017-TN5384). The NRC prepared a biological assessment (BA) (EIS Appendix M) that addresses these species in the vicinity of the CRN Site. Information for these species is summarized from the BA and provided below.

In an email dated August 18, 2017, the NRC requested that the Tennessee Natural Heritage Program (TNHP) provide a list of important species known to occur within 2 mi of the CRN Site, within 2 mi of the BTA, and within 0.125 mi on either side of the proposed 69-kV underground transmission line. On September 1, 2017 the TNHP provided a response email (TNHP 2017-TN5361). The TNHP (2017-TN5361) correspondence is used below to identify all important species with known occurrences in the vicinity of the CRN Site (Table 2-12).

Important Terrestrial Species

Indiana Bat (*Myotis sodalis*) – Federally Endangered (FE). The historic range of the Indiana bat includes much of the eastern United States, where the species has greatly declined (NatureServe 2017-TN5216). Significant threats to the Indiana bat include human-induced disturbance and alterations at hibernation sites; loss, fragmentation, and isolation of summer and fall swarming/spring staging habitat; contaminants (may affect bat health and decrease prey base); wind power development (collisions with equipment and barotrauma); and white-nose syndrome (WNS) (FWS 2007-TN934, FWS 2006-TN4167).

Bats enter hibernation by late November and survive on stored fat until spring (NatureServe 2017-TN5216). Before hibernation, and again during spring emergence, bats swarm around hibernation sites, hunt flying insects (NatureServe 2017-TN5216), and roost individually in surrounding forests (FWS 2007-TN934). Mating typically occurs during fall swarming and females store sperm through the winter (NatureServe 2017-TN5216). Reproductive females migrate from hibernacula to summer roosting habitat in late March and April. Fertilization occurs in spring, a single pup is born in June or July, and volancy occurs at 25 to 37 days of age (NatureServe 2017-TN5216). Nonreproductive female Indiana bats may remain close to their hibernaculum or migrate to summer habitat. Males are most commonly found in the vicinity of their hibernaculum but may also disperse throughout the summer range and roost individually or in small groups (FWS 2007-TN934).

In summer and fall, Indiana bats primarily use wooded or semi-wooded habitats, usually near water, and hunt flying insects along riparian areas, ponds, and wetlands, but also in upland forests and fields (NatureServe 2017-TN5216). Indiana bats generally roost under the exfoliating bark and occasionally in the longitudinal crevices within dead or nearly dead trees, and are only infrequently found using man-made structures (FWS 2007-TN934). A wide variety of tree species are used for maternity roosts and use is primarily related to the local availability of trees with suitable structure rather than a preference for a particular species. A roost tree study conducted by TVA in areas of forest cover on the CRN Site in January, April, and May 2011 found the site provided suitable roosting habitat (LeGrand et al. 2015-TN5188). The roost tree study did not include the BTA. Based on general observations of tree size and bark conditions made during the surveys of plant communities in the BTA in May 2015 (Cox et al. 2015-TN5193) (EIS Section 2.4.1.1), TVA has stated that the deciduous forest in the BTA should also be considered suitable Indiana bat roosting habitat.

Indiana bats were surveyed with mist nets and acoustically July 11–21, 2011, at eight locations across the CRN Site (LeGrand et al. 2015-TN5188). The species was surveyed acoustically in fall (October), spring (April), and summer (July) 2013 at six locations across the CRN Site (LeGrand et al. 2015-TN5188). The species was surveyed acoustically at four locations across the BTA in fall (November) 2014 and spring (April) and summer (June) 2015 (Hamrick 2015-TN5187; LeGrand et al. 2015-TN5188). The species was not detected with mist nets or acoustically in 2011 but was detected acoustically in 2013 both on the CRN Site and in the BTA (17 recordings on the CRN Site and 4 recordings in the BTA [note that multiple recordings may be from one individual]). Recordings from the BTA identified as belonging to the Indiana bat could not be considered definitive (Hamrick 2015-TN5187; LeGrand et al. 2015-TN5188). Because there were no mist-net captures and few acoustic recordings over three seasons, use of the CRN Site and BTA by the species for maternal roosting is also unlikely. The closest known Indiana bat maternity roost is in Cherokee National Forest in Blount County, at least 30 mi east of the CRN Site (TWRA 2017-TN5362). The CRN Site and BTA are most likely used for roosting and foraging by males and nonreproductive females, which roost singly or in small groups.

A roost tree study was conducted by TVA in areas of forest cover on the CRN Site in January, April, and May 2011, and the site was found to provide suitable roosting habitat (LeGrand et al. 2015-TN5188). The roost tree study did not include the BTA. Based on general observations of tree size and bark conditions made during the surveys of plant communities on the BTA in May 2015 (Cox et al. 2015-TN5193), TVA has stated that the deciduous forest in the BTA also should be considered suitable Indiana bat roosting habitat.

The first comprehensive acoustic survey of bats across the ORR was conducted by TDEC from April 15–October 31 in 2013 (TDEC 2014-TN5288). The Indiana bat was detected in areas across the ORR, including those closely surrounding the CRN Site (e.g., Grassy Creek in the northwest portion of the Grassy Creek Habitat Protection Area, and the junction of Bear Creek Valley Road and Highway 95 located just northeast of the CRN Site) and in the BTA (e.g., Gallaher Cemetery located just north of the BTA). Further, a male Indiana bat was captured on the ORR during a mist-net survey at Freels Bend in June 2013 (TDEC 2014-TN5288; McCracken et al. 2015-TN5287), confirming the species is present on the ORR during the nonhibernating season. This was the first confirmation of an Indiana bat on the ORR since 1950 (TDEC 2014-TN5288).

No known caves are located on the CRN Site or in the BTA; however, Rennies Cave and 2-Batteries Cave are located within the Grassy Creek Habitat Protection Area and there are three additional caves/karst openings near Grassy Creek (LeGrand et al. 2015-TN5188). Because the species was only detected in spring and summer but not fall (when swarming in the vicinity of a hibernaculum would occur), either on the CRN Site or in the BTA, a hibernaculum is currently likely not located in the immediate vicinity. The closest known Indiana bat hibernacula are Grassy Cove Saltpeter (Cumberland County) and White Oak Blowhole (Blount County, Smoky National Park), both more than 30 mi from the CRN Site (TWRA 2017-TN5362).

Further discussion of the life history of the Indiana bat is provided in the NRC's BA (Appendix M).

Northern Long-eared Bat (NLEB) (*Myotis septentrionalis*) – Federally Threatened (FT). The NLEB ranges over the eastern and north-central United States, (76 FR 38095-TN1798) and has experienced a 99 percent population reduction across the northeastern portion of its range due to WNS. The species was listed by FWS as threatened in 2015 in response to the effects of WNS (78 FR 61046-TN3207), which continues to spread across the remainder of the species' range.

NLEBs hibernate in caves or inactive mines (76 FR 38095-TN1798), but they may also overwinter in similar man-made structures (e.g., railroad tunnels, sewers, aqueducts, wells). The species enters hibernation in October and November, and leaves the hibernacula in March or April. Breeding occurs when males swarm hibernacula from late summer to early fall (78 FR 61046-TN3207) and may also occur during spring staging (76 FR 38095-TN1798). Fertilization of a single egg occurs in the spring after hibernation (78 FR 61046-TN3207). Birth of a single pup occurs in May to early June and volancy occurs in 21 days (78 FR 61046-TN3207).

Summer roosting habitat generally consists of late-successional forests with intact interior forest habitat, which typically provide a relatively large number of partially dead or decaying trees that the species uses for breeding, summer day roosting, and gleaning insects (76 FR 38095-TN1798). The species prefers forested hillsides and ridges for foraging, including hawking insects over small ponds and forest clearings under the forest canopy or along streams, and occasionally in forest clearings, over water, and along roads (76 FR 38095-TN1798; 78 FR 61046-TN3207). Summer habitat may also include some adjacent and interspersed non-forested habitats (e.g., old fields) as well as linear features (e.g., riparian forest) (78 FR 61046-TN3207).

During the summer, the species roosts underneath tree bark or in cavities or crevices of both live and dead trees (Johnson et al. 2011-TN1852; 78 FR 61046-TN3207). Females may form small maternity colonies (30 to 60 individuals) behind exfoliating bark (76 FR 38095-TN1798). Males typically roost singly and nonreproductive females roost singly or in small groups (76 FR 38095-TN1798) behind exfoliating bark, and both may also roost in caves and mines (78 FR 61046-TN3207). NLEBs likely are not dependent on certain tree species for roosts, but use trees that form suitable cavities or bark structure opportunistically.

Suitable summer forest habitat consists of a wide variety of wooded habitats where the species roosts, forages, and travels, and may include some adjacent and interspersed nonforested habitats such as emergent wetlands and adjacent edges of agricultural fields, oldfields, and pastures (80 FR 17974-TN4216). This includes forests and woodlots containing suitable roost trees (i.e., live trees and/or snags ≥3 in diameter at breast height that have exfoliating bark, cracks, crevices, and/or cavities), as well as linear features such as fencerows, riparian forests, and other wooded corridors with dense or loose aggregates of trees with variable amounts of canopy closure. NLEBs typically occupy summer habitat from mid-May through mid-August (80 FR 17974-TN4216). Spring staging/fall swarming habitat is similar and occurs near a hibernaculum (FWS 2014-TN4162). NLEBs typically occupy their spring staging/fall swarming habitat from between hibernation and migration to summer habitat and after migration to hibernacula but before hibernation (80 FR 17974-TN4216).

One individual was captured in mist nets in the summer of 2011 on the CRN Site, and there was a total of 25–32 acoustic recordings in spring, summer, and fall on the CRN Site and BTA in 2013 and 2015 (Hamrick 2015-TN5187; LeGrand et al. 2015-TN5188). The sex, age, and reproductive condition of the captured individual were not documented (LeGrand et al. 2015-TN5188). Because there was only one mist-net capture and few acoustic recordings over three seasons, use of the CRN Site and BTA by the species for maternal roosting is unlikely. The closest known NLEB maternity roost is in the Catoosa Wildlife Management Area (WMA) in Morgan County, at least 20 mi west of the CRN Site (TWRA 2017-TN5362). The CRN Site and BTA are most likely used for roosting and foraging by males and nonreproductive females, which roost singly or in small groups.

The NLEB was captured in mist nets on the ORR in 1997, 2006, 2011, and 2013 (McCracken et al. 2015-TN5287). The NLEB was also detected acoustically in areas across the ORR from April 15–October 31 in 2013 (TDEC 2014-TN5288), including those closely surrounding the CRN Site (e.g., Grassy Creek in the northwest portion of the Grassy Creek Habitat Protection Area, and the junction of Bear Creek Valley Road and SR 95 located just northeast of the CRN Site). None was detected near the BTA in 2013 (TDEC 2014-TN5288).

Thus, suitable habitat for the Indiana bat on the CRN Site and in the BTA (discussed above) is also suitable for the NLEB for summer and fall roosting and foraging. Acoustic recordings during fall may indicate the presence of a hibernaculum in the vicinity, but this is based on only four fall recordings. A hibernaculum about 8–9 mi away was discovered by TVA in January 2014 (LeGrand et al. 2015-TN5188), likely located in Marble Bluff Cave in Roane County (TWRA 2017-TN5362). Suitable habitat on the CRN Site and in the BTA likely also contains potential NLEB roost trees from 3 to 5 in. diameter at breast height that are unsuitable for the Indiana bat. There may also be early successional forest parcels on the CRN Site and in the BTA that were not considered in the Indiana bat roost tree study (discussed above) and would not provide suitable habitat for the Indiana bat because of a prevalence of smaller-diameter trees, but may provide suitable roosting habitat for the NLEB.

Further discussion of the life history of the NLEB is provided in the NRC's BA (Appendix M).

Gray Bat (*Myotis grisescens*) – Federally Endangered (FE). Gray bats occupy a limited geographic range in limestone karst areas of the southeastern United States. They are mainly found in Alabama, northern Arkansas, Kentucky, Missouri, and Tennessee (FWS 1997-TN5194). Gray bats are endangered largely because they live in very large numbers in only a few caves, making the species extremely vulnerable to disturbance (FWS 1997-TN5194).

With rare exceptions, gray bats live in caves year-round (FWS 1982-TN929; FWS 1997-TN5194). During the winter, the species hibernates in deep, vertical caves (FWS 1982-TN929; FWS 1997-TN5194) which act as cold air traps (FWS 1982-TN929). Most individuals migrate from hibernating to maternity caves, over distances of about 10 to 326 mi (FWS 1982-TN929). A wide variety of caves are used during the spring and fall transient period (FWS 1982-TN929). In summer, gray bats roost in caves that act as warm air traps and are scattered along rivers (FWS 1982-TN929; FWS 1997-TN5194). These caves are in limestone karst areas. They do not use human dwellings (FWS 1997-TN5194). Summer caves, especially maternity caves, are almost always located within 1 km (rarely more than 4 km) of a river or reservoir. A maternity colony may disperse from about 20 km to over several hundred kilometers of shoreline to feed. All bats fly in the protection of forest canopy between caves and foraging areas. Forested areas surrounding caves and between caves and over-water feeding habitat are advantageous for gray bat survival. Gray bat feeding areas have not been found over rivers or reservoirs where adjacent areas of forest have been cleared (FWS 1982-TN929). Foraging territories are used by the same individual bats from one year to the next (FWS 1982-TN929).

Upon arriving at hibernating caves in September and October, adults copulate and females immediately begin hibernation. Several weeks later juveniles of both sexes and adult males begin hibernation and most are in hibernation by early November. Adult females emerge from hibernation in late March or early April, followed by adult males and by juveniles of both sexes from mid-April to mid-May. Mortality is high in late March and April when fat reserves and food supply are low (FWS 1982-TN929).

Maternity colonies each occupy a traditional home range containing several roosting caves along about a 70--km stretch of river or reservoir shoreline (FWS 1982-TN929). Adult females store sperm over winter, become pregnant upon spring emergence, and give birth to a single young in late May or early June (FWS 1982-TN929; FWS 1997-TN5194). Reproductive females congregate in a single, traditional maternity cave, while males and nonreproductive females roost in peripheral caves. Most young begin to fly within 20–25 days after birth (FWS 1982-TN929).

One individual was captured in mist nets in summer on the CRN Site in 2011 and there was a total of 361–381 acoustic recordings in spring, summer, and fall on the CRN Site and in the BTA in 2013 and 2015 (Hamrick 2015-TN5187; LeGrand et al. 2015-TN5188). The sex, age, and reproductive condition of the captured individual were not documented (LeGrand et al. 2015-TN5188). No caves are known to be located on the CRN Site or BTA; however, Rennies Cave and 2-Batteries Cave are located within the Grassy Creek Habitat Protection Area and there are three additional caves/karst openings near Grassy Creek (LeGrand et al. 2015-TN5188). Thus, the species likely uses the CRN Site and BTA for foraging but does not roost there. Acoustic recordings during summer indicate the CRN Site and BTA may be part of a foraging territory for bats in a maternity or nonmaternity summer roost located somewhere offsite, likely within 1 km of the Clinch River. Acoustic recordings during spring and fall may indicate the presence of a hibernaculum in the vicinity. The five caves noted above have not been surveyed.

The gray bat was captured in mist nets on the ORR in 1996, 2006, 2011, and 2013 (McCracken et al. 2015-TN5287). The species was also detected acoustically in areas across the ORR from April 15–October 31 in 2013 (TDEC 2014-TN5288), including those closely surrounding the CRN Site (e.g., Grassy Creek in the northwest portion of the Grassy Creek Habitat Protection Area, the junction of Bear Creek Valley Road and SR 95 located just northeast of the CRN Site, and along the Clinch River between the CRN Site and Jones Island) and BTA (e.g., Gallaher Cemetery just north of the BTA) (TDEC 2014-TN5288).

Further discussion of the life history of the gray bat is provided in the NRC's BA (Appendix M).

Eastern Small-Footed Myotis (*Myotis leibii*) – State Status Rare (S2/S3). The eastern small-footed myotis is a small, insectivorous bat that hibernates in caves primarily under large rocks or in crevices and mine shafts in the winter, roosts in caves (or cracks and crevices in rock walls) and hollow trees (under bark) in the summer (PGC 2013-TN3845), and may use abandoned buildings, bridges, and barns seasonally (TDEC 2017-TN5217). Forest on the CRN Site and in the BTA may provide suitable summer roosting habitat for the species. Little is known about the species' reproductive behavior or habitat or food requirements because very few have been captured during summer.

The species was not caught in mist nets on the CRN Site in 2011, and was recorded acoustically onsite in spring and summer 2013 (LeGrand et al. 2015-TN5188). The species was not acoustically recorded in the BTA in 2015 (Hamrick 2015-TN5187). The species was also detected acoustically in areas across the ORR from April 15–October 31 in 2013 (TDEC 2014-TN5288), including those closely surrounding the CRN Site (e.g., Grassy Creek in the northwest portion of the Grassy Creek Habitat Protection Area, and east of the junction of Bear Creek Valley Road and SR 95 located northeast of the CRN Site). None was detected near the BTA in 2013 (TDEC 2014-TN5288). The species was also recorded on the ORR in 2014 and 2015 (McCracken et al. 2015-TN5287).

Tri-Colored Bat (*Perimyotis subflavus*) – Petitioned for listing under the ESA, State Status Rare (S2/S3). The tri-colored bat ranges across most of eastern North America. The species was petitioned for listing under the ESA in June 2016 (CBD and DoW 2016-TN5360). Threats to the species include WNS, habitat loss and degradation driven by agricultural and residential development, logging, mining and other resource extractive practices, industrial wind energy, environmental contaminants, and disturbance by vandalism and recreation. WNS has resulted in a dramatic drop in tri-colored bat populations throughout much of its range (greater than 98 percent in the northeastern United States) (CBD and DoW 2016-TN5360).

The tri-colored bat is an insectivorous bat that is found in a variety of terrestrial habitats, including grasslands, old fields, suburban areas, orchards, urban areas, and woodlands, especially hardwood woodlands. However, they generally avoid deep woods as well as large, open fields (CBD and DoW 2016-TN5360). The species prefers large trees and woodland edges (CBD and DoW 2016-TN5360; NatureServe 2017-TN5216), and often forages over waterways and forest edges (CBD and DoW 2016-TN5360; TNBWG 2017-TN5359).

Summer roosts are mainly in live and dead foliage in both live and dead deciduous and coniferous trees (CBD and DoW 2016-TN5360; TNBWG 2017-TN5359), and occasionally in buildings (NatureServe 2017-TN5216). Hibernation sites usually are in caves or mines (NatureServe 2017-TN5216; TNBWG 2017-TN5359). Mating occurs in autumn during swarming around hibernation sites, sperm are stored during winter, and fertilization takes place in early spring. The species usually bears twins in late spring or early summer (CBD and DoW 2016-TN5360; TNBWG 2017-TN5359).

Three individuals were caught in mist nets on the CRN Site in 2011 and the species was recorded acoustically on the CRN Site and BTA in spring, summer, and fall in 2013 and 2015 (LeGrand et al. 2015-TN5188). The species was the most prevalent species acoustically recorded in the BTA in 2015 (Hamrick 2015-TN5187). Recordings of the species in the fall may indicate a possible hibernaculum in the vicinity of the CRN Site or BTA. The species was also detected acoustically in areas across the ORR from April 15–October 31 in 2013 (TDEC 2014-TN5288), including those closely surrounding the CRN Site (e.g., Grassy Creek in the northwest portion of the Grassy Creek Habitat Protection Area, the junction of Bear Creek Valley Road and SR 95 located just northeast of the CRN Site, and along the Clinch River between the CRN Site and Jones Island) and BTA (TDEC 2014-TN5288). The species was also recorded on ORR in 2014 and 2015 (McCracken et al. 2015-TN5287).

Further discussion of the life history of the tri-colored bat is provided in the NRC's BA (EIS Appendix M).

Little Brown Bat (*Myotis lucifugus*) – Petitioned for listing under the ESA, no State status. This species was petitioned for listing under the ESA in 2010 (Kunz and Reichard 2010-TN5373). The range of the little brown bat extends across North America, from Alaska to central Mexico and from the Pacific to Atlantic coasts. The little brown bat was considered one of the most common and widespread bat species in North America. Its core range is considered the northeastern United States. The pre-WNS population of this species—both throughout its range and within its core northeastern range was viable. However, extinction is virtually certain to occur in the core range of this species by 2026, and range-wide extinction may very well follow based on the known and predicted infection dynamics of WNS (Kunz and Reichard 2010-TN5373).

Caves and mines serve as swarming sites during the autumn mating period and as hibernacula (NatureServe 2017-TN5216). The little brown bat swarms and mates at hibernacula and females store sperm during hibernation and fertilization occurs in spring after emergence (Kunz and Reichard 2010-TN5373). In spring, reproductive female bats form maternity colonies in barns, attics, and tree cavities. Nonreproductive females and adult males usually inhabit separate roosts individually or in small groups. A single pup is born during the late spring/early summer time frame. Pups are weaned and begin to fly at about 26 days (Kunz and Reichard 2010-TN5373). The little brown bat feeds on aerial insects over open water (Kunz and Reichard 2010-TN5373) and along the margins of lakes and streams, or in woodlands near water (NatureServe 2017-TN5216).

The species was not captured in mist nets on the CRN Site in 2011 (LeGrand et al. 2015-TN5188). It was recorded acoustically on the CRN Site and in the BTA in spring, summer, and fall in 2013 and 2015 (LeGrand et al. 2015-TN5188; Hamrick 2015-TN5187). Recordings of the species in the fall may indicate a possible hibernaculum in the vicinity of the CRN Site or BTA. The species was also detected acoustically in areas across the ORR from April 15–October 31 in 2013 (TDEC 2014-TN5288), including those closely surrounding the CRN Site (e.g., Grassy

Creek in the northwest portion of the Grassy Creek Habitat Protection Area, the junction of Bear Creek Valley Road and SR 95 located just northeast of the CRN Site, and along the Clinch River between the CRN Site and Jones Island) and BTA (e.g., Gallaher Cemetery just north of the BTA) (TDEC 2014-TN5288). The species was also recorded on the ORR in 2014 and 2015 (McCracken et al. 2015-TN5287).

Further discussion of the life history of the little brown bat is provided in the NRC's BA (EIS Appendix M).

Sharp-Shinned Hawk (*Accipiter striatus*) – Rare (S3B). The sharp-shinned hawk is considered a rare breeding bird in the State of Tennessee (TDEC 2017-TN5217) and may occur year-round in the area in which building and operating activities would occur at the CRN Site (Cornell 2015-TN4433) but was only observed in winter (LeGrand et al. 2015-TN5188). However, it is known to breed on the ORR (Roy et al. 2014-TN5154). It is a species that inhabits forests and open woodlands (TDEC 2017-TN5217). In summer, the species breeds in dense woods and during the non-breeding season hunts along forest edges (Cornell 2015-TN4433). Although the species was observed onsite only during winter, it may be assumed to potentially breed there due to plentiful suitable habitat.

Bald Eagle (*Haliaeetus leucocephalus*) – Rare (S3). The bald eagle is a bird of that inhabits aquatic ecosystems, frequenting major rivers, large lakes, reservoirs, estuaries, and some seacoast habitats. Fish are the major component of its diet, but waterfowl, seagulls, and carrion are eaten also. Bald eagles usually nest in large trees along shorelines in relatively remote areas that are free of disturbance (64 FR 36454-TN1848).

The bald eagle was previously listed as Federally Threatened but is now considered by the FWS to be recovered in the conterminous United States and was thus removed from the Federal list of endangered and threatened wildlife in 2007 (72 FR 37346-TN918). However, the bald eagle is still afforded Federal protection under the Bald and Golden Eagle Protection Act (16 U.S.C. § 668 *et seq*.-TN1447) and the Migratory Bird Treaty Act (16 U.S.C. § 703 *et seq*.-TN3331). Bald eagles were observed flying over the CRN Site and BTA in spring, summer, and fall but were not observed on these two sites. Numerous nests occur along Watts Bar Reservoir and the species may reside in nearby forested habitats. The closest documented nest is approximately 8 mi from the CRN Site on Watts Bar Reservoir (LeGrand et al. 2015-TN5188).

Shining Ladies'-Tresses (*Spiranthes lucida*) – Rare (S1S2). Shining ladies'-tresses occurs in alluvial woods and on moist slopes (TDEC 2017-TN5217). The species was located in 2000 at the southern end of the BTA (TVA 2017-TN4921), but was not observed in recent surveys (Cox et al. 2015-TN5193).

Spreading False-Foxglove (*Aureolaria patula*) – Rare (S3). Spreading false-foxglove grows on steep, partially shaded calcareous slopes above large streams and rivers and is often found within a few meters of water (Cox et al. 2015-TN5193). Calcareous forest (see EIS Section 2.4.1.1) occurs on portions of the Clinch River property underlain by limestone. Most of the calcareous forest occurs within the Grassy Creek Habitat Protection Area and along a few mesic slopes adjacent to the Clinch River. This habitat type supports spreading false-foxglove (Cox et al. 2015-TN5193). The species was located in 2000 at the southern end of the BTA (TVA 2017-TN4921), but was not observed in recent surveys (Cox et al. 2015-TN5193).

American Ginseng (*Panax quinquefolius*) – Rare (S-CE). American ginseng is a commercially exploited herb valued for the purported medicinal value of the roots. This species prefers mesic sites. Collection of ginseng is regulated by the State of Tennessee (Cox et al. 2015-TN5193). Calcareous forest (see EIS Section 2.4.1.1) occurs on portions of the Clinch River property underlain by limestone. Most of the calcareous forest occurs within the Grassy Creek Habitat Protection Area and along a few mesic slopes adjacent to the Clinch River. This habitat type supports American ginseng (Cox et al. 2015-TN5193).

Species described above that were not observed but that may occur on the CRN Site or in the BTA, based on known occurrence within 2 mi of the CRN Site or BTA, and suitable habitat being present on the CRN Site or BTA, are identified in Table 2-12.

Only two species are known occur within 0.125 mi of proposed 69-kV underground transmission line—the eastern slender glass lizard (*Ophisaurus attenuatus longicaudus*) and northern pine snake (*Pituophis melanoleucus melanoleucus*). These species are listed along with their status and habitat affinities in Table 2-12. Only the eastern slender glass lizard could potentially occur in the transmission line corridor based on habitat affinities (see Table 2-12).

<u>Important Terrestrial Habitats</u>

Important habitats include those identified by Federal or State agencies as unique, rare, or of priority for protection, such as sanctuaries, refuges, preserves, and Federally designated critical habitats. Critical habitats are those that are designated to support Federally listed threatened or endangered species (NRC 2000-TN614). Important habitats include lands that have been set aside by nongovernmental conservation organizations. Important habitats also include wetlands and floodplains (NRC 2000-TN614), which are discussed in EIS Section 2.4.1.1.

TVA identified natural areas on, adjacent to, and within 3 mi of the CRN Site (Pilarski-Hall 2015-TN5185). Baranski (2009-TN5133) identified and evaluated natural areas across the DOE ORR that compose the National Environmental Research Park (NERP). Those natural areas within about 2 mi of the CRN Site or BTA are summarized in Table 2-13 and depicted in Figure 2-28. Note that most of these are within the NERP on the ORR and that the acreages of those overlap (are not additive to) the total acreage of the ORR and NERP in Table 2-13. There is a long history of biological and ecological research on the ORR. The significance of ORR lands for the maintenance of biodiversity in the Ridge and Valley Ecoregion and nationally has long been recognized and is largely due to the extensive, relatively unfragmented forest (>75 percent cover across the ORR) that still exists there (Baranski 2009-TN5133).

Some of the characteristics of the natural areas adjacent to the CRN Site (Figure 2-28 and Table 2-13) may extend into similar habitats on the CRN Site. For example, Parr and Hughes (2006-TN5058) identified an area of about 100 ac in the eastern portion of the CRN Site that extended from just east of the CRBRP footprint to the Clinch River as having "very high biological significance" (Figure 2-28) due to confirmed and potential habitat for rare plants and wildlife. The Nature Conservancy (Giffen 2017-TN5393) identified this same area as containing significant river bluffs. There is a previous record for Appalachian bugbane (*Actaea rubifolia*) for this area (Giffen 2017-TN5394) and the species was also observed on the CRN Site by TVA during botanical surveys (see EIS Section 2.4.1.1). Appalachian bugbane is a species that was previously listed by the State of Tennessee (Giffen 2017-TN5394), but is no longer (TDEC 2017-TN5217). However, the species is yet considered of conservation concern on the ORR because of its rarity (Giffen 2017-TN5394). The 100-ac area likely also contained the (unidentified) rare plant species that were located just beyond the CRBRP footprint and that were protected from disturbance during redress (see EIS Section 2.4.1.1) (DOE 1984-TN5282; DOE et al. 1984-TN5221). However, Parr and Hughes (2006-TN5058) was superseded by

Table 2-12. Important Species within 2 mi of the CRN Site and within 2 mi of the BTA (TNHP 2017-TN5361)

Scientific Name	Common Name	Federal Status[(a)]	State Status[(a)]	State Rank[(b)]	Potentially Suitable Habitat Onsite	Observed or Likely to Occur Onsite (Y/N)	Habitat
Mammals							
Myotis grisescens	gray myotis	E	E	S2	Y	Y	Cave obligate year-round; frequents forested areas; migratory (TDEC 2017-TN5217).
Sorex dispar	long-tailed shrew		D	S2	N	N	Mountainous, forested areas with loose talus (TDEC 2017-TN5217).
Birds							
Accipiter striatus	sharp-shinned hawk		D	S3B	Y	Y	Forests and open woodlands (TDEC 2017-TN5217). Young, dense, mixed, or coniferous woodlands are preferred for nesting (LeGrand et al. 2015-TN5188).
Aimophila aestivalis	Bachman's sparrow		E	S1B	Y	Y	Dry open pine with an undercover of grasses and shrubs, hillsides with patchy brushy areas, overgrown fields with thickets and brambles, grassy orchards, and large clear-cuts. Breeding habitat is overgrown fields with scattered saplings, and open woods with thick grass cover (LeGrand et al. 2015-TN5188).
Amphibian							
Aneides aeneus	green salamander			S3S4	Y	Y	Damp crevices in shaded rock outcrops and ledges; beneath loose bark and cracks of trees and sometimes in/or under logs (TDEC 2017-TN5217).
Reptile							
Ophisaurus attenuatus longicaudus	eastern slender glass lizard		D	S3	Y	Y	Dry upland areas including brushy, cut-over woodlands and grassy fields (TDEC 2017-TN5217).

Table 2-12. (contd)

Scientific Name	Common Name	Federal Status[a]	State Status[a]	State Rank[b]	Potentially Suitable Habitat Onsite	Observed or Likely to Occur Onsite (Y/N)	Habitat
Pituophis melanoleucus melanoleucus	northern pinesnake		T	S3	N	Y	Well-drained sandy soils in pine/pine-oak woods (TDEC 2017-TN5217).
Plants							
Agalinis auriculata	earleaved false-foxglove		E	S2	N	N	Barrens (TDEC 2017-TN5217).
Aureolaria patula	spreading false-foxglove		S	S3	Y	Y	Oak woods and edges (TDEC 2017-TN5217).
Delphinium exaltatum	tall larkspur		E	S2	N	N	Glades and barrens (TDEC 2017-TN5217).
Draba ramosissima	branching whitlow-grass		S	S2	N	N	Calcareous bluffs (TDEC 2017-TN5217).
Helianthus occidentalis	naked-stem sunflower		S	S2	N	N	Limestone glades and barrens (TDEC 2017-TN5217).
Juglans cinerea	butternut		T	S3	Y	Y	Rich woods and hollows (TDEC 2017-TN5217).
Liatris cylindracea	slender blazing-star		T	S2	N	N	Barrens (TDEC 2017-TN5217).
Oligoneuron album	prairie goldenrod		E	S1S2	N	N	Barrens (TDEC 2017-TN5217).
Panax quinquefolius	American ginseng		S-CE	S3S4	Y	Y	Rich woods and hollows (TDEC 2017-TN5217).
Platanthera flava var. herbiola	tubercled rein-orchid		T	S2	Y	Y	Swamps and floodplains (TDEC 2017-TN5217).
Pseudognaphalium helleri	Heller's catfoot		S	S2	Y	Y	Dry sandy woods (TDEC 2017-TN5217).
Spiranthes lucida	shining ladies'-tresses		T	S1S2	Y	Y	Alluvial woods and moist slopes (TDEC 2017-TN5217).

(a) E = endangered; T = threatened; S = special concern; D = deemed in need of management; CE = commercially exploited.
(b) S1 = extremely rare, having 5 or fewer occurrences in the state; S2 = very rare, having 6 to 20 occurrences in the state; S3 = rare and uncommon, having 21 to 100 occurrences in the state; S4 = widespread, abundant, and apparently secure within the state, but with cause for long-term concern; B = breeds in Tennessee.

Table 2-13. Important Terrestrial Habitats within 2 mi of the CRN Site or BTA (Baranski 2009-TN5133; TVA 2017-TN4921).

Important Terrestrial Habitat	Location	Size (ac)	Resources
Adjacent Areas within ORR			
Oak Ridge Reservation (ORR)	Adjacent to CRN Site	34,000	Forest management and ecosystem process research.
Oak Ridge National Environmental Research Park	Adjacent to CRN Site	20,000 (in the ORR)	Managed by Oak Ridge National Laboratory (ORNL) for the U.S. Department of Energy (DOE) for education and research in environmental sciences.
Oak Ridge State Wildlife Management Area	Adjacent to the CRN Site. Includes the BTA but not the CRN Site	37,000 (mostly in the ORR)	Managed by the Tennessee Wildlife Resources Agency for hunting.
Grassy Creek Habitat Protection Area	Adjacent to CRN Site	265	Managed by TVA, habitat for spreading false-foxglove.
East Tennessee Technology Park (ETTP) Filtration Plant Wetland (ORR Natural Area 33)	Adjacent to CRN Site and BTA	7 (in the ORR)	Wetland, habitat for shining ladies'-tresses.
Grassy Creek Security Site (ORR Reference Area 22)	Adjacent to CRN Site and within the Grassy Creek Habitat Protection Area[(a)]	43 (in the ORR)	Red oak-tulip tree forest with limestone outcrops along a tributary to the Clinch River. Supports wild ginger and Jacob's ladder (Giffen 2017-TN5393). May serve as control area for research or monitoring.
Areas within 0.5 mi in ORR			
New Zion Boggy Area (ORR Natural Area 42)	Within ~0.5 mi of CRN Site	376 (in the ORR)	Rare natural community consisting of oak-hickory uplands and a boggy (groundwater seeps and a sinking creek) forested sphagnum moss/fern wetland and pools.
K-25 (ETTP) Beaver Pond Complex (ORR Natural Area 49)	Within ~0.5 mi of CRN Site	17 (in the ORR)	Loblolly pine plantation. Prime birding area, especially cavity-nesting birds and water birds.
Northwest Pine Ridge (ORR Natural Area 29)	Within ~0.5 mi of CRN Site	20 (in the ORR)	Fringeless orchid site
Sleepy Salamander Forest (ORR Natural Area 48)	Within ~0.5 mi of CRN Site	233 (in the ORR)	Forested and emergent wetlands. Wet meadow/shrub/herb complex in power line right-of-way. Oak forest on south slopes. Rare salamanders.
Raccoon Creek Barren (ORR Reference Area 8)	Within ~0.5 mi of CRN Site	62 (in the ORR)	Rare community, a cedar-post oak barren-glade on shallow limestone.

Table 2-13. (contd)

Important Terrestrial Habitat	Location	Size (ac)	Resources
Grassy Creek Power Line Area (ORR Cooperative management area 1)	Within ~0.5 mi of CRN Site and BTA (adjacent to Grassy Creek Habitat Protection Area)	51 (in the ORR)	Linear area extending northeast along Bear Creek Road.
Areas within 2 mi in ORR			
Clinch Floodplain Swamp/SR 95 Lily Area (ORR Natural Area 25)	Within 2 mi of CRN Site	18 (in the ORR)	Headwater riparian area and downstream wetlands. Several rare plants.
Raccoon Creek Golden Seal Area/Haw Ridge Uplands and Raccoon Creek Embayment (ORR Natural Area 6)	Within 2 mi of CRN Site	237 (in the ORR)	Forested with limestone outcrops. Diversity of forest communities and diverse species composition. Good embayment wetland, emergent, and scrub/shrub. Some high quality open old forests. Some river bluffs. Some other rare or uncommon ORR plant species.
Rein-orchid Swamp/Bear Creek Forested Wetland (ORR Natural Area 4)	Within 2 mi of CRN Site	421 (in the ORR)	Forested wetlands. Old channels, seeps, some uplands.
Duct Island Road Bluffs (ORR Natural Area 37)	Within 2 mi of BTA	12 (in the ORR)	Shoreline of a peninsula along Clinch River arm of Watts Bar Reservoir. Low limestone outcrops. Dry to moist hardwood or cedar forest and barrens.
Lower Poplar Creek Rookery (ORR Research Area 30)	Within 2 mi of BTA	6 (in the ORR)	Forested wetland. Heron nesting area.
Upper Poplar Creek Rookery (ORR Research Area 23)	Within 2 mi of BTA	17 (in the ORR)	Heron nesting area.
Haw Ridge Upland Hardwoods (ORR Research Area 9)	Within 2 mi of CRN Site	144 (in the ORR)	Representative upland hardwoods.
Areas within 2 mi outside ORR			
Campbell Bend Barrens state natural area	Within 2 mi of CRN Site	35 (outside the ORR)	Managed by the Tennessee Department of Environment and Conservation (TDEC), contains a small barrens that is a rare community type.
Crowder Cemetery Cedar Barrens state natural area	Within 2 mi of CRN Site	15 (outside the ORR)	Managed by TDEC, grasslands in a matrix of mixed oak-pine with eastern red cedar and hardwoods scattered throughout the barrens.

(a) The portion of Reference Area 22 within the Grassy Creek Habitat Protection Area not depicted in Figure 2-28.

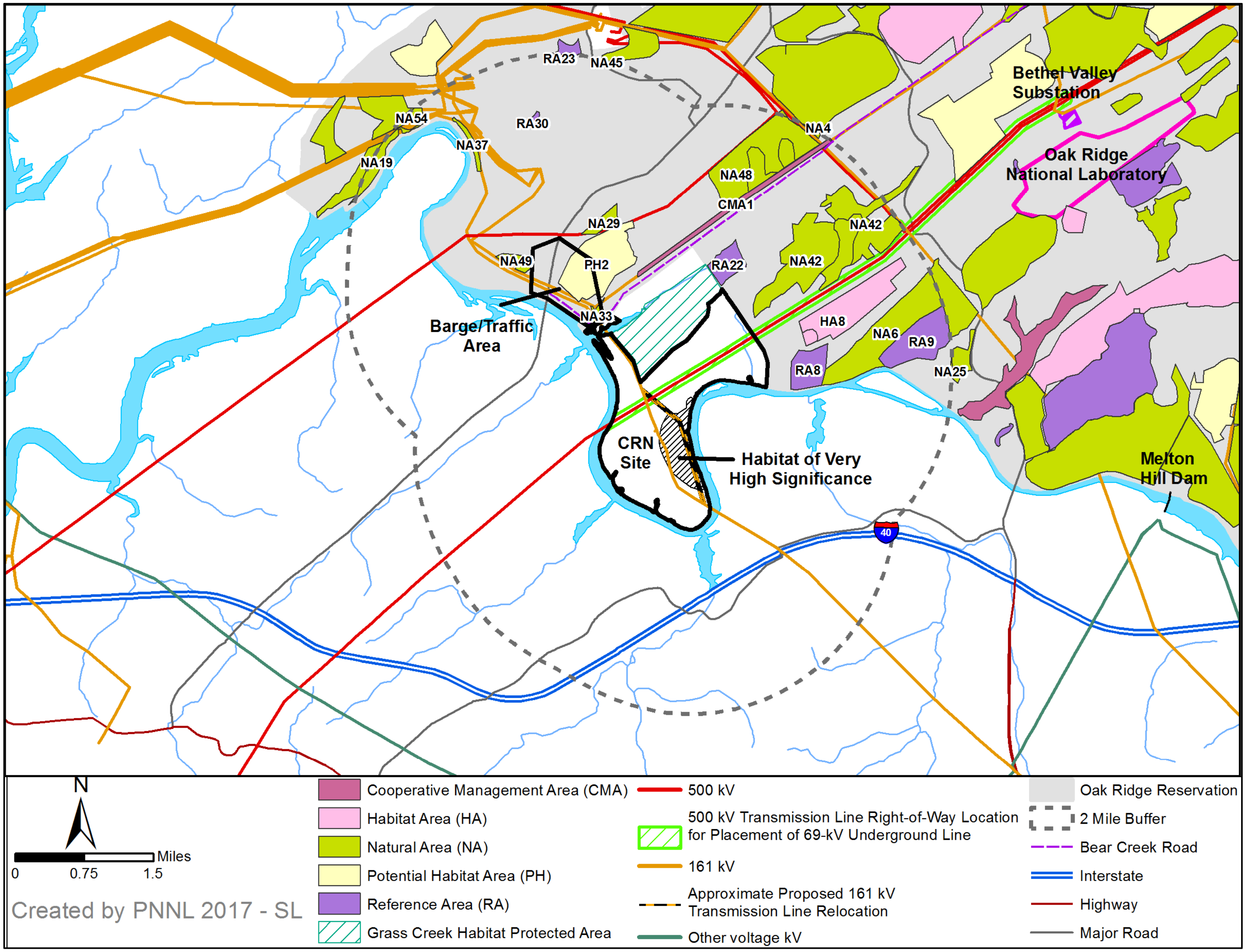


Figure 2-28. Important Terrestrial Habitats on and within 2 Mi of the CRN Site and BTA

Baranski (2009-TN5133), which does not indicate any important habitats occurring on the CRN Site, including this approximate 100-ac area. This approximate 100-ac area identified by Parr and Hughes (2006-TN5058) was excluded by Baranski (2009-TN5133) because it was not part of the ORR (Giffen 2017-TN5393). Thus, the area likely retains its original ecological significance as indicated by The Nature Conservancy in its 1995 unpublished report (Giffen 2017-TN5393) and Parr and Hughes (2006-TN5058).

Parr and Hughes (2006-TN5058) also identified an area in the eastern portion of the BTA (Figure 2-28) as terrestrially sensitive and providing potential habitat for rare species. This area is identified as “PH2” (potential habitat area 2) in Figure 2-28. Note that shining ladies’-tresses and spreading false-foxglove, important species discussed above, were previously known to occur in the BTA (likely in the PH2 portion) but were not observed in recent surveys. Baranski (2009-TN5133) also identifies the same area and indicates that many such areas are also found on the adjacent ORR (Parr and Hughes 2006-TN5058).

The ORR was approved as an Important Bird Area (IBA) site in 2005 (TWRA 2006-TN5301). The IBA program is an international effort to identify, conserve, and monitor a network of sites that provide essential migratory, breeding, and overwintering habitat for birds (Wells et al. 2005-TN133). IBAs are designated by the National Audubon Society across the United States to conserve critical sites for bird conservation. IBAs may include public or private lands and may be protected or unprotected; however, the designation does not confer regulatory or other protection (PLTA 2014-TN3977).

2.4.1.11.2 Offsite Transmission Line Corridors

Important Terrestrial Species

In an email dated August 18, 2017, PNNL requested that the TNHP provide a list of important species and habitats with known occurrences within 0.125 mi of the offsite transmission lines that would be upgraded (uprated, reconductored, and rebuilt). In emails on August 30 and September 1 and 11, 2017, the TNHP provided a response (TNHP 2017-TN5361). In an email dated September 6, 2017, PNNL requested that the Georgia Department of Natural Resources (GDNR) provide a list of important species and habitats with known occurrences within 0.125 mi of a segment of an offsite transmission line that would be upgraded (PNNL 2017-TN5401). On September 24, 2017 the GDNR provided a response email (GDNR 2017-TN5397). In emails dated September 13 and 27, 2017, PNNL requested that the Kentucky State Nature Preserves Commission (KSNPC) (PNNL 2017-TN5403) provide a list of important species and habitats with known occurrences within 0.125 mi of a segment of an offsite transmission line that would be upgraded. On October 2, 2017 the KSNPC provided a response email (KSNPC 2017-TN5400).

Important species known to occur within 0.125 mi of the offsite transmission lines that would be upgraded in Tennessee, Kentucky, and Georgia are listed in Table 2-14 (TNHP 2017-TN5361; GDNR 2017-TN5397; KSNPC 2017-TN5400). These species either may occur or are unlikely to occur within the transmission line corridors, depending on species habitat preferences and the availability of suitable habitat (Table 2-14). The FWS requested the review team also consider the little brown bat and tri-colored bat, species, which may be listed under the ESA in the future, in a telephone conference held October 24, 2017 (PNNL 2017-TN5384). These two additional bats are considered important species for the purposes of this review and any known occurrences within 0.125 mi of the offsite transmission line corridors were noted in the above responses from TNHP (TNHP 2017-TN5361), GDNR (GDNR 2017-TN5397), and KSNPC

(PNNL 2017-TN5403) (Table 2-14). The life histories of these two bat species are described above in Section 2.4.1.10.1.

Federally listed species known to occur within 0.125 mi of the offsite transmission lines (subset of the important species listed in Table 2-14) and that may occur within the corridors include four bat and one plant species. Norris Dam Cave occurs within the L5125 transmission line corridor in Campbell County, Tennessee (Tables 6-4 and 6-5 in the BA in Appendix M). The cave has been previously used by gray bats as a maternity, swarming, and hibernation site, and at one time supported an estimated 4,148 individuals of that species (Tables 6-4 and 6-5 and text in the BA in Appendix M). The cave has been previously used by NLEBs and Indiana bats as a hibernation site (Tables 6-4 and 6-5 in the BA in Appendix M). Little brown bats have also used the cave previously (TNHP 2017-TN5361, text in the BA in Appendix M). The cave's current use by these bat species is unknown. Virginia spiraea (*Spiraea virginiana*) occurs just outside the L5173 transmission line corridor in Rhea County, Tennessee (Table 2-15), and may also occur within the corridor if suitable habitat is present (Tables 6-4 and 6-5 in the BA in Appendix M). Further discussion of Federally listed species known to occur within 0.125 mi of the offsite transmission lines and that could occur or are unlikely to occur within the corridors is provided in NRC's BA (Appendix M).

The review team also consulted the FWS Information for Planning and Consultation (IPaC) database (FWS 2017-TN5328) and the TDEC Rare Species by County Database (TDEC 2017-TN5217) in order to identify the federally listed species known to occur in each of the counties traversed by the offsite transmission line corridors in Tennessee, Kentucky, and Georgia (Table 2-15). These species may occur or are unlikely to occur within the transmission line corridors, depending on species habitat preferences and the availability of suitable habitat (Table 2-15). Further discussion of these Federally listed species is provided in Tables 6-3 and 6-5 of NRC's BA in Appendix M.

A bald eagle nest occurred within 0.125 mi of the L5957 transmission line (Table 2-14). The nest was active in 2003 (TNHP 2017-TN5361).

<u>Important Terrestrial Habitats</u>

No important habitats were reported by TNHP (2017-TN5361), GDNR (2017-TN5397), or KSNPC (2017-TN5400) as occurring within 0.125 mi of the offsite transmission lines that would be uprated, reconductored, or rebuilt. The review team also consulted the IPaC database (FWS 2017-TN5328) to identify any designated critical habitat for the Federally listed species known to occur in each of the counties traversed by the offsite transmission line corridors in Tennessee, Kentucky, and Georgia. No critical habitats for terrestrial species occur within or near the line corridors (see BA in Appendix M).

<u>Invasive Plant Species</u>

Much of the CRN Site was extensively altered during site preparation for the CRBRP, resulting in the introduction and spread of invasive, non-native plant species. Invasive plants are typically vigorous and may lack some of the natural predators and diseases that tend to control populations of native plants. Invasive plants have the potential to spread rapidly and displace native vegetation and can reduce forest productivity, hinder forest use and management activities, reduce diversity, and degrade wildlife habitat. TVA has identified the most common invasive plant species on the CRN Site and in the BTA (TVA 2017-TN4921). They are listed along with their relevant characteristics in Table 2-16. All of these species are considered a severe threat by the State of Tennessee (TIPC 2009-TN5308).

Table 2-14. Important Species Known to Occur within 0.125 mi of the Offsite Transmission Lines that May Be Uprated, Reconductored, or Rebuilt (TNHP 2017-TN5361; GDNR 2017-TN5397; KSNPC 2017-TN5400). For Federally listed species and the little brown bat refer to Tables 6-3 and Table 6-5 and associated text in the BA (EIS Appendix M) for further detail on potential occurrences within 0.125 mi of the Offsite Transmission Lines.

Scientific Name	Common Name	Federal Status[(a)]	State Status[(a)]	State Rank[(b)]	Potentially Suitable Habitat in Transmission Line Corridor	Possible Occurrence in Transmission Line Corridor (Y/N)	Habitat
Tennessee							
L5092 (Volunteer-N Knoxville No 1) – Rebuild							
No important species or habitats within the 0.125-mi buffer.							
L5125 (Norris HP– Lafollette-Pineville (Including Sweet Gum Flats) – Reconductor							
Myotis grisescens	gray myotis	E	E	S2	Y	Y	Cave obligate year-round; frequents forested areas; migratory (TDEC 2017-TN5217).
Myotis lucifugus	little brown bat			S3	Y	Y	Maternity colonies in barns, attics, and tree cavities (Kunz and Reichard 2010-TN5373). Caves and mines are hibernacula (NatureServe 2017-TN5216).
Myotis leibii	eastern small-footed myotis		D	S2S3	Y	Y	Hibernates in caves and mines; also uses abandoned buildings, bridges, and barns seasonally (TDEC 2017-TN5217).
Myotis septentrionalis	northern long-eared bat	T		S1S2	Y	Y	A forest bat whose summer roosts may include caves, mines, live trees and snags; hibernates in caves and mines (TDEC 2017-TN5217).

Table 2-14. (contd)

Scientific Name	Common Name	Federal Status[a]	State Status[a]	State Rank[b]	Potentially Suitable Habitat in Transmission Line Corridor	Possible Occurrence in Transmission Line Corridor (Y/N)	Habitat
Myotis sodalis	Indiana bat	E	E	S1	Y	Y	Hibernates in caves; spring/summer maternity roosts are normally under the bark of standing trees (TDEC 2017-TN5217).
Meehania cordata	heartleaf meehania		T	S2	N	N	Wooded mountain slopes (TDEC 2017-TN5217).
L5167 (Winchester – Smith Mountain SW STA (Including Pelham, Coalmont) – Uprate							
Cyperus plukenetii	Plukenet's galingale		S	S1	Y	Y	Sandy barrens (TDEC 2017-TN5217).
Eleocharis wolfii	wolf spike-rush		E	S1	N	N	Wet woods on floodplains (TDEC 2017-TN5217).
Glyceria acutiflora	sharp-scaled mannagrass		S	S2	Y	Y	Swamps, ponds (TDEC 2017-TN5217).
Neobeckia aquatica	lake cress		S	S2	Y	Y	Gum or cypress swamps (TDEC 2017-TN5217).
Ranunculus flabellaris	yellow water-crowfoot		T	S2	Y	Y	Ponds and marshes (TDEC 2017-TN5217).
L5173 (Watts Bar HP – Great Falls HP [Including Pikeville]) – Uprate							
Neotoma magister	Allegheny woodrat		D	S3	N	N	Outcrops, cliffs, talus slopes, crevices, sinkholes, caves, and karst (TDEC 2017-TN5217).
Carex lonchocarpa	southern long sedge		E	S2	Y	Y	Wet soils in open areas (TDEC 2017-TN5217).
Lilium philadelphicum	wood lily		E	S1	Y	Y	Dry openings, powerlines (TDEC 2017-TN5217).
Phyllanthopsis phyllanthoides	maidenbush		S	S1	N	N	Limestone outcrops (TDEC 2017-TN5217).

Table 2-14. (contd)

Scientific Name	Common Name	Federal Status[(a)]	State Status[(a)]	State Rank[(b)]	Potentially Suitable Habitat in Transmission Line Corridor	Possible Occurrence in Transmission Line Corridor (Y/N)	Habitat
Spiraea virginiana	Virginia spiraea	T	E	S2	Y	Y	Banks of high-gradient sections of second- and third-order streams in oft-disturbed early successional areas (Ogle 1992-TN5379).
Spiranthes lucida	shining ladies'-tresses		T	S1S2	N	N	Alluvial woods and moist slopes (TDEC 2017-TN5217).
Vitis rupestris	sand grape		E	S2	Y	Y	Sandy, rocky riverbanks (TDEC 2017-TN5217).
L5186 (John Sevier FP – Cherokee HP No 1) – Uprate							
No important species or habitats within the 0.125-mi buffer.							
L5204 Monterey (Peavine SW STA 161 kV [Including Campbell Junction, Fredonia, Crossville, W Crossville]) – Reconductor							
Aneides aeneus	green salamander			S3S4	N	N	Damp crevices in shaded rock outcrops and ledges; beneath loose bark and cracks of trees and sometimes in/or under logs (TDEC 2017-TN5217).
Desmognathus welteri	black mountain salamander		D	S3	Y	Y	Spring runs and permanent streams in wooded mountainous terrain (TDEC 2017-TN5217).
Drosera intermedia	spoonleaf sundew		S	S2	Y	Y	Acidic wetlands (TDEC 2017-TN5217).
L5205 (Rockwood – Peavine SW STA [Including Crossville]) – Uprate							
Desmognathus welteri	black mountain salamander		D	S3	Y	Y	Spring runs and permanent streams in wooded mountainous terrain (TDEC 2017-TN5217).
Lilium philadelphicum	wood Lily		E	S1	Y	Y	Dry openings, powerlines (TDEC 2017-TN5217).

Table 2-14. (contd)

Scientific Name	Common Name	Federal Status[(a)]	State Status[(a)]	State Rank[(b)]	Potentially Suitable Habitat in Transmission Line Corridor	Possible Occurrence in Transmission Line Corridor (Y/N)	Habitat
Symphyotrichum pratense	barrens silky aster		E	S1	Y	Y	Barrens (TDEC 2017-TN5217).
L5235 (Elza – Spallation Neutron Source) – Reconductor							
Myotis grisescens	gray myotis	E	E	S2	Y	Y	Cave obligate year-round; frequents forested areas; migratory (TDEC 2017-TN5217).
Dendroica cerulea	cerulean warbler		D	S3B	N	N	Mature deciduous forest, particularly in floodplains or mesic conditions (TDEC 2017-TN5217).
Delphinium exaltatum	tall larkspur		E	S2	Y	Y	Glades and barrens (TDEC 2017-TN5217).
L5280 Oak Ridge National Laboratory – Spallation Neutron Source 161 KV – Reconductor							
Dendroica cerulea	cerulean warbler		D	S3B	N	N	Mature deciduous forest, particularly in floodplains or mesic conditions (TDEC 2017-TN5217).
Delphinium exaltatum	tall larkspur		E	S2	Y	Y	Glades and barrens (TDEC 2017-TN5217).
L5624 (John Sevier FP – White Pine No 2 [including Greenville]) – Uprate							
No important species or habitats within the 0.125-mi buffer.							
L5659 (Bull Run FP – N Knoxville No 1) – Reconductor							
No important species or habitats within the 0.125-mi buffer.							
L5697 Oglethorpe – Concord (Including Cloud Springs) – Reconductor							
No important species or habitats within the 0.125-mi buffer.							
L5702 (Franklin – Winchester) – Reconductor							

Table 2-14. (contd)

Scientific Name	Common Name	Federal Status[(a)]	State Status[(a)]	State Rank[(b)]	Potentially Suitable Habitat in Transmission Line Corridor	Possible Occurrence in Transmission Line Corridor (Y/N)	Habitat
Myotis grisescens	gray myotis	E	E	S2	Y	Y	Cave obligate year-round; frequents forested areas; migratory (TDEC 2017-TN5217).
Marshallia trinervia	broad-leaved Barbara's-buttons		T	S2S3	Y	Y	Rocky ravines (TDEC 2017-TN5217).
L5743 (Kingston FP – Rockwood – Roane No 1 [Including Harriman, K33]) – Reconductor							
Marshallia trinervia	broad-leaved Barbara's-buttons		T	S2S3	Y	Y	Rocky ravines (TDEC 2017-TN5217).
Panax quinquefolius	American ginseng		S-CE	S3S4	N	N	Rich woods and hollows (TDEC 2017-TN5217).
Symphyotrichum pratense	barrens silky aster		E	S1	Y	Y	Barrens (TDEC 2017-TN5217).
Thuja occidentalis	northern white cedar		S	S3	N	N	Calcareous rocky seeps cliffs (TDEC 2017-TN5217).
L5882 Elza – Huntsville (Including Braytown, Windrock) – Uprate/Reconductor							
Dendroica cerulea	cerulean warbler		D	S3B	N	N	Mature deciduous forest, particularly in floodplains or mesic conditions (TDEC 2017-TN5217).
Desmognathus welteri	black mountain salamander		D	S3	Y	Y	Spring runs and permanent streams in wooded mountainous terrain (TDEC 2017-TN5217).
Myotis grisescens	gray myotis	E	E	S2	Y	Y	Cave obligate year-round; frequents forested areas; migratory (TDEC 2017-TN5217).

Table 2-14. (contd)

Scientific Name	Common Name	Federal Status[a]	State Status[a]	State Rank[b]	Potentially Suitable Habitat in Transmission Line Corridor	Possible Occurrence in Transmission Line Corridor (Y/N)	Habitat
L5940 (White Pine – Dumplin Valley) – Reconductor							
No important species or habitats within the 0.125-mi buffer.							
L5957 (Douglas HP – White Pine (Including Newport) – Reconductor							
Haliaeetus leucocephalus	bald eagle		D	S3	N	N	Areas close to large bodies of water; roosts in sheltered sites in winter; communal roost sites common (TDEC 2017-TN5217).
Georgia							
L5697 (Oglethorpe – Concord (Including Cloud Springs) – Reconductor							
Baptisia australis var. *aberrans*	glade blue wild indigo			S3	Y	Y	Limestone glades and barrens (GDNR 2017-TN5397).
Kentucky							
L5125 (Norris HP – Lafollette-Pineville (Including Sweet Gum Flats) – Reconductor							
Corydalis sempervirens	rock harlequin			S3	N	N	Dry rocky woods, and usually associated with rock outcrops, on ridge summits (KSNPC 2014-TN5297).
Fumonelix wetherbyi	clifty covert			S2	N	N	Under logs and in moist leaf litter on wooded hillsides and in ravines. Steep, forested slopes adjacent to cliff lines, near rock outcrops, or in and around boulder talus (KSNPC 2015-TN5296).

(a) E = endangered; T = threatened; S = special concern; D = deemed in need of management; CE = commercially exploited.
(b) S1 = extremely rare, having 5 or fewer occurrences in the state; S2 = very rare, having 6 to 20 occurrences in the state; S3 = rare and uncommon, having 21 to 100 occurrences in the state; S4 = widespread, abundant, and apparently secure within the state, but with cause for long-term concern; B = breeds in Tennessee; B = breeds in Tennessee.

Table 2-15. Federally Listed Species Occurring in the Counties with the Proposed Transmission Lines that Would Be Uprated, Reconductored, and Rebuilt (FWS 2017-TN5091, EIS Appendix M)

Scientific Name	Common Name	Federal Status[(a)]	State Status[(a)]	State Rank[(b)]	Potentially Suitable Habitat in Transmission Line Corridor	Possible Occurrence in Transmission Line Corridor (Y/N)	Habitat
Mammals							
Corynorhinus (= Plecotus) townsendii virginianus	Virginia big-eared bat	E		S1	Y	Y	Caves typically in limestone karst regions dominated by mature hardwood forests. Prefers cool, well-ventilated caves for hibernation. Maternity colonies deep within caves (TDEC 2017-TN5217).
Glaucomys sabrinus coloratus	Carolina northern flying squirrel	E	E	S1S2	N	N	Spruce-fir or mature hardwood forest with snags; in tree cavities or leaf nests; higher elevations of the Appalachians (TDEC 2017-TN5217).
Myotis grisescens	gray bat	E	E	S2	Y	Y	Cave obligate year-round; frequents forested areas; migratory (TDEC 2017-TN5217).
Myotis septentrionalis	northern long-eared bat	T		S1S2	Y	Y	A forest bat whose summer roosts may include caves, mines, live trees and snags; hibernates in caves and mines, often using small cracks and fissures. Notably susceptible to WNS (TDEC 2017-TN5217).
Myotis sodalis	Indiana bat	E	E	S1	Y	Y	Hibernates in caves; spring/summer maternity roosts are normally under the bark of standing trees (TDEC 2017-TN5217).

Table 2-15. (contd)

Scientific Name	Common Name	Federal Status[(a)]	State Status[(a)]	State Rank[(b)]	Potentially Suitable Habitat in Transmission Line Corridor	Possible Occurrence in Transmission Line Corridor (Y/N)	Habitat
Arachnid							
Microhexura montivaga	spruce-fir moss spider	E		S1	N	N	Moss mats in high-elevation spruce-fir forests; Southern Appalachians (TDEC 2017-TN5217).
Insect							
Bombus affinis	rusty-patched bumble bee	E		S1	N	N	Once occupied grasslands and tallgrass prairies of the Upper Midwest and Northeast, but most have been lost, degraded, or fragmented by conversion to other uses. Needs undisturbed soil for overwintering sites (FWS 2017-TN5376).
Snail							
Anguispira picta	painted tigersnail	T	E	S1	N	N	A calciphile; limestone outcrops and cliff faces of karstic woods (TDEC 2017-TN5217). Not found in habitats no longer having forest cover (43 FR 28932-TN5374).
Plants							
Apios priceana	Price's potato-bean	T	E	S3	Y	Y	Lightly disturbed areas, such as forest openings, woodland edges, where bluffs descend to streams, and highway right-of-way and powerline corridors (FWS 2015-TN5375).

Table 2-15. (contd)

Scientific Name	Common Name	Federal Status[(a)]	State Status[(a)]	State Rank[(b)]	Potentially Suitable Habitat in Transmission Line Corridor	Possible Occurrence in Transmission Line Corridor (Y/N)	Habitat
Arenaria cumberlandensis	Cumberland sandwort	E			N	N	Restricted to sandstone rock houses, ledges, and solution pockets on sandstone rock faces. Needs shade, moisture, relatively constant cool temperatures, and high humidity (McKerrow 1996-TN5302).
Asplenium scolopendrium var. americanum	Hart's-tongue fern	T	E	S1	N	N	Southern populations (e.g., Tennessee) found only within limestone pits that trap cold air, have high humidity, and are well shaded (Currie 1993-TN5306).
Clematis morefieldii	Morefield's leather flower	E	E	S2	N	N	Seeps/springs in rocky limestone woods (TDEC 2017-TN5217; Norquist 1994-TN939; FWS 2017-TN5411).
Conradina verticillata	Cumberland rosemary	T	T	S3	Y	Y	Grows in full to moderate sunlight in the floodplain of major streams flowing over sandstone bedrock (Shea and Roulston 1996-TN5303; TDEC 2017-TN5217).
Geum radiatum	spreading avens	E	E	S1	N	N	Pioneer perennial herb communities at high-elevation rocky sites exposed to direct sunlight for at least part of the day. Populations occur at altitudes ranging from 1,400 to 1,911 m (Murdock 1993-TN5377).

Table 2-15. (contd)

Scientific Name	Common Name	Federal Status[a]	State Status[a]	State Rank[b]	Potentially Suitable Habitat in Transmission Line Corridor	Possible Occurrence in Transmission Line Corridor (Y/N)	Habitat
Isotria medeoloides	small whorled pogonia	T	E	S1	N	N (However, note the species may occur on corridor fringes)	Young forests and maturing stands in second- or third-growth successional stages, including near logging roads, streams, or other features that create long persisting breaks in the forest canopy (FWS 2017-TN5412).
Platantherea integrilabia	white fringeless orchid	T	E	S2S3	Y	Y	Acidic seeps and stream heads (TDEC 2017-TN5217). TVA has stated that nearly 20 percent of occurrences are located in transportation or utility right-of-ways (81 FR 62826-TN5378).
Scutellaria montana	large-flowered skullcap	T	T	S4	N	N	Rocky, submesic to xeric, well-drained, slightly acidic slope, ravine and stream bottom forests. Recruitment into disturbed sites is not likely (McKerrow 1996-TN5304).
Spiraea virginiana	Virginia spiraea	T	E	S2	Y	Y	Banks of high-gradient sections of second- and third-order streams, or on meander scrolls and point bars, natural levees, and other braided features of lower reaches in oft-disturbed early successional areas (Ogle 1992-TN5379).

Table 2-15. (contd)

Scientific Name	Common Name	Federal Status[(a)]	State Status[(a)]	State Rank[(b)]	Potentially Suitable Habitat in Transmission Line Corridor	Possible Occurrence in Transmission Line Corridor (Y/N)	Habitat
Fungus							
Gymnoderma lineare	rock gnome lichen	E	E	S1	N	N	Primarily limited to vertical rock faces with seepage water. Common associates include spreading avens (discussed above in this table). Most populations occur above 1,524 m elevation (Murdock and Langdon 1997-TN5380).

(a) E = endangered; T = threatened.
(b) S1 = extremely rare, having 5 or fewer occurrences in the state; S2 = very rare, having 6 to 20 occurrences in the state; S3 = rare and uncommon, having 21 to 100 occurrences in the state; S4 = widespread, abundant, and apparently secure within the state, but with cause for long-term concern.

Table 2-16. Local Invasive Plant Species (TVA 2017-TN4921)

Latin Name	Common Name	Characteristics[a]
Albizia julibrissin	Mimosa	Tree that occurs on dry-to-wet sites and spreads along stream banks. Forms colonies from root sprouts and spreads by animal- and water-dispersed seeds. Seeds prolifically and resprouts when cut.
Elaeagnus umbellata	autumn olive	Shrub that grows well in disturbed areas, open fields, margins of forests, roadsides, and clearings. Fruits eaten by a variety of wildlife; seeds may be distributed in forest openings.
Lespedeza cuneata	Chinese (sericea) lespedeza	Herb that forms dense stands by sprouting stems from rootcrowns that prevent forest regeneration. Both cross- and self-pollinates, and spreads slowly from plantings by seeds. It occurs in forest openings, dry upland woodlands to moist savannas, old fields, right-of-ways.
Ligustrum sinense	Chinese privet	Shade-tolerant shrub that readily grows from seed or from root and stump sprouts. Seed eaten and distributed by wildlife, particularly birds. Forms dense thickets, particularly in bottom-land forests and along fencerows, gaining access to forests, fields, and right-of-ways.
Lonicera japonica	Japanese honeysuckle	Vine that occurs as dense infestations along forest margins and right-of-ways as well as under dense canopies and as arbors high in canopies. Shade-tolerant, persists via large woody rootstocks, spreads by rooting at vine nodes and animal-dispersed seeds. Most commonly occurring invasive plant in Tennessee; overwhelms and replaces native flora.
Microstegium vimineum	Japanese stilt grass (Nepalese browntop)	Annual that is colonial, rooting from the nodes, and may form dense monotypic stands. Reproduction exclusively from seed. Seed dispersal primarily by animals, flooding, and fill dirt deposition. Spreads rapidly into disturbed areas and may invade undisturbed areas, where it may overwhelm the forest floor displacing groundcover plants.
Rosa multiflora	multiflora rose	Shrub that reproduces by seed, root sprouts, and layering (rooting from the tips of arching branches). It grows rapidly forming dense, impenetrable thickets and can climb into trees.
Sorghum halepense	Johnson grass	Spreads by seed and a very extensive rhizome. Seeds are dispersed by wind, water, wildlife, livestock, and contaminated crops, vehicles, and machinery. Up to 80,000 seeds and 8 kg of rhizomes can be produced by one plant in one growing season.

(a) TIPC 2009-TN5308

Terrestrial Pests and Disease Vectors

White-nose syndrome is a fungal disease that affects hibernating bats. The disease was first documented in the State of New York in the winter of 2006-2007 and has since spread rapidly across much of the eastern United States and Canada (FWS 2017-TN5309), and there have been occurrences in the central (Oklahoma and Nebraska) and even northwestern (Washington State) United States (FWS 2017-TN5310). The disease has been in Tennessee since about 2009 (FWS 2017-TN5310) and is considered widespread in the state (TWRA 2017-TN5410). It was confirmed to occur in Roane County in 2014 and occurs in some surrounding counties in Tennessee (Anderson, Cumberland, Meigs) (TNBWG 2017-TN5043). The disease has killed more than 6 million bats in the Northeast and Canada. In some hibernacula, 90 to 100 percent of bats have died. It is known to affect numerous bat species, including the Indiana bat, gray bat, NLEB, tri-colored bat, little brown bat, big brown bat, and the eastern small-footed myotis, all of which occur on the CRN Site and in the BTA (see EIS Sections 2.4.1.1 and 2.4.1.3). The fungus has been documented on other bat species but with no confirmation of disease, including the eastern red bat and silver-haired bat, both of which are also known to occur on the CRN Site and in the BTA (see EIS Section 2.4.1.1) (FWS 2017-TN5309).

Species of Commercial or Recreational Value

American ginseng is commercially exploited for the purported medicinal value of its roots. Collection of ginseng is regulated by the State of Tennessee through the Ginseng Dealer Registration Act of 1983 and the Ginseng Harvest Season Act of 1985. The closest known populations of American ginseng to the CRN Site are within the Grassy Creek Habitat Protection Area and are not available for commercial harvesting (TVA 2017-TN4921).

Terrestrial wildlife species that are hunted recreationally in the vicinity and occur on the CRN Site and in the BTA include white-tailed deer, gray squirrel, eastern cottontail, raccoon, Canada goose, wood duck, and wild turkey. The Oak Ridge State WMA (Table 2-13) is located primarily on the ORR and is managed by the TWRA for hunting of small and large game (Table 2-13). The CRN Site is not within the WMA (Table 2-13), but limited hunting is currently allowed on the CRN Site under a revised agreement between DOE and TWRA that incorporated the CRN Site into the ORR WMA managed-hunt program for deer and wild turkey. The BTA is within the WMA (Table 2-13) (TVA 2017-TN4921).

2.4.2 Aquatic Ecology

The aquatic habitats and species that could be affected by building and operating activities at the CRN Site are described in this section. The habitats include those in the streams and ponds on the CRN Site, adjacent to the site in the Clinch River arm of the Watts Bar Reservoir, and in the BTA (TVA 2017-TN4921). The habitats also include those in the streams and ponds that occur within the right-of-ways for the 500-kV transmission line and the 69-kV underground transmission line and those in the streams, ponds, and waterways that may be affected by upgrading offsite transmission lines (TVA 2017-TN4921).

2.4.2.1 Site and Vicinity

The CRN Site is bordered on three sides by the Clinch River arm of the Watts Bar Reservoir, as shown in Figure 2-1. Multiple ponds, streams, and ephemeral streams (also termed wet-weather conveyances) are located on the site. This section first discusses the ponds, streams, and ephemeral streams that are on or in the immediate surroundings of the CRN Site and then discusses the habitats and species in the reservoir (Clinch River) where it borders the site.

2.4.2.1.1 Ponds and Streams

TVA surveyed and mapped the locations of the waterbodies using a global positioning system within the CRN Site in April and May of 2011 and October of 2014. TVA conducted additional surveys the same year in the BTA[4] (TVA 2017-TN4921).

Figure 2-19 shows the waterbodies present on the CRN Site and within the BTA (Howard et al. 2015-TN5049). Each pond found on the CRN Site is man-made, and all but one were

(4) The BTA is located between Tennessee State Highway 58 and the entrance to the CRN Site.

developed to serve as stormwater-retention ponds. The sixth pond is described as a “small dug out pond”. Two additional ponds were identified on the southeast edge of the BTA. One is characterized as a large pond (P08) and the other as a “small pond connected to the backwater of the reservoir” (P07) (TVA 2017-TN4921).

The streams are classified as:

- perennial 5 streams on the CRN Site and 2 in the BTA,
- intermittent 1 on the CRN Site and 4 in the BTA, or
- ephemeral 19 on the CRN Site and 15 in the BTA.

Perennial streams are those that maintain a well-defined channel, and contain flowing water under normal weather conditions throughout a normal year. Perennial streams are able to provide permanent habitat for aquatic organisms throughout the year. Intermittent streams also have a well-defined channel but water only flows during parts of a normal year when seasonal groundwater discharge is abundant or as a result of major rainfall events. Intermittent streams may support aquatic organisms when water is present in their channels. Ephemeral streams may or may not have a defined channel but flow only during or immediately after precipitation events. Instead the water flows diffusely along the ground and into depressions. Ephemeral streams are not associated with groundwater sources and do not provide habitat for aquatic organisms (TVA 2017-TN4921; TDA 2003-TN5161).

Streamside management zones (SMZs) are areas that encompass a stream and an additional adjacent area. SMZs are managed to protect water quality and enhance the riparian and aquatic habitats associated with the stream (TDA 2003-TN5161). TVA indicated that they follow established best management practices (BMPs) to minimize adverse impacts on SMZs and associated waterbodies (TVA 2017-TN4921). SMZs are considered along the border of perennial streams and intermittent streams that have a well-defined channel and where water flows occur 40 to 90 percent of the time (TVA 2017-TN4921). TVA stated that they follow established BMPs when working in SMZs to minimize or avoid adverse impacts on the associated waterbodies (TVA 2017-TN4921). SMZs are also applied to the ponds. TVA has designated a 50-ft SMZ for all ponds, intermittent streams, and all but two of the perennial streams on the CRN Site or in the BTA. Two streams are designated by a 100-ft SMZ. The first is stream S06 located along the east side of the CRN Site and described as a “spring with small spring/run channel.” The second is stream S07, described as a “small channel with gravel/silt substrate” in the southeast corner of the BTA (TVA 2017-TN4921).

During March 2015, TVA conducted biological surveys on four perennial and three intermittent streams within pools, riffles, and runs that were considered to have habitat that appeared likely to support communities of aquatic biota. Three streams (S01, S05 and S06) were located on the CRN Site, and four (S07, S08, S09 and S12) were in the BTA. An eighth stream, Grassy Creek, which is located close to the site but not within the boundaries of the project, was also sampled. The surveys were timed and conducted using a seine and a backpack electrofishing unit (TVA 2017-TN4921). Few fish or crustaceans were found in any of the streams on the CRN Site or in the BTA. Stream S01 near the proposed water intake only resulted in a few crayfish that were too small to identify species. Only one fish, a Banded Sculpin (*Cottus carolinae*), and one unidentified crayfish (a crustacean) were observed in the streams on the CRN Site and were located in Stream S05 on the eastern border of the site. Surveying Stream S09 in the BTA similarly resulted in no fish and only one crayfish (upland burrowing crayfish, *Cambarus dubius*). In contrast, 70 individual fish of nine species were identified in Grassy

Creek. The most numerous species were Logperch (*Percina caprodes*), Largescale Stoneroller (*Campostoma oligolepis*), and Bluegill (*Lepomis macrochirus*) (Henderson and Phillips 2015-TN5162).

A report of the visual observations from a stream survey study (Henderson and Phillips 2015-TN5162) indicated that streams on the CRN Site and in the BTA either lacked stable suitable habitat or the existing habitats did not appear to be able to support fish communities. Based on the number of species identified in Grassy Creek, and the observations of this study, the review team agrees with the stream survey study assessment.

TVA proposes to build a 69-kV underground transmission line in an existing 500-kV transmission line corridor that runs from the Bethel Valley Substation to the CRN Site. The right-of-way crosses six streams.

The first stream is Ish Creek, which is a second-order tributary of the Clinch River stream and contains a 2.1-mi Aquatic Natural Area. An Aquatic Natural Area is a designation of the Tennessee Natural Areas Program, as defined in the Natural Areas Preservation Act of 1971 (T.C.A. § 11-14-101 *et seq*.-TN5163). According to this Act, "Natural areas represent some of Tennessee's best examples of intact ecosystems and serve as reference areas for how natural ecological processes function". Ish Creek originates as a spring and flows toward the Clinch River approximately 0.5 mi east of the site. Baranaski (2011-TN5164) indicated that the fish species richness score for this stream is "high" with 18 species documented in this stream system. Subsequent studies in the fall of 2016 and spring of 2017 resulted in 11 species and 10 species, respectively (ORNL 2017-TN5358). The Tennessee Dace (*Chrosomus tennesseensis*), which TDEC has listed as being "in need of management," has been found in this stream as recently as 2016 (ORNL 2017-TN5358). Tennessee Dace inhabit small low-gradient woodland tributaries that are smaller than 2 m in width. They are usually found in shallow pools with undercut banks and debris (Etnier and Starnes 1993-TN5054).

The second and third streams are part of the Northwest Tributary of White Oak Creek, which is an aquatic reference area that consists of four streams. White Oak Creek is a second- and third-order stream (depending on specific location) and the Northwest Tributary consists of three first-order streams and the larger part of a second-order stream (Baranski 2011-TN5164). Two of these streams cross the right-of-way at approximately 2 to 2.5 mi from the CRN Site (TVA 2017-TN4921). Baranski (2011-TN5164) reports that the fish diversity is "appropriate for this type of stream." Baranski further reports that the stream at the study site contains a highly diverse benthic invertebrate community in comparison to downstream areas that have previously been impacted by proximity to mowed fields and parking lots.

The fourth stream, Upper Fifth Creek, is located slightly southwest of the Bethel Valley Substation and is characterized as a spring-fed first-order stream. It is also part of the White Oak Creek drainage. Baranski (2011-TN5164) reports that this stream has an intact forested buffer for only a small segment. It has a very productive population of two fish species and a high benthic invertebrate diversity.

The fifth and sixth streams are Streams S03 and S06 near the northwest corner of the CRN Site and are shown in Figure 2-19. Stream S06 is a perennial stream, for which no fish or crayfish were reported during sampling studies. S03, an intermittent stream, was not sampled because of lack of water at the time of the surveys (Henderson and Phillips 2015-TN5162).

Transmission system structures within the right-of-ways outside the CRN Site (other than the 69-kV underground line) would require modification by uprating, reconductoring, or rebuilding activities. Additional right-of-way area would not be developed. Aquatic resources within the right-of-ways include designated critical habitat for one Federally endangered mussel species and one Federally threatened fish species, discussed in further detail in NRC's BA (Appendix M) (TVA 2017-TN4921).

2.4.2.1.2 Clinch River Arm of the Watts Bar Reservoir

A description of the hydrology of the Clinch River was provided previously in EIS Section 2.3. The CRN Site is located approximately between CRM 14.5 and CRM 19.0 and is on the Clinch River arm of Watts Bar Reservoir that was impounded by Watts Bar Dam in 1942. The CRN Site is located approximately 4 mi downstream of Melton Hill Dam, which was completed in 1963. Approximately 57 mi upstream from Melton Hill Dam is Norris Dam, which was built in 1936.

Historical impoundment of the river below and above the CRN Site has greatly altered the dynamics of river flow. 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 system no longer exist (Etnier and Starnes 1993-TN5054). In addition, changes in water depth and temperature, reductions in the amount of dissolved oxygen, and increased sedimentation result from placement of dams. These changes have affected or are continuing to affect biota and have resulted in detectable changes in the aquatic ecosystem compared to pre-impoundment conditions (NRC 2013-TN5165).

The assemblage of organisms living in the river changed in response to the impoundments. According to Parmalee and Bogan (1998-TN5166), 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 direct or indirect results of impoundment. As Neves and Angermeier (1990-TN5053) reported, obligate river species typically do not survive in reservoirs. Further, they reported that, even though fish sampling on the Tennessee River system was not extensive in the years before construction of the dams, enough surveys were conducted to allow documentation of the adverse effect that impoundment had on native fish species. For example, fish surveys conducted before and after impoundment of Melton Hill Reservoir (as reported in 1968) showed a shift in fauna. Those species requiring shoal and riffle habitats were no longer present in the post-impoundment surveys (NRC 2013-TN5165).

The impoundments created good reservoir fisheries for sport and commercial fishermen. According to Etnier and Starnes (1993-TN5054), 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. Further discussion of these species and their potential effect on the native aquatic biota is detailed later in this section (NRC 2013-TN5165).

As discussed in EIS Section 2.2, the water temperature in the Clinch River arm of the Watts Bar Reservoir is affected by operation of the Bull Run Fossil Plant located in the Melton Hill Reservoir in combination with the operation of Norris and Melton Hill Dams. The thermal discharges from the Bull Run Fossil Plant result in the thermal stratification of the Melton Hill Reservoir. This results in hourly water-temperature fluctuations of as much as 4°F between a monitor at CRM 22.6 (downstream of Melton Hill Dam) and one further downstream at CRM 16.1 at the location of the proposed plant discharge (TVA 2017-TN4921).

Section 2.3 of this draft EIS addresses the hazardous and radioactive contamination of the sediments in the Clinch River from above Melton Hill Reservoir (CRM 44) to the confluence of the Clinch River with the main stem of the Tennessee River (CRM 0). As a result, the State of Tennessee has issued fish-consumption advisories for contaminants (PCBs) for Striped Bass (*Morone saxatilis*) with a precautionary advisory for Catfish (Family Ictaluridae) and Sauger (*Sander canadensis*) as a result of PCBs (TDEC 2016-TN5172).

A description of the aquatic habitats and organisms in the Watts Bar arm of the Clinch River that could be affected by building and operating the proposed project follows.

2.4.2.1.3 Zooplankton and Phytoplankton

Plankton are small plants or animals that float, drift, or swim weakly in the water column of any body of water. There are two main categories of plankton: phytoplankton and zooplankton. Phytoplankton, 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 monthly from March through December in 2011 at three different locations: CRM 15.5 in the vicinity of the proposed discharge, CRM 18.5 approximately half a mile above the proposed intake, and CRM 22 near the Clinch inflow from Melton Hill Dam. A total of 81 phytoplankton taxa were collected, although the phytoplankton were numerically dominated by Cyanophytes (also called blue-green bacteria), which composed 90 to 99 percent of the samples at all locations and all sampling times. Diatoms accounted for the greatest fraction of the biovolume during most months. The highest abundance of phytoplankton was at Melton Hill Reservoir, followed by the sampling location below the proposed CRN Site. The lowest abundance was in the middle location at CRM 18.5. TVA indicated that similar patterns occur at other reservoirs along the Tennessee River. The density of phytoplankton closest to the dam is often high because phytoplankton densities in the water released from the upper reservoirs is also high. The density of phytoplankton decreases as water flows downstream at higher velocities. The water velocity slows as it enters the next reservoir where the density of phytoplankton increases because phytoplankton are able to obtain enough light to grow and reproduce (TVA 2013-TN5167).

TVA indicated that zooplankton were characterized by low abundance and diversity likely as a result of turbulence and advection caused by releases from Melton Hill Dam. Eighteen taxa were collected from three taxa: suborder Cladocera (water fleas), phylum Rotifera (rotifers), and small crustaceans of the subclass Copepoda (copepods). Copepods are the most common taxa in the months of March and April. Rotifers were dominant in May and Cladocera were dominant in abundance and biomass in June and/or July. The seasonal variation was largely due to the occurrence of increased summer water temperatures and general low flows (TVA 2013-TN5167).

2.4.2.1.4 Aquatic Macrophytes

Aquatic macrophytes are vascular aquatic plants (plants with true stems, roots, and leaves), mosses, and in some cases large algae. An assessment of 16 shoreline sections downstream of the CRN Site and 15 shoreline sections upstream of the CRN Site indicated that no macrophytes were observed on either bank (TVA 2013-TN5167) likely as a result of the proximity of the site to the inflow from Melton Hill Dam.

2.4.2.1.5 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 remain in the same location.

TVA conducted benthic macroinvertebrate sampling in 2011 at two locations, CRM 15.0 (slightly downstream from the proposed discharge) and CRM 18.8 (approximately a mile upstream of the proposed intake). Ten samples were taken at each location in May, July, and October of 2011. The average number of taxa in each sample ranged from 14.8 to 24 species at the upstream location, and the number of taxa increased from May to October. The average number of taxa in each sample at the downstream location was lower and ranged from 10.6 to 14, also with an increase from May to October. The total number of taxa identified (the taxa richness) varied from a low of 41 species at the downstream location in May to 59 species in October. The upstream location exhibited a larger number of taxa; 53 different species were identified in May and 67 in October. The greater the number of taxa in an ecosystem, the more diverse the ecosystem is, indicating that the ecosystem at CRM 18.8 is more diverse than that at CRM 15.0. The mean density of individual benthic organisms per square meter at the upstream location increased between May and October and ranged from 2,482 in May to 12,426 in October. Likewise, the mean density per square meter at the downstream location increased from 2,670 in May to 6,940 in October, with a drop in July to 2,281. The most abundant species during May and July at both the upstream and downstream locations were a snail (*Amnicola limosa*) and members of the family Chironomidae (nonbiting midge larvae); together, these species constituted approximately 70–80 percent of the individuals observed at both locations during the spring and summer. In the fall the population of zebra mussels (*Dreissena polymorpha)* outnumbered both the Chironomidae and *A. limosa* in samples at both the upstream and downstream locations. The combination of zebra mussels and Chironomidae were approximately 74 percent of the total individuals at the upstream location and approximately 85 percent at the downstream location (TVA 2013-TN5167).

Amnicola limosa is a common and widespread species of snail that prefers slow-moving rivers, such as those found in reservoirs in the Tennessee River system. Zebra mussels are an invasive species that are discussed later in this section. Chironomidae are one of the most abundant macroinvertebrates in aquatic ecosystems. More than 55 distinct species of Chironimidae were identified in the samples (TVA 2013-TN5167).

Between September 21 and 26, 2011, a mollusk and habitat survey was conducted using semi-quantitative and qualitative sampling methods (TRC 2011-TN5168). A total of 74 living native mussels were collected from 6 different species as shown in Table 2-17. Only 12 of the individuals were under 10 years old, meaning reproduction had occurred within the last 10 years. However, almost half of the mussels were 15 years or older (TRC 2011-TN5168).

Table 2-17. Abundance of Native Mussels in Clinch River, CRM 15.0 to 19.0

Scientific Name	Common Name	Abundance	Relative Abundance (percent)
Amphinaias pustulosa (=Quadrula pustulosa)	Pimpleback	53	71.6
Leptodea fragilis	Fragile papershell	13	17.6
Cyclonaias tuberculata	Purple wartyback	3	4.1
Potamilus alatus	Pink heelsplitter	2	2.7
Pyganodon grandis	Giant floater	2	2.7
Elliptio crassidens	Elephant ear	1	1.4
	Total	**74**	

Source: TRC 2011-TN5168.

The survey also observed the number of zebra mussels found on the collected mussels. Only 3 of the 74 mussels had no zebra mussels attached. The average area of coverage on an individual mussel was 28 percent and coverage ranged from 5 percent to 100 percent. The zebra mussels were abundant in areas where bedrock or other solid, stable substrates were located. Divers during the study describe the density as “a blanket of zebra mussels” (TRC 2011-TN5168). The presence of zebra mussels is detrimental to the survival of native mussels. Zebra mussels affect the growth and reproduction of native mussels by competing for space and food, interfering with the native mussel’s ability to open and close their shells, impairing movement of the native mussels, and depositing metabolic wastes on the native mussels (FWS 2015-TN5218).

2.4.2.1.6 Fish

TVA performed sampling studies in 2011 at two sampling locations downstream between CRM 14 and 15 and upstream between CRM 18 and 19.8 using electrofishing and gillnetting techniques. Surveys were conducted during the months of February, May, July, and October. The fish were identified by species, counted, and examined for parasites, disease, deformation or hybridization. The species collected are described in TVA 2013-TN5167.

TVA (2013-TN5167) reports relatively high species diversity with an average of 33 species (28 of which are indigenous) at the downstream location, and 36 species (31 of which are indigenous) at the upstream location. However, TVA also reported that overall catch rates were low and suggested that this may be due to cooler water temperatures that are released from Norris Dam into Melton Hills Reservoir, thus limiting overall productivity in the Clinch River below Melton Hills Dam (TVA 2013-TN5167).

The most common fish caught both upstream and downstream were Bluegill (*Lepomis macrochirus*) in February and May. Mississippi Silverside (*Menidia audens*), an invasive species, was the second most commonly caught fish at the downstream site but was rarely or not found at the upstream site. Gizzard Shad (*Dorosoma cepedianum*) numbers increased by July to replace Bluegill as the most common fish in the surveys. By October the Spotted Sucker (*Minytrema melanops*) was the most common fish at the downstream location and one of the top fish caught in the upstream location. Other fish that were numerous in the sampling in at least one location and one sampling event included White Bass (*Morone chrysops*), Yellow

Bass (*Morone mississippiensis*), Yellow Perch (*Perca flavescens*), an invasive species, Green Sunfish (*Lepomis cyanellus*), Redear Sunfish (*Lepomis microlophus*), Black Redhorse (*Moxostoma duquesnii*), and Sauger (*Sander canadensis*).

The following paragraphs present life-history information relevant to the potential of building and operating activities at the CRN Site to affect specific commercially and recreationally important fish.

Sunfish (*Lepomis* spp.)

Sunfish species found in the vicinity of CRN Site include the Bluegill, Redear Sunfish, Green Sunfish, Redbreast Sunfish (*L. auritus*), and Warmouth (*L. gulosus*). The Bluegill was the most common fish caught at the upstream and downstream sampling sites between February and May. Bluegill are both a forage fish and a game fish. The young are prolific and provide prey for bass. Bluegill frequent shallow water that features vegetative cover, submerged wood, or rocks. They spawn from late spring into summer. Sunfish construct nests in shallow water on varied substrates (although they prefer gravel) and guard their 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-TN5054). Etnier and Starnes (1993-TN5054) report that Bluegill select larger prey items when they are abundant but become less selective feeders as the abundance of their favorite prey decreases. The population of Bluegill can affect the Largemouth Bass population.

Gizzard Shad (*Dorosoma cepedianum*) and Threadfin Shad (*D. petenense*)

As mentioned previously, the numbers of Gizzard Shad in the vicinity of the CRN Site had increased by July to replace Bluegill as the most common fish in the surveys. Shad are valuable forage fish. The Gizzard Shad is possibly less likely to be a forage fish because of its rapid growth and larger maximum size (52.1 cm [20.5 in.] total length; 1.59 kg [3.5 lb]). Threadfin Shad on the other hand have a maximum total length of 21.6 cm (8.5 in.). Spawning occurs along the shorelines. Both species are prolific spawners. An average size female Gizzard Shad produces about 300,000 eggs a year. Gizzard Shad deposit their eggs in substrate such as boulders, logs, or debris. The eggs adhere to the substrate and hatch in 2 to 3 days. Gizzard Shad typically spawn from mid-May to mid-June in Tennessee, although researchers indicate that Threadfin Shad may spawn well into the summer and possibly fall. The fish synchronize their spawning time and spawn as a group activity. In particular, Threadfin Shad spawn a few hours after sunrise. Ecologists think the synchronous behavior is important for avoiding predators and rapidly building up populations that may have been depleted during the winter (Etnier and Starnes 1993-TN5054). Shad feed on plankton (Mettee et al. 1996-TN5169). Threadfin Shad and Gizzard Shad are susceptible to large winter die-offs when temperatures drop. The Threadfin Shad is less cold-tolerant than the Gizzard Shad. Sublethal effects such as feeding cessation can begin at 10°C (50°F). Inactivity occurs at 6 to 7°C (43 to 45°F) and death at 4 to 5°C (39 to 41°F), although death has been reported at temperatures as high as 12°C (54°F) (Etnier and Starnes 1993-TN5054).

Black Bass (*Micropterus spp.*)

Black Bass are popular recreational fish and include Largemouth Bass (*M. salmoides*) and Smallmouth Bass (*M. dolomieu*), which are also members of the sunfish family. Largemouth Bass and Spotted Bass (*M. punctulatus*) inhabit sluggish portions of streams and larger lakes and reservoirs. In reservoirs, Smallmouth Bass prefer steep rocky slopes along the submerged river and creek channels. Smallmouth and Spotted Bass spawn in April or early May, and Largemouth Bass spawn from late April to June. Black Bass construct nests in coarse gravel at depths less than 1 m (3.3 ft) near the margins of streams or lakes (Smallmouth Bass) or in other types of gravel or firm substrates (Spotted Bass and Largemouth Bass) along the shallow margins of lakes. For all three species, the males guard the nests until the fry have hatched and dispersed. For Smallmouth Bass, hatching requires about 4 to 6 days; fry swim up from the nest 5 to 6 days later. The fecundity of females varies with the size of the fish but they may produce from 2,000 to 145,000 eggs. Young bass feed on zooplankton, insects, and small fish, and are cannibalistic (Etnier and Starnes 1993-TN5054). Smallmouth and Spotted Bass feed primarily on small fish, crayfish, and aquatic insects. Largemouth Bass prey on Bluegill, Redear Sunfish, shad, minnows, crayfish, and amphibians (Mettee et al. 1996-TN5169).

<u>Catfish (Family Ictaluridae)</u>

Catfish that occur in the Clinch River arm of the Watts Bar Reservoir include the Blue Catfish (*Ictalurus furcatus*), Channel Catfish (*I. punctatus*), and Flathead Catfish (*Pylodictis olivaris*). Catfish are both recreationally and commercially important species. Members of the family Ictaluridae spawn in summer and deposit their eggs in depressions or nests they construct in natural cavities and crevices in rivers. Male catfish display territorial behavior after spawning and aggressively defend their eggs. Catfish are opportunistic feeders and eat aquatic insect larvae, crayfish, mollusks, and small fish (live and dead) (Etnier and Starnes 1993-TN5054; Mettee et al. 1996-TN5169).

2.4.2.2 Offsite Areas

2.4.2.2.1 Offsite Transmission Line Corridors

The offsite overhead transmission line right-of-ways identified by TVA for possible uprating, reconductoring, or rebuilding traverse a number of ephemeral, intermittent and perennial streams, rivers, ponds, and reservoirs. Because TVA's identification of the corridors proposed for upgrades is conceptual and because TVA has not identified where specific upgrades would occur, the locations of all relevant waterbodies are currently unknown. Nevertheless, some water bodies relating to ESA listed aquatic species and associated designated critical habitats have been identified along the offsite transmission lines in NRC's BA (Appendix M).

2.4.2.2.2 Offsite Borrow Areas

In addition to potentially using borrow material from the CRN Site, TVA indicated that nine existing borrow pits (Figure 2-9) totaling 227 ac may be used to support construction activities (TVA 2016-TN5145).

2.4.2.3 Important Species and Habitats

As noted for terrestrial resources in EIS Section 2.4.1.11, the NRC has defined important species as those that are rare or meet other specific criteria for deserving individualized evaluation (NRC 2000-TN614). This includes fish that are valued as commercial and recreational species including those species that are purposely placed by the State to support recreational fishing. It also includes invasive species that may affect indigenous species or their habitat. And finally it includes rare species that have been afforded Federal and/or State legal protections.

2.4.2.3.1 Commercial and Recreational Fishing

Currently there is no commercial fishing in the Watts Bar Reservoir, which includes the Clinch River arm that is adjacent to the CRN Site (TWRA 2016-TN5171).

Based on the surveys conducted in 2011, TVA has identified the following recreationally valuable fish at the upstream and downstream locations listed in Table 2-18, which includes fish that are forage for the larger species (TVA 2013-TN5167).

Table 2-18. Recreationally Valuable Fish in the Clinch River Arm of the Watts Bar Reservoir in the Vicinity of the CRN Site (TVA 2013-TN5167)

Scientific Name	Common Name	Upstream Location (CRM 18.5)	Downstream Location (CRM 15.0)
Alosa chrysochloris	Skipjack Herring	X	X
Ambloplites rupestris	Rock Bass	X	X
Aplodinotus grunniens	Freshwater Drum	X	X
Campostoma oligolepis	Largescale Stoneroller	X	
Cyprinus carpio	Common Carp	X	X
Dorosoma cepedianum	Gizzard Shad	X	X
Dorosoma petenense	Threadfin Shad	X	X
Esox masquinongy	Muskellunge		X
Ictalurus furcatus	Blue Catfish	X	X
Ictalurus punctatus	Channel Catfish	X	X
Labidesthes sicculus	Brook Silverside	X	
Lepomis auritus	Redbreast Sunfish	X	X
Lepomis cyanellus	Green Sunfish	X	X
Lepomis gulosus	Warmouth	X	X
Lepomis macrochirus	Bluegill	X	X
Lepomis microlophus	Redear Sunfish	X	X
Menidia audens	Mississippi Silverside	X	X
Micropterus dolomieu	Smallmouth Bass	X	X
Micropterus punctulatus	Spotted Bass		X
Micropterus salmoides	Largemouth Bass	X	X
Morone chrysops	White Bass	X	X
Morone mississippiensis	Yellow Bass	X	X
Morone saxatilis	Striped Bass	X	X
Notemigonus crysoleucas	Golden Shiner	X	
Perca flavescens	Yellow Perch	X	X
Pimephales promelas	Fathead Minnow	X	
Pomoxis annularis	White Crappie	X	
Pomoxis nigromaculatus	Black Crappie	X	
Pylodictis olivaris	Flathead Catfish	X	X
Sander vitreus	Walleye	X	X
Sander canadensis	Sauger	X	X

The TWRA stocks warmwater fish in TVA reservoirs. During 2017, TWRA stocked Florida Largemouth Bass, Striped Bass, and Walleye in the Watts Bar Reservoir. TWRA also stocked the Melton Hill Reservoir with 500 Muskellunge (TWRA 2017-TN5170).

2.4.2.3.2 Non-Native and Nuisance Species

By 2008 approximately 80 non-native aquatic species (animals and plants) had been identified in the State of Tennessee. Some of these species are considered "invasive" because they are deemed to cause environmental or economic harm. The staff identified the invasive species most likely to be present in the Clinch River arm of the Watts Bar Reservoir based on TVA's sampling studies (TVA 2013-TN5167), USGS data (USGS 2017-TN5066), and a 2008 management plan by the Tennessee Aquatic Nuisance Species Task Force (TANSTF 2008-TN5244). These species include the following:

- Clams and Mussels
  - Asiatic clam (*Corbicula fluminea*)
  - Zebra mussel (*Dreissena polymorpha*)
- Fish
  - Common carp (*Cyprinius carpo*)
- Plants
  - Eurasian watermilfoil (*Myriophyllum spicatum L.*)
  - Hydrilla (*Hydrilla verticillata*)
  - Spiny-leaf naiad (*Najas minor*)
  - Curly-leaved pondweed (*Potamogeton crispus L.*).

Two of these species, Asiatic clams and zebra mussels have already significantly affected the population of native freshwater mussels in the Clinch River arm of the Watts Bar Reservoir. Asiatic clams inhabit the section of the Tennessee River near the CRN Site. There is a large population of invasive, non-native, Asiatic clams. The Asiatic clam is in almost every river and reservoir in Tennessee and 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.

Zebra mussels have had an increasing population, particularly in the section of the Tennessee River near the CRN Site. Zebra mussels can also cause biofouling problems. Similar to Asiatic clams, 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 (Raikow 2004-TN5182). They also negatively affect freshwater mussels as discussed previously.

2.4.2.4 Protected Species

The FWS provided a list of Federal species that they wanted to be considered in the EIS within the vicinity of the CRN Site. These species are listed in Table 2-19. The FWS also recommended consideration of the hellbender (*Cryptobranchus alleganiensis*), a large salamander that is currently petitioned for listing (FWS 2017-TN5091). These species are discussed further in this section.

Table 2-19. Federally Listed Aquatic Species in the Vicinity of the CRN Site

Scientific Name	Common Name	Federal Status
Lampsilis abrupta	Pink Mucket	Endangered
Plethobasus cyphyus	Sheepnose Mussel	Endangered
Erimonax monachus	Spotfin Chub	Threatened

Source: FWS 2017-TN5091.

Table 2-20 lists the State-listed aquatic species from Roane County along with brief descriptions of the preferred habitat for each of the species. TDEC provided information from their Natural Heritage Program regarding the known occurrences of the State-listed species in the vicinity of the CRN Site (TNHP 2017-TN5361). With the exception of the Federally listed species discussed later, the ring pink mussel (*Obovaria retusa*) and the fanshell (*Cyprogenia stegaria*) were most recently observed in 1994 downstream of the Melton Hill Dam and all other species either were last seen in 1919, were observed only as empty shells or in collections, or have not been observed in the vicinity of the site.

Table 2-20. State-Listed Aquatic Species in Roane County, Tennessee

Scientific Name	Common Name	Tennessee Status	Habitat
Mussels			
Cyprogenia stegaria	Fanshell	Endangered	Medium-to-large streams and rivers with coarse sand and gravel substrates.
Villosa perpurpurea	Purple bean	Endangered	Creeks to medium-size rivers, headwaters, in riffles with course sand and gravel and some silt. Upper Tennessee River watershed.
Quadrula cylindrica strigillata	Rough rabbitsfoot	Endangered	Small-to-medium size rivers, in clear, shallow riffles with sand-gravel substrates.
Fusconaia cor	Shiny pigtoe	Endangered	Shoals and riffles of small-to-medium size rivers with moderately fast current over sand-cobble substrates.
Lampsilis virescens	Alabama lampmussel	Endangered	Found in sand and gravel substrates in shoal areas of small-to-medium size rivers; recently rediscovered in Emory River.
Fusconaia cuneolus	Fine-rayed pigtoe	Endangered	Riffles of fords and shoals of moderate gradient streams in firm cobble and gravel substrates.
Plethobasus cooperianus	Orangefoot pimpleback	Endangered	Large rivers in sand-gravel-cobble substrates in riffles and shoals in deep flowing water.
Obovaria retusa	Ring pink	Endangered	Large rivers in gravel and sand bars; many historical locations currently inundated.
Plethobasus cyphyus	Sheepnose mussel	Endangered	Large-to-medium size rivers, in riffles and coarse sand/gravel substrate.
Lampsilis abrupta	Pink mucket	Endangered	Generally a large river species, preferring sand-gravel or rocky substrates with moderate to strong currents.
Crustaceans			
Cambarus deweesae	Valley Flame crayfish	Endangered	Primary burrower; open areas with high water tables; northern ridge and valley
Fish			
Hemitremia flammea	Flame Chub	Deemed in Need of Management	Springs and spring-fed streams with lush aquatic vegetation.

Table 2-20. (contd)

Scientific Name	Common Name	Tennessee Status	Habitat
Erimonax monachus	Spotfin Chub	Threatened	—
Chrosomus tennesseensis	Tennessee Dace	Deemed in Need of Management [(a)]	First-order spring-fed streams of woodlands in Ridge and Valley limestone region.
Percina aurantiaca	Tangerine Darter	Deemed in Need of Management	Large-to-moderate size headwater tributaries to Tennessee River, in clear, fairly deep, rocky pools usually below riffles.
Erimonax monachus	Spotfin Chub	Threatened	Clear upland rivers with swift currents and boulder substrates
Cycleptus elongatus	Blue Sucker	Threatened	Swift waters over firm substrates in big rivers.
Amphibians			
Gyrinophilus gulolineatus	Berry Cave salamander	Threatened	Aquatic cave obligate; ridge and valley.
Hemidactylium scutatum	four-toed salamander	Deemed in Need of Management	Woodland swamps, shallow depressions and sphagnum mats on acidic soils
Cryptobranchus alleganiensis	hellbender	Deemed in need of management	Rocky clear creeks and rivers with large shelter rocks.

[a]TWRA does not list the Tennessee Dace as “Deemed in Need of Management” but has proposed this status (TNDOS 2017-TN5323).

Source: TDEC 2017-TN5217.

The Lake Sturgeon (*Acipenser fulvescens*), although not identified in Roane County, has recently been reported in the Watts Bar Reservoir in the vicinity of the Clinch River (Saidak 2015-TN5181).

Species of particular interest to the FWS and State-listed species that are known to be in the vicinity of the site are described further below. These species include the two Federally listed mussels, the Federally listed Spotfin Chub, the hellbender, the State Endangered Lake Sturgeon, and the Tennessee Dace, which is deemed in need of management.

2.4.2.4.1 Pink Mucket Mussel (Lampsilis abrupta)

The FWS designated the pink mucket mussel as endangered in 1976 (41 FR 24062-TN5173). Historically, this species was recorded from the Mississippi, Ohio, and Cumberland Rivers and in the Tennessee River up to the lower Clinch River (Parmalee and Bogan 1998-TN5166). Currently, it occurs only in the riverine reaches downstream of Wilson Dam in Tennessee and downstream of Guntersville Dam in Alabama (Mirarchi et al. 2004-TN5174) and in the Cumberland River in Smith County, Tennessee (Parmalee and Bogan 1998-TN5166). However, FWS considers the species to be uncommon to rare. Researchers report specimens younger than 10 years of age as being 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 Bass, Spotted Bass, and Largemouth Bass as well as Freshwater Drum and possibly Sauger (Mirarchi et al. 2004-TN5174). The most recent siting of a pink mucket in the Clinch River was in 1984 at CRM 19.1, slightly upstream of the CRN Site. No pink muckets, either living or as relic shells, were found in the 2011 surveys at the CRN Site. TVA has found the pink mucket mussel more recently elsewhere in the Tennessee River system. A single individual was found as recently as a September 2010 survey (TRC 2010-TN5175) in the tailrace of Watts Bar Dam in Chickamauga Reservoir. Declines in the number of pink mucket mussels are assumed to be the result of impoundment, siltation, and pollution.

The Clinch River arm of the Watts Bar Reservoir adjacent to the CRN Site lacks the appropriate habitat for the pick mucket mussel. Furthermore, the extent to which zebra mussels have invaded this area and the lack of recent sightings of any individual pink muckets have led the review team to conclude that it is unlikely that the pink mucket is present in the vicinity of the site. The pink mucket is therefore not considered further in this EIS.

Additional information regarding the life history and baseline of the pink mucket mussel in the vicinity of the CRN Site is provided in NRC's BA (Appendix M).

2.4.2.4.2 Sheepnose Mussel (Plethobasus cyphyus)

The FWS listed the sheepnose mussel as endangered in the *Federal Register* on March 13, 2012 (77 FR 14914-TN5177). It occurs across the Southeast and the Midwest, but appears extirpated from two-thirds of streams where it had been known to occur. The Sauger is the only known host for sheepnose mussel glochidia (Parmalee and Bogan 1998-TN5166). Sheepnose mussels live nearly 30 years (77 FR 14914-TN5177). Parmalee and Bogan (1998-TN5166) indicated that the most suitable substrate is "a mixture of coarse sand and gravel." Further, in unimpounded rivers sheepnose mussels can be found in less than 0.6 m (2 ft) of water and in relatively fast currents. In reservoirs, sheepnose mussels have been reported at depths of 3.6 to 4.6 m (12 to 15 ft) (Parmalee and Bogan 1998-TN5166), though they have also been reported at depths exceeding 6 m (20 ft) (77 FR 14914-TN5177).

Parmalee and Bogan (1998-TN5166) indicated that the most stable and viable populations of sheepnose mussels in Tennessee were located in the upper Clinch River (Hancock County) and below Pickwick Landing Dam (Harding County) in the Tennessee River. The sheepnose mussel was last observed in 1994 at CRM 21.4 downstream of Melton Hill Dam (TWRA 2017-TN5410). More recent sightings have occurred elsewhere in the Tennessee River system. In September 2010, TVA found a specimen, judged to be approximately 20 years old, during sampling in the tailrace of Watts Bar Dam in Chickamauga Reservoir (TRM 526 to 527) (TRC 2010-TN5175). The sheepnose is known to have existed recently farther upstream in the Clinch River above CRM 168 and the last recorded sightings occurred between 2004 and 2006 (Jones et al. 2014-TN5324). Habitat destruction and degradation, including impoundment and siltation, are likely reasons for the population decline.

A few of the sampled areas of the Clinch River arm of the Watts Bar Reservoir adjacent to the CRN Site contain substrate (sand and gravel) at the appropriate depth for sheepnose mussels. Even so, the extent to which zebra mussels have invaded this area and the lack of recent sightings of any individual sheepnose mussels in Roane County have led the review team to conclude that it is unlikely that the sheepnose mussel is present in the vicinity of the site. The sheepnose mussel is therefore not considered further in this EIS.

Additional information regarding the life history and baseline of the sheepnose mussel in the vicinity of the CRN Site is provided in NRC's BA (Appendix M).

2.4.2.4.3 Spotfin Chub (Erimonax monachus)

The FWS listed the Spotfin Chub as threatened in 1977 (42 FR 45526-TN5178). It is also listed by the State of Tennessee as threatened. The Spotfin Chub was historically found in Alabama, Georgia, North Carolina, Virginia, and Tennessee from streams in the upper and middle Tennessee River system. Experimental populations (where individuals have been reintroduced into areas of former range to determine whether they can reconstitute a sustaining population) are now found in three river systems including the Tellico River, French Broad River, and Holston River in Tennessee (FWS 2017-TN5219). The Spotfin Chub is a small fish less than 4.75 in. long. They inhabit clear upland rivers and are typically found in habitats with boulders in swift currents. Their diet is primarily aquatic insects such as midges, mayflies, and caddisfly larvae (Etnier and Starnes 1993-TN5054). Spotfin Chub were not identified in the Clinch River or streams on the CRN Site or in the transmission line corridor. Declines are also due to habitat destruction and degradation.

The Clinch River arm of the Watts Bar Reservoir adjacent to the CRN Site lacks the appropriate habitat (described above) for Spotfin Chub. Furthermore the lack of recent sightings during sampling (TVA 2013-TN5167) has led the review team to conclude that it is unlikely that Spotfin Chub are present in the vicinity of the site. The Spotfin Chub is therefore not considered further in this EIS.

Additional information regarding the life history and baseline of the Spotfin Chub in the vicinity of the CRN Site is provided in NRC's BA (Appendix M).

2.4.2.4.4 Hellbender (Cryptobranchus alleganiensis)

The hellbender, also called the mudpuppy or waterdog, is an aquatic salamander that grows from 30 to 74 cm (12 to 29 in.) long. Members of this species are found distributed from southern New York to northern Georgia and Alabama. They prefer habitats with swift running, fairly shallow, highly oxygenated waters. This species finds flat rocks, logs, or other cover in the vicinity of riffle areas, essential for feeding and breeding (Mayasich et al. 2003-TN5179). Its habitat is generally medium-to-large clear, fast-flowing streams with rocky bottoms, especially riffle areas and upper pool reaches. A hellbender was most recently observed in 1989 in the Clinch River downstream of Jones Island below Melton Hill Dam (TNHP 2017-TN5361).

The Clinch River arm of the Watts Bar Reservoir adjacent to the CRN Site lacks the appropriate habitat (described above) for the hellbender, but this species could still exist in the area upstream of the site below Melton Hill Dam.

Additional information regarding the life history and baseline of the hellbender in the vicinity of the CRN Site is provided in NRC's BA (Appendix M).

2.4.2.4.5 Tennessee Dace (Chrosomus tennesseensis)

The Tennessee Dace (Table 2-20) was discussed previously as being found in Ish Creek, which may be crossed by the 69-kV underground transmission line that would be installed in an existing 500-kv transmission line corridor that runs from the Bethel Valley Substation to the CRN Site. The Tennessee Dace inhabits small, low-gradient woodland tributaries and prefers areas with shallow pools, undercut banks, and debris. The preferred tributaries usually measure less than 2 m (6.5 ft) wide. They have previously been considered abundant in the East Popular Creek system on the ORR (Etnier and Starnes 1993-TN5054).

2.4.2.4.6 Lake Sturgeon (Acipenser fulvescens)

Lake Sturgeon populations in Tennessee are considered State Endangered, and stocking efforts have been implemented in an effort to reestablish or supplement existing populations. Over 140,000 juvenile lake sturgeon have been released into the upper Tennessee River system (TN Aquarium 2017-TN5180). Sturgeon fitted with acoustic tags have been tracked as far upstream in Watts Bar Reservoir as river mile 576, near upper Paint Rock Refuge (Saidak 2015-TN5181).

2.4.2.4.7 Offsite Transmission Line Corridors

The offsite overhead transmission line right-of-ways identified by TVA for possible uprating, reconductoring, or rebuilding traverse a number of ephemeral, intermittent and perennial streams, rivers, ponds, and reservoirs in densely forested and agricultural landscapes similar to those surrounding the CRN Site. Federally listed species in aquatic habitats that are in counties that are traversed by the transmission line right-of-ways are listed in Table 2-21.

Critical habitat for the slabside pearly mussel (*Pleuronaia dolabelloides*) in the Sequatchie River intersects transmission line corridor L5173 in Bledsoe County, Tennessee. Critical habitat for the spotfin chub (*Erimonax monachus*) in the Gum Branch of Clear Creek and in the Obed River intersects transmission line corridor L5204 in Cumberland County, Tennessee. Critical habitat for the Spotfin Chub also intersects transmission line corridor L5205 in Daddy's Creek, also in Cumberland County. Further discussions of known occurrences and critical habitat in the vicinity of, but not in, the offsite transmission lines are discussed in NRC's BA (Appendix M).

Table 2-21. Federally Listed Aquatic Species that May Occur in Proximity to the Transmission Lines Proposed for Upgrade (TNHP 2017-TN5361; GDNR 2017-TN5397; KSNPC 2017-TN5400) in: Franklin, Warren, White, Van Buren, Bledsoe, Rhea, Putnam, Cumberland, Roane, Anderson, Scott, Knox, Campbell, Grainger, Hawkins, Greene, Jefferson, Hamblen, Claiborne, Grundy, Hamilton, Sequatchie, Sevier, and Cocke Counties, Tennessee; Bell and Whitely counties Kentucky, and Catoosa County Georgia.

Scientific Name	Common Name	Federal Status	Presence of Critical Habitat
Mollusks			
Lampsilis virescens	Alabama lampmussel	Endangered	
Athearnia anthonyi	Anthony's riversnail	Endangered	
Alasmidonta ravenliana	Appalachian elktoe	Endangered	
Quadrula sparsa	Appalachian monkeyface	Endangered	
Lemiox rimosus	Birdwing pearlymussel	Endangered	
Epioblasma obliquata	Catspaw	Endangered	
Pleurobema clava	Clubshell	Endangered	
Hemistena lata	Cracking pearlymussel	Endangered	
Villosa trabalis	Cumberland bean	Endangered	
Alasmidonta atropurpurea	Cumberland elktoe	Endangered	Yes
Theliderma intermedia (=Quadrula intermedia)	Cumberland monkeyface	Endangered	
Pleurobema gibberum	Cumberland pigtoe	Endangered	
Epioblasma brevidens	Cumberlandian combshell	Endangered	Yes
Dromus dromas	Dromedary pearlymussel	Endangered	
Cyprogenia stegaria	Fanshell	Endangered	
Fusconaia cuneolus	Fine-rayed pigtoe	Endangered	
Ptychobranchus subtentum	Fluted kidneyshell	Endangered	Yes

Table 2-21. (contd)

Scientific Name	Common Name	Federal Status	Presence of Critical Habitat
Pegias fabula	Little-wing pearlymussel	Endangered	
Plethobasus cooperianus	Orangefoot pimpleback	Endangered	
Epioblasma capsaeformis	Oyster mussel	Endangered	Yes
Toxolasma cylindrellus	Pale lilliput	Endangered	
Lampsilis abrupta	Pink mucket	Endangered	
Villosa perpurpurea	Purple bean	Endangered	Yes
Theliderma cylindrica (=Quadrula cylindrica)	Rabbitsfoot	Threatened	
Villosa fabalis	Rayed bean	Endangered	
Obovaria retusa	Ring pink	Endangered	
Pleurobema plenum	Rough pigtoe	Endangered	
Quadrula cylindrica strigillata	Rough rabbitsfoot	Endangered	Yes
Plethobasus cyphyus	Sheepnose mussel	Endangered	
Fusconaia cor	Shiny pigtoe	Endangered	
Pleuronaia dolabelloides	Slabside pearlymussel	Endangered	Yes
Epioblasma triquetra	Snuffbox	Endangered	
Margaritifera monodonta (=Cumberlandia monodonta)	Spectaclecase	Endangered	
Epioblasma florentina walkeri	Tan riffleshell	Endangered	
Epioblasma torulosa	Tubercled blossom	Endangered	
Epioblasma turgidula	Turgid blossom	Endangered	
Plethobasus cicatricosus	White wartyback	Endangered	
Fish			
Phoxinus cumberlandensis	Blackside Dace	Threatened	
Etheostoma akatulo	Bluemask (Jewel) Darter	Endangered	
Etheostoma wapiti	Boulder Darter	Endangered	
Noturus crypticus	Chucky Madtom	Endangered	Yes
Etheostoma susanae	Cumberland Darter	Endangered	
Etheostoma percnurum	Duskytail Darter	Endangered	
Etheostoma spilotum	Kentucky Arrow Darter	Threatened	
Chrosomus saylori	Laurel Dace	Endangered	Yes
Notropis albizonatus	Palezone Shiner	Endangered	
Notorus stanauli	Pygmy Madtom	Endangered	
Erimystax cahni	Slender Chub	Threatened	Yes
Percina tanasi	Snail Darter	Threatened	
Erimonax monachus	Spotfin Chub	Threatened	Yes
Etheostoma lemniscatum	Tuxedo Darter	Endangered	
Noturus flavipinnis	Yellowfin Madtom	Threatened	Yes

2.5 Socioeconomics

This section describes socioeconomic resources that could be affected by building and operating two or more SMR units at the CRN Site. It is organized into two major subsections providing details on demographics and community characteristics. These subsections include discussions of spatial (e.g., regional, vicinity, and site) and temporal (e.g., 10-year increments of population growth) considerations, where appropriate.

After reviewing the TVA ER (TVA 2017-TN4921) and other information provided by the applicant such as consultant reports and other supporting documentation, and based on the results of the review team's independent analysis, including interviews with local economic experts (NRC 2018-TN5386), the NRC staff's socioeconomic analysis focused on Anderson, Knox, Loudon, and Roane Counties in Tennessee, defined as the economic region. In addition, analytical attention is given in proportion to the expected degree of impact that might affect these resources. Thus, where minimal impacts are expected, relatively less baseline discussion is provided.

The review team's baseline analysis began with the 50-mi region surrounding the CRN Site, which is a wider geographic area than the four-county economic region described above. The review team performed an independent analysis of the potential demographic and socioeconomic impacts of the proposed project contained in TVA's ER (TVA 2017-TN4921) and concurs that the construction and operations workers for a new nuclear power plant would likely settle in these same areas with the same residence patterns as the current ORR workforce. Approximately 87 percent of the current ORR workforce lives in the four Tennessee counties of the economic region: Anderson County (23.5 percent of the current ORR workforce), Knox County (43.5 percent), Loudon County (5.2 percent), and Roane County (14.8 percent) (TVA 2017-TN4921). The remaining 13 percent of the construction and operations workers for a new nuclear power plant would be scattered across neighboring counties and cities and would not have a discernible impact in those locations.

TVA assumes approximately 66.2 percent of the workforce required to build a new nuclear power plant would come from within 50 mi of the proposed site. TVA assumes the remaining 33.8 percent of workers would relocate to the region from beyond 50 mi and would choose to reside in the economic region in the same proportion as the current ORR workforce (TVA 2017-TN4921). These assumptions are consistent with the workforce distribution processes performed in most of the ERs and EISs related to the siting, construction, and operations of a nuclear power facility. The review team found TVA's workforce distribution assumptions to be reasonable and has incorporated them into this analysis. Two recent studies covering the local area inform the review team analysis. The East Tennessee Economic Council (ETEC 2014-TN4963) completed a study of the 2013 economic impact of DOE operations on the State of Tennessee, with cooperation from the University of Tennessee. DOE sponsored a study performed by the University of Tennessee (2015-TN4964) that estimates the localized economic impact of the operation of DOE's Oak Ridge Environmental Management program in Federal fiscal year 2014. These studies and the review team's interviews with the authors of these studies helped identify the appropriate economic region. Thus, the review team expects both adverse and beneficial socioeconomic impacts of building and operating a new plant would not be noticeable except in these four counties.

2.5.1 Demographics

This section describes the population of the economic region, focusing first on residents who live in the area permanently, then on transients who may temporarily live in or visit the area, and finally on migrant workers who travel into the area to work and then leave after their jobs are done.

The review team evaluated the demographic characteristics of resident populations, transient populations, and migrant workers within 50 mi of the CRN Site. Because the focus of the review team's analysis was on the economic region, the data presented focuses on Anderson, Knox, Loudon, and Roane Counties in Tennessee. For definitional purposes, "residents" live permanently in the area, while "transients" may temporarily live in the area but have permanent residences elsewhere, and "migrant workers" are employed seasonally in the area. "Transients" are not defined by the U.S. Census Bureau (USCB), which generally only captures individuals residing in the area during the time of the census.

The data used in this section were derived by the review team from the 2000 and 2010 censuses; other estimates are from the USCB, including the 2010 and 2015 American Community Survey (ACS) 5-Year Summary Files; the U.S. Department of Agriculture's 2012 Census of Agriculture data on farms and farm workers. Census data and ACS estimates were used to make comparisons across the region (by sector), among counties, and with the states of Tennessee, North Carolina, and Kentucky.

The review team relied on TVA's analysis of transient populations. Data regarding transient populations were drawn from various national and local data sources (TVA 2017-TN4921).

The review team relied on county population projections prepared by the University of Tennessee (UTK 2015-TN4935).

2.5.1.1 Resident Population

Oak Ridge is the largest city in close proximity to the site, but the economic region is dominated by the City of Knoxville. As shown in Table 2-22, the University of Tennessee reports the combined population of the four counties in the economic region as being 646,632 people in 2015. More than 71 percent of the four-county population lives in Knox County, with 28 percent of the economic region's population (183,066 people) living in the City of Knoxville. Roane County, the host county of the CRN Site, has 8.6 percent of the area's population. Anderson County, including the City of Oak Ridge, has 12 percent of the area population and Loudon County has the remaining 8.1 percent (UTK 2015-TN4935). Table 2-23 lists the 2016 population of municipalities and townships within 10 mi of the site.

Table 2-22 indicates the population of the economic region increased at an average rate of 1.20 percent per year between 2010 and 2015, and the average annual growth ranged from 1.96 percent in Loudon County to 0.45 percent in Roane County. Between 2000 and 2010, population growth in the economic region averaged 2.42 percent per year, led by growth in Knox and Loudon Counties (UTK 2015-TN4935).

Table 2-22. Recent Population and Growth Rates of Counties in the Economic Region

County	2000	2010	2015	Annual Growth Rate, 2010–2015 (%)
Anderson County, TN	71,330	75,129	77,285	0.57
Knox County, TN	382,032	432,226	460,612	1.31
Loudon County, TN	39,086	48,556	53,324	1.96
Roane County, TN	51,910	54,181	55,411	0.45
Total Economic Region	544,358	610,092	646,632	1.20
State of Tennessee	6,346,105	6,735,347	7,112,424	1.12

Source: UTK 2015-TN4935.

Table 2-23. Population of Municipalities within 10 mi of the CRN Site

Township/Municipality	Population, 2016
Oak Ridge	29,350
Kingston	5,840
Harriman	6,218
Lenoir City	9,106

Source: USCB 2016-TN4933.

Table 2-24 presents longer-term population trends and projections for counties in the economic region. Staff obtained historic population data for the State of Tennessee and the four counties of the economic region from the USCB's decennial censuses between 1970 and 2010. The University of Tennessee provided population projections for the period between 2010 and 2040. These projections indicate the population of the overall area is expected to continue growing, although at a slower rate than in recent decades. UTK forecasts Loudon County will grow at the highest rate, with the lowest rate of growth predicted for Roane County. Over the 2015–2060 period, the economic region is projected to grow at a slower pace than the State of Tennessee as a whole (TVA 2017-TN4921; UTK 2015-TN4935).

Table 2-25 provides the age and gender distribution of the resident population within the four counties of the economic region and the State. Women account for more than half of the population in all the counties. The distribution across the counties is relatively uniform; women make up over 51 percent and men account for under 49 percent. Knox County has the youngest population in the economic region with a median age of 37.3 years, while the other three counties have median ages noticeably higher, ranging from 43.2 to 46.5 years. The median age for the economic region is 39.5 years, compared to the State median age of 38.4 years (USCB 2017-TN4934).

Table 2-26 provides household income distribution and poverty information based on 2011–2015 ACS data from the USCB (USCB 2017-TN4936). Median household income in the economic region ranges from nearly $41,000 in Roane County to just over $51,000 in Loudon County. The median family income in Tennessee is slightly more than $45,000 per year. The 2015 5-year ACS reports 11.4 percent of the families in the economic region live below the poverty level, compared to 13.2 percent of the families in Tennessee. The 2015 5-year ACS reported that the two most populous counties in the economic region—Anderson and Roane—had a proportion of families living below the poverty level that was at least as large as the proportion in the State of Tennessee as a whole. Among the four counties of the economic region, Anderson County had the highest proportion of households below the poverty level—13.9 percent. Roane County ranked second with 13.2 percent; then Knox County with 10.9 percent and Loudon County with 10.2 percent—the lowest proportion of families below the poverty level.

Table 2-27 provides the racial and ethnic distribution of residents within the economic region. The economic region is less racially and ethnically diverse than Tennessee as a whole. African-American residents make up 7.2 percent of the population within the economic region, ranging from 1.3 percent of the population of Loudon County to 9.0 percent of the population of Knox County. Hispanic residents represent less than 4 percent of the population of the four-county economic region. Roane County has the lowest proportion of Hispanic residents (1.6 percent), and Loudon County the highest (7.7 percent). White residents are the most prominent race in all four counties, ranging from 83.1 percent in Knox County to 93.2 percent in Roane County (USCB 2017-TN4937).

Table 2-24. Historical and Projected County Populations in the Economic Region, 1970–2040

	Anderson County		Knox County		Loudon County		Roane County		Economic Region	
Year	Population	Annual Percent Growth	Population	Annual Percent Growth	Population	Annual Percent Growth	Population	Annual Percent Growth	Population	Annual Percent Growth
1970	60,300	NA	276,293	NA	24,266	NA	38,881	NA	399,740	NA
1980	67,346	1.17	319,694	1.57	28,553	1.77	48,425	2.45	464,018	1.61
1990	68,250	0.13	335,749	0.50	31,255	0.95	47,227	-0.25	482,481	0.40
2000	71,330	0.45	382,032	1.38	39,086	2.51	51,910	0.99	544,358	1.28
2010	75,129	0.53	432,226	1.31	48,556	2.42	54,181	0.44	610,092	1.21
2015	77,285	0.57	460,612	1.31	53,324	1.96	55,411	0.45	646,632	1.20
2020	79,061	0.46	488,993	1.23	57,923	1.72	56,301	0.32	682,278	1.10
2025	80,713	0.42	516,603	1.13	62,151	1.46	56,805	0.18	714,968	0.96
2030	82,202	0.37	538,071	0.93	65,869	1.20	59,209	0.42	745,351	0.85
2035	83,444	0.30	561,445	0.87	68,918	0.93	59,938	0.25	773,745	0.76
2040	84,438	0.24	584,406	0.82	71,421	0.73	60,274	0.11	800,539	0.69
2045	85,270	0.20	607,803	0.80	73,776	0.66	60,374	0.03	827,223	0.67
2050	86,158	0.21	631,888	0.79	76,277	0.68	60,450	0.03	854,773	0.67
2055	87,216	0.25	657,011	0.80	79,158	0.76	60,641	0.06	884,026	0.68
2060	88,556	0.31	683,540	0.81	82,475	0.84	61,012	0.12	915,583	0.71

Sources: TVA 2017-TN4921; UTK 2015-TN4935

Table 2-25. 2015 Percentage Age and Gender Distribution in the Economic Region and State

Age Groups	Anderson County		Knox County		Loudon County		Roane County		Economic Region		Tennessee	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Under 5 years	3,998	5.3	26,243	5.9	2,511	5.0	2,552	4.8	35,304	5.7	402,574	6.2
5 to 14 years	9,202	12.2	53,375	12.0	5,676	11.3	6,114	11.5	74,367	11.9	837,613	12.9
15 to 24 years	8,901	11.8	70,277	15.8	5,174	10.3	5,848	11.0	90,199	14.5	883,065	13.6
25 to 44 years	17,651	23.4	116,091	26.1	10,799	21.5	11,164	21.0	155,705	25.0	1,688,212	26.0
45 to 64 years	21,799	28.9	116,091	26.1	13,964	27.8	16,533	31.1	168,387	27.0	1,740,157	26.8
65 years and over	13,879	18.4	62,271	14.0	12,105	24.1	10,951	20.6	99,207	15.9	947,996	14.6
Total	75,430	100	444,348	100	50,229	100	53,162	100	623,169	100	6,499,615	100
Median Age (years)	43.2		37.3		46.5		46.1		39.5		38.4	
Gender												
Male	36,585	48.5	215,996	48.6	24,438	48.7	26,021	48.9	303,040	48.6	3,167,756	48.7
Female	38,845	51.5	228,352	51.4	25,791	51.3	27,141	51.1	320,129	51.4	3,331,859	51.3

Source: USCB 2017-TN4934.

Table 2-26. Household Income Distribution (Percent of Households) within the Economic Region in 2015 Inflation-Adjusted Dollars

Income Range	Anderson County	Knox County	Loudon County	Roane County	Economic Region	Tennessee
Total Households	30,612	180,729	20,009	21,887	253,237	2,504,556
Less than $10,000	8.2	8.4	5.0	10.5	8.3	8.6
$10,000 to $14,999	7.6	5.4	6.2	7.6	5.9	6.3
$15,000 to $24,999	14.8	12.0	12.3	13.5	12.5	12.7
$25,000 to $34,999	11.0	11.5	10.8	11.9	11.4	11.8
$35,000 to $49,999	14.7	13.7	14.8	15.1	14.0	14.8
$50,000 to $74,999	16.7	17.7	20.9	17.7	17.9	18.2
$75,000 to $99,999	10.0	11.7	12.9	9.0	11.3	11.0
$100,000 to $149,999	10.9	11.4	10.5	9.9	11.1	10.2
$150,000 to $199,999	3.9	4.0	3.3	3.3	3.9	3.3
$200,000 or more	2.3	4.2	3.3	1.5	3.6	3.2
Median Household Income	42,880	48,701	51,107	40,854	47,509	45,219
Percentage of Families below Poverty Level	13.9	10.9	10.2	13.2	11.4	13.2

Source: USCB 2017-TN4936.

Table 2-27. 2015 Racial and Ethnic Percentage Distribution within the Economic Region

Racial or Ethnic Category	Anderson County	Knox County	Loudon County	Roane County	Economic Region	Tennessee
Total population (persons)	75,430	444,348	50,229	53,162	623,169	6,499,615
White	90.0	83.1	88.9	93.2	85.2	77.8
Racial and ethnic minorities	10.0	16.9	11.1	6.8	14.8	22.2
Black or African American	3.8	9.0	1.3	2.6	7.2	16.8
American Indian and Alaska Native	0.3	0.2	0.2	0.4	0.2	0.3
Asian	1.3	2.0	0.8	0.4	1.7	1.6
Native Hawaiian and Other Pacific Islander	0.0	0.0	0.1	0.0	0.0	0.1
Some other race	0.0	0.2	0.0	0.1	0.1	1.5
Two or more races	2.1	1.8	1.1	1.6	1.7	2.0
Hispanic or Latino	2.5	3.8	7.7	1.6	3.8	4.9
Not Hispanic or Latino	97.5	96.2	92.3	98.4	96.2	95.1

Source: USCB 2017-TN4937.

2.5.1.2 Transient Population

Transient populations include people from outside the area who work in or visit large workplaces, schools, hospitals and nursing homes, correctional facilities, hotels and motels, recreational areas, or special events in the area. TVA characterizes the transient population in its ER. The review team evaluated TVA's transient population assessment, found it reasonable; and incorporated that information into this EIS. TVA estimates that the 2013 peak transient population within 50 mi was 573,138 (TVA 2017-TN4921). Nearly 70 percent of this population occurs 20 to 30 mi from the CRN Site and includes a mix of commuters, tourists, recreationists, and event attendees. Approximately 2.7 percent of the peak transient population occurs within 10 mi of the CRN Site. Based on the most recent USCB data covering worker commuting flows

(USCB 2017-TN4938), in 2013 the economic region had a net commuting daily in-flow of 34,810 workers. TVA estimates that the peak transient population will grow to 885,887 by 2067.

2.5.1.3 Migrant Labor

The USCB defines a migrant laborer as someone who works seasonally or temporarily and moves one or more times per year to perform seasonal or temporary work. Migrant labor in the economic region consists mainly of construction workers and migrant farm laborers. The 2012 Census of Agriculture indicates there are 12 farms in the economic region that employ migrant labor, but the total number of migrant workers is not disclosed (USDA 2014-TN4940). The review team assumes the population of migrant agricultural workers to be negligible compared to the resident population of the economic region and anticipates that while migrating construction workers would outnumber migrant agricultural workers, they also would be negligible compared to the total population.

2.5.2 Community Characteristics

This section characterizes the communities that could be affected by building and operating a new nuclear power plant at the CRN Site. The following subsections describe the socioeconomic conditions in the area, including the economy, tax-based revenue, transportation, aesthetics and recreation, housing, and public services. Insights into local conditions were provided by interviewing local officials in each of the counties in the economic region (NRC 2018-TN5386).

2.5.2.1 Economy

This section presents information about the labor force, employment, and income within the economic region. The review team expects the majority of direct impacts from building and operating a new plant would occur in Roane County, where the CRN Site is located. Unemployment data presented in this section suggest the economy of the economic region grew from 2002 through 2007, experienced a downturn between 2008 and 2011, and recovered through 2016. The economy of each county is described below.

Table 2-28 lists the labor force size, number of employed and unemployed persons, and the unemployment rate for 2016 for each county in the economic region and for Tennessee. Table 2-29 chronicles the change in the unemployment rates for each area for the period between 2005 and 2016.

Table 2-28. 2016 Annual Average Labor Force, Employment, and Unemployment in Counties of the Region and Tennessee

	Civilian Labor Force	Employed	Unemployed	Unemployment Rate
Tennessee	3,135,102	2,984,259	150,843	4.8
Anderson County	33,901	32,220	1,681	5.0
Knox County	233,354	223,849	9,505	4.1
Loudon County	22,346	21,283	1,063	4.8
Roane County	23,015	21,719	1,296	5.6
Economic Region	312,616	299,071	13,545	4.3

Source: BLS 2017-TN4928.

Table 2-29. Annual Unemployment Rates (percent) for Counties of the Economic Region and Tennessee, 2005 to 2016

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Tennessee	5.6	5.2	4.7	6.6	10.5	9.7	9.0	7.8	7.8	6.5	5.6	4.8
Anderson County	5.1	4.7	4.2	5.8	9.9	9.3	8.8	7.9	7.9	6.8	5.8	5.0
Knox County	4.2	3.9	3.4	5.0	8.1	7.4	6.9	6.1	6.3	5.4	4.6	4.1
Loudon County	4.7	4.4	3.9	5.7	9.7	9.3	8.6	7.6	7.8	6.6	5.6	4.8
Roane County	5.8	5.4	4.4	5.9	9.1	9.2	9.1	8.6	9.1	7.6	6.4	5.6
Economic Region	4.5	4.2	3.6	5.2	8.5	7.9	7.4	6.6	6.8	5.8	5.0	4.3

Source: BLS 2017-TN4928.

The data in Table 2-28 show that Knox County is the largest employment center of the economic region; it accounts for more than 70 percent of the labor force and employed persons in the area in 2016. Knox County also has the lowest unemployment rate in the economic region. Taken together, the counties of the economic region show lower unemployment than the statewide average.

Table 2-29 indicates that the local area experienced lower levels of unemployment during the recession period of 2008–2011, relative to the state as a whole. All counties in the economic region experienced gradually declining rates of unemployment through 2007. By 2009, however, unemployment rates increased significantly in all the counties, ranging from increases of 3.1 percentage points in Knox County to 4.1 percentage points in Anderson County. Since peaking in 2009, unemployment has been steadily falling and has returned to pre-recession levels.

Table 2-30 presents data on total employment by industry type in the economic region in 2016, based on data from the Bureau of Economic Analysis and the Tennessee Department of Labor.

2.5.2.2 Economic Region

The economic region, anchored by Knoxville and Knox County, is a relatively balanced economy, based on industry employment with no one industry grouping has more than 12 percent of total regional employment. Retail trade, healthcare, ORR-related employment, and government sector employment make up the largest industry groupings.

The presence of the ORR and all associated contractors, suppliers, and ancillary services provides a concentration of nuclear technology-related expertise and experience in the labor force that is greater than most metropolitan areas of the country. Two recent studies covering the local economy document the concentration of nuclear technology-related economic sectors.

- In cooperation with the University of Tennessee, the East Tennessee Economic Council (ETEC 2014-TN4963) completed a study of the 2013 economic impact of DOE operations on the State of Tennessee.
- DOE (2015-TN4964) estimates the localized economic impact of the operation of DOE's Oak Ridge Environmental Management program in Federal fiscal year 2014. This study also was performed by the University of Tennessee.

Table 2-30. Total Employment by Industry in the Economic Region (2016)

Industry	Anderson	Knox	Loudon	Roane	Total	Percent
Farm employment	411	897	960	493	2,761	0.67
Forestry, fishing, and related activities	24	213	0	0	237	0.06
Mining, quarrying, and oil and gas extraction	28	459	0	0	487	0.12
Utilities	412	1,301	153	422	2,405	0.56
Construction	1,902	16,549	1,675	0	20,126	4.89
Manufacturing	11,564	13,444	2,838	1,096	28,942	7.04
Wholesale trade	935	15,087	563	442	17,027	4.14
Retail trade	4,104	37,143	2,690	2,325	46,262	11.25
Transportation and warehousing	53	1,145	1,536	0	2,734	0.66
Information services	256	5,827	99	0	6,182	1.50
Finance and insurance	1,842	15,086	833	482	18,243	4.43
Real estate and rental and leasing	1,151	14,142	902	623	16,818	4.09
Professional, scientific, and technical services	5,672	19,448	1,061	6,531	32,712	7.95
Management of companies and enterprises	81	5,441	23	56	5,601	1.36
Admin/support and waste/remediation services	3,888	28,506	1,192	1,478	35,064	8.52
Educational services	419	5,144	198	163	5,924	1.44
Healthcare and social assistance	4,882	39,668	1,568	2,260	48,378	11.76
Arts, entertainment, and recreation	494	5,780	397	220	6,891	1.68
Accommodation and food services	3,242	26,519	1,884	1,391	33,036	8.03
Other services (except public administration)	0	17,554	1,664	0	19,218	4.67
Federal government, civilian	891	3,534	138	406	4,969	1.21
Federal government, military	225	1,402	151	155	1,933	0.47
State government	690	14,258	126	1,275	16,349	3.97
Local government	3,453	16,438	1,822	2,047	23,760	5.78
Unallocated (D)	2,709	10,270	0	2,474	15,453	3.76
Total Employment (Jobs)	49,328	315,255	22,473	24,339	411,395	100.00

Some values indicated by the “Unallocated” line (D) are not disclosed by the reporting agency under Federal disclosure guidelines.

Sources: BEA 2017-TN4941; TDOL 2017-TN4931

These studies characterize the economic impacts accruing locally and to the rest of the State from DOE-related employment at the ORR and from DOE direct non-labor (goods and services) expenditures tied to activities at the ORR. The referenced studies, DOE's workforce location estimates, and the review team's outreach to the affected communities and economic researchers form the basis for determining the economic region to be the four-county area (Anderson, Knox, Loudon, and Roane) and indicate a potential for a greater proportion of nuclear-related services and labor to be found within the economic region. Each county's economy is discussed in greater detail below.

2.5.2.2.1 Anderson County

Anderson County includes the principal cities of Oak Ridge and Clinton. The municipal boundaries of Oak Ridge span a portion of Roane County and entirely envelop the ORR lands owned by DOE and the CRN Site owned by TVA. Oak Ridge is somewhat dependent on tax-equivalent payments provided by DOE and TVA as a main source of revenue. The City's geography limits its ability to develop modern housing projects and commercial developments, beyond the housing built during the Manhattan Project in the early 1940s and subsequent years, as the Oak Ridge site was developed. Consequently, as the housing stock has aged, it has been converting to rental housing and has been depreciating relative to widespread expansion of housing elsewhere in the county and surrounding area between Oak Ridge and Knoxville. Thus, Oak Ridge has not prospered economically to the same degree as Anderson County and greater Knoxville.

Although they are in close proximity to Oak Ridge, workers on the ORR have little opportunity to interact with the businesses of the City of Oak Ridge. Staff learned the retail contribution of reservation workers was limited to gasoline and grocery purchases at small venues along the commuter route, with infrequent visits to downtown Oak Ridge restaurants or stores. The portion of the county outside of Oak Ridge has been prospering economically as the area has recovered from the 2009–2011 economic recession. New automotive part manufacturers have located plants in the northern portion of the county and the fishing-related outdoor recreation industry centered on Norris and Melton Hill Lakes has greatly expanded in recent years. New housing projects have provided middle and upper income options that are missing in the Oak Ridge area. The growth in housing in Anderson County outside the ORR has been fueled by the construction of the Uranium Processing Facility at the ORR.

2.5.2.2.2 Knox County

Knox County is dominated by the City of Knoxville, which is the economic heart of the four-county region, and hosts TVA's headquarters and the main campus of the University of Tennessee. Knox County is the economic region's principal hub for wholesale and retail trade, healthcare services, higher education, and construction trades. Housing growth has expanded increasingly to the west of Knoxville, toward Clinton and Oak Ridge, and to the south, into Blount County and the Marysville area. Approximately 43.5 percent of the current DOE-related workforce at the ORR commutes there from Knox County.

Economic development is expected to continue at a healthy pace, especially to the west of downtown Knoxville in the direction of Oak Ridge. The Knox County Metropolitan Planning Commission reports that in 2016, over 3,000 new single-family housing permits and 131 nonresidential building permits were issued, representing substantial increases over recent history (KCMPC 2017-TN4942). Most of this development is occurring to the south and west of the city.

2.5.2.2.3 Loudon County

Loudon County includes the cities of Loudon and Lenoir City. Approximately 5.2 percent of the current DOE-related workforce at the ORR commutes there from Loudon County. In recent years, the economy of Loudon County has diversified with the growth of recreation and leisure industries and the growth of the Tellico Village retirement community on the shore of Tellico Reservoir. In addition, manufacturing, trade, and agriculture are important industries.

2.5.2.2.4 Roane County

Roane County hosts the CRN Site and includes a portion of the city limits of Oak Ridge where the CRN Site and the ORR are located. Kingston is the County Seat and other principal towns include Rockwood, Harriman, and Oliver Springs. Historically, Roane County was a hub of the hosiery and apparel manufacturing industries. Currently, approximately 14.8 percent of the ORR workforce commutes there from Roane County. Principal access to the CRN Site from the south is through Roane County. The largest employer is ORNL, with about 4,400 employees on the ORR site.

2.5.2.3 Taxes

This section identifies and examines the tax systems that would be potentially affected by building and operating the proposed SMR units. It evaluates the State tax structure and those in the four-county economic region. It also presents an overview of the sources and uses of funds for the affected counties. Table 2-31 presents the recent trend in tax-equivalent payments TVA has made to the State of Tennessee and to the individual counties of the economic region. Table 2-32 summarizes the individual tax rates that apply within the four counties of the economic region. Table 2-33 presents the current revenue sources and budget expenditures for the counties of the economic region.

Table 2-31. TVA Tax-Equivalent Payments to State of Tennessee and Local Counties FY 2011 through FY 2016 (millions of nominal dollars)

Fiscal Year	Total Distribution to State	Total Distribution to Counties	Anderson County	Knox County	Loudon County	Roane County
2010-2011	$319.3	$93.3	$1.1	$3.3	$1.0	$1.5
2011-2012	$351.0	$99.9	$1.1	$3.5	$1.1	$1.6
2012-2013	$334.3	$98.8	$1.1	$3.5	$1.1	$1.6
2013-2014	$331.6	$96.1	$1.1	$3.4	$1.1	$1.6
2014-2015	$350.6	$100.8	$1.2	$3.6	$1.1	$1.6
2015-2016	$344.8	$102.3	$1.2	$3.6	$1.2	$1.6

Source: TACIR 2017-TN4927.

Table 2-32. Current Applicable Tax Rates by County and Principal Tax Type

Tax	Anderson County	Knox County	Loudon County	Roane County
Property Tax ($ per $100 assessed value)	2.7903	2.32	1.8587	2.575
Local Option Sales Tax (percent)	2.75	2.25	2.00	2.50
Motor Vehicle Tax ($fee/vehicle)	NA	36	NA	NA
Local Lodging Tax (percent)	5	5	5	5
Mineral Severance Tax ($/ton)	0.15	NA	0.15	0.15

Source: CTAS 2016-TN4943.

Table 2-33. 2016 Summarized Revenue and Expenses by County Governments ($Million)

Revenues and Expenses	Anderson	Knox	Loudon	Roane	Economic Region
County Revenue Sources					
Charges for Current Services	2.0	36.4	0.6	4.1	3.8%
Federal Government	10.6	18.9	4.6	7.7	3.7%
Fees Received from County Officials	4.0	20.6	2.3	2.5	2.6%
Fines, Forfeitures, and Penalties	0.5	1.0	0.5	0.2	0.2%
Licenses and Permits	0.3	1.4	0.7	0.5	0.3%
Local Property, Sales, Other Taxes	45.9	556.4	33.8	42.4	60.0%
Other Governments and Citizens Groups	3.1	0.8	0.4	0.1	0.4%
Other Local Revenues	1.0	5.2	0.8	1.2	0.7%
State of Tennessee	36.7	220.8	26.5	35.8	28.3%
Total Revenue	104.1	861.6	70.1	94.5	100.0%
County Expense Categories					
Administration of Justice	3.1	28.9	1.9	2.1	3.1%
Agriculture and Natural Resources	0.2	0.6	0.1	0.1	0.1%
Capital Expenditures	0.6	26.4	0.0	0.1	2.4%
Finance and Debt Service	9.3	48.1	9.0	7.2	6.4%
General Government	3.5	35.5	3.1	3.1	4.0%
Public Works and Highways	0.0	23.8	0.0	0.0	2.1%
Public Instruction	33.6	565.7	26.2	34.5	57.7%
Operation of Non-Instructional Services	7.1	3.3	3.7	4.8	1.7%
Other Operations	1.2	6.2	0.7	1.3	0.8%
Public Health and Welfare	2.7	24.6	1.5	4.7	2.9%
Public Safety	12.3	105.3	7.4	7.1	11.5%
Social, Cultural, and Recreational Services	0.6	26.6	0.5	0.4	2.5%
Support Services	22.5	0.0	12.6	20.5	4.9%
Total Expenditure	96.7	895.1	66.6	85.8	100.0%

Use of individual expenditure categories varies between counties and may not always be comparable.

Sources: Tennessee Comptroller 2017-TN5001; Knox County 2016-TN4929.

Although TVA is a nonprofit entity not subject to conventional state and local taxation, it makes payments in-lieu-of-taxation. In accordance with Section 13 of the TVA Act of 1933, as amended (16 U.S.C. § 831-TN5024), TVA makes payments in lieu of taxes to states and counties in which they conduct power operations or in which TVA has acquired power-producing properties previously subject to state and local taxation. One-half of the payments to states is determined by the percentage of total TVA gross proceeds of power sales within each state, and the other half is apportioned by the percentage of book value of TVA power property in each state (TVA 2017-TN4921). These payments amount to 5 percent of gross revenues from the sale of power during the preceding year, excluding sales or deliveries to other Federal agencies and power sales to utilities not on the TVA grid. There is a provision for minimum payments under certain circumstances.

Except for certain direct payments that TVA is required to make to counties, distribution of payments in lieu of taxes within a state is determined by individual state legislation. Under Tennessee Code, Title 67, Chapter 9, 48.5 percent of the total payments received by the State are distributed to the State's counties and municipalities. Of the 48.5 percent of total payments, 30 percent (14.55 percent of total payments) is distributed to counties based on county shares of the total State population, 30 percent to counties based on county acreage shares of the State total, and 30 percent to incorporated municipalities based on each municipality's share of the total population of all incorporated municipalities in the State. The remaining 10 percent (4.85 percent of total payments) is allocated to counties based on each county's share of TVA-owned land in the State, including 3 percent that is paid to local governing areas that are experiencing TVA construction activity on facilities built to produce power, as designated by TVA. Such payments to affected areas are made during the period of construction activity and for one full year after completion of such activity. The recent payments in lieu of taxes received by the counties of the economic region are provided in Table 2-31. TVA's current levels of payments in lieu of taxes represent only a minor fraction of the revenue streams available to the counties of the economic region as reported in Table 2-33.

2.5.2.3.1 Property Taxes

Residential and business property owners pay property taxes to the counties and/or municipalities within which their property is located. The specific rates for the counties of the economic region are provided in Table 2-32. Property tax revenue is the largest single source of tax revenue in each of the counties.

Property tax revenue impacts would be generated by the relocation of construction and operations workers from outside the economic region to one of the four counties making up the economic region. These impacts are discussed in Chapters 4 and 5 of this draft EIS. As noted above, TVA does not pay property taxes on its real property, but instead, makes tax-equivalent payments as noted in Table 2-31.

2.5.2.3.2 Sales and Use Taxes

After property taxes, local option sales taxes provide the majority of revenue to the counties of the economic region. Tennessee has a variable base sales tax of 4 percent on food and 7 percent on most other goods and services, with some exceptions. Each county collects a local-use tax as an added component to the State sales tax paid on the purchase of goods and services. Within the economic region, the local option use tax rate varies between 2.00–2.75 percent (CTAS 2016-TN4943).

TVA is exempt from sales taxes, and would not incur such taxes on the local purchase of goods and services related to the building and operation of the proposed SMR units at the CRN Site. Construction and operations employees relocating to the area or making purchases while transiting through the economic region would be a source of revenue impacts from sales taxes. In addition, some purchases made by contractors supporting TVA's building and operations may be subject to sales taxes. Sales tax impacts are discussed in Chapters 4 and 5 of this draft EIS.

2.5.2.3.3 Corporate and Income Taxes

Title 67 of the Tennessee Code Annotated and its revisions (T.C.A. Title 67-TN4962) govern the taxing authorities in Tennessee. TVA itself is not subject to corporate income taxes, although some contractors and suppliers may be subject to corporate income taxes. Employees contribute Federal income taxes, but there is no State income tax in Tennessee.

Other Taxes and Fees

In addition to standard State motor vehicle registration, Knox County also levies an annual motor vehicle privilege (wheel) tax of $36 per vehicle. Workers relocating to Knox County as a result of the proposed project would become a minor source of new county revenue from the vehicles they would need to register.

Each county levies a 5 percent hotel/motel tax on area visitors. A minor revenue impact would be generated by workers choosing overnight lodging accommodations during plant construction or operations activities.

Anderson, Loudon, and Roane Counties levy a mineral severance tax of $0.15/T on the extraction of all sand, gravel, sandstone, chert, and limestone mined within the county. To the degree that such resources would be sourced from local counties for building the proposed SMR units at the CRN Site, minor revenue impacts would occur in the economic region.

2.5.2.4 Transportation

Available transportation resources include a diverse road network, rail lines, airports, waterways, and public transportation. This section describes each of these resources.

2.5.2.4.1 Roads and Highways

The roads in the economic region range from major interstate highways, to urban street networks in local population centers, to open highways and roads in more rural areas.

Vehicles access the CRN Site primarily via SR 58 (Gallaher Road/Oak Ridge Turnpike), which is a five-lane paved arterial that runs northeast-southwest connecting Oak Ridge with Interstate 40. Access also is possible using Bear Creek Road (northeast-southwest), approaching form the north from SR 95 to the CRN Site access road. SR 58 intersects Interstate 40 (east-west orientation) 4.1 mi south of the intersection with Bear Creek Road, which provides access to the CRN Site. SR 58 intersects SR 95 (northwest-southeast) north of the intersection with Bear Creek Road. Bear Creek Road also intersects SR 95 3.4 mi north of the CRN Site access road. The local transportation network appears in Figure 2-11.

In 2015, AECOM Technical Services, Inc. (AECOM) completed a traffic impact study to evaluate the impact of building and operating the proposed SMR units on the road network in the vicinity of the CRN Site (AECOM 2015-TN5000). A conceptualized map of local access routes is provided as part of this study. AECOM produced baseline traffic and level of service (LOS) estimates for the affected roadway access points approaching the CRN Site. Table 2-34 summarizes those estimates. The baseline was estimated using 2013 peak-hour traffic flow metrics. The LOS designation is an ordinal scale with “A” (free flow) being the best LOS and “F” (forced or breakdown flow) being the worst.

The AECOM study evaluated the baseline LOS for each interchange during both the a.m. and p.m. peak periods and indicates that the affected intersections operate at an LOS of “A” (free flow) or “B” (reasonably free flow) during morning peak traffic. During afternoon peak traffic, Bear Creek Road at the ramp to SR 58 and Bear Creek Road at the intersection with SR 95 operate at an LOS of “C” (fair progression, higher delay). The minimum standard for LOS on Tennessee roadways is “D” (unfavorable progression, congestion becomes apparent) (AECOM 2015-TN5000).

Table 2-34. Peak-Hour Traffic Volume and Level of Service at Key Intersections (2013)

	AM Peak Hour			PM Peak Hour		
Principal Access Route	**Peak Traffic**	**LOS**	**Delay (sec.)**	**Peak Traffic**	**LOS**	**Delay (sec.)**
SR 58 at Bear Creek Road Ramp (Unsignalized)	**146**	**B**	**10.1**	**97**	**C**	**15.2**
Eastbound Approach	10	B	10.1	90	C	15.2
Northbound Approach	82	A	7.7	5	B	10.4
Southbound Approach	54	-	-	2	-	-
SR 95 at Bear Creek Road (Unsignalized)	**808**	**B**	**10.5**	**784**	**C**	**24.9**
Eastbound Approach	504	B	10.5	299	B	12.2
Westbound Approach	303	A	0.0	320	C	24.9
Northbound Approach	1	A	7.6	33	A	8.0
Southbound Approach	0	A	9.4	132	A	8.0
Bear Creek Road at Bear Creek Road Ramp (Unsignalized)	**162**	**A**	**9.3**	**219**	**A**	**8.6**
Eastbound Approach	8	A	3.6	8	A	3.6
Westbound Approach	14	-	-	200	-	-
Southbound Approach	140	A	9.3	11	A	8.6

Source: AECOM 2015-TN5000.

Tennessee's 25-Year Transportation Plan presents a statewide 10-year corridor initiative to improve the operation of key corridors, including the roads that serve the Oak Ridge and Knoxville areas (TDOT 2015-TN4944). In 2017, approximately 63 roadway projects were under way in the economic region (TDOT 2017-TN4930). All of these projects were scheduled on roads that are not on the access routes to the CRN Site, though some affect local interstate freeways that connect the main access routes with the commuting workers.

Anticipated project-related modifications to the existing Bear Creek Road ramp from SR 58 are described in EIS Chapter 3. The impacts on traffic LOS values during potential building and operations activities are presented in EIS Chapters 4 and 5.

2.5.2.4.2 Railway

Figure 2-11 shows railways within the region surrounding the CRN Site. EnergySolutions, LLC operates the 11.5-mi Heritage Railroad spur serving the ETTP on the ORR. TVA anticipates using the Heritage Railroad spur for delivery of construction materials and equipment to the CRN Site, given the close proximity of and access to the national rail network. Norfolk Southern Corporation operates several rail lines running through Knoxville, connecting to rail network hubs in Chattanooga, Tennessee; Cincinnati, Ohio; St. Louis, Missouri; and Roanoke, Virginia (NSCORP 2011-TN4945).

2.5.2.4.3 Air Service

The greater Knoxville area is served by the McGhee-Tyson Airport in Alcoa. Commercial air service from 18 carriers serving McGhee-Tyson airport transported 1.8 million passengers in the 12 months ending in May 2017. Over 93 million pounds of cargo were shipped during this period, as well (BTS 2017-TN4946). The Knoxville Downtown Island Airport is located in Knoxville. It has a single runway and is a base for over 150 private and corporate aircraft. Over 71,000 flight operations used this airport in 2016 (GCR 2017-TN4947).

The Metropolitan Knoxville Airport Authority is planning to build a general aviation airport in Oak Ridge, Tennessee. The airport would be funded by Federal, State and local sources. The proposed airport would be on the site of the ETTP, located approximately 3.5 mi north of the CRN Site. The airport design includes a 5,000-ft runway that could be used by corporate jets, private airplanes, and emergency medical service aircraft. Construction could begin as early as 2018 with the airport open for operations by the end of 2021 (MKAA 2017-TN4948; Oak Ridge Today 2018-TN5409).

2.5.2.4.4 Water

TVA may use barge transportation to deliver large components to the CRN Site during building activities. The CRN Site is adjacent to the Clinch River between approximately CRMs 14.5 and 19 (TVA 2017-TN4921). The Tennessee River navigable channel is 652 mi long, beginning at Knoxville and merging with the Ohio River in Paducah, Kentucky. This channel is controlled by a series of nine dams and locks, which are part of TVA's integrated river control system consisting of 49 dams and 15 navigation locks. Commercial navigation occurs on the Clinch River for 61 river miles. The commercially navigable portion of the Clinch River extends from its mouth near Kingston, Tennessee, upstream of the CRN Site to Clinton, Tennessee. In 2015, commercial shipping operations transported 35.6 million tons of cargo up and down the Tennessee River between the Ohio River and Knoxville (USACE 2016-TN4949).

2.5.2.4.5 Public Transportation

Full-service public transportation, including special needs services, is available throughout the economic region. The East Tennessee Human Resource Agency provides transportation to the economic region and 12 other counties in East Tennessee. Additional local municipal public transit services are provided in Oak Ridge and Knoxville. Bus ridership trends are reported for Knoxville Area Transit, and have averaged over 220,000 unlinked trips per month for the July 2016–June 2017 period (FTA 2017-TN4955).

2.5.2.5 Aesthetics and Recreation

The economic region is located in the Ridge and Valley landform region of Tennessee, which is characterized by long linear ridges and parallel lowland valleys that trend in a northeast to southwest direction. The ridges usually have elevations of 1,100 to 1,500 ft, while the adjacent valley floors vary from 700 ft to 1,000 ft. The ridges and valleys are generally higher in the northern part of the region and lower to the south (Tennessee Air Agencies 2010-TN4956).

The immediate visual environment of the CRN Site is dominated by the Clinch River, which borders the site to the west, south, and east. The Clinch River is approximately 400–700 ft wide at this point and features the occasional presence of commercial and recreational water craft. The immediate shoreline is vegetated with native shrubbery and trees. Just beyond the shoreline, on the opposite side of the river, the topography changes to upland agricultural areas dominated by cultivated fields, deciduous wooded areas, and rural residential development. Inland from the peninsula on which the CRN Site would be located, the ORR consists predominately of upland forest with some developed spaces that house DOE's facilities, such as ORNL, the Y-12 Complex, the ETTP, and other small industrial facilities.

The CRBRP in the 1980s created an industrial visual character for the proposed site. This site has been subject to redress activities that have restored much of that viewshed to native shrubs and trees. The lack of development on the peninsula and associated controlled access has kept the CRN Site in relative solitude and free of noise or other evidence of human activity. Tree canopy cover and the hilly topography of the site screen the site from view, except for those residents living in close proximity across the Clinch River. The closest residence to the proposed site is approximately 1,900 ft away to the southeast.

The economic region offers numerous opportunities for outdoor recreation. The Tennessee and Clinch Rivers are used for recreational boating and fishing. In addition, a number of WMAs, state parks, and other protected areas provide settings for diverse outdoor recreation, including boating, fishing, hunting, nature observation, hiking, and camping. Sport-fishing tournaments have become popular in the economic region, resulting in a measurable economic impact on the local economy, according to local officials (NRC 2018-TN5386).

Public recreation facilities near the CRN Site and associated recreational opportunities include the following:

- Melton Hill Reservoir Park and Campground: boating, fishing, hiking, camping, picnicking, sightseeing, swimming, and nature viewing
- Clinch River arm of the Watts Bar Reservoir: boating, fishing, hunting, swimming, bicycling, picnicking, nature viewing
- Gallaher boat ramp and fishing access: fishing, boating
- ETTP Visitor Overlook: sightseeing, picnicking, cultural history
- Oak Ridge State Wildlife Management Area: seasonal special hunts
- Local fishing tournaments, including hundreds of amateur and professional tournaments throughout the year.

2.5.2.6 Housing

Construction workers and operations staff relocating from outside the economic region would need to acquire permanent or temporary housing. As discussed earlier, 87 percent of the current ORR workforce lives in the four Tennessee counties of the economic region: Anderson County (23.5 percent of the current ORR workforce), Knox County (43.5 percent), Loudon County (5.2 percent), and Roane County (14.8 percent) (TVA 2017-TN4921). The economic region is a medium-size metropolitan area centered on Knoxville, which has abundant housing resources available.

Table 2-35 provides data summarizing the housing stock in the economic region based on 2011–2015 Census ACS data. In 2015, there were 280,634 housing units in the economic region, of which approximately 90.2 percent were occupied. Of the occupied units, approximately 66 percent were owner-occupied, and the remainder were rental units.

Table 2-35 indicates that 27,397 vacant housing units were available for purchase or rent in the economic region and that every county had a significant supply of vacant units, and Knox County contained nearly two-thirds of all available units. The median value of homes in the economic region ranged from $120,000 in Roane County to $178,000 in Loudon County. The median rent in the economic region ranged between $682 in Roane County to $793 in Knox County (USCB 2017-TN4939).

Some construction workers would need temporary housing while supporting the activities at the CRN Site. The economic region has more than 9,500 hotel rooms, approximately 85 percent of which are located in the Knoxville area. In addition, the economic region hosts at least 1436 overnight camp sites (e.g., tent, RV, cabin), of which more than 630 are in Roane County, the host county (TVA 2017-TN4921).

Table 2-35. Housing Data for Counties in the Economic Region (2015)

	Anderson	Knox	Loudon	Roane	Economic Region	Tennessee
Total housing units	34,767	198,119	22,144	25,604	280,634	2,854,542
Occupied	30,612	180,729	20,009	21,887	253,237	2,504,556
Owner-occupied	20,901	115,584	15,358	15,888	167,731	1,672,329
Renter-occupied	9,711	65,145	4,651	5,999	85,506	832,227
Vacant units	4,155	17,390	2,135	3,717	27,397	349,986
Median monthly rent ($)	685	793	712	682	769	764
Vacancy rate (%)	12.0	8.8	9.6	14.5	9.8	12
Median value ($)	131,200	160,700	178,000	120,000	154,753	142,100

Source: USCB 2017-TN4939.

2.5.2.7 Public Services

The following subsections provide information about public services provided to residents of the economic region. The public services discussed include water and wastewater; police, fire protection, and medical services; social services; and education.

2.5.2.7.1 Water and Wastewater

Residents of the economic region obtain drinking water from both communal water systems and individual wells. Anderson, Knox, Loudon, and Roane Counties are served by 16 major public water systems that obtain water primarily from surface waterbodies (TDEC 2017-TN5032). In addition, some private wells are used by individual homeowners, homeowners associations, and businesses. Table 2-36 summarizes 2016 service demand and capacity information for the major public water systems in the four-county region. Most of these systems have excess capacity; demand in the four-county region was approximately 67 percent of available capacity and the total excess capacity for 2016 was 65 Mgd (TDEC 2017-TN5032).

The four-county region is served by 20 major wastewater-treatment systems (Table 2-37). According to Table 2-37, most of these systems were operating below their design capacity in 2012. Total wastewater flow in the four-county region was approximately 72 percent of total design capacity, and the available excess capacity was 33 Mgd (EPA 2016-TN5037).

2.5.2.7.2 Police, Fire Protection, and Medical Services

Police protection in the economic region is provided by the four county governments and the municipalities within them. Table 2-38 presents information about the number of law enforcement personnel in each jurisdiction. Roane County, the host county, has 147 law enforcement personnel, including 110 officers and 37 civilian employees. Anderson County has 283 law enforcement personnel, including 152 officers and 131 civilian employees. Knox County has 1556 law enforcement personnel, including 915 officers and 641 civilian employees. There are 133 law enforcement personnel in Loudon County, including 88 officers and 35 civilian employees (FBI 2017-TN4958). For the economic region, the ratio of population to police officers was 511:1 in 2015.

Table 2-36. Major Water Supply Systems (Serving 5,000 or More People) in the Economic Region

Water System Name	Population Served	Primary Water Source	Total Daily Capacity (Mgd)	Peak Daily Demand[(a)] (Mgd)	Demand as % of Capacity	Excess Capacity (Mgd)
Anderson County						
Anderson County Water Authority	25,404	Clinch River	5.64	3.10	54.8	2.55
Clinton Utilities Board	18,288	Clinch River	4.49	2.37	52.7	2.13
Oak Ridge Dept. of Public Works	36,842	Clinch River	15.00	13.78	91.8	1.22
Subtotal			25.1	19.2	76.5	5.9
Knox County						
First Utility District of Knox County	86,593	Tennessee River Fort Loudon Reservoir	34.63	21.34	61.6	13.29
Hallsdale-Powell Utility District	72,822	Clinch River Melton Hill Reservoir	18.40	8.70	47.3	9.70
Knox-Chapman Utility District	32,974	French Broad River	8.00	5.73	71.7	2.27
Knoxville Utilities Board-KUB	236,326	Tennessee River	62.50	41.85	67.0	20.65
Northeast Knox U B	22,887	Holston River	6.91	2.79	40.4	4.12
West Knox Utility District	62,812	Clinch River Melton Hill Reservoir	12.76	7.09	55.5	5.67
Subtotal			143.2	87.5	61.1	55.7
Loudon County						
Lenoir City Utility Board	23,329	Tennessee River	3.01	3.37	112.0	-0.36
Loudon Utilities Board	12,444	Tennessee River	14.30	14.12	98.8	0.18
Subtotal			17.3	17.5	-1.2	-0.2
Roane County						
Cumberland Utility District	10,856	Little Emory River	2.50	2.61	104.5	-0.11
Harriman Utility Board	15,139	Emory River	3.17	2.44	77.1	0.73
Kinston Water System	9,907	Tennessee River Watts Bar Reservoir	2.00	1.02	50.8	0.98
Oliver Springs Water Board	5,116	Bacon Spring	0.86	1.03	119.2	-0.17
Rockwood Water System	11,054	Tennessee River Watts Bar Reservoir	5.00	2.68	53.5	2.32
Subtotal			13.5	9.8	72.6	3.8
Total			**199**	**134**	**67.3**	**65**

(a) Demand values for year 2016.

Source: TDEC 2017-TN5032.

Table 2-37. Public Wastewater-Treatment Systems in the Economic Region (2012)

Wastewater-Treatment System	Population Served	Design Total Flow (Mgd)	Existing Total Flow (Mgd)	Existing Flow as % of Design	Excess Capacity (Mgd)
Anderson County					
Clinton STP #1	17,974	3	1.04	34.7	2.0
Lake City STP	1,888	0.98	0.4	40.8	0.6
Norris WWTP	1,439	0.2	0.111	55.5	0.09
Oak Ridge STP	29,750	10	4.58	45.8	5.4
Subtotal		14.2	6.1	43.2	8.1
Knox County					
Karns Beaver Creek STP	51,000	4	3.8	95.0	0.2
Kuwahee WWTP	143,454	40	30.27	75.7	9.7
KUB - Fourth Creek WWTP	52,500	10.8	7.21	66.8	3.6
Loves Creek STP	17,183	3.3	2.12	64.2	1.2
Eastbridge STP	12,000	0.87	0.46	52.9	0.41
Turkey Creek STP	96,000	15	8.886	59.2	6.1
Hallsdale-Powell Beaver Creek STP	74,555	12	11.4	95.0	0.6
Hallsdale-Powell Raccoon Valley STP	1,750	0.15	0.056	37.3	0.09
Subtotal		86.1	64.2	74.6	21.9
Loudon County					
Lenoir City WWTP	15,657	2	2.32	116.0	-0.3
Loudon STP	10,251	7.6	6.9	90.8	0.7
Subtotal		9.6	9.2	96.0	0.4
Roane County					
Harriman WWTP	5,071	1.5	1.2	80.0	0.3
Oak Ridge Rarity Ridge WWTP	3,200	0.6	0.202	33.7	0.40
Oliver Springs WWTP	3,300	0.74	0.476	64.3	0.26
Rockwood WWTP	5,502	1.65	1.17	70.9	0.48
Roane Co. STP	1,800	1	0.262	26.2	0.7
Kingston STP	5,300	1	0.57	57.0	0.4
Subtotal		6.5	3.9	59.8	2.6
Total		**116**	**83**	**71.6**	**33**

STP = sewage treatment plant; WWTP = wastewater-treatment plant.

Source: EPA 2016-TN5037.

Table 2-38. Local Law Enforcement Personnel in Counties of the Economic Region (2015)

Jurisdiction	Total Law Enforcement Employees	Total Officers	Total Civilians
Anderson County Sheriff	170	63	107
Clinton	38	31	7
Oak Ridge	75	58	17
Total Anderson County	283	152	131
Knox County Sheriff	956	443	513
Knoxville	491	397	94
Norris	6	6	0
Rocky Top	10	7	3
University of Tennessee:	77	50	27
University of the South	16	12	4
Total Knox County	1,556	915	641
Lenoir City	26	24	2
Loudon	14	13	1
Loudon County Sheriff	83	51	32
Total Loudon County	123	88	35
Harriman	20	19	1
Kingston	13	12	1
Oliver Springs	14	10	4
Roane County Sheriff	75	47	28
Roane State Community College	8	6	2
Rockwood	17	16	1
Total Roane County	147	110	37
Economic Region	2,109	1,265	844

Source: FBI 2017-TN4958.

Fire protection in the economic region is provided by 36 fire departments staffed by 1,167 firefighters. Anderson County has 8 fire departments and 214 firefighters, Knox County has 8 departments and 592 firefighters, Loudon County has 7 departments and 166 firefighters, and Roane has 13 departments and 195 firefighters. The ratio of residents per firefighter is 554:1 for the economic region. Most urban fire departments rely on professional firefighters, while the outlying rural departments rely mostly or entirely on volunteers (FD 2017-TN4959).

The 11 medical centers in the economic region have a total of 2,664 hospital beds. Methodist Medical Center of Oak Ridge is the closest hospital to the CRN Site; it has 301 beds, 2 trauma suites, 38 treatment rooms, and a chest pain center. The University of Tennessee Medical Center (583 beds) is the closest level-1 trauma center to the site. The review team estimates that more than 500 beds have been added in the economic region since 2015 (TVA 2017-TN4921).

2.5.2.7.3 Social Services

The Tennessee Department of Human Resources (TDHS) is responsible for social services in the state. All counties in the state are required to have public health facilities meeting state standards. Each county also hosts a TDHS office that provides family assistance and child support, rehabilitation services, other community and social services. TDHS has programs in administration of Federal and State family aid programs, vocational rehabilitation, technology access, child and adult protective care, and nutrition (TDHS 2017-TN4932).

2.5.2.7.4 Education

Table 2-39 lists public school districts in the economic region along with their enrollments, number of teachers, and student-to-teacher ratios. Knox County has 90 public schools in 1 public school district serving 59,733 students. There are about 15.1 students per teacher in the county, a rate that is roughly equivalent the statewide rate of 15.2 students per teacher. Roane County, the host county, also has 17 public schools with an enrollment of 7,008 students and a ratio of 15.5 students per teacher, just slightly above the State average ratio. The student-teacher ratio in Anderson County Schools is 13.3, somewhat below the State average. These values are well within the State-mandated ratio of 25 students per teacher (ECS 2014-TN5395).

Table 2-39. Public School Enrollment, Teachers, and Student-to-Teacher Ratios in the Economic Region and State

Public School District	Number of Public Schools	Number of Students (full-time equivalents)	Number of Teachers (full-time equivalents)	Number of Students per Teacher
Anderson County Schools	18	6,650	500	13.3
Clinton School District	3	931	66	14.1
Knox County Schools	90	59,733	3,960	15.1
Lenoir City Schools	3	2,397	140	17.1
Loudon County Schools	9	4,947	333	14.8
Oak Ridge School District	8	4,436	350	12.7
Roane County Schools	17	7,008	452	15.5
Tennessee School for the Deaf	3	160	50	3.2
All Public Schools	151	86,262	5,851	14.7
State of Tennessee	1,883	995,475	65,341	15.2

Source: NCES 2017-TN4960.

The review team visited cities and towns in the economic region on one or more occasions to understand local planning concerns regarding the proposed project. Through its review of the TVA ER (TVA 2017-TN4921), its own outreach and research, and scoping comments, the review team did not identify any specific public school capacity issues that would require further consideration.

There are six 4-year colleges and universities, two 2-year community colleges, and six vocational colleges within the economic region, serving more than 64,000 students. Pellissippi State Community College and Roane State Community College serve more than 23,000 students and are located within the economic region. Knoxville hosts the main campus of the University of Tennessee, the largest college in the state, with an enrollment of more than over 33,000 students (CollegeStats 2017-TN4961).

2.6 Environmental Justice

Executive Order (EO) 12898 established requirements for each Federal agency to identify and address, as appropriate, disproportionately high and adverse human health and environmental effects of its programs, policies, and activities on minority and low-income populations (59 FR 7629-TN1450). Although the NRC is not required to comply with EO 12898, the Commission issued a policy statement stating the agency would voluntarily commit to undertaking environmental justice reviews as a part of its National Environmental Policy Act of 1969, as amended (NEPA) process (69 FR 52040 -TN1009). NRC Interim Staff guidance COL/ESP-ISG-26 establishes environmental justice minority categories as the following: American Indian or Alaskan Native; Asian; Native Hawaiian, or other Pacific Islander; Black races; and Hispanic ethnicity (NRC 2014-TN3767). The staff also considers a Census category called "other" to be a separate minority category. Low income refers to individuals living in households meeting the official poverty measure (USCB 2016-TN5458).

This section describes the existing demographic and geographic characteristics of the CRN Site and its surrounding communities. It offers a general description of minority and low-income populations within a 50-mi region surrounding the site. The characterization in this section forms the analytical baseline from which the determination of potential environmental justice impacts will be made. The characterization of populations of interest also includes an assessment of populations of particular interest or unusual circumstances, such as minority communities exceptionally dependent on subsistence resources or identifiable in compact locations, such as Native American settlements.

2.6.1 Methodology

The review team first examined the geographic distribution of minority and low-income populations within the 50-mi radius of the CRN Site that was available in the TVA ER and performed an independent verification of that information by using data from the USCB ACS 5-year summary files (2011–2015). The review team then verified its analysis by conducting field inquiries of numerous agencies and groups (see Appendix B of this draft EIS for the list of organizations contacted and NRC 2018-TN5386, for the field notes).

The first step in the review team's environmental justice review is to examine each census block group that is fully or partially included within the 50-mi demographic region to determine whether it should be considered a population of interest. Census block groups are the smallest defined area for which minority and low-income populations are disaggregated. USCB defines census block groups as "statistical divisions of census tracts … generally defined to contain between 600 and 3,000 people" (USCB 2016-TN5458). If either of the two criteria discussed below identifies a census block group, that census block group is considered an environmental justice (EJ) population of interest. The two criteria are whether:

- the population of interest exceeds 50 percent of the total population for the block group, or
- the percentage of the population of interest is 20 percentage points (or more) greater than the same population's percentage in the block group's state.

The identification of census block groups that meet either of the above criteria (i.e., an EJ population of interest) is not, in and of itself, sufficient for the review team to conclude that disproportionately high and adverse impacts would occur on that population. Likewise, the lack of census block groups meeting either of the above criteria cannot be construed as conclusive evidence of there being no disproportionately high and adverse impacts on a population of interest. Finally, a determination of a SMALL impact on the general public in the socioeconomic assessment of the area in EIS Chapters 4 and 5 does not mean there is no disproportionately high and adverse impact on an EJ community in the same area. To reach an environmental justice conclusion, the review team must investigate all populations in greater detail to determine if there are potentially significant environmental impacts that may have disproportionately high and adverse effects on minority or low-income communities. To determine whether disproportionately high and adverse effects may occur, the review team considers the following:

- Health Considerations
  - Are the radiological or other health effects significant or above generally accepted norms?
  - Is the risk or rate of hazard significant and appreciably in excess of the general population?
  - Do the radiological or other health effects occur in groups affected by cumulative or multiple adverse exposures from environmental hazards?
- Environmental Considerations
  - Is there an impact on the natural or physical environment that significantly and adversely affects a particular group?
  - Are there any significant adverse impacts on a group that appreciably exceed or are likely to appreciably exceed those of the general population?
  - Do the environmental effects occur in groups affected by cumulative or multiple adverse exposure from environmental hazard? (NRC 2007-TN2487).

If the more detailed investigation does not yield any potential pathways for disproportionately high and adverse impacts on populations of interest, the review team may conclude there are no disproportionately high and adverse effects. If, however, the review team finds any potential pathways by which a project-related activity could result in disproportionately high and adverse impacts on a population of interest, the review team would fully characterize the nature and extent of those impacts and consider possible mitigation measures to lessen those impacts. The remainder of this section discusses the results of the search for potentially affected populations of interest.

Drawing on data presented in EIS Section 2.5.1, this section presents the demographics of the minority and low-income populations that reside within a 50-mi radius of the CRN Site, including the economic region consisting of Anderson, Knox, Loudon, and Roane County, Tennessee. The consideration of a 50-mi comparative geographic area surrounding the site is based on guidance provided by NUREG–1555 (NRC 2000-TN614).

The review team evaluated all census block groups within the 50-mi region to identify minority and low-income populations. In accordance with the threshold criteria described above, the review team identified block groups where minority or low-income populations either exceeded 50 percent of the block group total population or were at least 20 percentage points higher than the corresponding population for the State in which the block group was located. Table 2-40 presents, for the 50-mi demographic region, the percentage of minority category populations in each state and the associated threshold values for the second (20 percentage points) criterion.

Table 2-40. Statewide Percent Minority Populations and Associated 20 Percentage Point Threshold Criteria for the 50-Mi Demographic Region

	Tennessee		North Carolina		Kentucky	
Minority Category	**Percent of Population**	**Threshold Criterion**	**Percent of Population**	**Threshold Criterion**	**Percent of Population**	**Threshold Criterion**
Black	16.7	36.8	21.2	41.5	7.8	27.9
American Indian or Native Alaskan	0.2	20.3	1.1	21.2	0.2	20.2
Asian	1.5	21.6	2.4	22.5	1.2	21.3
Native Hawaiian or Other Pacific Islander	0.04	20.1	0.1	20.1	0.04	20.0
Some Other Race	0.1	21.5	0.2	23.0	0.1	20.9
Multiracial	1.7	21.8	1.9	22.1	1.7	21.9
Aggregate Minority	4.8	42.2	8.7	50.5	3.2	32.4

Source: USCB 2016-TN5333.

In addition to the minority definitions stated above, the review team considered Hispanic ethnicity in identifying minority populations. According to the USCB, Hispanic ethnicity is not a race; therefore, a Hispanic individual can be counted in any of the race categories as well as the Hispanic ethnicity category (USCB 2000-TN2488). The aggregate minority category includes the combination of racial minorities or persons of Hispanic ethnicity. Because a person of Hispanic or Latino ethnicity may also be from one of the defined races, to avoid double counting, the staff calculated the Aggregate Minority population (i.e., all minority races and ethnicity combined) to be the difference between the "Total Population" value and the value of "White, Not Hispanic or Latino" in the ACS 5-year Survey.

Figure 2-29 and Figure 2-30 show the census block groups with minority populations, as defined above, within a 50-mi demographic region. There are 760 census block groups in the demographic region, of which 3.6 percent had an "Aggregate Minority" population that exceeded one of the above criteria and 2.1 percent had Black population that exceeded one of the above criteria. The most intense concentrations of both Aggregate Minority and Black populations in the region occur in Knox County. Most of the block groups exceeding the threshold criteria for minority populations do so because of the number of Black residents (see Table 2-40).

Table 2-41 presents data on census block groups exceeding the environmental justice thresholds in the four-county economic region. The economic region population is mostly white, and most racial and ethnic diversity occurs in Knoxville and Knox County. Knox County has the largest percentage of block groups exceeding the threshold for Aggregate Minority population. None of the four counties record any block groups exceeding the threshold criteria for the categories of Asian, Other race, or Two or more races. None of the block groups exceeding minority thresholds used for environmental justice impact assessment are in close proximity (10 mi) to the CRN Site.

Figure 2-30 shows the census block groups with low-income populations, as defined above, within a 50-mi demographic region. Approximately 7.6 percent of the 760 census block groups in the demographic region had a low-income population that exceeded one of the above criteria. The greatest concentrations of block groups exceeding the low-income criteria are located in Knox County (11.2 percent) and Loudon County (9.7 percent).

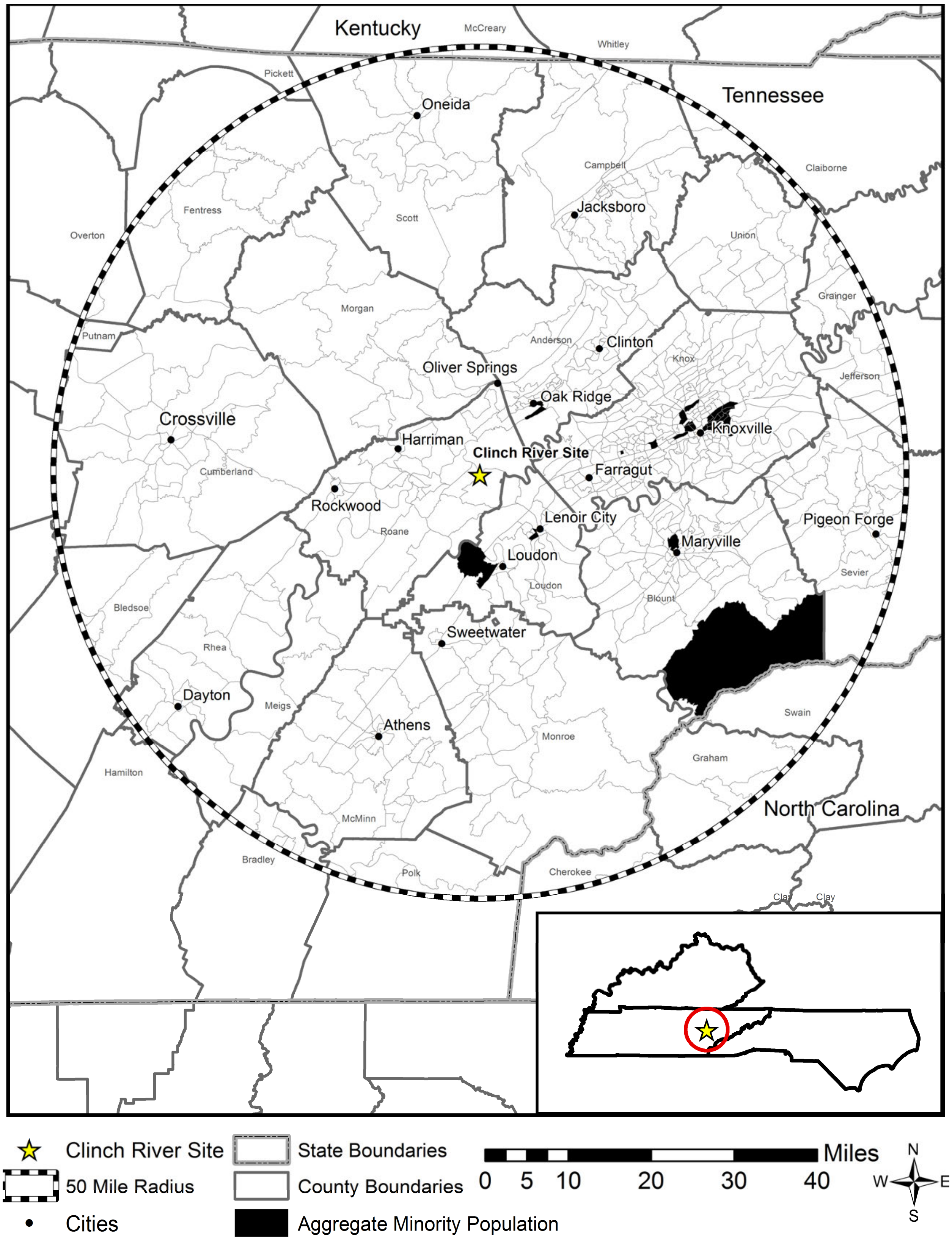


Figure 2-29. Aggregate Minority Block Groups within 50 Mi of the CRN Site

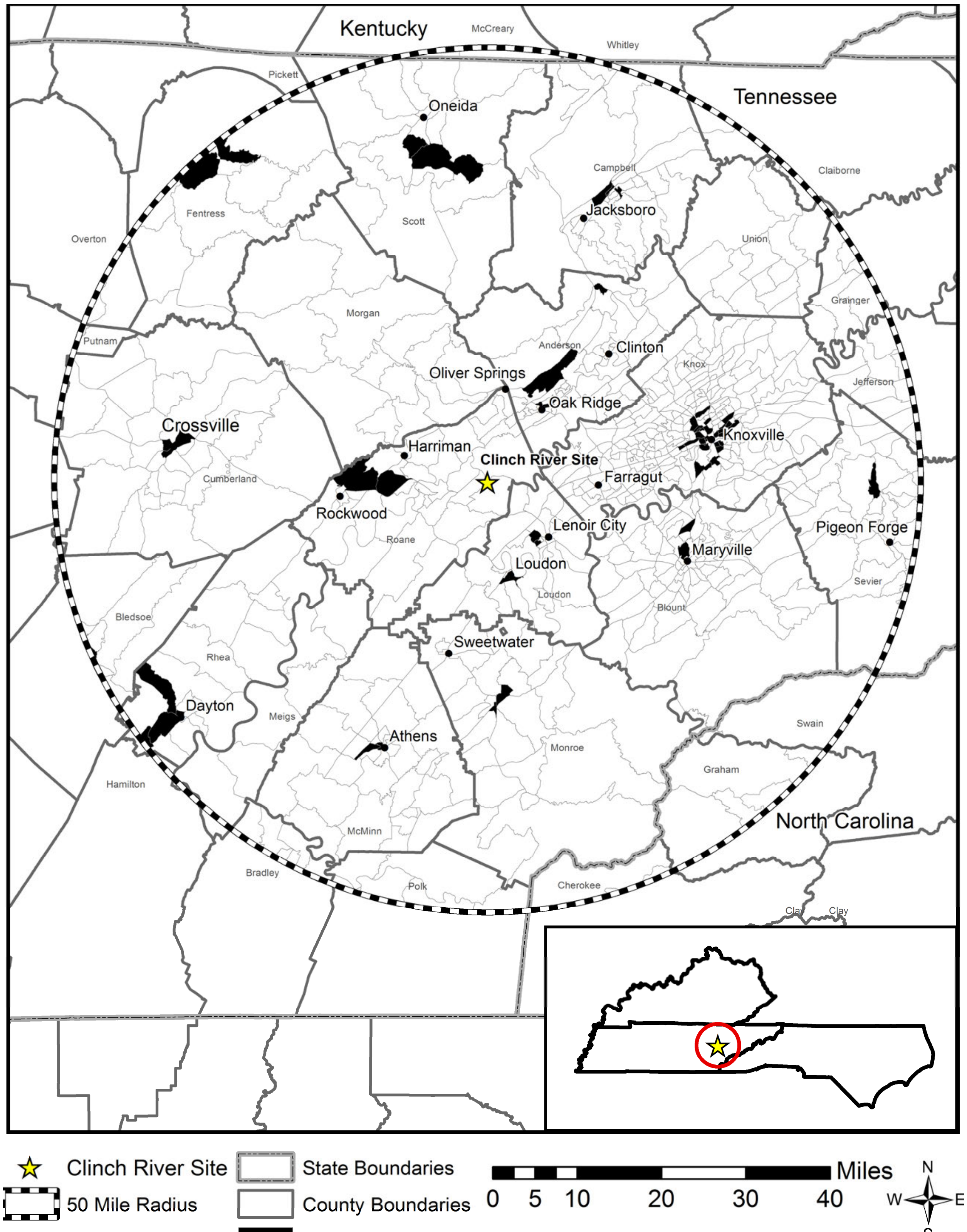


Figure 2-30. Low-Income Block Groups within 50 Mi of the CRN Site

Table 2-41. Distribution of Census Block Groups Exceeding Environmental Justice Thresholds within a 50-Mi Radius of the CRN Site and the Counties of the Economic Region

	Anderson		Knox		Loudon		Roane		Total 50-Mi Region	
	Number of Block Groups	% of Total	Number of Block Groups	% of Total	Number of Block Groups	% of Total	Number of Block Groups	% of Total	Number of Block Groups	% of Total
Number of block groups	53	100	242	100	31	100	41	100	760	100
Black	0	0	15	6.2	0	0	0	0	16	2.1
Asian	0	0	0	0	0	0	0	0	0	0
Other race	0	0	0	0	0	0	0	0	0	0
Two or more races	0	0	0	0	0	0	0	0	0	0
Hispanic	0	0	0	0	1	3.2	0	0	2	0.3
Aggregate Minority	1	1.9	22	9.1	2	6.5	0	0	27	3.6
Low Income	4	7.6	27	11.2	3	9.7	2	4.9	58	7.6

Sources: USCB 2016-TN5149.

Within the four-county economic region, the data in Table 2-41 show that each county has pockets of low-income population. These pockets occur in Knoxville, Lenoir City, Oak Ridge and near Rockwood. None of the block groups exceeding low-income thresholds used for environmental justice impact assessment are in close proximity (10 mi) to the CRN Site.

2.6.2 Scoping and Outreach

The NRC staff issued advance notice of public EIS scoping meetings in accordance with Commission guidance and conducted two public scoping meetings in Oak Ridge, Tennessee, on May 15, 2017. Also, during the week of May 15, 2017, members of the review team met with local agency officials of each county in the economic region. One purpose of these meetings was to identify and assess the potential for disproportionately high and adverse effects on minority and low-income populations. Through these meetings, the review team did not identify any additional groups of minority or low-income populations that might be affected by the proposed project.

2.6.3 Special Circumstances of the Minority and Low-Income Populations

The NRC environmental justice methodology includes an assessment of “pockets” of populations that have unique characteristics that may not be discerned by the census but might receive a disproportionately high and adverse impact from building and operating activities at the CRN Site. Examples of unique characteristics might include lack of vehicles, sensitivity to noise, close proximity to the plant, or subsistence activities. Such unique characteristics need to be demonstrably present in the population and relevant to the potential effects of the plant. If the impacts from the proposed project could affect an identified minority or low-income population more than the general population because of one of these or other unique characteristics, then the review team determines whether the impact on the minority or low-income population is disproportionately high and adverse when compared to the general population.

2.6.3.1 High-Density Communities

High-density communities are minority or low-income “pockets” of populations that are hidden within the demographic data of a larger area but might suffer a disproportionately high and adverse impact from building or operating activities at the CRN Site. Examples include densely populated low-income housing projects such as public housing or U.S. Department of Housing and Urban Development rental housing assistance. The review team visited the cities and towns in the economic region on one or more occasions and inquired about and searched for such communities. Through its review of the TVA ER (TVA 2017-TN4921) and its own outreach, research, and scoping comments, the review team did not identify any high-density minority or low-income communities that would require further consideration.

2.6.3.2 Subsistence

The review team also thoroughly searched for populations that may have common subsistence behaviors including gardening, gathering of plants, fishing, and hunting. These behaviors are often used to supplement household income (by substituting for store-bought foodstuffs or medications for budgetary purposes) or for ceremonial and traditional cultural purposes (typically among Native American groups). Subsistence information is typically site-specific, and the review team must take care to differentiate between subsistence and recreational uses of natural resources. The review team made multiple visits to the site and immediate vicinity to inquire about and search for such practices. Through its review of the TVA ER (TVA 2017-TN4921) and its own outreach, research, and scoping comments, the review team did not identify any communities with unique characteristics that would require further consideration.

2.6.4 Migrant Populations

The USCB defines a migrant laborer as someone who works seasonally or temporarily and moves one or more times per year to perform seasonal or temporary work. EIS Section 2.5.1.3 discusses the two largest migrant populations within the economic region: those associated with local construction activity and those associated with agricultural activities in the area. That discussion finds that minimal migrant labor occurs in the economic region. Through its review of the TVA ER (TVA 2017-TN4921) and its own outreach, research, and scoping comments, the review team did not identify any migrant labor populations that would require further consideration.

2.6.5 Environmental Justice Summary

As discussed above, the review team found that 3.6 percent of the census block groups in the 50-mi demographic region had an Aggregate Minority population that exceeded one of the criteria established for environmental justice analyses and that 2.1 percent of the census block groups had an African-American population that exceeded one of the criteria. The review team found that 7.6 percent of the census block groups in the 50-mi demographic region had a low-income population that exceeded one of the criteria.

The review team found that, within the four-county economic region, most of the block groups with Aggregate Minority or low-income populations exceeding the environmental justice thresholds were located in Knox County. Though none of the block groups with populations exceeding the criteria are located in close proximity to the CRN Site, those nearest to the CRN Site are located within the City of Oak Ridge and between Kingston and Rockwood to the southwest of the site.

The review team did not identify any communities that have specific concentrations of minority or low-income populations or that have any subsistence or other unique practices that would provide linkage to the building and operating of SMR units at the CRN Site.

Because the Census data identified minority or low-income block groups in the counties of the economic region, the review team performed analyses in greater detail before making a final environmental justice determination. These analyses can be found in EIS Chapter 4 for building-related activities and in EIS Chapter 5 for project operations.

2.7 Historic and Cultural Resources

Historic and cultural resources refer to archaeological sites, historic buildings, shipwrecks, and other resources considered through the National Historic Preservation Act (NHPA) (54 U.S.C. § 300101 *et seq*. -TN4157) of 1966, as amended. Historic and cultural resources that have been determined to be significant include those that have been determined eligible for inclusion on or formally listed in the National Register of Historic Places (NRHP). Section 106 of the NHPA requires Federal agencies to take into account the effects of their undertakings on historic properties that are listed or eligible for listing on the NRHP (36 CFR Part 800 -TN513). If historic and cultural resources are present, the eligibility of any historic properties for listing on the NRHP is determined through the application of the NRHP criteria in 36 CFR 60.4

(TN1682)[5] in consultation with State Historic Preservation Office (SHPO), Tribal representatives, and other interested parties.

In accordance with 36 CFR 800.8(c) (TN513), the NRC has elected to use the NEPA (42 U.S.C. § 4321 *et seq*. -TN661) process to comply with Section 106 of the NHPA. As a cooperating agency on the NEPA review, the USACE is part of the review team. The NRC's undertaking would be the issuance of an ESP, which determines the suitability of the CRN Site for potential future building and operation of two or more SMRs. An ESP does not, however, authorize construction and operation of a nuclear power plant. Such authorization would require an additional application and review and would be addressed in the future at the COL stage of the application process. The NRC is consulting with the SHPO and Tribes on the potential impact (including visual impacts) of building and operating two or more SMRs at the CRN Site, and upgrades to offsite areas including modifications to the Melton Hill Dam, transmission lines and borrow source areas. Because the USACE has no action as part of the ESP, the USACE will defer its Section 106 NHPA consultation until the COL stage of the application process and will define its permit area at that time.

As a Federal land-managing agency, TVA has NHPA Section 106 compliance requirements. TVA's undertaking is to build and operate two or more SMRs at the CRN Site and involves upgrades of offsite areas. The NRC's issuance of an ESP to TVA would authorize TVA to use the CRN Site as the location at which to construct and operate two or more SMR's, but the ESP would not authorize construction and operation. Accordingly, TVA has initiated its NHPA Section 106 consultation with the Tennessee Historical Commission (THC) and American Indian Tribes and has executed a Programmatic Agreement (PA) (TVA and TSHPO 2016-TN5298). TVA's PA outlines a process by which TVA will comply with NHPA Section 106 as plans are finalized and specific onsite and offsite project areas associated with these plans are identified.

The NRC has determined that the direct-effects area of potential effect (APE) within its authority for this review is the area at the CRN Site and its immediate environs that may be directly or indirectly affected by activities associated with building and operating a new nuclear power plant. Specifically, the onsite direct-effects APE is defined as the 1,305-ac area comprised of the CRN Site (1,200 ac) and the associated BTA located along Bear Creek Road and SR 58 (105 ac) as depicted in Figure 2-31. The onsite indirect-effects APE is defined as the 0.5-mi area around the lands being cleared of vegetation on the CRN Site (Figure 2-31). An offsite APE has also been defined at the Melton Hill Dam. The offsite direct-effects APE is confined to the Melton Hill Dam structure, and the indirect-effects APE is defined as a 0.5-mi area around the Melton Hill Dam depicted in Figure 2-32. APEs have not been established for other offsite areas (i.e., proposed transmission lines and borrow source areas) because specific plans for these areas have not been finalized (TVA 2017-TN4922).

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(5) The list was established by the NHPA and is maintained by the National Parks Service. The eligibility of cultural resources for listing on the NRHP are assessed based on four criteria:

- Criterion A: Associated with events that have made a significant contribution to broad patterns of our history; or
- Criterion B: Associated with the lives of persons significant in our past; or
- Criterion C: Embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
- Criterion D: Have yielded, or are likely to yield, information important to prehistory and history.

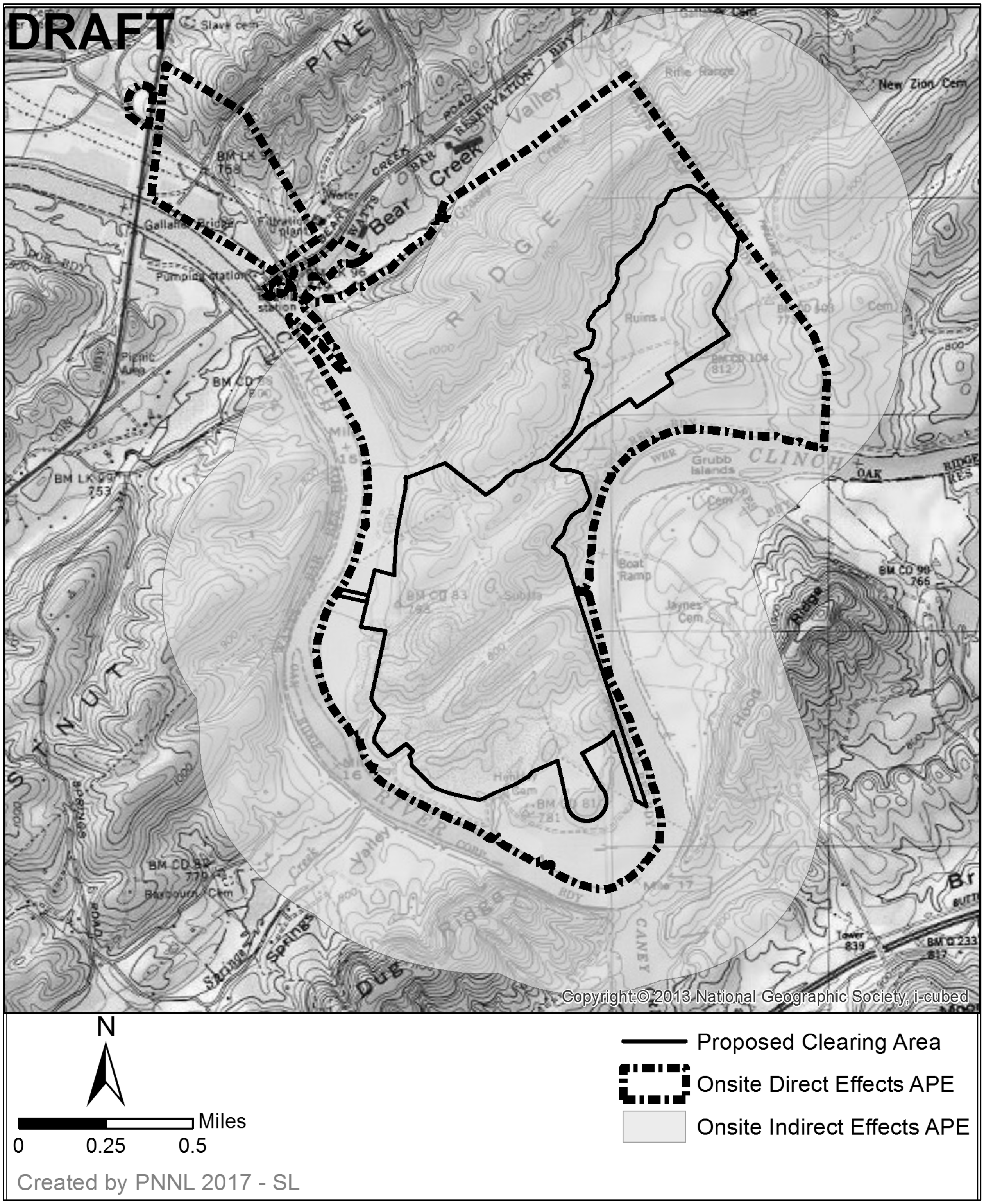

Figure 2-31. Onsite Direct- and Indirect-Effects APEs at the CRN Site

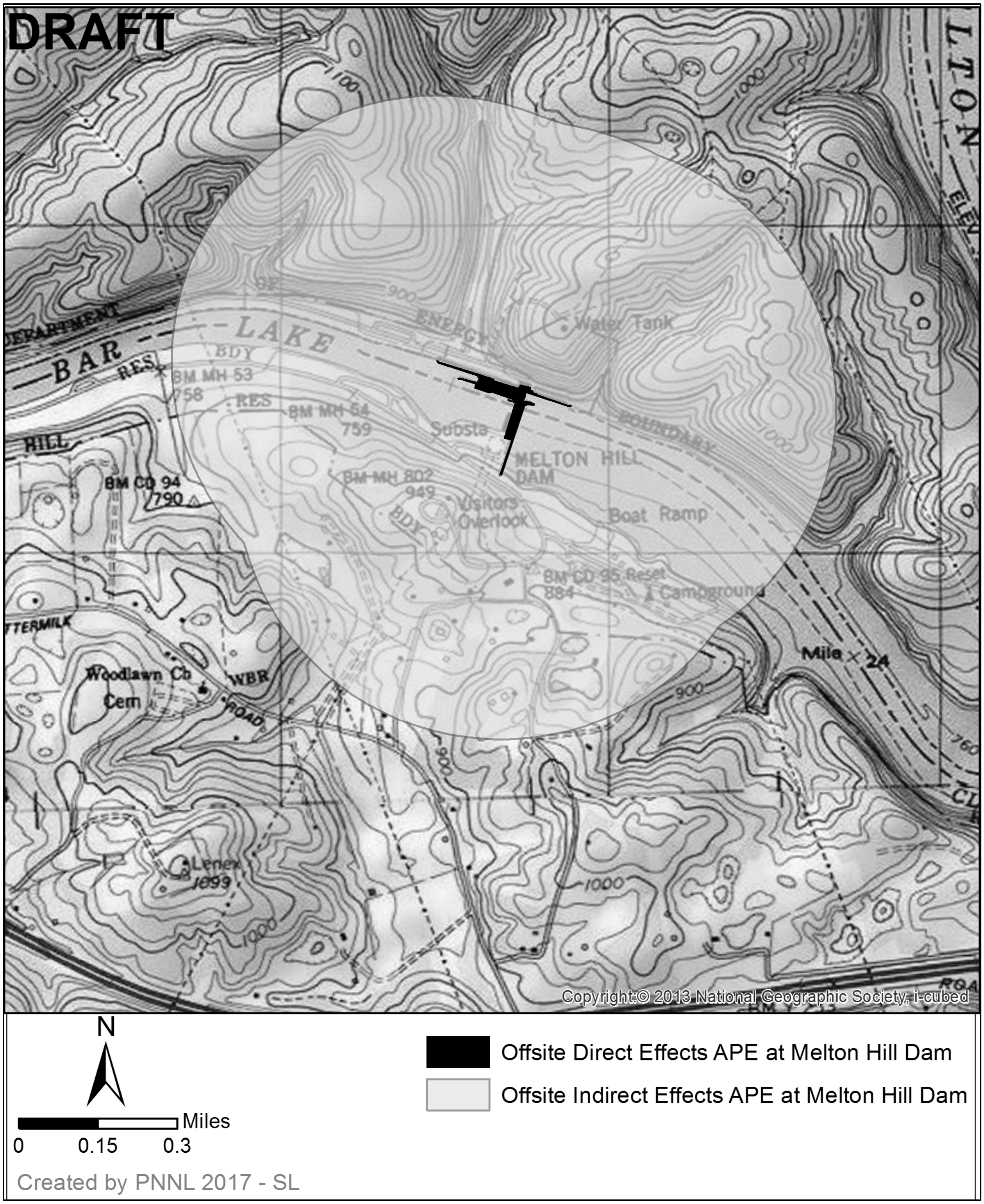

Figure 2-32. Offsite Direct- and Indirect-Effects APEs at the Melton Hill Dam

For the purposes of NHPA Section 106 review, the NRC conducted consultation with the THC, Federally recognized American Indian Tribes, the Advisory Council on Historic Preservation (ACHP), and TVA for onsite and offsite activities. Consultation efforts are described in EIS

Section 2.7.4. Additional information about consultation is also located in Appendices C and F. Assessments of the effects of construction are provided in EIS Section 4.6; associated assessments related to operations are provided in EIS Section 5.6. Cumulative effects are discussed in EIS Section 7.5.

2.7.1 Cultural Background

This section discusses the historic and cultural background of the CRN Site and region, including the identification of resources within the onsite and offsite direct- and indirect-effects APEs. The proposed project area is located in Roane County, Tennessee, approximately 16 mi west of Knoxville along the Clinch River. The cultural background is derived from the pre-contact and historic overviews provided by Hunter et al. (2015-TN4971) and Barrett et al. (2011-TN4974, 2011-TN4975).

Archaeologists divide the pre-contact period in East Tennessee into four distinct phases: Paleo-Indian, Archaic, Woodland, and Mississippian. Based on these divisions, archaeologists estimate that human occupation in this region began in at least 10,000 BC if not earlier. The Paleo-Indian period is estimated to span from 10,000 BC to 8,000 BC (Hunter et al. 2015-TN4971). Paleo-Indian archaeological finds identified in the region are limited to the recovery of a few Paleo-Indian Clovis-style projectile points suggesting an infrequent pattern of resource utilization (Hunter et al. 2015-TN4971).

The Archaic period is divided into three eras: Early (8,000 to 6,000 years BC), Middle (6,000 to 3,000 BC), and Late (3,000 to 1,000 years BC). In East Tennessee, the early part of the Archaic Period is recognized by phases of projectile point style, which include the "Lower Kirk, Upper Kirk, St. Albans, LeCroy, and Kanawha phases" (Hunter et al. 2015-TN4971 citing Schroedl 1990-TN5341). Settlement patterns associated with the Early Archaic Period are characterized by short-term resource use areas and base camps. The archaeological record associated with the Middle Archaic Period reveals an increased diversity in artifact type as well as increased complexity in tool making. Settlement patterns are similar to the Early Archaic Period with an increase in population and longer-term use of camp occupations. The Late Archaic Period is characterized by an increase in sedentary settlement patterns consisting of seasonal base camps and more short-term camps. Archaeological material associated with the Late Archaic Period reflects the use of locally available materials such as quartzite, rhyolite, cherts, chalcedony, and quartz.

Only two eras are associated with the Woodland Period in East Tennessee: Early (1,000 BC to 200 BC) and Middle (200 BC to A.D. 900). Archaeological evidence suggests that rather than a transition to Late Woodland after the Middle Woodland Period, there is a transition to the Mississippian Period beginning in A.D. 900. The Early Woodland Period is characterized by mound building and widespread use of pottery. Archaeological finds associated with this period indicate an increase in horticultural practices, including the cultivation of seeds, berries and grains. Burial practices include interment in mounds and the development of more complex mortuary and ritual practices. Settlement patterns associated with the Early Woodland Period continue to be seasonally based camps. The Middle Woodland Period is characterized by an increase in sedentism and the development of a more complex social system. At the end of the Middle Woodland Period, there is an abrupt shift from base camp settlement to permanent villages. This shift is correlates with an increased dependence on the cultivation of maize. The Mississippian Period (A.D. 900 to 1540) is characterized by the increased reliance upon agriculture and the establishment of fortified villages and chiefdoms. Archaeological evidence suggests that social complexity also increased during the Mississippian Period and included the development of organized warfare and complex burial practices, as evidenced by non-platform and platform mounds.

The first European explorers arrived in the vicinity of the CRN Site in 1540 as part of the DeSoto expedition and likely encountered the Coosa American Indian population (Hunter et al. 2015-TN4971). By the 1700s, the Overhill Cherokee inhabited the CRN Site land and vicinity. With the arrival of fur traders in the 1700s, skirmishes between the French, British, and Indian groups increased in the area and led to the French-Indian War. In 1796, the State of Tennessee was formed. Between 1794 and 1838, as a result of three treaties with the Cherokee Indians and through forcible removal at the time of the Trail of Tears, the Cherokee Indians were evicted from their ancestral homelands and required to relocate to Oklahoma (Hunter et al. 2015-TN4971).

After the Depression, development in the Tennessee Valley, including the establishment of TVA, led to a more-varied economic base in the region (Hunter et al. 2015-TN4971). TVA's first dam commenced operation in 1936 with the opening of the Norris Dam upstream from the CRN Site (Barrett et al. 2011-TN4975). In 1943, the Federal government established the Manhattan Project Clinton Engineer works, in the area which later became known as the DOE ORR (Valk et al. 2011-TN4972; Hunter et al. 2015-TN4971). Several agricultural communities in the area at that time (i.e., the Wheat Community) were relocated to accommodate Manhattan Project-related construction activities.

The K-25 Oak Ridge Gaseous Diffusion Plant was constructed on the ORR between 1943 and 1945, and produced enriched uranium later used in the atomic bombing of Hiroshima in 1945 (Valk et al. 2011-TN4972). Happy Valley Worker Camp, a temporary housing camp for the K-25 plant construction workers operated between 1943 and1947. Portions of the Happy Valley Worker Camp are located within the direct-effects onsite APE (Valk et al. 2011-TN4972). In the mid-1950s, TVA's Kingston Steam Generating Plant became operational and is located adjacent to the direct-effects onsite APE. In the early 1970s, TVA initiated plans to construct the CRBR within the direct-effects onsite APE (Barrett et al. 2011-TN4975). Plans were cancelled in the early 1980s due to insufficient funding for the project (Barrett et al. 2011-TN4975). Between 1960 and 1964, TVA constructed the Melton Hill Dam, which is located within the offsite APE.

2.7.2 Historic and Cultural Resources at the CRN Site and Offsite Areas

The information presented in this section is based on documents collected from the THC, Tennessee Division of Archaeology, and TVA. Historic properties (resources eligible or potentially eligible for nomination to the NRHP) and other cultural resources identified as a result of these efforts are included in the discussion.

2.7.2.1 Historic and Cultural Resources Located within the Onsite Direct- and Indirect-Effects APE

Between 1941 and 2015, TVA conducted several historic and cultural resources investigations within the onsite direct- and indirect-effects APE resulting in the documentation of 58 archaeological sites (44 pre-contact, 13 historic, and 2 multi-component), one historic cemetery, and two caves. One archaeological site has been formally determined to be NRHP-eligible (40RE233) and 16 have been recommended as being potentially NRHP-eligible (40RE104, 40RE105, 40RE106, 40RE107, 40RE108, 40RE124, 40RE128, 40RE138, 40RE140, 40RE165,

40RE166, 40RE167, 40RE549, 40RE595, 40RE600, and 40RE601) (TVA and TSHPO 2016-TN5298). The remaining archaeological resources have either been determined to be NRHP-ineligible or have not been evaluated. While no architectural resources have been identified in the onsite direct-effects APE, seven have been identified in the onsite indirect-effects APE (TVA 2015-TN4981, TVA 2017-TN4922; Karpynec 2011-TN4976; NRC 2017-TN5413). Four of these architectural resources were recommended by TVA as being NRHP-ineligible (Structures 4-7) and one, upon field inspection, was established as no longer being extant (Structure 2). The remaining two structures (RE1439 and Structure 3) were not evaluated for NRHP eligibility because activities occurring on the CRN Site would not be visible due to vegetation screening. See Table 2-42 for a complete list of historic and cultural resources located within the onsite direct- and indirect-effects APE and their NRHP-eligibility status.

Table 2-42. Historic and Cultural Resources Located within the Onsite and Offsite Direct- and Indirect-Effects APEs

Site Number	Site Type	Time Period	National Register of Historic Places (NRHP) Status	Recommendations	Location
40RE104	Pre-contact	Undetermined Pre-contact	Potentially eligible per Programmatic Agreement (PA)	Site should be avoided if possible; if site disturbance is necessary, further investigation is recommended to determine NRHP eligibility.	Onsite direct-effects area of potential effect (APE)
40RE105	Pre-contact	Woodland	Potentially eligible per PA	Site should be avoided if possible; if site disturbance is necessary, further investigation is recommended to determine NRHP eligibility	Onsite direct-effects APE
40RE106	Pre-contact	Middle and Late Woodland	Potentially eligible per PA	Site should be avoided if possible; if site disturbance is necessary, further investigation is recommended to determine NRHP eligibility	Onsite direct-effects APE
40RE107	Pre-contact	Early Archaic and Woodland	Potentially eligible per PA	Site should be avoided if possible; if site disturbance is necessary, further investigation is recommended to determine NRHP eligibility	Onsite direct-effects APE
40RE108	Pre-contact	Late Archaic, Woodland, Mississippian	Potentially eligible per PA	Site should be avoided if possible; if site disturbance is necessary, further investigation is recommended to determine NRHP eligibility	Onsite direct-effects APE
40RE120	Historic	Late 19th to Early 20th Century	Not Eligible	No Further Work	Onsite direct-effects APE
40RE121	Historic	Late 19th to Early 20th Century	Not Eligible	No Further Work	Onsite direct-effects APE
40RE122	Historic	Late 19th to Mid-20th Century	Not Eligible	No Further Work	Onsite direct-effects APE
40RE123	Historic	20th Century	Not Eligible	No Further Work	Onsite direct-effects APE

Table 2-42. (contd)

Site Number	Site Type	Time Period	National Register of Historic Places (NRHP) Status	Recommendations	Location
40RE124	Pre-contact	Late Woodland	Potentially eligible per PA	Site should be avoided if possible; if site disturbance is necessary, further investigation is recommended to determine NRHP eligibility	Onsite direct-effects APE
40RE125	Pre-contact	Archaic and Woodland	Not Eligible	No further work	Onsite direct-effects APE
40RE128	Pre-contact	Woodland	Potentially eligible per PA	Site should be avoided if possible; if site disturbance is necessary, further investigation is recommended to determine NRHP eligibility	Onsite direct-effects APE
40RE129	Historic	20th Century	Not Eligible	Determined to be modern. Site number vacated by Tennessee Division of Archaeology.	Onsite direct-effects APE
40RE135	Pre-contact	Undetermined Pre-contact	Not Eligible	No Further Work. Site destroyed.	Onsite direct-effects APE
40RE138	Pre-contact	Early Archaic through Mississippian	Potentially eligible per PA	Site should be avoided if possible; if site disturbance is necessary further investigation is recommended to determine NRHP eligibility	Onsite direct-effects APE
40RE139	Pre-contact	Undetermined Pre-contact	Not Eligible	No Further Work. Site inundated	Onsite direct-effects APE
40RE140	Pre-contact and Historic	Late Archaic to Early Woodland, and 20th Century	Potentially eligible per PA	Site should be avoided if possible; if site disturbance is necessary, further investigation is recommended to determine NRHP eligibility	Onsite direct-effects APE
40RE151	Pre-contact	Undetermined Pre-contact	Not Eligible	No Further Work	Onsite direct-effects APE
40RE152	Pre-contact	Undetermined Pre-contact	Not Eligible	No Further Work	Onsite direct-effects APE
40RE153	Pre-contact	Undetermined Pre-contact	Not Eligible	No Further Work	Onsite direct-effects APE
40RE154	Pre-contact	Undetermined Pre-contact	Not Eligible	No Further Work	Onsite direct-effects APE
40RE155	Pre-contact	Undetermined Pre-contact	Not Eligible	No Further Work	Onsite direct-effects APE
40RE156	Pre-contact	Undetermined Pre-contact	Not Eligible	No Further Work	Onsite direct-effects APE
40RE157	Pre-contact	Undetermined Pre-contact	Not Eligible	No Further Work	Onsite direct-effects APE
40RE158	Pre-contact	Undetermined Pre-contact	Not Eligible	No Further Work	Onsite direct-effects APE
40RE159	Pre-contact	Undetermined Pre-contact	Not Eligible	No Further Work. Site destroyed	Onsite direct-effects APE
40RE160	Pre-contact	Undetermined Pre-contact	Not Eligible	No Further Work	Onsite direct-effects APE
40RE161	Pre-contact	Undetermined Pre-contact	Not Eligible	No Further Work	Onsite direct-effects APE
40RE162	Pre-contact	Undetermined Pre-contact	Not Eligible	No Further Work	Onsite direct-effects APE
40RE163	Pre-contact	Undetermined Pre-contact	Not Eligible	No Further Work	Onsite direct-effects APE

Table 2-42. (contd)

Site Number	Site Type	Time Period	National Register of Historic Places (NRHP) Status	Recommendations	Location
40RE164	Pre-contact	Undetermined Pre-contact	Not Eligible	No Further Work	Onsite direct-effects APE
40RE165	Pre-contact	Early and Late Archaic; Historic	Potentially eligible per PA	Site should be avoided if possible; if site disturbance is necessary, further investigation is recommended to determine NRHP eligibility	Onsite direct-effects APE
40RE166	Pre-contact	Middle to Late Archaic and Early to Middle Woodland	Potentially eligible per PA	Site should be avoided if possible; if site disturbance is necessary, further investigation is recommended to determine NRHP eligibility	Onsite direct-effects APE
40RE167	Pre-contact	Early Archaic, Woodland, and Mississippian	Potentially eligible per PA	Site should be avoided if possible; if site disturbance is necessary, further investigation is recommended to determine NRHP eligibility	Onsite direct-effects APE
40RE202	Pre-contact	Undetermined Pre-contact	Not Eligible	No Further Work. Site destroyed.	Onsite direct-effects APE
40RE233	Historic	Mid-20th Century	Determined Eligible. Mentioned in PA	Site should be avoided if possible; if site disturbance is necessary, mitigation will need to be developed in accordance with the PA.	Onsite direct-effects APE
40RE547	Pre-contact	Undetermined Pre-contact	Not Eligible	No Further Work	Onsite direct-effects APE
40RE548	Pre-contact	Undetermined Pre-contact	Not Eligible	No Further Work	Onsite direct-effects APE
40RE549	Pre-contact	Undetermined Pre-contact; possible pre-Woodland	Potentially eligible per PA	Site should be avoided if possible; if site disturbance is necessary, further investigation is recommended to determine NRHP eligibility	Onsite direct-effects APE
40RE585	Pre-contact	Undetermined Pre-contact	Not Eligible	No Further Work	Onsite direct-effects APE
40RE586	Historic	Late 19th to Mid-20th Century	Not Eligible	No Further Work	Onsite direct-effects APE
40RE587	Historic	Late 19th to Mid-20th Century	Not Eligible	No Further Work	Onsite direct-effects APE
40RE588 (previously 40RE119)	Historic	Early to Mid-20th Century	Not Eligible	Hensley cemetery; site should be avoided if possible; if site disturbance is necessary, Tennessee State law regarding treatment of cemeteries must be followed	Onsite direct-effects APE
40RE589	Pre-contact	Undetermined pre-contact	Not Eligible	No Further Work	Onsite direct-effects APE
40RE590	Historic	20th Century	Not Eligible	No Further Work	Onsite direct-effects APE
40RE591	Historic	Late 19th to 20th Century	Not Eligible	No Further Work	Onsite direct-effects APE
40RE592	Pre-contact	Undetermined Pre-contact	Not Eligible	No Further Work	Onsite direct-effects APE
40RE593	Historic	Late 19th to 20th Century	Not Eligible	No Further Work	Onsite direct-effects APE

Table 2-42. (contd)

Site Number	Site Type	Time Period	National Register of Historic Places (NRHP) Status	Recommendations	Location
40RE594	Historic	Late 19th to 20th Century	Not Eligible	No Further Work	Onsite direct-effects APE
40RE595	Pre-contact	Early Archaic	Potentially eligible per PA	Site should be avoided if possible; if site disturbance is necessary, further investigation is recommended to determine NRHP eligibility	Onsite direct-effects APE
40RE596	Historic	Late 19th to 20th Century	Not Eligible	No Further Work	Onsite direct-effects APE
40RE597	Historic	20th Century	Not Eligible	No Further Work	Onsite direct-effects APE
40RE598	Historic	Late 19th to 20th Century	Not Eligible	No Further Work	Onsite direct-effects APE
40RE600	Pre-contact	Undetermined Pre-contact	Potentially eligible per PA	Site should be avoided if possible; if site disturbance is necessary, further investigation is recommended to determine NRHP eligibility	Onsite direct-effects APE
40RE601	Pre-contact	Undetermined Pre-contact	Potentially eligible per PA	Site should be avoided if possible; if site disturbance is necessary further investigation is recommended to determine NRHP eligibility	Onsite direct-effects APE
40RE602	Pre-contact	Late Woodland to Mississippian	Not Eligible	No Further Work	Onsite direct-effects APE
40RE605	Pre-contact	Undetermined Pre-contact	Not Eligible	No Further Work	Onsite direct-effects APE
40RE606	Historic	Mid-20th Century	Not Eligible	No Further Work	Onsite direct-effects APE
40RE607	Historic	Mid-20th Century	Not Eligible	No Further Work	Onsite direct-effects APE
Cave 1	NA	NA	Not Eligible	No Further Work	Onsite direct-effects APE
Cave 2	NA	NA	Not Eligible	No Further Work	Onsite direct-effects APE
Melton Hill Dam District	Historic	Mid-20th Century	Determined Eligible. It will be addressed in the PA as part of the ongoing NHPA Section 106 review	If site disturbance is necessary, mitigation will need to be developed in accordance with the PA.	Offsite direct-effects APE
Access Road	Historic	1930s	Undocumented and unevaluated. It will be addressed in the PA as part of the ongoing NHPA Section 106 review	Site should be avoided if possible; if site disturbance is necessary, further investigation is recommended to determine NRHP eligibility	Onsite direct-effects APE
River Road	Historic	Mid-20th Century	Undocumented and unevaluated. It will be addressed in the PA as part of the ongoing NHPA Section 106 review	Site should be avoided if possible; if site disturbance is necessary, further investigation is recommended to determine NRHP eligibility	Onsite direct-effects APE

Table 2-42. (contd)

Site Number	Site Type	Time Period	National Register of Historic Places (NRHP) Status	Recommendations	Location
RE1439 (Structure 1)	Historic building	Early 20th Century	Unevaluated	Impacts will be avoided due to tree cover and vegetation screening.	Onsite indirect-effects APE
Structure 2	Historic building	Unknown	Unevaluated	Field inspection established that the building is no longer extant.	Onsite indirect-effects APE
Structure 3	Historic building	Early 20th Century	Unevaluated	Abandoned and ruinous condition. Impacts will be avoided due to tree cover and vegetation screening	Onsite indirect-effects APE
Structure 4	Historic building	Unknown	Recommended NRHP-ineligible	No Further Work	Onsite indirect-effects APE
Structure 5	Historic building	Unknown	Recommended NRHP-ineligible	No Further Work	Onsite indirect-effects APE
Structure 6	Historic building	Unknown	Recommended NRHP-ineligible	No Further Work	Onsite indirect-effects APE
Structure 7	Historic building	Unknown	Recommended NRHP-ineligible	No Further Work	Onsite indirect-effects APE

Many of these investigations were completed in response to various Federal projects. The first investigation was completed by archaeologist Charles Nash in 1941 prior to the construction of the Watts Reservoir project (Jolley 1982-TN4977). Several investigations were also completed for TVA's proposed CRBRP between 1972 and 1982 (Schroedl 1972-TN4983, Schroedl 1974-TN4985, Schroedl 1990-TN5341, Schroedl 1974-TN4986; Schroedl 1974-TN4984; Thomas 1973-TN4973; Cole 1974-TN4970; Fielder 1975-TN4978; Jolley 1982-TN4977). Historic and cultural resource investigations were also completed in response to State highway improvements (Pace 1995-TN4969), DOE developments on the ORR (Valk et al. 2011-TN4972), and a proposed TVA storage disposal facility (Stanyard et al. 2003-TN4979). In addition, TVA has completed several historic and cultural resource investigations as part of TVA's NHPA Section 106 compliance process completed specifically for its proposal to build and operate two or more SMRs at the CRN Site (Barrett et al. 2011-TN4974, Barrett et al. 2011-TN4975; Hunter et al. 2015-TN4971; Karpynec 2011-TN4976; TVA 2015-TN4981).

Given the numerous historic and cultural resource investigations that have occurred at the CRN Site, many historic and cultural resources have been revisited multiple times for varying purposes and with varying levels of field investigation (i.e., survey, archaeological site excavation and NRHP evaluations). This section is presented in two parts. The first part provides a brief overview highlighting past historic and cultural resource investigation efforts of note. The second part provides an overview of TVA's NHPA Section 106 compliance activities conducted specifically for its proposed project.

2.7.2.1.1 Overview of Past Historic and Cultural Resources Investigations

Archaeologist Gerald Schroedl completed extensive archaeological investigations at the CRN Site between 1972 and 1976 in support of TVA's proposed CRBRP (Schroedl 1972-TN4983, Schroedl 1974-TN4985, Schroedl 1974-TN4986, Schroedl 1974-TN4984). In 1990, Schroedl completed a comprehensive archaeological report analyzing and documenting the results of archaeological excavation activities conducted at archaeological sites 40RE107, 40RE108, and 40RE124 (Schroedl 1990-TN5341). The report reveals that limited lithic material associated with stone tool production was uncovered at 40RE107 (Schroedl 1990-TN5341). Extensive archaeological material (i.e., lithic material, stone tools, ceramics, faunal remains and mussel shell) associated with Late Archaic, Late Woodland and Early Mississippian Periods was uncovered at 40RE108 (Schroedl 1990-TN5341). Archaeological excavation and analysis at 40RE124, a Late Woodland burial mound, revealed three separate stages of mound construction and the remains of 35 individuals and associated grave goods (Schroedl 1990-TN5341). Human remains and archaeological material associated with 40RE124 are currently curated at the University of Tennessee's archaeological laboratory, but are in the process of being moved to the McClung Museum of Natural History and Culture in Knoxville. TVA intends to initiate disposition for these remains after they have been moved to the McClung Museum in accordance with the Native American Graves Protection and Repatriation Act of 1990 (NAGPRA) (25 U.S.C. § 3001 *et seq*.-TN1686) (TVA 2017-TN4922:E3-7). As part of TVA's NHPA Section 106 compliance activities for its proposed project, all of these archaeological sites were later revisited in 2011 (Barrett et al. 2011-TN4974, Barrett et al. 2011-TN4975). While these sites have not been formally evaluated for NRHP eligibility, TVA has recommended that they be considered potentially eligible. If these archaeological sites cannot be avoided, TVA further recommended that mitigation actions be undertaken.

Valk et al. and Pace completed historic and cultural resource investigations at the Happy Valley Worker Camp (comprised of two discrete archaeological sites 40RE233 and 40RE577) in 1995 (Pace 1995-TN4969) and 2011 (Valk et al. 2011-TN4972). This work resulted in the recommendation that both sites are NRHP-eligible under Criteria A, C, and D (Valk et al. 2011-TN4972). Portions of 40RE233, the location of the former African-American Hutments section of the Happy Valley Worker Camp, is located within the onsite direct-effects APE near the BTA (Pace 1995-TN4969; Valk et al. 2011-TN4972). Site 40RE577 is located adjacent to but outside the onsite direct-effects APE. This site is the location of the northeastern portion of the former Happy Valley Worker Camp and contained a mess hall, lavatories, barracks, trailers, and hutments (Valk et al. 2011-TN4972). Valk et al. (2011-TN4972) also revisited the previously recorded African-American Wheat Community Burial Ground (40RE219), which is located adjacent to but outside the onsite direct-effects APE. Both 40RE577 and 40RE219 will not be affected because they are located outside the onsite direct-effects APE. As part of TVA's NHPA Section 106 compliance activities for its proposed project, Hunter et al. (2015-TN4971) did not revisit 40RE233 because it had recently been investigated by Valk et al. (2011-TN4972) in 2011. Hunter et al. (2015-TN4971) recommended that the NRHP-eligible site be avoided or mitigation actions be undertaken if it cannot not be avoided.

In 1999, TVA completed a geomorphological assessment of the alluvial soils on the CRN Site (Leigh 1999-TN4980). The purpose of the study was to assess the potential for deeply buried archaeological-bearing deposits. This assessment concluded that the age of the sediments suggests that there is a high potential for the soils to contain deeply buried archaeological deposits (Leigh 1999-TN4980).

2.7.2.1.2 Historic and Cultural Resource Investigations Completed by TVA for its Proposed Project

<u>Archaeological Resources</u>

Between 2011 and 2015, TVA conducted five historic and cultural resource investigations as part of its NHPA Section 106 compliance responsibilities for its proposed project (Barrett et al. 2011-TN4974, Barrett et al. 2011-TN4975; Hunter et al. 2015-TN4971; Karpynec 2011-TN4976; TVA 2015-TN4981). These investigations taken together with the field efforts completed by Stanyard et al. in 2003 (TN4979) resulted in an updated and complete inventory of archaeological and architectural resources located within the onsite direct- and indirect-effects APEs. A summary of these investigations is presented below and summarized in Table 2-43.

In 2003, TVA completed a historic and cultural resources investigation of approximately 180 ac of the onsite direct-effects APE as part of a proposed alternative site for storage and disposal of coal burning by-products produced by the nearby Kingston Steam Plant (Stanyard et al. 2003-TN4979). Three newly identified archaeological sites were recorded: 40RE547 and 40RE548, two pre-contact surface lithic scatters recommended as NRHP-ineligible, and 40RE549, a pre-contact site with a deep subsurface component that was recommended as being potentially NRHP-eligible. Five previously recorded sites consisting of two historic house sites (40RE121, 40RE122) and three pre-contact lithic extraction sites (40RE156, 40RE157, 40RE158) were recommended as being ineligible for the NRHP. No architectural resources were identified during this field investigation (Stanyard et al. 2003-TN4979). In May 2003, TVA recommended archaeological sites 40RE121, 40RE122, 40RE156, 40RE157, 40RE158, 40RE547, and 40RE548 as being NRHP-ineligible, and recommended that site 40RE549 be avoided or evaluated for NRHP eligibility if avoidance is not possible (TVA 2003-TN4953). In July 2003, THC stated that site 40RE549 should either be avoided or if avoidance was not possible that archaeological testing be completed to determine its NRHP eligibility (THC 2003-TN5252).

In early 2011, TVA completed a historic and cultural resources investigation of a portion of the onsite direct-effects APE (310 ac) (Barrett et al. 2011-TN4974). This archaeological survey resulted in the documentation of 14 archaeological sites: 9 pre-contact (40RE106, 40RE107, 40RE108, 40RE152, 40RE154, 40RE163, 40RE166, 40RE585, and 40RE589), 3 historic (40RE120, 40RE586, and 40RE587), 1 cemetery (40RE588/Hensley Cemetery), and 1 multicomponent site associated with both the pre-contact and historic eras (40RE165).(6) Barrett et al. recommended that five pre-contact-era archaeological sites (40RE106, 40RE107, 40RE108, 40RE165, 40RE166) be investigated further to determine their NRHP eligibility or be avoided by TVA activities associated with its proposed project (Barrett et al. 2011-TN4974). Barret et al. further recommended that the Hensley Cemetery, while not NRHP-eligible, should be avoided in accordance with Tennessee cemetery protection laws (Barrett et al. 2011-TN4974). The remaining eight archaeological sites (40RE120, 40RE152, 40RE154, 40RE163, 40RE585, 40RE586, 40RE587, and 40RE589) were recommended as being NRHP-ineligible (Barrett et al. 2011-TN4974).

On March 11, 2011, TVA submitted the Barrett et al. report (Barrett et al. 2011-TN4974) to THC recommending 40RE120, 40RE152, 40RE154, 40RE163, and 40RE585-40RE589 as being NRHP-ineligible (TVA 2011-TN5265). TVA had also previously recommended 40RE106, 40RE107, 40RE108, 40RE165, and 40RE166 as potentially being NRHP-eligible and committed to avoiding these sites (TVA 2011-TN5390) and THC had previously concurred with in a February 28, 2011 letter to TVA (THC 2011-TN5391). In addition, TVA committed to avoiding the Hensley Cemetery (40RE588). On March 31, 2011, THC concurred with TVA's recommendations (THC 2011-TN5266).

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(6) During a visit to the Tennessee Division of Archaeology archaeological site files, NRC staff discovered that although the Hensley Cemetery was originally recorded by Schroedl in 1972 (Schroedl 1972-TN4983) and designated as 40RE119, this site number was later vacated. With no site documentation on the Hensley Cemetery at the Tennessee Division of Archaeology, THC re-designated the Hensley Cemetery as a new archaeological site and it was therefore assigned a new site number 40RE588.

Table 2-43. Summary of TVA's Historic and Cultural Resource Investigations Completed of the Onsite Direct-Effects APE at the CRN Site for NHPA Section 106 Compliance Purposes

Historic and Cultural Resources Investigation	Total	Recommendations
Stanyard et al. 2003 (TN4979) (archaeological survey of approximately 180 ac)	8 archaeological sites	Recommended avoidance of 1 potentially NRHP-eligible site (40RE549). Recommended 7 archaeological sites NRHP-ineligible (40RE121, 40RE122, 40RE156-158, 40RE547, and 40RE548).
Barrett et al. 2011 (TN4974) (archaeological survey of 310 ac)	16 archaeological sites and the Hensley Cemetery (40RE588)	Recommend avoidance of 5 potentially NRHP-eligible sites (40RE106, 40RE107, 40RE108, 40RE165, and 40RE166) and the Hensley Cemetery (40RE588). Recommend 11 archaeological sites NRHP-ineligible (40RE120, 40RE129, 40RE152, 40RE153, 40RE154, 40RE159, 40RE163, 40RE585-587, and 40RE589).
Barrett et al. 2011 (TN4975) (archaeological survey of 692 ac)	35 archaeological sites, 3 isolated finds and 2 caves	Recommend avoidance of 12 potentially NRHP-eligible sites be avoided (40RE104, 40RE105, 40RE106[a], 40RE108[a], 40RE124, 40RE128, 40RE140, 40RE167, 40RE549[b] 40RE595, 40RE600, 40RE601). Recommend 23 archaeological sites (40RE122[b] 40RE123, 40RE125, 40RE151, 40RE153, 40RE155, 40RE160-164, 40RE590-594, 40RE596-598, 40RE602, and 40RE605-607), 2 caves and 3 isolated finds (IF-1, IF-2, and IF-3) NRHP-ineligible.
Hunter et al. 2015 (TN4971) (archaeological survey of the barge/traffic area)	5 archaeological sites, 1 isolated find, 1 non-site locality	Recommend avoidance of 1 potentially NRHP-eligible pre-contact site (40RE138) and 1 NRHP-eligible historic site (40RE233). Recommend three sites (40RE135, 40RE139, and 40RE202), 1 non-site locality, and 1 isolated find as NRHP-ineligible.
Karpynec 2011 (TN4976) (architectural survey of initial onsite indirect-effects APE at the CRN Site)	4 architectural resources	Recommend 4 architectural resources as NRHP-ineligible (Structures 4–7).
TVA 2015 (TN4981) (architectural evaluation of expanded indirect-effects APE at the CRN Site)	3 architectural resources	Unevaluated because project impacts can be avoided due to vegetation screening (RE1439 and Structure 3). One is no longer extant (Structure 2).

(a) Archaeological sites were also visited by Barrett 2011 (TN4974).
(b) Archaeological sites were also visited by Stanyard in 2003 (TN4979).

In March and April of 2011, TVA conducted another investigation of an additional 692 ac of the onsite direct-effects APE (Barrett et al. 2011-TN4975). This investigation resulted in the documentation of 23 pre-contact sites (40RE104, 40RE105, 40RE106, 40RE108, 40RE124, 40RE125, 40RE128, 40RE151, 40RE153, 40RE155, 40RE160, 40RE161, 40RE162, 40RE163, 40RE164, 40RE167, 40RE549, 40RE592, 40RE595, 40RE600, 40RE601, 40RE602, and 40RE605) 11 historic sites (40RE122, 40RE123, 40RE590, 40RE591, 40RE593, 40RE594, 40RE596, 40RE597, 40RE598, 40RE606, and 40RE607), and 1 multicomponent site (40RE140), 2 caves (Cave 1 and 2), and 3 isolated finds (IF1-IF3) (Barrett et al. 2011-TN4975). Of the 35 archaeological sites identified, Barrett et al.(2011-TN4975) recommended that 12 archaeological sites (40RE104-106, 40RE108, 40RE124, 40RE128, 40RE140, 40RE167, 40RE549, 40RE595, 40RE600, 40RE601) be avoided or be investigated to determine their NRHP eligibility. The remaining 23 archaeological sites, 3 isolated finds and 2 caves were recommended as being NRHP-ineligible with no further action required (Barrett et al. 2011-TN4975).

On August 26, 2011, TVA sent a letter to the THC (TVA 2011-TN5267) and to American Indian Tribes (TVA 2011-TN5254) transmitting the results and recommendations contained in Barrett's second 2011 report. In response to this letter, on August 29, 2011, the United Keetowah Band of Cherokee Indians indicated that they had no concerns with the project and requested that in the event of the inadvertent discovery of human remains, TVA stop work immediately and contact the United Keetowah Band of Cherokee Indians Tribal Historic Preservation Officer (UKB 2011-TN5255). On September 12, 2011, the THC concurred with TVA's findings about the potential NRHP eligibility of 12 sites as listed above and the NRHP ineligibility of the remaining 23 sites (THC 2011-TN4982). THC also stated that the 12 potentially NRHP-eligible sites be avoided or subject to additional NRHP-eligibility archaeological testing if avoidance was not possible (THC 2011-TN4982).

In 2015, TVA completed historic and cultural resources investigations of the remaining 110.5 ac of the onsite direct-effects APE (Hunter et al. 2015-TN4971). While located within the onsite direct-effects APE, the NRHP-eligible archaeological site 40RE233 (Happy Valley Worker Camp) was not revisited because it had been recently investigated in 2011 by Valk et al. (2011-TN4972) (Hunter et al. 2015-TN4971). Two previously mapped pre-contact sites (40RE135[7] and 40RE202) were determined to have been destroyed, and no extant archaeological material was located at a third previously mapped pre-contact site, 40RE139. One pre-contact site (40RE138) was recommended for further investigation and avoidance. In April 2015, TVA transmitted the results of this investigation (Hunter et al. 2015-TN4971) to the THC and American Indian Tribes (TVA 2015-TN5256, TVA 2016-TN5319). TVA noted the presence of the NRHP-eligible Happy Valley Worker Construction Camp (40RE233) within the onsite direct-effects APE, and recommended 40RE138 be investigated further to establish its NRHP eligibility. TVA also recommended 40RE135 and 40RE202 as being NRHP-ineligible and noted that no archaeological deposits associated with 40RE139 were located within the onsite direct-effects APE. On April 7, 2015, the THC concurred with all of TVA's recommendations (THC 2015-TN5263). In an e-mail response dated May 12, 2015, the Muscogee (Creek) Nation stated that they were not aware of any culturally significant sites in the APE, and concurred with the determination that site 40RE233 is NRHP-eligible (TVA 2016-TN5319).

(7) During the site audit, NRC staff reviewed archaeological site files at the Tennessee Division of Archaeology and established that 40RE135 recorded location is outside the survey area and onsite direct-effects area of potential effect.

Architectural Resources

In 2011 and 2015, TVA also completed historic and cultural resource investigations to identify architectural resources located within the onsite direct- and indirect-effects APE for NHPA Section 106 compliance purposes associated with its proposed project (Karpynec 2011-TN4976; TVA 2017-TN4922:E3-4, TVA 2015-TN4981; NRC 2017-TN5413). These investigations did not identify any architectural resources within the onsite direct-effects APE, but did identify seven architectural resources (Smith house/RE1439, and Structures 2–7) within the onsite indirect-effects APE. TVA recommended that Structures 4–7 are NRHP-ineligible (TVA 2017-TN4922:E3-4, TVA 2015-TN4981; NRC 2017-TN5413). Structures 1, 2, and 3 were visited by a TVA archaeologist (TVA 2017-TN4922:E3-5; NRC 2017-TN5413); Structure 2 was found to be no longer extant (TVA 2017-TN4922:E3-5; TVA 2015-TN4981; NRC 2017-TN5413). Structure 1 was determined to be the previously recorded site of the Smith House (RE1439) and Structure 3 was identified as an abandoned and dilapidated structure (TVA 2017-TN4922:E3-5). During this field visit, TVA archaeologists further established that the activities occurring on the CRN Site would not be visible from Structures 1 and 3 due to the presence of vegetation screening and, therefore, would not be affected (TVA 2017-TN4922:E3-5, TVA 2015-TN4981). On May 20, 2015, TVA transmitted its findings regarding architectural resources to THC (TVA 2015-TN4981) and recommended that no further investigation or evaluation of these properties occur, concluding that the proposed project, as currently planned, would not affect any NRHP-eligible historic architectural resources (TVA 2015-TN4981).

On May 27, 2015, THC concurred with TVA's findings that there are no NRHP-eligible architectural resources located within the onsite direct- and indirect-effects APE, and that none of the structures would be affected by the proposed undertaking (THC 2015-TN5392).[(8)]

Two historic roads (Access Road and River Road) are located within the onsite direct-effects APE (TVA 2017-TN4921). Access Road appears on 1939 aerial photographs and may have connected "individual homesteads to Bear Creek Road" (TVA 2017-TN4921). River Road is not present on 1943 TVA land transfer maps, but appears on a 1952 aerial photograph (TVA 2017-TN4921). According to TVA, Access Road may be associated with the Manhattan Project era K-25 Gaseous Diffusion Plant located on the ORR (TVA 2017-TN4921). Both roads have not been evaluated for NRHP eligibility. The extent of future modifications to existing roads are not known at this time. In accordance with TVA's PA for the proposed project, once plans are finalized, and if avoidance is not possible, TVA will complete formal NRHP evaluations of these roads at that time and mitigate as necessary (TVA 2017-TN4922).

Traditional Cultural Properties

The results of TVA's NHPA Section 106 consultation efforts (i.e., transmittal of historic and cultural resources investigations and PA) conducted with American Indian Tribes for its

(8) TVA did not specifically reach out to local historical societies regarding the 2011 and 2015 architectural resources inventories because no significant architectural resources were identified (TVA 2017-TN4922:E3-5). However, TVA does consult with such groups "when a survey identifies resources that TVA deems would be of interest to parties other than the SHPO and federally-recognized Tribes" (TVA 2017-TN4922:E3-5). TVA also did not consult with American Indian Tribes regarding architectural resources located within the onsite direct- and indirect-effects APE, because "tribes have made it clear that they do not expect TVA to consult on such projects where there is no connection to tribal culture, religion or history" (TVA 2017-TN4922:E3-4).

proposed project indicate that no traditional cultural properties are known to be located within the CRN onsite direct- or indirect-effects APE.

TVA's Programmatic Agreement

Between 2015 and 2016, TVA developed and executed a PA in consultation with THC and American Indian Tribes[9] to address how TVA would comply with ongoing NHPA Section 106 requirements associated with its proposed project (TVA and TSHPO 2016-TN5298; TVA 2017-TN4922, TVA 2016-TN5319, TVA 2015-TN4951, TVA 2015-TN4952, TVA 2015-TN4954, TVA 2017-TN5246, TVA 2017-TN4922). TVA also consulted with the ACHP regarding the PA on August 24, 2016 (TVA 2017-TN4922).

The final version of the PA was signed by the United Keetoowah Band of Cherokee Indians as a concurring party on July 20, 2016, and by the THC as a signatory on May 12, 2016 (TVA and TSHPO 2016-TN5298). On August 10, 2016, TVA submitted the final PA to the THC, the United Keetoowah Band of Cherokee Indians in Oklahoma (TVA 2017-TN4922), and to the ACHP on August 24, 2016 (TVA 2017-TN4922). While the United Keetoowah Band of Cherokee Indians in Oklahoma are the only consulting American Indian Tribe that signed the final 2016 PA, TVA intends to continue consultation with American Indian Tribes regarding future NHPA Section 106 compliance activities (TVA 2017-TN4922:E3-3).

The PA indicates that TVA's proposed undertaking has the potential to adversely affect an unknown number of the 16 potentially eligible archaeological sites and the NRHP-eligible 40RE233 (Happy Valley Worker Construction Camp) (TVA and TSHPO 2016-TN5298). The PA outlines specific steps TVA will follow to avoid, minimize, or mitigate adverse effects to historic properties. These include completing NRHP-eligibility evaluations for the 16 potentially NRHP-eligible sites. If impacts cannot be avoided, mitigation measures would be implemented to resolve adverse effects. The PA commits TVA to complying with NHPA Section 106 in consultation with THC and American Indian Tribes as project plans are finalized. Given the potential for deeply buried deposits at the CRN Site, as noted in Leigh (1999-TN4980), the PA also describes a process of amending the vertical APE if "future proposed actions connected with the undertaking" entail excavations or trenching that exceed 80 cm in these high-potential areas (TVA 2017-TN4922:E3-1); TVA and TSHPO 2016-TN5298).

(9) During the course of TVA's NHPA Section 106 compliance consultation for its proposed project, TVA consulted with 16 of 18 Federally recognized American Indian Tribes that have indicated to TVA that they have an interest in TVA's Public Service Area (TVA 2017-TN4921, TVA 2017-TN5246, TVA 2016-TN5319, TVA 2017-TN4922). These American Indian Tribes include the Eastern Band of Cherokee Indians, Cherokee Nation, Chickasaw Nation, Alabama Quassarte Tribal Town, Muscogee (Creek) Nation, Alabama Coushatta Tribe of Texas, Thlopthlocco Tribal Town, Seminole Nation of Oklahoma, Eastern Shawnee Tribe of Oklahoma, Absentee Shawnee Tribe of Oklahoma, Kialegee Tribal Town, United Keetoowah Band of Cherokee Indians in Oklahoma, Seminole Tribe of Florida, Shawnee Tribe, Coushatta Tribe of Louisiana and Poarch Band of Creek Indians. The Seminole Tribe of Florida later indicated to TVA that they do not have an interest in TVA's power service area, thereby bringing the total number of American Indian Tribes that TVA consulted with to 15. It was not until after the development of the PA for the CRN Site, that the Coushatta Tribe of Louisiana indicated to TVA that they wanted to be consulted with on future activities (TVA 2017-TN4922).

2.7.2.2 Historic and Cultural Resources Located within the Offsite Direct- and Indirect-Effects APE

Several offsite areas are associated with building two or more SMRs at the CRN Site. These include potential modifications at the Melton Hill Dam, upgrades and modifications to existing transmission line corridors, and use of existing offsite borrow source areas for fill material. Project plans for all offsite areas have not been finalized. However, TVA has only established a direct- and indirect-effects APE for the Melton Hill Dam portion of the offsite areas.[10] The following sections describe known historic and cultural resources information associated with the Melton Hill Dam offsite project direct- and indirect-effects APE. TVA will follow its PA, which outlines how TVA will address impacts on historic properties that may be affected by offsite activities (TVA 2017-TN4922:E3-1; TVA and TSHPO 2016-TN5298).

The National Register-eligible Melton Hill Dam is the only historic and cultural resource that has been identified within the Melton Hill Dam direct-effects APE. The Melton Hill Dam is part of the Melton Hill Dam District which is considered to be a contributing component of the NRHP-eligible Tennessee Valley Hydroelectric System Multiple Properties District (Martens et al. 2015-TN5262; Martens and Thomason 2015-TN5260). Draft individual documentation completed by TVA of the Melton Hill Dam District indicates that it is considered to be NRHP-eligible under Criteria A and C for its association with important events in national history as well as its unique design (Martens and Thomason 2015-TN5260). The historical period of significance spans 1964–1969, and associated themes of significance include engineering, industry, social history, and transportation (Martens and Thomason 2015-TN5260). The NRHP-eligible Melton Hill District consists of a total of 14 contributing resources, including 8 buildings (Powerhouse, Lock Control Building 1, Lock Control Building 2, Lock Operation Building, Visitor Building, Main Office Building, Bathhouse 1, and Bathhouse 2), two sites (Visitor Building Picnic Area and Recreation Area), and 5 structures (Melton Hill Dam, Navigational Lock, Switchyard and Transmission Lines, Flammable Materials Storage Shed, and Hazardous Materials Storage Shed) (Martens and Thomason 2015-TN5260). Thirteen of the 14 NRHP-eligible contributing resources are located within the 0.5-mi indirect-effects APE.

The NRC staff review of Tennessee Division of Archaeology files indicated that no archaeological resources are located within the offsite Melton Hill Dam direct-effects APE. The NRC staff also reviewed THC's historic properties viewer and architectural survey files, which revealed that the closest previously recorded architectural resource (LD-174) is located just outside the indirect-effects APE. Structure LD-174 is described as a plain traditional style house with bungalow influences constructed in 1915.

The results of TVA's NHPA Section 106 consultation efforts (i.e., transmittal of historic and cultural resources investigations, amended APE, and PA) conducted to date with American Indian Tribes indicate that no known traditional cultural properties are located within the offsite direct- or indirect-effects APE.

As project designs become finalized for the Melton Hill Dam and other offsite areas (i.e., transmission lines, borrow pit areas), TVA will adhere to stipulations outlined in TVA's PA in

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(10) On August 18, 2016, TVA notified the THC and American Indian Tribes of its expanded APE consisting of Melton Hill Dam and a 0.5-mi area surrounding the dam (TVA 2016-TN5259). In this letter TVA indicated that TVA will "continue to adhere to the stipulations of the PA in evaluating the undertaking's possible effects on historic properties" (TVA 2016-TN5259). On August 23, 2016, THC concurred with the TVA's amended APE (THC 2016-TN4950).

consultation with THC and American Indian Tribes as part of its ongoing NHPA Section 106 obligations such that additional historic and cultural resources identification efforts occur and impacts are avoided, minimized, or mitigated (TVA 2017-TN4922:E3-1).

2.7.3 Federal Requirements

TVA is a Federal land-managing agency, and as such, is required to comply with other Federal historic and cultural resources compliance requirements in addition to those required by NHPA Section 106 (54 U.S.C. § 306101-TN4840) and NEPA (42 U.S.C. § 4321 *et seq*.-TN661). This includes NHPA Section 110, Archaeological Resources Protection Act (ARPA; 16 U.S.C. § 470aa *et seq*.-TN1687), American Indian Religious Freedom Act (42 U.S.C. § 1996 *et seq*.-TN5281), NAGPRA (25 U.S.C. § 3001 *et seq*.-TN1686), EO 13007 "Indian Sacred Sites" (TN5250), EO 13175 "Consultation and Coordination with Indian Tribal Governments" (TN4846), as well as implementing regulations governing the curation of artifacts as articulated in 36 CFR Part 79 (TN5251). TVA has a robust cultural resources program comprising individual components that confer compliance with each of these regulations (TVA 2017-TN4922, TVA 2011-TN5257). As part of TVA's Natural Resource Plan, TVA has committed to developing formal guidance through the completion of a cultural resources management plan overseeing all of its Federal cultural resources compliance requirements throughout lands managed in its Public Service Area (TVA 2017-TN4922:E3-3, TVA 2011-TN5257). TVA has deferred completion of its cultural resources management plan until completion of its integrated cultural resources database (TVA 2017-TN4922:E3-3). In the interim, TVA is developing guidelines and policies to comply with Federal cultural resources requirements.

Specifically, TVA's has appointed a NAGPRA coordinator to oversee the agency's NAGPRA compliance. TVA is in the process of developing a comprehensive agreement in consultation with 18 Federally recognized American Indian Tribes outlining a process for dealing with "post-1990 unintentional discoveries of NAGPRA cultural items" (TVA 2017-TN4922:E3-3 and E3-7). TVA also has an ARPA compliance program that includes monitoring of sensitive archaeological sites located on TVA property, "law enforcement investigations and civil and criminal proceedings for ARPA violations; and the "Thousand Eyes" Archaeological Outreach Program" (TVA 2017-TN4922:E3-7).

In addition, all archaeological material recovered from the CRN Site prior to the year 2000 (including human remains recovered from 40RE124), are in the process of being moved from University of Tennessee's archaeological laboratory to the McClung Museum (TVA 2017-TN4922:E3-7). Archaeological materials recovered from the CRN Site during the 2011 and 2015 field investigations are currently curated at University of Alabama facilities in Moundville Archaeological Park, Moundville, Alabama (Hunter et al. 2015-TN4971; Barrett et al. 2011-TN4974; Barrett et al. 2011-TN4975).

2.7.4 Consultation

The NRC initiated consultation via letter dated April 20, 2017 with the THC, the ACHP, and 20 Federally recognized American Indian Tribes (Eastern Band of Cherokee Indians of North Carolina [NRC 2017-TN5202], United Keetowah Band of Cherokee Indians in Oklahoma [NRC 2017-TN5214], Cherokee Nation of Oklahoma [NRC 2017-TN5198], Chickasaw Nation [NRC 2017-TN5199], Choctaw Nation of Oklahoma [NRC 2017-TN5200], Coushatta Tribe of Louisiana [NRC 2017-TN5201], Jena Band of the Choctaw Indians [NRC 2017-TN5204], Mississippi Band of the Choctaw Indians [NRC 2017-TN5206], Quapaw Tribe of Oklahoma [NRC 2017-TN5209], Alabama Quassarte Tribal Town [NRC 2017-TN5197], Muscogee (Creek)

Nation of Oklahoma [NRC 2017-TN5207], Alabama Coushatta Tribe of Texas [NRC 2017-TN5196], Thlopthlocco Tribal Town [NRC 2017-TN5213], Seminole Nation of Oklahoma [NRC 2017-TN5210], Shawnee Tribe of Oklahoma [NRC 2017-TN5212], Absentee Shawnee Tribe of Oklahoma [NRC 2017-TN5215], Kialegee Tribal Town [NRC 2017-TN5205], Seminole Tribe of Florida [NRC 2017-TN5211], Eastern Shawnee Tribe of Oklahoma [NRC 2017-TN5203], and Poarch Band of Creek Indians [NRC 2017-TN5208]). All letters are presented in Appendix F. No Federally recognized American Indian Tribes are located within the State of Tennessee.

On May 12, 2017, the Cherokee Nation responded to the NRC, stating that the APE for the proposed project is located within the Cherokee Nation's historic homelands (Cherokee Nation 2017-TN5247). The Cherokee Nation stated that TVA should complete an EIS, comply with the NHPA Section 106 process, and requested that a copy of the EIS be sent to them for review. The Cherokee Nation also requested that inquiries be made with other Tribal Historic Preservation Officers if "items of cultural significance are discovered while developing this project report," and that activities stop and the Cherokee Nation be notified for additional consultation (Cherokee Nation 2017-TN5247).

The Choctaw Nation responded to the NRC by e-mail dated June 5, 2017, stating that the proposed project is located outside the Choctaw Nation's area of historic concern (Choctaw Nation 2017-TN5248). On June 12, 2017, the TDEC concurred with TVA's plan to conduct Phase I/II National Register evaluations of archaeological sites, and if any are determined to be NRHP-eligible, that additional considerations may be necessary (TDEC 2017-TN5261).

On June 28, 2017, the United Keetoowah Band of Cherokee Indians in Oklahoma responded to the NRC's letter stating that the proposed project APE lies in "traditional territory of the UKB and the surrounding area contains important historic, ethnographic and traditional resources of significance to the UKB" (2017-TN5249). The United Keetoowah Band of Cherokee Indians also requested that a "cultural resources inventory" be completed prior to the commencement of project activities (UKB 2017-TN5249).

The NRC conducted public scoping meetings in Oak Ridge, Tennessee, on May 15, 2017. No comments regarding historic and cultural resources were provided at the meeting.

The NRC conducted follow-up phone calls with American Indian Tribes in January and February 2018. The Mississippi Band of Choctaw Indians (NRC 2018-TN5435) stated that they do not consult on projects located in Tennessee. The Quapaw Tribe of Oklahoma stated that the CRN Site lies outside their area of interest (NRC 2018-TN5435). In response to the follow-up phone call, on January 22, 2018, the Chickasaw Nation sent an e-mail to the NRC stating that they have no additional comments on the proposed permit (Chickasaw Nation 2018-TN5428).

Representatives of the Seminole Nation of Oklahoma, the Alabama-Coushatta Tribe of Texas, the Alabama-Quassarte Tribal Town, and Thlopthlocco Tribal Town requested that the NRC re-send the initial consultation letter (NRC 2018a). NRC re-sent the consultation letters via email as requested (NRC 2018-TN5431, NRC 2018-TN5432, NRC 2018-TN5430, NRC 2018-TN5429). On January 20, 2018, the Seminole Nation of Oklahoma replied to the staff's email requesting that intensive archaeological surveys be completed, copies of survey reports and a listing of all flora be provided to the Seminole Nation (Seminole Nation of Oklahoma 2018-TN5419). In addition, the Seminole Nation of Oklahoma requested to be notified in the event archaeological, cultural materials or human remains are encountered during the course of the project and that all work stop. In response, the NRC forwarded a summary of TVA's identification efforts performed at the CRN site and information relating to inadvertent discovery provisions on March 5, 2018 (NRC 2018-TN5434). On February 19, 2018, a response was received from Thlopthlocco Tribal Town stating that their office would refrain from commenting until the DEIS is submitted for review (Thlopthlocco Tribal Town 2018-TN5424- see ML18051A732).

The Coushatta Tribe of Louisiana stated that the CRN site lies within their area of interest and requested a copy of the DEIS (NRC 2018-TN5435). The Absentee Shawnee Nation and the Shawnee Tribe of Oklahoma confirmed that they received the NRC's consultation letter and stated they would contact NRC if they have any questions (NRC 2018a).

On February 15, 2018, the Poarch Band of Creek Indians requested that the NRC re-send the initial consultation letter. On February 16, 2018, the NRC re-sent the consultation letter via email as requested (NRC 2018-TN5425 - see ML18051A743).

2.8 Geology

This section provides a general description of the surface and subsurface geology at the CRN Site. Groundwater and surface water are more completely described in EIS Section 2.3.1. A detailed description of the regional and site-specific geology, seismology, and geotechnical engineering aspects of the CRN Site are provided in Section 2.5 of the SSAR (TVA 2017-TN5387). The NRC staff's description of the site and vicinity geologic features will be included in the safety evaluation report, along with a detailed analysis and evaluation of the CRN Site's geological, seismological, and geotechnical data—as required for a site-safety assessment. The information that follows is informed by Section 2.6 of TVA's ER (TVA 2017-TN4921) and other direct sources as identified.

The CRN Site lies within the Valley and Ridge Physiographic Province, which has an extent of about 50 to 100 mi (east to west) in eastern Tennessee. The province is characterized by a northeast-trending sequence of folded and thrust-faulted sedimentary rocks of primarily Ordovician and Cambrian age. In the area of the CRN Site, the thrust faults are closely spaced, which resulted in sequences of geologic units being repeated across the landscape (illustrated in Figure 2-33 and Figure 2-34; TVA 2017-TN5387). The general sequence consists of Chickamauga Group, Knox Group, Conasauga Group, and Rome Formation geologic units (from youngest to oldest). Present-day topography in the Valley and Ridge Physiographic Province is influenced by erosional processes. In general, the valleys in the province are underlain by soluble carbonate rocks and easily eroded shale, and the ridges are underlain by more erosion-resistant sandstone, siltstone, and cherty dolomite (Lloyd and Lyke 1995-TN4988). Smaller ephemeral and perennial streams generally flow perpendicular to, and drain, the ridges, or flow parallel to the valleys. Larger streams, such as the Clinch River, have cut and maintained water gaps through the erosion-resistant ridges.

The CRN Site is located in the southwest extension of Bethel Valley between Chestnut Ridge to the northwest and Haw/Hood Ridge to the southeast (TVA 2017-TN4921). Haw/Hood Ridge was formed by the Copper Creek thrust fault. This fault crosses the southern portion of the CRN Site, and resulted in the placement of the older Rome Formation over the Chickamauga Group units. The erosion-resistant Rome Formation that forms Haw/Hood Ridge has been eroded on the CRN Site where the ridge has been cut by the Clinch River.

Surface materials at the CRN Site consist of residual soils, artificial fill, and some alluvial and colluvial soils in the southern portion of the site, along the Clinch River, and in some drainage channels across the site (TVA 2017-TN4921). Surface sediments and drainage of the CRN Site have been substantially altered by previous construction activities associated with the CRBRP. The surface materials overlie weathered rock, which varies in thickness across the site. The underlying rock units outcrop in some portions of the site.

The CRN Site is underlain by in excess of 12,000 ft of bedded sedimentary rock units striking approximately N 52°E, and dipping consistently 32 to 35°SE in the uppermost 400 ft characterized in the CRN Site investigation (TVA 2017-TN4921). A stratigraphic section for the CRN Site and the vicinity is shown in Figure 2-35. Borings from the site investigation identified nine stratigraphic layers corresponding to the Chickamauga Group, the uppermost Knox Group, and the Rome Formation (at the southernmost end of the CRN Site). Rocks belonging to the Conasauga Group are not present at the CRN Site except at depths in excess of 5,000 ft. Descriptions of the geologic units present at the CRN Site, provided below, are from the SSAR (TVA 2017-TN5387). The CRN Site plant parameter envelope power-block location extends from the Knox Group through the Benbolt Formation as shown in the Figure 2-36 cross section.

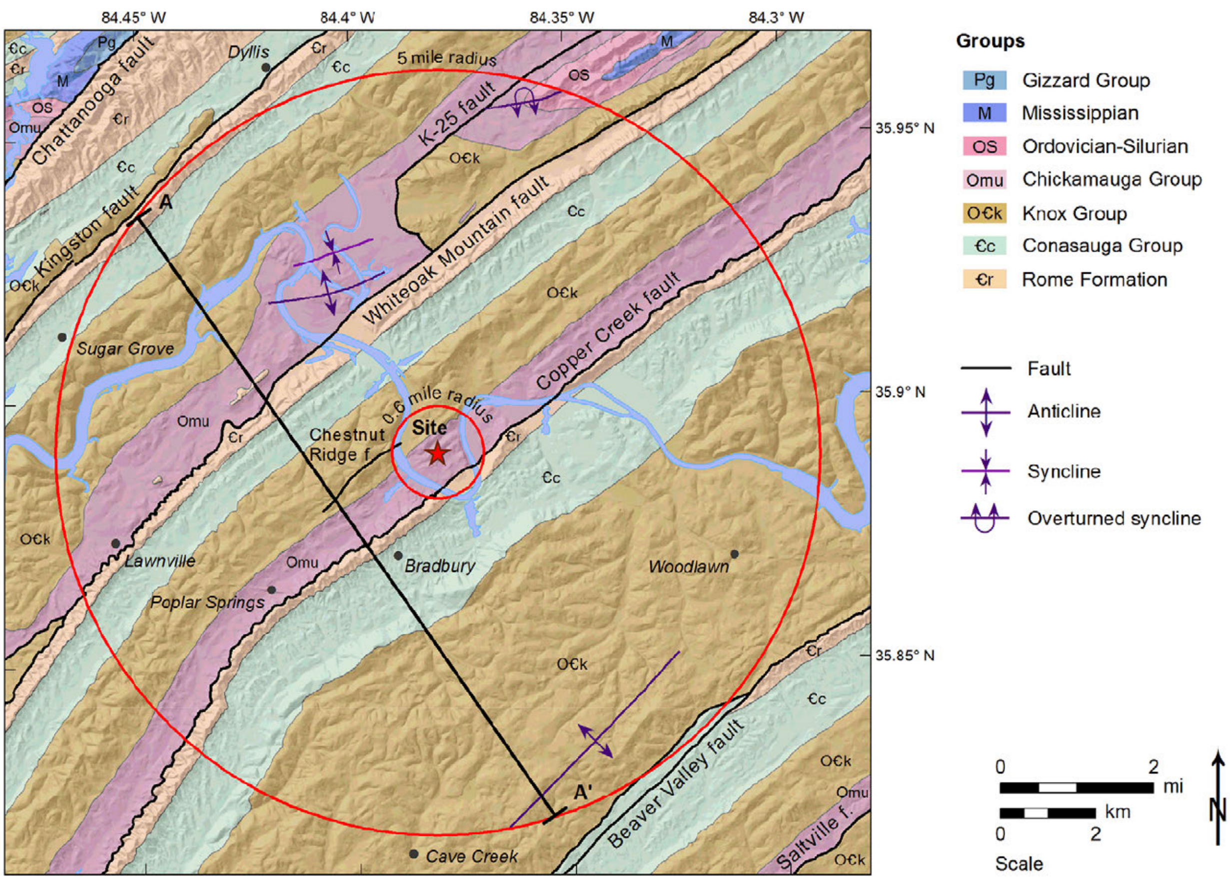


Figure 2-33. Simplified Geologic Map of the CRN Site and Vicinity (Source: TVA 2016-TN5018)

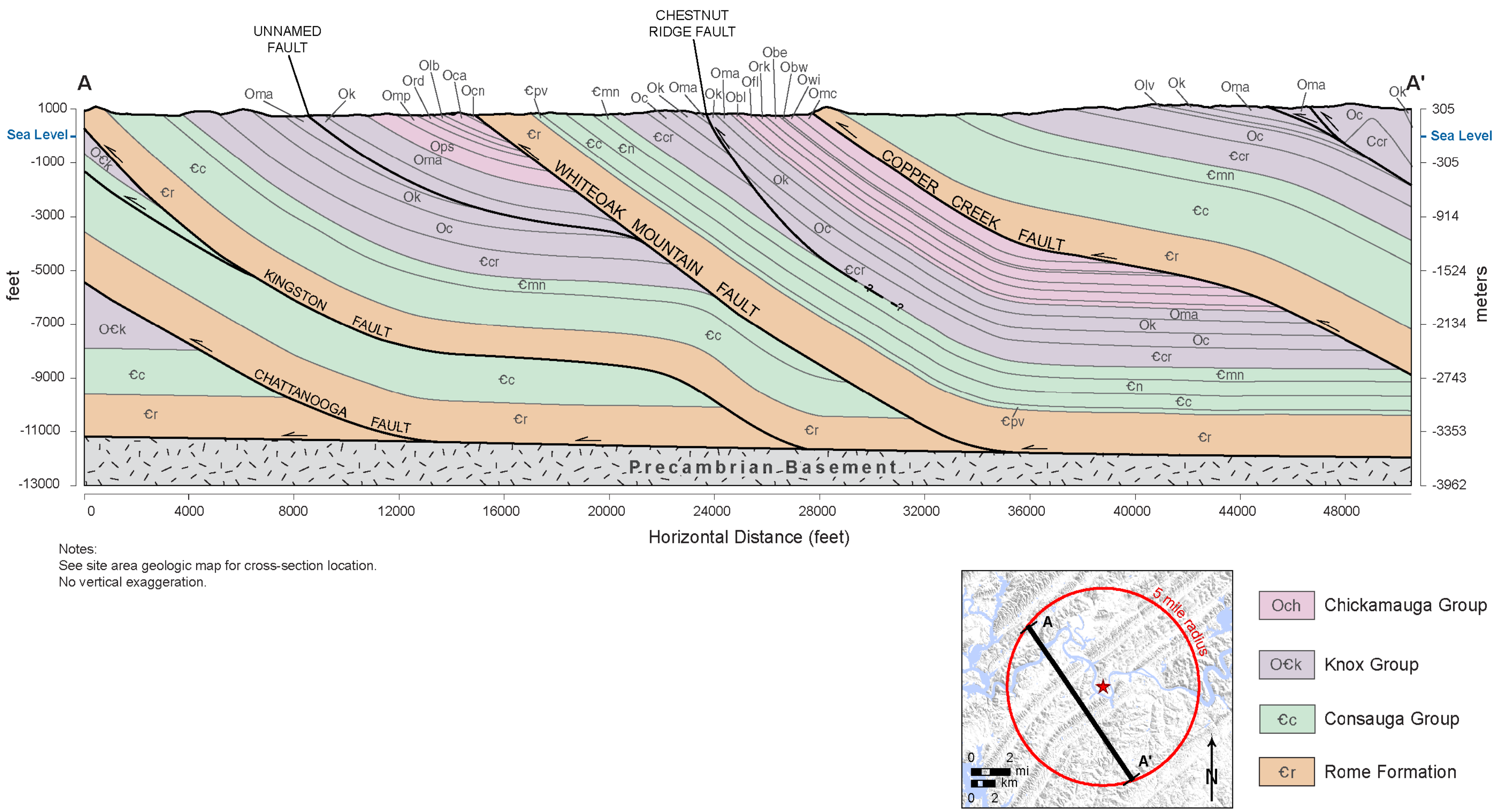


Figure 2-34. Geologic Cross Section near the CRN Site and Vicinity (projected to Precambrian basement, no vertical exaggeration) (Source: TVA 2017-TN5387)

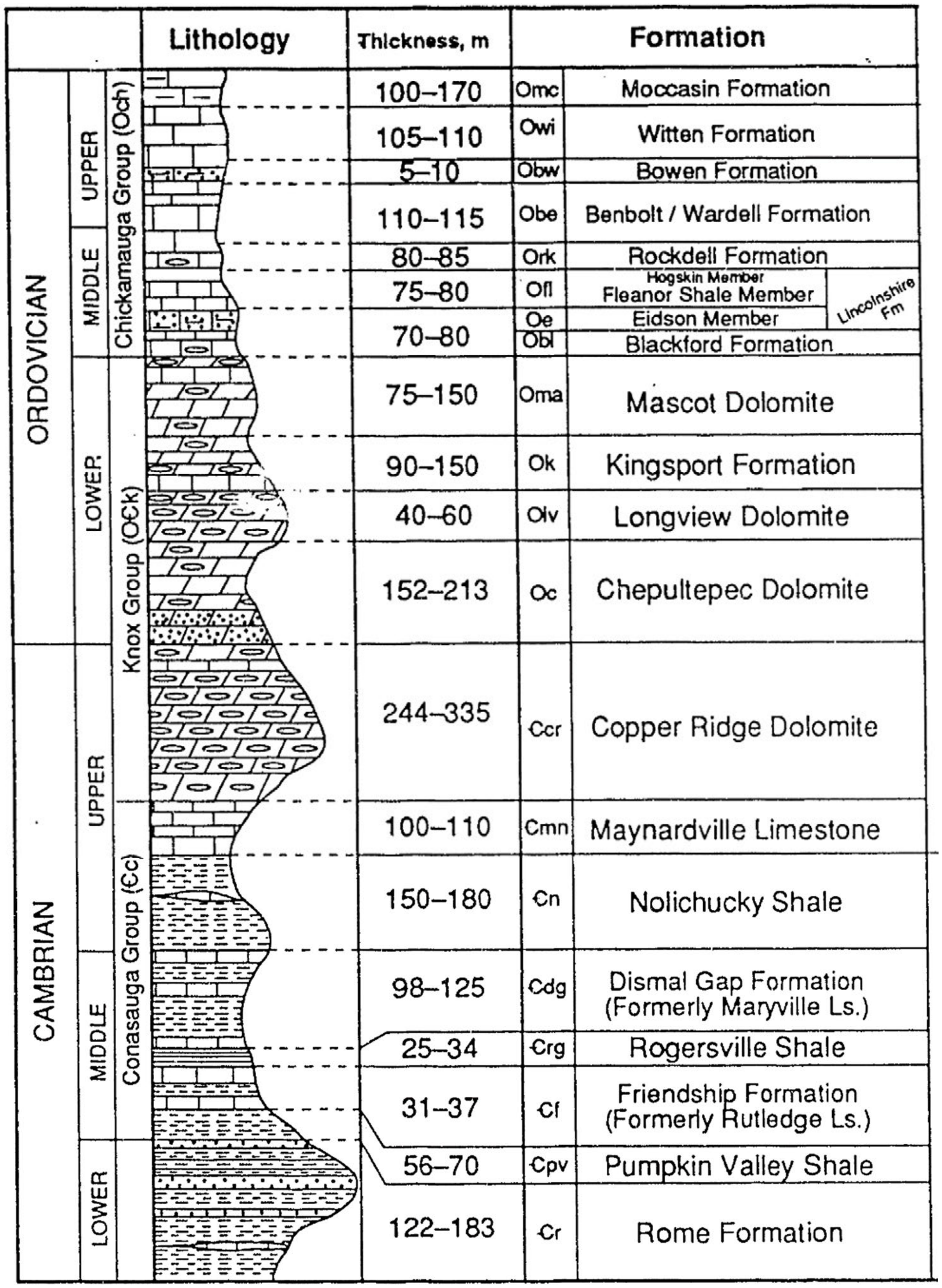


Figure 2-35. Stratigraphic Section for the CRN Site and Vicinity (Source: Hatcher et al. 1992-TN4989)

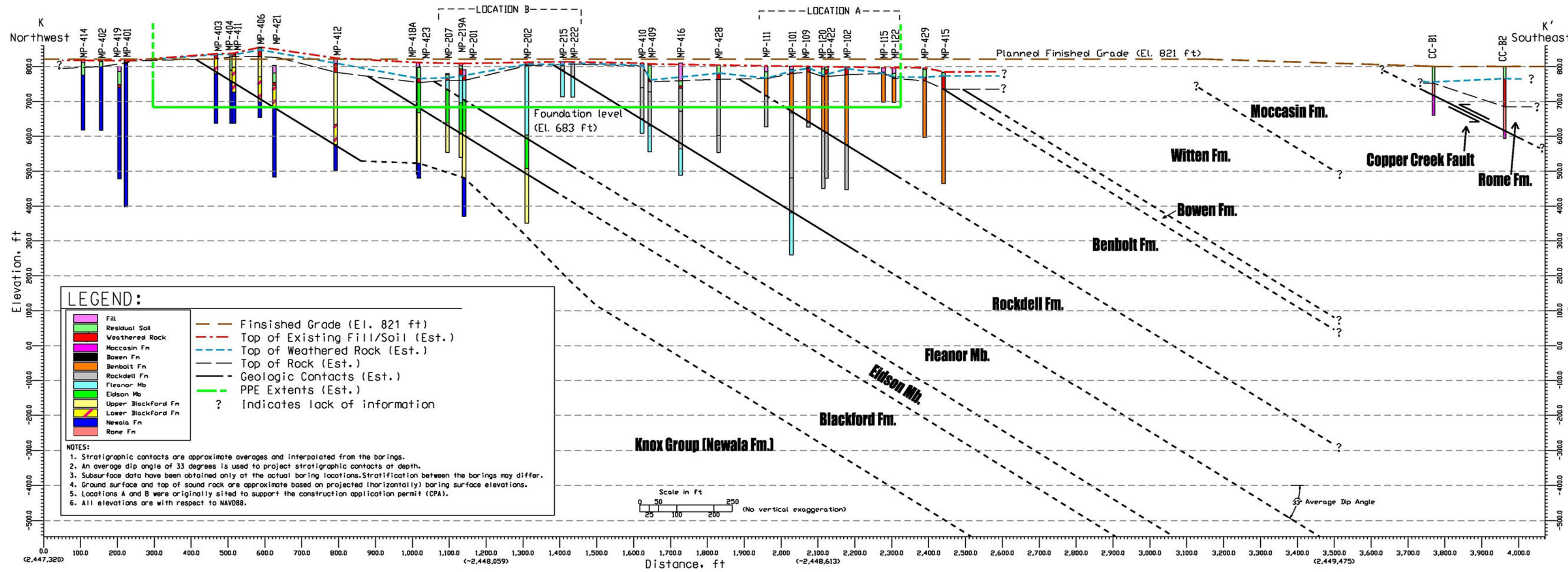


Figure 2-36. Geotechnical Cross Section through the CRN Site Power-Block Area (Source: TVA 2017-TN5387, TVA 2017-TN4921)

The Chickamauga Group occupies the majority of the CRN Site, including the area and depth to be excavated, and includes the following formations, listed from youngest to oldest:

- Mocassin Formation, a laminated to moderately bedded argillaceous, micritic limestone with very thin clayey calcareous siltstone interbeds; of unknown thickness at the CRN Site.
- Witten Formation, differentiated into fossiliferous limestone, calcarenite, and interbedded siltstone and limestone subunits; 319 ft thick on the ORR.
- Bowen Formation, a calcareous siltstone of limited, but unknown thickness at the CRN Site (average thickness was 25 ft from two rock cores at the CRN Site [TVA 2017-TN5387]).
- Benbolt Formation, a very thinly to moderately bedded limestone; 277 ft thick at the CRN Site.
- Rockdell Formation, a very thinly to moderately bedded micritic limestone, interbedded with calcareous siltstone; 241 ft thick at the CRN Site.
- Fleanor Shale Member of the Lincolnshire Formation, a laminated to moderately bedded calcareous siltstone; 216 ft thick at the CRN Site.
- Eidson Member of the Lincolnshire Formation, a laminated to thinly bedded argillaceous, micritic limestone; 86 ft thick at the CRN Site.
- Blackford Formation, a dolomitic limestone in its lower portion, and a calcareous siltstone in its upper portion; 213 ft thick at the CRN Site.

Outcropping in the northern portion of the CRN Site and underlying the Blackford Formation are the uppermost units of the Knox Group, the Kingsport Formation, and Mascot Dolomite unit, referred to as the Newala Formation where the contact between these two units is not present (TVA 2017-TN5387). The Newala Formation is a crystalline dolomite in which limestone and dolomitic limestone interbeds and some chert are present. Karstic features in the Knox Group dolomites are much more common than in the rocks of the Chickamauga Group (TVA 2017-TN5387).

The Rome Formation was encountered at two boreholes in the southern portion of the site used to characterize the Copper Creek thrust fault. The Rome Formation is primarily shale and siltstone; samples at the CRN Site were described as calcareous siltstone. A fault gouge 4 to 7 ft thick consisting of calcareous, clayey shale and siltstone was observed between the Rome Formation and the underlying Moccasin Formation.

2.9 Meteorology and Air Quality

The CRN Site is located in a region of eastern Tennessee that is commonly referred to as "The Great Valley," an area of ridges and valleys, which influences the climate of the site. Elevations range from 700 ft MSL to 1,500 ft MSL. The site experiences a humid subtropical climate with typically moderate conditions due to the jet stream situated to the north of the site during warmer months, which allows maritime tropical air masses from the Gulf of Mexico, or, to a lesser extent, the Atlantic Ocean, to influence the region. During winter months, the jet stream shifts toward the south, but with a west-to-east orientation, and conditions remain moderate. When the jet stream is farther south into the southern states, colder temperatures are experienced at the CRN Site due to the polar continental air mass, but the region's topography often blocks these polar air masses and limits temperature extremes (TVA 2017-TN4921).

The nearest National Weather Service (NWS) Stations to the CRN Site are the Oak Ridge Station, located 12 mi to the northeast, and the Knoxville NWS Station, located 25 mi to the east-northeast. Comparisons of these two locations were made to characterize the regional climate, and other stations were used as needed (e.g., Chattanooga, Bristol/Johnson City/Kingsport, Knoxville, Tri-Cities, and Nashville).

2.9.1 Climate

2.9.1.1 Wind

The winds at the CRN Site are influenced by the local topography of “The Great Valley.” The southwest-northeast topographical orientation causes channeling such that the prevailing winds are primarily southwesterly or northeasterly. The prevailing wind direction at the nearby Oak Ridge NWS Station is northeast. Surface winds are typically low due to the complex terrain as well, so that the mean annual wind speed at the Oak Ridge NWS Station is 2.9 mph (TVA 2017-TN4921). The average wind speed measured at the onsite meteorological tower sensor located at a height of 27.6 ft was 2.6 mph during the measurement record from June 1, 2011 through May 31, 2013 (TVA 2016-TN5014).

2.9.1.2 Temperature

The region surrounding the CRN Site typically experiences warm summers and mild winters. The normal temperatures from 30 years of measurement data from five nearby NWS stations were evaluated by the applicant. The annual average temperature at Oak Ridge was about 59°F. The highest normal daily maximum temperature at Oak Ridge was 88.4°F in July, while the lowest normal daily minimum temperature was 28.9°F in January. The Knoxville site had similar annual average, normal daily maximum, and normal daily minimum temperatures (TVA 2017-TN4921). The average temperature measured at the onsite meteorological tower sensor located at 27.5 ft was 59°F during the measurement record from June 1, 2011 through May 31, 2013 (TVA 2016-TN5014).

2.9.1.3 Atmospheric Water Vapor

Wet-bulb temperature, dew point temperature, and relative humidity data summaries were determined from a 30-year measurement record from the Oak Ridge and the Knoxville NWS Station. The mean annual wet-bulb temperature at Oak Ridge is 50.2°F, and at Knoxville is 51.9°F (TVA 2017-TN4921).

Dew point temperatures were also similar between the Oak Ridge and Knoxville sites. The mean annual dew point temperature is 50.8°F at Oak Ridge and 51.9°F at Knoxville. The highest mean dew point is 69.7°F at Oak Ridge and 68.7°F at Knoxville, both in July. The lowest mean dew point at Oak Ridge is 31.8°F, and 31.1°F at Knoxville, both in January (TVA 2017-TN4921). The dew points measured at the onsite meteorological tower sensor located at 27.6 ft were similar to the mean NWS measurements. The mean dew point during the measurement record from June 1, 2011 through May 31, 2013 was 49.1°F. The mean dew point for July 2012 was 68.9°F, and the mean dew point for January 2013 was 33.8°F (TVA 2016-TN5014).

The annual average relative humidity from the Knoxville NWS Station is 73 percent. Month to month variability in the normal relative humidity is minimal, ranging from a maximum relative humidity in August of 76 percent to a minimum relative humidity in April of 65 percent (TVA 2017-TN4921).

2.9.1.4 Precipitation

Average annual precipitation at the Oak Ridge NWS Station is about 51 in. Precipitation amounts range from about 41 in. at the Tri-Cities NWS Station, to about 52 in. at the Chattanooga NWS Station. At Oak Ridge, the wettest month is July, which averages 5.27 in. of precipitation. This is followed by the driest period of the year—three consecutive months with the lowest precipitation amounts. August through October have average precipitation amounts between 2.76 in. and 3.69 in. The wettest season, January through March, has average precipitation amounts between 4.54 and 5.06 in. (TVA 2017-TN4921). The total precipitation measured during 2012 at the onsite meteorological tower location was 48.8 in. (TVA 2016-TN5014).

Annual average snowfall amounts are 11.1 in. at the Oak Ridge NWS Station and 6.5 in. at the Knoxville NWS Station. Snowfall usually occurs during November through March, with normal amounts per snowfall event that are typically between 0.1 and 4 in. at the Oak Ridge NWS Station (TVA 2017-TN4921).

2.9.1.5 Severe Weather

2.9.1.5.1 Thunderstorms

Thunderstorm occurrence is common at the surrounding NWS stations; about 40–55 days of thunderstorm activity are recorded annually at nearby stations (Chattanooga, Bristol/Johnson City/Kingsport, Knoxville, and Nashville). The majority (about 60 to 75 percent) of thunderstorms occurred between May and August at these nearby stations (TVA 2017-TN4921).

2.9.1.5.2 Lightning

The frequency of cloud-to-ground lightning strikes per square mile per year is 13 for the CRN Site. The power-block area of the CRN Site is expected to be 28 ac. Given the annual average lightning strike frequency, the estimated frequency of lightning strikes to the area the size of the power block is 0.57 per year (TVA 2017-TN4921).

2.9.1.5.3 Extreme Winds

The applicant analysis, confirmed by the review team, found that extreme winds at the CRN Site are relatively infrequent, and usually associated with lines of thunderstorms along or ahead of cold fronts. These tend to occur more frequently in late winter and spring. On average, approximately 3.3 thunderstorm wind events occur in Roane County per year. The maximum estimated wind speed from climatological records from nearby Oak Ridge and Knoxville NWS Stations is 73 mph, which corresponds to a 3-second gust at 87 mph (TVA 2017-TN4921). The maximum observed hourly wind speed from the CRN Site meteorological tower was 15.1 mph, which corresponds to a 3-second gust at 23 mph (TVA 2016-TN5014).

Based on guidance from the American Society of Civil Engineers and the Structural Engineering Institute (ASCE/SEI 7-05) (see NUREG-0800, Section 2.3.1, NRC 2007-TN613), the basic design wind speed for the CRN Site is 90 mph. This is the minimum wind load for buildings under Exposure Category C, which corresponds to scattered obstructions of various sizes in the immediate site area. This design basis wind speed is for a 50-year return period and 3-second gust at 33 ft above ground level. This wind gust corresponds to a 100-year return, 3-second gust at 33 ft above ground level wind at 96.3 mph (90 mph multiplied by 1.07) (TVA 2017-TN4921).

2.9.1.5.4 Tornadoes

The applicant analysis, confirmed by the review team, found that, for the area within 10 mi of the CRN Site, five tornadoes were reported for the period from 1950 through 2013. Only one tornado, which occurred on February 21, 1993, had a magnitude greater than F0. The probability of a tornado strike around the CRN Site is low. Based on the principle of geometric probability, the annual probability that a tornado strike would occur within a 1° latitude by 1° longitude square is calculated to be 1.43E-04 (TVA 2017-TN4921).

According to Regulatory Guide (RG) 1.76 (NRC 2007-TN3294), the CRN Site is located in tornado-intensity Region I. For this region, design basis tornado characteristics include a maximum wind speed of 230 mph resulting from passage of a tornado that has a probability of occurrence of 10^{-7} per year. The translation and rotation components of the maximum tornado wind speed are 46 mph and 184 mph, respectively. The distance from the center of the tornado at which the maximum rotational wind speed occurs is 150 ft. The maximum pressure drop from normal atmospheric pressure resulting from passage of the tornado is 1.2 psi, and the rate of pressure drop is 0.5 psi/s (TVA 2017-TN4921).

2.9.1.5.5 Hail, Snowstorms, and Ice Storms

For the period from 1950 through January 31, 2015, severe hail (3/4 in. in diameter or larger) was reported on 32 days in Roane County. For the same period, severe hail was reported on 44 and 84 days in Loudon and Knox Counties, respectively (TVA 2017-TN4921).

Eastern Tennessee experiences few winter storms with snowfall or glaze ice in excess of 1 in. The National Climatic Data Center Storm Events Database reports 18 winter storms in Roane County for the period from 1950 to January 31, 2015. The maximum 24-hour snowfall observed near the CRN Site occurred in March 1993 and was 20.0 in. at the Chattanooga NWS Station. The maximum 24-hour snowfall observed at the Oak Ridge NWS Station was 12 in. in March 1960. At the Knoxville NWS Station, the maximum monthly snowfall was 23.3 in. in February 1960. The normal maximum number of days per year with snowfall in excess of 1 in. is 2.2 days per year (TVA 2017-TN4921).

Regional estimates of ice for Region V, which contains Tennessee, predicts that storms with ice greater than or equal to 2.5 cm (1 in.) occur 5 times in 50 years, while ice thickness greater than or equal to 5.0 cm (2 in.) occur 2 times in 50 years. Ice storms with gusts greater than or equal to 20 m/s (44.7 mph) result in ice thickness less than 2.5 cm (1 in.) for 25- and 50-year return periods, and 3.6 cm (1.4 in.) for 100-year return periods (TVA 2017-TN4921).

2.9.1.5.6 Tropical Cyclones

Tropical storms are rare in the area of the CRN Site due to the distance to the Atlantic Ocean and Gulf of Mexico. One tropical storm was recorded for Roane County for the period 1950 to January 31, 2015. It occurred on September 16, 2004, and was a remnant of Hurricane Ivan (TVA 2017-TN4921).

2.9.1.5.7 Droughts

Droughts are uncommon, because precipitation is typically well spread throughout the year. From 1950 to January 31, 2015, drought conditions in Roane and surrounding counties occurred on three occasions: in the late summer of 1998, much of 2007 and 2008, and mid-summer of 2012 (TVA 2017-TN4921).

2.9.1.5.8 Heavy Fog

Heavy fog is a relatively common occurrence in the area of the CRN Site. The Oak Ridge NWS Station reported heavy fog (visibility of less than or equal to 0.25 mi) on average 51.9 days per year, while the Knoxville NWS Station reported 29.7 days of heavy fog. At the Oak Ridge NWS Station, the maximum mean number of days with heavy fog occurs in September and October, with 7.5 days in each month. The minimum mean number of heavy fog days occurs in February, with 1.4 days (TVA 2017-TN4921).

2.9.1.6 Atmospheric Stability

Stability class is based on the meteorological tower 60–10 m vertical temperature difference (delta-T) (TVA 2017-TN4921). Table 2.7.4-13 in the CRN Site early site permit application (ESPA) (TVA 2017-TN4921) provides the distribution of Pasquill atmospheric stability class for the period June 1, 2011 to May 31, 2013. Atmospheric stability is a critical parameter for estimating atmospheric dispersion characteristics.

There is a predominance of slightly stable (Pasquill stability class E) and neutral (Pasquill stability class D) conditions at the CRN Site. Extremely unstable conditions (Pasquill stability class A) occur about 3 percent of the time, while extremely stable conditions (Pasquill stability class G) occur about 17 percent of the time (TVA 2017-TN4921). Based on past NRC experience with stability data at various sites, a predominance of slightly stable (Pasquill stability class E) and neutral (Pasquill stability class D) conditions at the CRN Site is generally consistent with expected meteorological conditions.

2.9.2 Air Quality

The discussion of air quality includes the six “criteria” pollutants for which the EPA has set National Ambient Air Quality Standards (EPA 2016-TN5013): ozone (O_3), particulate matter (PM_{10} and $PM_{2.5}$, which are particulate matter with a mean aerodynamic diameter of less than or equal to 10 μm and 2.5 μm, respectively), carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and lead (Pb). The air-quality discussion also includes heat-trapping greenhouse gases (GHGs), primarily carbon dioxide (CO_2), which has been the principal factor causing climate change over the last 50 years (GCRP 2014-TN3472).

Areas with pollutant concentrations that are greater than the acceptable levels established by the National Ambient Air Quality Standards are nonattainment areas. The EPA has designated a portion of Sullivan County as a nonattainment area for SO_2 (40 CFR 81.343-TN5012). Anderson, Blount, Knox, and Loudon Counties and a portion of Roane County were nonattainment areas for 1997 annual $PM_{2.5}$ and for 2006 24-hour $PM_{2.5}$, but have been re-designated as attainment areas effective August 29, 2017 and September 27, 2017, respectively (82 FR 40718-TN5016; 82 FR 40953-TN5015). Emissions from new sources in attainment areas are evaluated by the State of Tennessee through the Prevention of Significant Deterioration program.

Federal Class I areas are afforded additional protection under Section 169A of the Clean Air Act (42 U.S.C. § 7401 *et seq*.-TN1141) for visibility criteria. The closest mandatory Class I Federal areas to the CRN Site are the Great Smoky Mountains National Park near Gatlinburg, Tennessee, approximately 31 mi east-southeast of the CRN Site (40 CFR 81.428-TN5047) and the Joyce Kilmer-Slickrock Wilderness Area, in Monroe County, Tennessee, and Graham County, North Carolina, approximately 36 mi southeast of the CRN Site (40 CFR 81.428-TN5047).

Climate-related changes are under way in the United States and globally, and their extent is projected to continue to grow substantially over the next several decades unless concerted measures are taken to reverse this trend. Climate-related changes include rising temperatures and sea levels; increased frequency and intensity of extreme weather (e.g., heavy downpours, floods, and droughts); earlier snowmelts; more frequent wildfires; and reduced snow cover, glaciers, permafrost, and sea ice. Climate-related changes are closely linked to increases in GHGs (GCRP 2014-TN3472). GHGs are transparent to incoming short-wave radiation from the sun but are opaque to outgoing long-wave (infrared) radiation from the earth's surface. The net effect over time is a trapping of absorbed radiation and a tendency to warm the Earth's atmosphere, which together constitute the "greenhouse effect." Since the onset of the Industrial Revolution in the mid-1700s, human activities have contributed to the production of GHGs, primarily through the combustion of fossil fuels (such as coal, oil, and natural gas) and deforestation. The principal GHGs that enter the atmosphere because of human activities include CO_2, methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. However, some GHGs such as CO_2, CH_4, and N_2O are emitted to the atmosphere through natural processes as well.

2.9.3 Atmospheric Dispersion

2.9.3.1 Projected Air Quality

Generation of electricity from a new nuclear power plant at the CRN Site would not be a source of criteria pollutants. However, supporting equipment such as cooling towers, auxiliary boilers, emergency diesel generators, and/or combustion turbines would emit criteria pollutants. Air-quality impacts of these sources are discussed in EIS Section 5.7. Impacts of air emissions during development of the CRN Site are discussed in EIS Section 4.7.

2.9.3.2 Restrictive Dispersion Conditions

Inversion (stagnation) conditions restrict the atmospheric dispersion and can contribute to pollution episodes due to limited vertical mixing of the atmosphere. As an indicator of inversion conditions, periods of consecutive hours of stability classes E, F, or G were evaluated. The longest period of stable conditions was 19 hours, and it occurred at the CRN Site four times during the April 21, 2011 through June 30, 2013 period (TVA 2017-TN4921). The potential for air pollution also is related to atmospheric mixing heights and wind speeds through the mixing layer (Holzworth 1972-TN3024). Table 2-44 summarizes approximate mean seasonal and annual morning and afternoon mixing heights. Lowest morning mixing heights occur during autumn, and highest morning mixing heights occur during spring. Afternoon mixing heights are lowest during winter and highest during summer.

Table 2-44. Mean Seasonal and Annual Morning and Afternoon Mixing Heights near the CRN Site

Parameter	Winter	Spring	Summer	Autumn	Annual
Morning Mixing Height (m)	563	606	441	357	492
Afternoon Mixing Height (m)	1,123	1,783	1,874	1,473	1,563

Source: Holzworth 1972-TN3024.

2.9.3.3 Short- and Long-Term Dispersion Estimates from Power Plant Operation

Atmospheric dispersion consists of two components: (1) atmospheric transport due to organized or mean wind flow in the atmosphere, and (2) atmospheric diffusion due to disorganized or random air movements. The magnitude of the atmospheric dispersion is a function of the wind speed, wind direction, and atmospheric stability class. The lower the alphabetic atmospheric stability class designation (Class A) in NRC RG 1.145 (NRC 1983-TN279), the more unstable the atmosphere and the more rapid the atmospheric dispersion.

2.9.3.3.1 Short-Term Dispersion Estimates

TVA calculated short-term dispersion estimates using 2 years of meteorological data (June 1, 2011 through May 31, 2013). These estimates were based on distances to the exclusion area boundary (EAB) and outer boundary of the low-population zone (LPZ) as defined in Section 2.7 of the ER (TVA 2017-TN4921).

The NRC staff reviewed these data and calculations to determine whether the short-term dispersion estimates were appropriate for use in the design basis accident (DBA) calculations. Short-term dispersion estimates calculated by TVA for use in the DBA calculations are listed in Table 2-45. They are based on the PAVAN computer code (Bander 1982-TN538) calculations of 1-hour and annual average atmospheric dispersion (χ/Q) values from a joint frequency distribution of wind speed, wind direction, and atmospheric stability. These values were calculated for the shortest distances from a release boundary envelope that encloses the nuclear effluent release boundary to the EAB (335 m) and to the LPZ (1,609 m). The 50 percent EAB χ/Q value listed in Table 2-45 is the median 1-hour χ/Q, which is assumed to persist for 2 hours. The 50 percent LPZ χ/Q values listed in Table 2-45 were determined by logarithmic interpolation between the median 1-hour χ/Q, which was assumed to persist for 2 hours, and the annual average χ/Q following the procedure described in NRC RG 1.145 (NRC 1983-TN279). The NRC staff concludes that the site-specific short-term dispersion estimates are appropriate for use in the EIS DBA review.

Table 2-45. Atmospheric Dispersion Factors for Design Basis Accident Calculations

Time Period[(a)]	Boundary	χ/Q (s/m^3)
0 to 2 hr	Exclusion Area Boundary	5.58×10^{-4}
0 to 8 hr	Low-Population Zone	4.27×10^{-5}
8 to 24 hr	Low-Population Zone	3.80×10^{-5}
1 to 4 days	Low-Population Zone	2.94×10^{-5}
4 to 30 days	Low-Population Zone	2.04×10^{-5}

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

Source: TVA 2017-TN4921.

2.9.3.3.2 Long-Term Dispersion Estimates

Long-term dispersion estimates for use in evaluation of the radiological impacts of normal operations were calculated by TVA using the XOQDOQ computer code (Sagendorf et al. 1982-TN280) and 2 years of meteorological data (June 1, 2011 through May 31, 2013) (TVA 2017-TN4921). This code implements the guidance set forth in Revision 1 of NRC RG 1.111 (NRC 1977-TN91) for estimation of χ/Q and deposition factors (D/Q) for use in evaluation of the consequences of normal reactor operations. The results of the CRN Site calculations of maximum annual average dispersion and deposition are presented in Table 2-46 for receptors of interest, such as the site boundary, residence, milk cow, milk goat, meat animal, and vegetable garden.

Table 2-46. Maximum Annual Average Atmospheric Dispersion (χ/Q) and Deposition Factors (D/Q) for Evaluation of Normal Effluents for Receptors of Interest

			χ/Q (s/m^3)			
Receptor	**Downwind Sector**	**Distance (mi)**	**No Decay Undepleted**	**2.26-Day Decay Undepleted**	**8-Day Decay Depleted**	**D/Q (1/m^2)**
Site Boundary	WNW	0.21	2.0×10^{-4}	2.0×10^{-4}	1.9×10^{-4}	5.2×10^{-8}
Meat Animal[(a)]	WNW	0.70	2.3×10^{-5}	2.3×10^{-5}	2.1×10^{-5}	7.8×10^{-9}
Residence	WNW	0.66	2.5×10^{-5}	2.5×10^{-5}	2.3×10^{-5}	8.5×10^{-9}
Vegetable Garden	WNW	1.15	1.0×10^{-5}	9.9×10^{-6}	8.7×10^{-6}	3.3×10^{-9}

(a) No milk-producing animals within 5 mi of the CRN Site. The maximum concentration beef animal was analyzed instead.

Source: TVA 2017-TN4921.

2.9.4 Meteorological Monitoring

The CRN Site totals 935 ac and is located in a valley between the Cumberland Mountains to the northwest and the Great Smoky Mountains to the southeast. The Clinch River arm of the Watts Bar Reservoir runs along three sides of the CRN Site (east, south, and west), and the DOE's ORR and the TVA's Grassy Creek Habitat Protection Area is located to the north. The surrounding terrain is a mix of grasses, low shrub-like plants, and bare dirt. The meteorological tower used for the ESPA, Meteorological Tower 3 (henceforth referred to as the meteorological tower), was located to the southeast of the proposed power-block area. This meteorological tower was established in the late 1970s and was modified to meet NRC RG 1.23 guidance for use in the development of the ESPA. This tower collected data from April 21, 2011 to July 9, 2013, and was removed in 2014. Distances between the meteorological tower and significant features in the area are as follows (TVA 2017-TN4921):

- 830 ft south of the main plant area,
- 150 ft northwest of a 10-ft tall instrument building,
- 225 ft northwest of a stand of trees surrounded by a 6-ft high chain-link fence,
- 400 ft southwest of a power line transmission tower, and
- 310 ft to 440 ft from a tree line surrounding the meteorological site in an approximate circle.

See Figure 2-37 for the general site layout at the meteorological tower. The elevation of the meteorological tower was 799.9 ft MSL. Although the local terrain and region's topography may influence the meteorological conditions at this site, the meteorological tower was located on a plateau, at an elevation similar to the proposed SMRs at the CRN Site, which is expected to be 821 ft MSL (TVA 2017-TN4921).

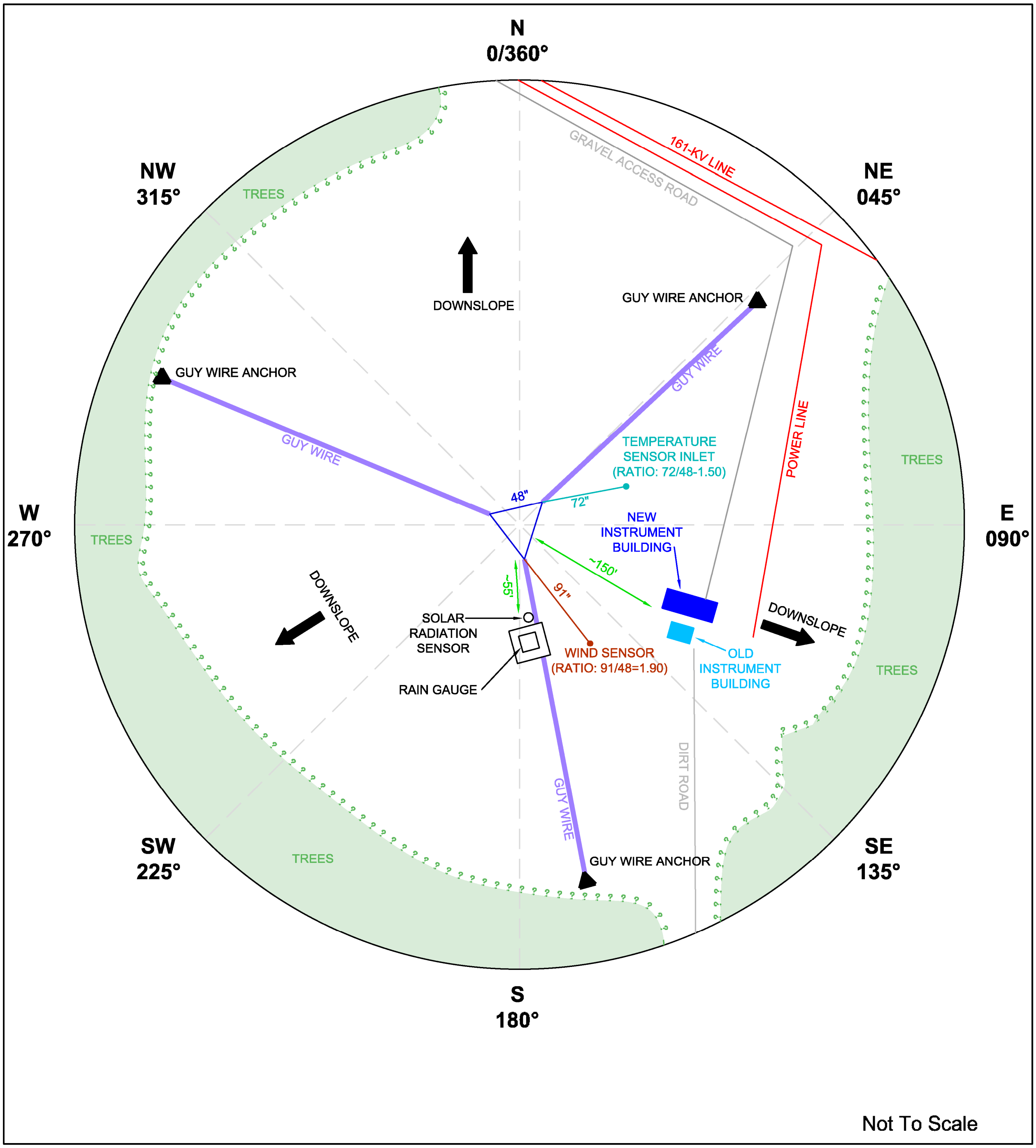


Figure 2-37. Site Layout at the Meteorological Tower (Source: TVA 2017-TN4921)

Nearby obstructions with heights at or over 16.4 ft above the meteorological tower base elevation at distances of 10 times the height of the nearby obstructions were evaluated in accordance with NRC RG 1.23. One potential obstruction is the 10-ft tall instrument building; however, its 10-ft height is less than half of the height of the lower wind measurement at 32.8 ft, so this structure is not an influence on the wind measurements taken on the meteorological tower. A second potential obstruction is a stand of trees located approximately 225 ft to the southeast of the tower. A final potential obstruction is a power line transmission tower located approximately 400 ft northeast of the tower. These obstructions were evaluated by the applicant, and verified by the review team, and determined to have minimal impact on the

meteorological tower measurements. Sigma theta values, which indicate the level of turbulence in the atmosphere, were compared between wind directions from these potential flow obstructions and unobstructed wind directions on either side of the obstruction. No elevated sigma theta trends were observed for the directions from the potential wind flow obstructions, so the trees and the transmission tower have minimal impact on the wind measurements taken on the meteorological tower (TVA 2017-TN4921).

The meteorological tower was a 360.9-ft (110-m) guyed, triangular, open-lattice tower with a solid cement base. Instrumentation booms extended outward to the southeast, perpendicular to the two prevailing wind directions from the northeast and the southwest, in accordance with guidance provided in NRC RG 1.23. The sensors were initially mounted on the booms that were slightly less than twice the tower maximum horizontal dimension, but this boom was replaced on October 18, 2011 with a 100-in. boom that was 2.08 times the tower maximum horizontal dimension, to meet specifications provided in NRC RG 1.23 (TVA 2017-TN4921).

2.9.4.1 Instrumentation

The Environmental Data Station includes a small instrument building containing computer and communications systems used to collect, store, and transmit data; the 360.9-ft (110-m) meteorological tower; and the following instrumentation mounted on the tower (TVA 2017-TN4921):

- 60-m level – wind speed and direction, sigma theta, dry bulb temperature, and dew point temperature;
- 10-m level – wind speed and direction, sigma theta, dry bulb temperature, and dew point temperature; and
- surface (1 m) – precipitation, and solar radiation.

The wind speed, wind direction, and sigma theta sensors were Vaisala Model 425 ultrasonic wind sensors, while the temperature sensors were Weed Instrument Company Model 101 platinum wire resistance temperature detectors. Temperature sensors were mounted within an R.M Young Company, Model 43408 aspirated shield. Delta-temperature measurements were computed when both the 60-m and 10-m temperature values were valid. The dew point measurements were made by a Vaisala Model HMT337 humidity and temperature transmitter for high-humidity applications. The dew point sensor was mounted within an R.M. Young Company, Model 43502 solar radiation shield. Solar radiation measurements were made with an Eppley Laboratories Model 8-48 pyranometer, and precipitation measurements were made with a Sutron Corporation Model 5600-0420-1h heated tipping bucket rain gauge (TVA 2017-TN4921). See Table 2-47 for instrumentation specifications.

Table 2-47. Meteorological Tower Instrumentation Performance Specifications

Parameter	Sensor	Range	Time-Averaged System Accuracy	Resolution
Wind Speed	Vaisala Model 425 Ultrasonic Wind Sensor	0.1 to 144 mph	±0.06 mph	0.1 mph
Wind Direction	Vaisala Model 425 Ultrasonic Wind Sensor	0–360°	±2.1°	1.0°
Sigma Theta	Vaisala Model 425 Ultrasonic Wind Sensor	–	–	1.0°
Ambient Temperature	Weed Instrument Company Model 101 platinum wire resistance temperature detector	–30°F to +120°F	+0.657°F during high solar rad -0.157°F during low solar rad ±0.157°F during no solar rad (night)	0.01°F
Dew Point	Vaisala Model HMT337 Humidity and Temperature Transmitter for High Humidity	–4.°F to +85.°F	±0.507°F	0.01°F
Precipitation	Sutron Corporation Model 5600-4020-1h heated tipping bucket rain gauge	0.00 to 1.00 in.	–	0.01 in.
Solar Radiation	Eppley Laboratories Model 8-48 pyranometer	0.00 to 3.00 Langleys/min	±0.021 at 0.28 Langleys/min ±0.022 at 0.45 Langleys/min ±0.026 at 1.50 Langleys/min	0.01 Langleys /min

Source: TVA 2017-TN4921.

2.9.4.2 Data Recording

Meteorological sensors (with the exception of the rain gauge) were sampled at five-second intervals. The rain gauge was interrogated at 15-minute intervals for the number of counts (number of times the rain gauge empties automatically). The wind speed and wind direction were sampled digitally, while the remaining variables (temperature, solar radiation, and precipitation) were converted from analog to digital signals with the use of a data acquisition switch unit (DASU). Data were logged onsite and processed to 15-minute and hourly files. These data were transmitted via cellular modem to an external File Transfer Protocol server (TVA 2017-TN4921).

2.9.4.3 Instrument Maintenance

The rain gauge and signal processing units were calibrated in place, while the DASU, wind sensors, air temperature sensors, dew point sensor, and radiation sensor were exchanged and calibrated at an offsite laboratory. The DASU was calibrated every 6 months. Wind sensors, air temperature sensors, and dew point sensors were calibrated by their individual calibration dates or before 184 days of service. The radiation sensor is exchanged within 1 year of the previous calibration (TVA 2017-TN4921).

The meteorological monitoring system maintenance was performed according to TVA emergency planning field support procedures. Additionally, the Environmental Data Station computer was serviced bi-weekly at a minimum. Nonroutine maintenance was performed for system components as needed. Spare parts were on hand to minimize extended data outages, including a spare computer, sensors, and components (TVA 2017-TN4921).

Calibration and maintenance activities were performed to ensure an annual data recovery rate of 90 percent or better. However, the tipping bucket rain gauge experienced repeated problems with the instrument or power supply, which resulted in lost data. Nearly half of the data from the onsite tipping bucket rain gauge were not available. As a result, the hourly precipitation data from the Oak Ridge NWS Station, located 12 mi northeast of the CRN Site, were used to assess the precipitation at and surrounding the CRN Site. Data recovery rates for wind speed and wind direction as well as temperature difference data were greater than 90 percent (TVA 2017-TN4921).

2.9.4.4 Operational Monitoring

Structural and functional integrity concerns about the meteorological tower used for the CRN Site ESPA led to the decision to remove the tower in October 2013. For operational monitoring, a new tower is planned for the same location. Details concerning the new tower and associated equipment have not been finalized, but are expected to meet the TVA and NRC regulatory requirements for the meteorological monitoring program (TVA 2017-TN4921).

2.10 Nonradiological Environment

This section describes aspects of the environment at the CRN Site and within the vicinity of the site associated with nonradiological human health impacts. It provides the basis for evaluation of impacts on human health from building and operation of the proposed SMR units. Building activities have the potential to affect public and occupational health, create impacts from noise, and affect the health of the public and workers by transportation of construction materials and personnel to the CRN Site. Operation of the proposed units has the potential to affect the public and workers at the CRN Site from operation of the cooling system, noise generated by operations, electromagnetic fields (EMFs) generated by transmission systems, and transportation of operations and outage workers to and from the CRN Site.

2.10.1 Public and Occupational Health

This section describes public and occupational health at the CRN Site and vicinity associated with air quality, occupational injuries, and etiological agents (i.e., disease-causing microorganisms).

2.10.1.1 Air Quality

Section 2.9.2 of this draft EIS provides the baseline air-quality information for the proposed CRN Site. Public and occupational health can be affected by changes in air quality from building activities that contribute to fugitive dust, vehicle and equipment exhaust emissions, and automobile exhaust from commuter traffic (NRC 1996-TN288). Fugitive dust and other particulate matter such as PM_{10} and $PM_{2.5}$ (i.e., particulate matter with a mean aerodynamic diameter of less than or equal to 10 and 2.5 μm, respectively) can be released into the atmosphere during any site excavations and while grading is being conducted. Most of these activities that generate fugitive dust are short in duration, would occur over a small area, and could be controlled by watering unpaved roads, stabilizing construction roads and spoil piles, and other BMPs (as described in EIS Section 4.7.1). Mitigation measures to minimize and control fugitive dust are required for compliance with all Federal, State, and local regulations that govern such activities (NRC 1996-TN288; TVA 2017-TN4921).

Exhaust emissions during normal plant operations associated with onsite vehicles and equipment as well as from commuter traffic can affect air quality and human health. As stated in EIS Section 4.7.1, air permits under Tennessee and Federal laws would address the impact of air emissions on sensitive receptors, located across the Clinch River Arm of the Watts Bar Reservoir (TVA 2017-TN4921). Additionally, the applicant plans to implement an emissions mitigation plan (TVA 2017-TN4921). Based on estimates provided by TVA in Section 3.6.3.1 of the ER, the annual releases of criteria pollutants (see Section 2.9.2 of this chapter for the full list of criteria pollutants) at the CRN Site related to the operation of the cooling towers and facility auxiliary systems would be minimal due to infrequent and short duration of use (TVA 2017-TN4921). The projected emissions from facility auxiliary systems are provided in EIS Section 3.4.4.3 (TVA 2017-TN4921). These emission sources are not expected to significantly affect ambient air-quality levels at the CRN Site or in the vicinity of the site.

2.10.1.2 Occupational Injuries

In general, occupational health risks to workers and onsite personnel engaged in activities related to building and operating nuclear power plants would be dominated by occupational injuries (e.g., falls, electric shock, asphyxiation) or occupational illnesses. Historically, actual injury and fatality rates at nuclear reactor facilities have been lower than the average U.S. industrial rates (BLS 2015-TN4903; BLS 2016-TN4904). The U.S. Bureau of Labor Statistics provides reports that account for occupational injuries and illnesses as incidence rates, which represent the number of injuries and illnesses per 100 full-time workers (full-time equivalent employees [FTEs]). In 2015, the national incidence rate for “utility system construction” was 2.4 illness/injuries per 100 FTEs, and rate for “nuclear power generation” was 0.2 illness/injuries per 100 FTEs (BLS 2016-TN4904). The State of Tennessee also tracks annual incidence rates of injuries and illnesses for “utility system construction” but only reported to the level of “utilities” to represent operations data (BLS 2017-TN4906). These records of statistics are used to estimate the likely number of occupational injuries and illnesses for the proposed new unit.

Occupational injury and fatality risks are reduced by strict adherence to NRC and Occupational Safety and Health Administration safety standards, practices, and procedures to minimize worker exposures to injuries or illnesses (29 CFR Part 1910-TN654). Appropriate State and local statutes also must be considered when assessing the occupational hazards and health risks associated with the proposed nuclear power plant at the CRN Site. Compliance with site permits, adherence to worker safety and health procedures, and application of BMPs would be protective of workers during all phases of the project (TVA 2017-TN4921; NRC 2018-TN5386). TVA would implement Health and Safety Plans for the proposed site for building and operating SMRs (TVA 2017-TN4921). TVA would implement Occupational Safety and Health Administration requirements throughout all phases of the proposed project (TVA 2017-TN4921; NRC 2018-TN5386). TVA would require all contractors and subcontractors to review and comply with all safety policies and safe work practices, including all Federal and State regulations (NRC 2018-TN5386).

2.10.1.3 Etiological Agents

Public and occupational health can be compromised by activities at the CRN Site that encourage the growth of disease-causing microorganisms (etiological agents). Thermal discharges from the proposed cooling system into the Clinch River have the potential to increase the growth of thermophilic microorganisms. The types of microorganisms of concern for public and occupational health include enteric pathogens (such as *Salmonella* spp. and *Pseudomonas aeruginosa*), bacteria (such as *Legionella* spp.), thermophilic fungi, and free-living amoeba (such as *Naegleria fowleri* and *Acanthamoeba* spp.) (CDC 2017-TN5146; Visvesvara et al. 2007-TN4907). These microorganisms are known to occur in many types of freshwater bodies such as lakes, rivers, and thermally polluted effluents from power plants throughout the United States and proliferate during warm summer months (CDC 2017-TN5146; Visvesvara et al. 2007-TN4907; Yoder et al. 2010-TN5009).

A review of the outbreaks of human waterborne diseases from data published from 2006 to 2015 from Tennessee indicate the incidence of most of the diseases mentioned above is not common (CDC 2017-TN4902). Available data assembled by the U.S. Centers for Disease Control and Prevention (CDC) for the years 2003 to 2012 (CDC 2017-TN4902) report a total of 24 cases of waterborne disease from untreated recreational water in the State of Tennessee (CDC 2017-TN4902). Of the total 24 cases, 3 of them occurred in 2006, 14 in 2007, and 7 cases occurred in 2009. From 2006 to 2015, the CDC surveillance system for waterborne-disease outbreaks documented 37 fatal cases of primary amebic meningoencephalitis (PAM – a disease caused by *N. fowleri*) in the United States; however, most of the cases occurred in southern states during the warm summer months (July through September) and none occurred in Tennessee (CDC 2017-TN4902). In fact, there have been no recorded cases of PAM in Tennessee since 1962 (Yoder et al. 2010-TN5009). Outbreaks of Legionellosis, Salmonellosis, or Shigellosis from recreational water that occurred in Tennessee were within the range of national trends (CDC 2017-TN4902) in terms of cases per 100,000 population or total cases per year, and the outbreaks were associated with pools, spas, or lakes.

Epidemiological reports from the State of Tennessee indicate a very low risk of outbreaks from etiologic agents associated with recreational water (CDC 2017-TN4902). A total of 12 water quality monitoring stations are located on the Clinch River arm of the Watts Bar Reservoir upstream and downstream of the proposed site, the closest one downstream of the proposed discharge is at CRM 15 (TVA 2017-TN4921; TDEC 2005-TN5007; TDEC 2016-TN5006). However, this portion of the Lower Clinch River is designated as Category 5 on the State of Tennessee 303(d) list of impaired waterbodies under the CWA for PCBs, mercury, and chlordane, which makes it a State priority for water-quality improvements (TDEC 2005-TN5007; TDEC 2016-TN5006). The main recreational activities associated with the Clinch River near the proposed CRN Site are boating, fishing, and hunting (TVA 2017-TN4921). There are also public swimming beaches along the Clinch River near the discharge at the Gallaher Recreation Area (TVA 2017-TN4921).

Recreational areas located within the proposed CRN Site vicinity include:

- Melton Hill Dam Recreation Area
- Soaring Eagle Campground and Recreational Vehicle Park
- Gallaher Recreation Area
- Oak Ridge Reservation, a Tennessee Wildlife Management Area
- ETTP Visitor’s Overlook
- Southern Appalachia Railway Museum
- Wheat Community African Burial Ground.

2.10.2 Noise

Sources of noise at the proposed CRN Site and in the surrounding local community are those associated with vehicle traffic, environmental noise (i.e., birds, wind through the trees, etc.), industrial/construction equipment, and boating/water craft (TVA 2017-TN4921; AECOM 2014-TN5004). TVA reported the closest sensitive receptor to noise producing equipment at the CRN Site is 0.36 mi (1,900 ft) from the planned cooling-tower location, across the Clinch River (TVA 2017TN4921).

Sound pressure levels are typically measured by using the logarithmic decibel (dB) scale. To make assessments of potential noise impacts on humans, a special weighting scale was developed to account for human sensitivities to certain frequencies of sound. The A-weighted scale, denoted as dBA, is widely used in environmental noise assessments because it correlates well with a human's subjective reaction to sound (Cowan 1994-TN3905).

Several sound descriptors have been developed to account for variations of sound perception at different times because human responses to noise differ depending on the time of the day (e.g., higher sensitivity to noise during nighttime hours because of lower background noise levels). The day-night average sound level (L_{dn} or DNL) is a single dBA value calculated from hourly observations over a 24-hour period, with the addition of a 10 dBA "penalty" applied to sound levels from 10 p.m. to 7 a.m. (Cowan 1994-TN3905). In addition, the L_{90} is the sound level exceeded 90 percent of the time, called the residual sound level (or background level) or steady lower sound level on which discrete single sound events are superimposed. The equivalent continuous sound level (L_{eq}) is a sound level that, if it were continuous during a specific time period, would contain the same total energy as a time-varying sound (Cowan 1994-TN3905). It is important to note that L_{eq} must be qualified by a time period in order to have meaning (e.g., $L_{eq(24)}$ equals a 24-hour measurement) (Cowan 1994-TN3905).

For context, Tipler and Mosca (2008-TN1467) lists the sound intensity of a quiet office as 50 dBA, normal conversation as 60 dBA, busy traffic as 70 dBA, and a noisy office with machines or an average factory as 80 dBA.

TVA conducted initial baseline noise surveys at the CRN Site in July and December of 2013 to establish background noise levels at nine sensitive receptor locations on and near the CRN Site (AECOM 2014-TN5004). Figure 2-38 shows the sound sampling locations (1–9) and Table 2-48 shows sound levels measured during the baseline survey, the date of the survey, and the distances of each location from the center point of the CRN Site. Because noise levels attenuate with intervening foliage, continuous measurements were taken for a 24-hour period at locations 1-–7 for a leaf-on survey in July, and one 24-hour period at locations 8 and 9 for a leaf-off survey in December (AECOM 2014-TN5004).

Monitoring locations included two stations (locations 1 and 2) located on the proposed CRN Site, the four closest offsite receptors (locations 3, 5, 6 and 7), and two stations south and east of the CRN Site (locations 8 and 9 respectively) (AECOM 2014-TN5004; TVA 2017-TN4921).

The City of Oak Ridge has established noise ordinances based on adjacent property uses and sets a maximum limit of 80 dBA during the hours from 7:00 a.m. to 10:00 p.m. and a maximum of 75 dBA between 10:00 p.m. and 7:00 a.m. when the adjacent property use is residential. In addition, the City of Oak Ridge established that sound levels should not exceed 65 dBA longer than half an hour or 70 dBA for more than 10 minutes during a one-hour survey (City of Oak Ridge 2013-TN4999). Noise level exceedance values are slightly higher when adjacent property is zoned Industrial. Property adjacent to the CRN Site consists of the ORR to the east, the Clinch River Industrial Park to the north, and the Clinch River arm of the Watts Bar Reservoir to the remaining directions from the CRN Site. Residential areas are also on the opposite bank of the Clinch River arm in close proximity to the CRN Site (near locations 3 and 6).

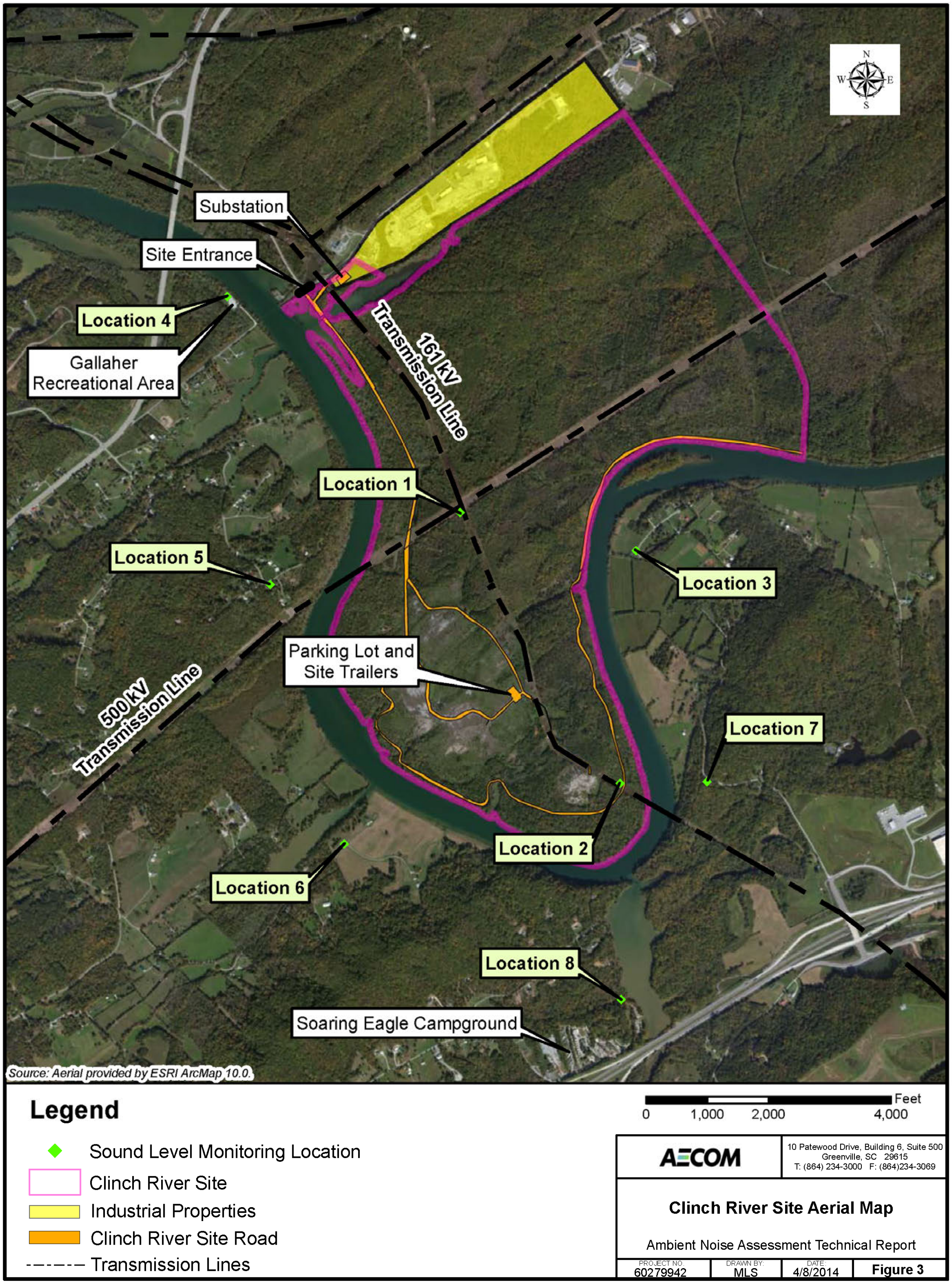


Figure 2-38. CRN Site Aerial Map (Source: AECOM 2014-TN5004)

Table 2-48. Sound Levels Measured during the Baseline Survey

Sound Level Monitoring Locations	Distance from Center of CRN Site (mi)	Date	Sound Levels (L_{eq}) (dBA)		
			L_d	L_n	L_{dn}
1 - CRN Site	0.53	7/14 -7/15	47.6	41.8	49.7
2 - CRN Site	0.51	7/14 -7/15	46.7	49.1	55.2
3 - Blackburn Lane	0.61	7/14 -7/15	58.4	45.9	57.6
4 - Gallaher Recreational Area	1.45	7/15 -7/16	47.7	48.3	54.6
5 - Smith Hill Lane	0.75	7/15 -7/16	48.6	53.2	59.2
6 - Speers Road	0.68	7/15 -7/16	42.9	45.6	51.7
7 - Blackburn Lane	0.74	7/16 -7/17	52.2	57.9	63.9
8 - Soaring Eagle Campground	1.07	12/17 -12/18	52.1	50.7	57.3
9 - Melton Hill Dam Recreation Area	4.73	12/17 -12/18	62.1	35.8	60.1

L_{eq} – the equivalent A-weighted sound level over a given time
L_d – the average daytime sound level in L_{eq} (7:00 a.m. to 10:00 p.m.)
L_n – the average nighttime sound level in L_{eq} (10:00 p.m. to 7:00 a.m.)
L_{dn} – the day-night average sound level in L_{eq} over a 24-hour period with a 10-decibel (dBA) penalty applied to nighttime levels (10:00 p.m. to 7:00 a.m.)

Source: AECOM 2014-TN5004.

No known State or county noise ordinances exist for the proposed CRN Site; however, the EPA established guidance for noise levels to protect human health or welfare, which included an L_{dn} value of 55 dBA for residential and other outdoor areas (EPA 1974-TN3941). In addition, U.S. Department of Housing and Urban Development guidance set an L_{dn} value of 65 dBA to be acceptable (24 CFR Part 51B [TN1016]). Regulations discussed in previous subsections of this draft EIS governing noise associated with the activities at the CRN Site are generally limited to worker health. However, because residential receptors are adjacent to the site, City of Oak Ridge requirements will be considered. Federal regulations governing construction noise are found in 29 CFR Part 1910 (TN654), "Occupational Health and Safety Standards," and 40 CFR Part 204 (TN653), "Noise Emission Standards from 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.

2.10.3 Transportation

The highway and rail transportation network surrounding the CRN Site is shown in Figure 2-39 (TVA 2017-TN4921). The arterials located near the CRN Site are Interstate 40 (south of the CRN Site), SR 58 (northwest of CRN Site), and SR 95 (northeast of CRN Site). Access to the CRN Site is via Bear Creek Road (from either of the three arterials). No known major roadway improvements are planned for the area, but TVA will add an interchange at Bear Creek Road. However, modifications and improvement will occur on several roadways on and around the CRN Site (TVA 2017-TN4921).

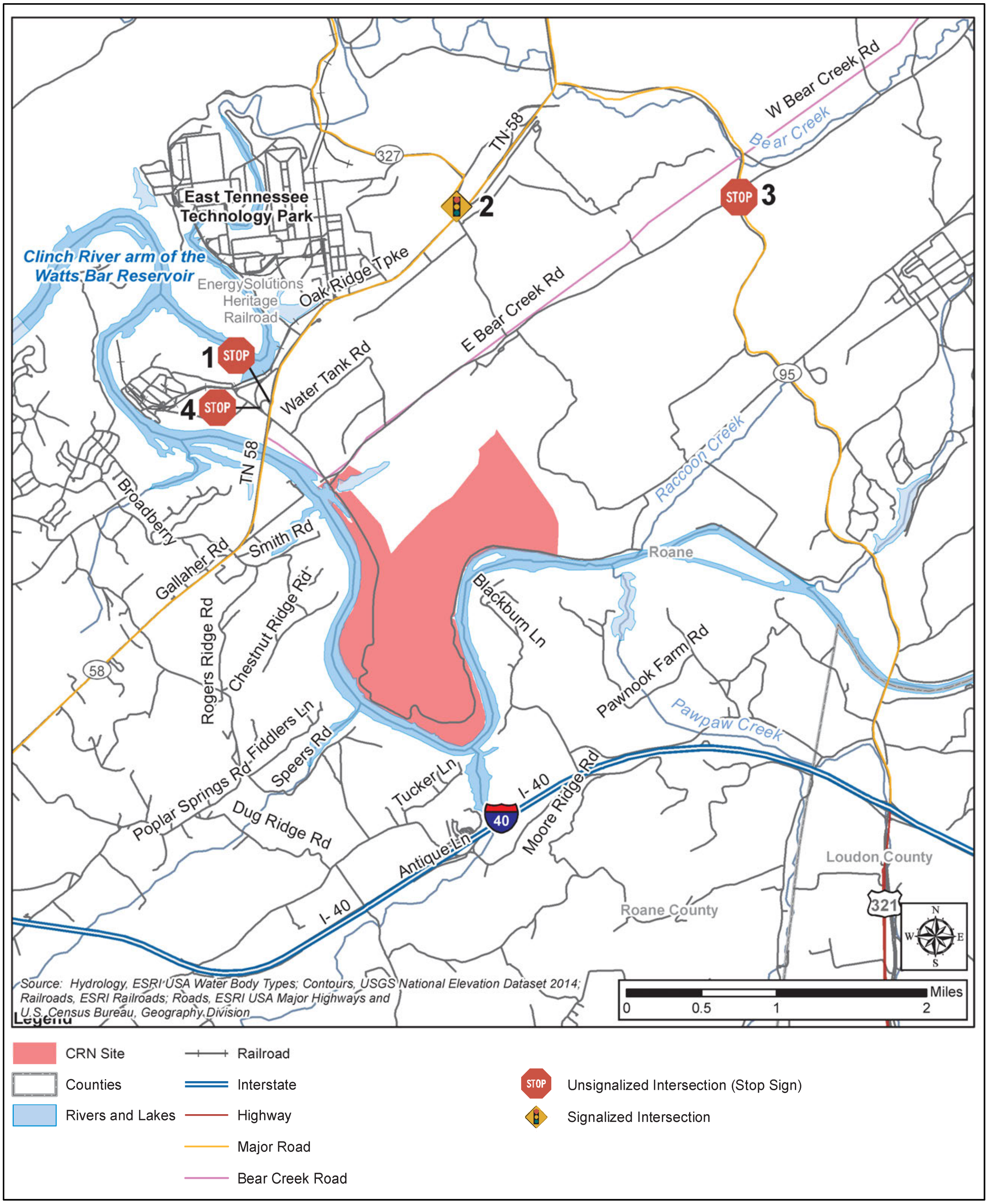


Figure 2-39. Traffic Study Intersections Potentially Affected by the Proposed Project (Source: TVA 2017-TN4921)

2.10.4 Electromagnetic Fields

Operation of power transmission systems generate both electric and magnetic fields, referred to collectively as EMFs. Public and worker health can be compromised by acute and chronic exposure to electrical sources associated with power transmission systems, including switching stations (or substations) on the site and transmission lines connecting the plant to the regional electrical distribution grid. Transmission lines operate at a frequency of 60 Hz (60 cycles per second), which is considered to be an extremely low frequency. In comparison, television transmitters have frequencies of 55 to 890 MHz, and microwaves have frequencies of 1,000 MHz and greater (NRC 1996-TN288). The existing transmission corridors from the CRN Site are shown in Figure 3-6 of this draft EIS and modifications to the existing system to support the proposed project at the CRN Site are described in EIS Section 3.2.2.3.5. In its ER, TVA states that upgrades to existing transmission lines would be required for the SMRs to service new power generation at the CRN Site, along with new switchyards and other ancillary facilities (TVA 2017-TN4921).

2.11 Radiological Environment

No operations involving radioactive materials have occurred at the CRN Site; the CRBRP was proposed in the late 1970s, but was not built and some site redress was performed by TVA. As described in Section 2.2.1 of this draft EIS, the proposed CRN Site would be located on a partially developed area that has not been noticeably disturbed since the termination of the CRBRP in 1983 and subsequent site redress work.

Baseline groundwater monitoring performed at the CRN Site detected the presence of Sr-90, H-3, and Tc-99, along with metals barium, cadmium, and chromium (TVA 2017-TN4921). The presence of these contaminants at the CRN Site is the result of legacy activities conducted at nearby radiological facilities, including ORNL. The broader region, including the Clinch and Tennessee Rivers, has been characterized extensively in annual site environmental reports prepared for ORNL and other facilities associated with the Manhattan Project (e.g., DOE 2017-TN5081), along with annual reports prepared for Watts Bar Nuclear Power Plant (e.g., TVA 2017-TN5082) and the Final Environmental Statement Related to the Construction and Operation of Clinch River Breeder Reactor Plant (NRC 1977-TN5083).

Various monitored groundwater plumes in the region are known to contain H-3, Cr-6, Co-60, Sr-90, Tc-99, and Cs-137, along with arsenic, uranium, nitrate, and mercury. Sediments in local rivers are known to contain radionuclides, but the radionuclide levels in the local rivers' water remains negligible (DOE 2017-TN5081). A review of historical (2007–2016) surface-water monitoring performed on the Clinch River at two locations just 2 and 6 mi downstream of the CRN Site gave a maximum result of 0.3 percent of the derived concentration guide (DCG) in 2007, with no result greater than 0.1 percent of either the DCG or Derived Concentration Standard (DCS) since 2010 (ORR 2017-TN5080). The DCG is the concentration of a radionuclide in air or water that, under conditions of continuous exposure for 1 year by one exposure mode (i.e., ingestion of water, submersion in air, or inhalation), would result in an effective dose equivalent of 100 mrem (1 mSv) (DOE Order 5400.5 Change 2 1993-TN5334). In 2011, the DCG was replaced by the DCS, which represents the concentration of a given radionuclide in either water or air that results in a member of the public receiving a 100-mrem effective dose following continuous exposure for 1 year for each of the following pathways: ingestion of water, submersion in air, and inhalation (DOE 2011-TN5292). In other words, a person using the Clinch River as their sole-source of drinking water for 1 year with a DCS of 0.1 percent would be estimated to receive an annual effective dose equivalent of 0.1 mrem.

Two main sources of natural background radiation exist: cosmic radiation produced by collisions of high-energy particles in the upper atmosphere, and naturally occurring terrestrial radionuclides in rocks and soils. The cosmic ray background varies with geomagnetic latitude and elevation; the cosmic ray dose rate in the region surrounding the CRN Site (elevation 600–1,200 ft) averages between 27 and 31 mrem/yr (National Research Council 1980-TN5291). The dose rate from uranium, thorium, potassium, and related natural radionuclides depends on the underlying geology; the terrestrial dose rates in the region surrounding the CRN Site average between 35 and 75 mrem/yr (National Research Council 1980-TN5291). When combined with the cosmic ray contribution, direct natural radiation in this area of Tennessee ranges from 62 to 106 mrem/yr. Therefore, the naturally occurring background radiation dose rates at the CRN Site should be in the anticipated range of 62 to 106 mrem/yr, which is consistent with the United States average of about 100 mrem/yr from direct radiation (NCRP 2009-TN420).

Two years prior to the operation of any SMRs at the CRN Site, a radiological environmental monitoring program would be used to establish the baseline for local radiological environmental conditions along the pathways of exposure, as discussed in EIS Section 5.9.1.

2.12 Related Federal Projects and Consultation

This section describes Federal activities within the 50-mi region that could warrant consideration along with the building and operation of two or more new SMRs at the CRN Site as part of a cumulative impacts analysis in accordance with 40 CFR 1508.25 (TN428). The NRC is required under NEPA Section 102(2)(c) to consult with and obtain comments from any Federal agency that has jurisdiction by law or special expertise with respect to any environmental impact involved in the subject matter of this EIS. During the course of preparing this EIS, the NRC consulted with various Federal, State, and local agencies and Tribal contacts. Appendix F provides a list of consultation correspondence. As discussed in EIS Chapter 1, the USACE is cooperating with the NRC in the preparation of this EIS. The NRC is also consulting with the FWS in the preparation of a Biological Assessment (see EIS Appendix M). Consultation correspondence is listed in Appendix F.

According to the guidance in NUREG–1555 (NRC 2000-TN614), Federal project activities meeting the following criteria should be identified and described:

- project activities related to the acquisition and/or use of the site and transmission corridors or of any other offsite property needed for the proposed project,
- project activities required either to provide an adequate source of plant cooling water or to ensure an adequate supply of cooling water over the operating lifetime of the plant,
- project activities completed as a condition of plant construction or operation,
- project activities that result in significant new power purchases within the applicant's service area that have been used to justify the need for power, and
- planned Federal projects that are contingent on the new plant construction and operation.

The Clinch River property is located within Federal lands managed by TVA, adjacent to the ORR. Therefore, no Federal action would be required to acquire or use the proposed site. There are no known other Federal projects or activities scheduled that would affect the construction or operation of the proposed site.

Federal lands within a 50-mi radius of the CRN Site include DOE laboratories and facilities, as well as lands and structures previously used in the production of uranium for nuclear weapons during the Manhattan Project and Cold War years. Ongoing Federal project activities identified within the region are listed in Table 7-1 and include ongoing ORR actions at the following locations:

- Oak Ridge National Laboratory
- Y-12 National Security Complex, including the Uranium Processing Facility
- East Tennessee Technology Park
- Environmental Management Waste Management Facility
- Proposed Bear Creek Valley low-level waste landfill
- Other Manhattan Project cleanup sites on the Oak Ridge Reservation.

The USACE plans to construct a replacement for the Chickamauga Dam lock on the Tennessee River. Congress authorized the construction of a replacement lock, which commenced in 2004 with the building of a coffer dam and related infrastructure. The replacement project was interrupted in 2013 due to lack of Federal funding. Construction resumed in 2016; the new lock is expected to be finished in 2023 (USACE 2016-TN5079). The completion of this project will allow continued barge access to the Clinch River in the vicinity of the proposed CRN Site.

3.0 SITE LAYOUT AND PROJECT DESCRIPTION

The Clinch River Nuclear (CRN) Site, for which an early site permit (ESP) application has been submitted, is located in Oak Ridge (Roane County), Tennessee, approximately 25 mi west-southwest of Knoxville. For the CRN Site ESP, the Tennessee Valley Authority (TVA) used a plant parameter envelope (PPE) approach to estimate the potential environmental impacts of building and operating two or more small modular reactors (SMRs) with a maximum electric output of 800 megawatts electric (MW(e)). TVA developed its PPE using information provided by four SMR vendors together with site-specific information. The PPE represents "a 'surrogate plant' that can bound two or more [SMR] technologies" (TVA 2017-TN4921). The PPE for the CRN Site ESP is provided in Appendix I of this draft environmental impact statement (EIS).

This chapter describes the key characteristics of the proposed project that are used to assess the environmental impacts of the proposed action. The information for this chapter was drawn from TVA's PPE and other information in its Environmental Report (ER) (TVA 2017-TN4921), its Site Safety Analysis Report (SSAR) (TVA 2017-TN5387) and supplemental documentation (TVA 2016-TN5008, TVA 2017-TN4920, TVA 2017-TN4922, TVA 2017-TN4987).

This chapter describes the physical aspects of the proposed project. It also describes the physical activities involved in building and operating nuclear reactor technologies represented by the bounding surrogate plant described by the PPE. The environmental impacts of building and operating the surrogate plant are discussed in Chapters 4 and 5, respectively. This chapter is divided into four sections. The external appearance and layout of the proposed project is described in Section 3.1. The major structures are described in Section 3.2. Section 3.2 also distinguishes structures that routinely interface with the environment from those that minimally interface with the environment, or that interface temporarily with the environment. Activities involved in building or installing each of the structures are described in Section 3.3. Operational activities of the surrogate plant that interface with the environment are described in Section 3.4.

3.1 External Appearance and Site Layout

The 935-ac CRN Site is not currently used for power-generating activities. All future systems and structures directly supporting power generation would be built as new independent facilities, including the cooling system and electrical switchyards. Although a specific reactor design has not been selected, TVA's PPE provides bounding parameters for a surrogate plant that a future selected SMR design is expected to fall within. The four SMR technologies used to develop the PPE all represent pressurized water reactors with below-grade containment, passive containment cooling for the ultimate heat sink, and closed-cycle wet cooling for the circulating-water system (CWS). The proposed project would also include parking areas, a barge-unloading area, local road and railway improvements, a new transmission line, relocation of an existing transmission line on the CRN Site, and upgrades to the regional transmission system (TVA 2017-TN4921, TVA 2017-TN4922). The project layout is presented in Figure 3-1 and includes the power block, turbine island, switchyard, cooling tower, independent spent fuel storage installation (ISFSI) areas, offsite traffic improvement areas, and the areas that would be permanently or temporarily disturbed on and near the CRN Site. An example conceptualization of two SMRs superimposed on the CRN Site is shown in Figure 3-2; the actual design could be different but would be expected to fall within the PPE.

Makeup water for the CWS and other plant uses would be supplied from the Clinch River arm of the Watts Bar Reservoir adjacent to the site. Cooling-tower blowdown and other plant effluents would be discharged to the Clinch River arm of the Watts Bar Reservoir approximately 2.5 mi downstream of the intake. Potable water would be obtained from the City of Oak Ridge, and sanitary waste would be discharged to the City of Oak Ridge wastewater-treatment system (TVA 2017-TN4921).

3.2 Proposed Plant Structures and Plant Parameter Envelope

This section describes the reactor power system and structures that would interface with the environment during operation. In Chapter 4, all plant structures are considered in the assessment of impacts of activities related to building and installing those structures. Only the structures that interface with the environment during operation are relevant to the operational impacts discussed in Chapter 5.

As described in Section 2.2 of this draft EIS, in 1982 and 1983 the CRN Site was partially developed in preparation for the Clinch River Breeder Reactor Project (CRBRP); the present site topography reflects the backfilling and grading done to remediate the site after the CRBRP was cancelled, as well as surface drainage infrastructure and retention ponds that were left in place. Approximately 240 ac of the site were disturbed during CRBRP site preparation; TVA anticipates that future power-generating facilities on the CRN Site would occupy the previously disturbed area as well as some additional undisturbed area as shown in Figure 3-1 (TVA 2017-TN4921).

3.2.1 Reactor Power-Conversion System

The PPE was developed using input from vendors of four SMR technologies: BWXT mPower™ (Generation mPower LLC), SMR-160 (Holtec SMR, LLC), NuScale (NuScale Power, LLC), and Westinghouse SMR (Westinghouse Electric Company, LLC). All four are pressurized water reactors that generate steam to drive turbines that generate electricity. TVA used a combination of vendor-supplied information about each reactor technology and CRN Site characteristics to develop its PPE values for a potential plant with thermal power of 800 MW(t) (core), 805 MW(t) (core plus reactor coolant pump[s], if in the design), and a total of 2,420 MW(t) for the entire site. The proposed gross electrical power in the PPE is a total of 800 MW(e) for the site. Without a specific reactor design, TVA could not estimate net power output because the station and auxiliary service load is not known. TVA's PPE for plant capacity factor ranges from 90 percent to 98 percent. The maximum fuel enrichment would be less than 5 percent uranium-235, the maximum average assembly burnup would be 51,000 megawatt-days per metric ton of uranium (MWD/MTU), and the peak fuel rod exposure would be 62,000 MWD/MTU (TVA 2017-TN4921).

3.2.2 Structures with a Major Environmental Interface

The review team (the NRC staff, its contractor staff, and USACE staff) divided the plant systems and structures into two primary groups: (1) those that interface with the environment and (2) those that are internal to the reactor and associated facilities but do not take material from or release material to the environment outside the facilities. Examples of environmental interfaces are withdrawal of water from the environment at the intake structure, release of water to the environment at the discharge structure, and release of excess heat to the atmosphere. The interaction of structures with the environment is considered in the review team's assessment of the environmental impacts of facility construction and preconstruction, and facility operation in Chapters 4 and 5, respectively. The power-production processes that would occur within a plant and not affect the environment are not discussed further in this draft EIS because they are

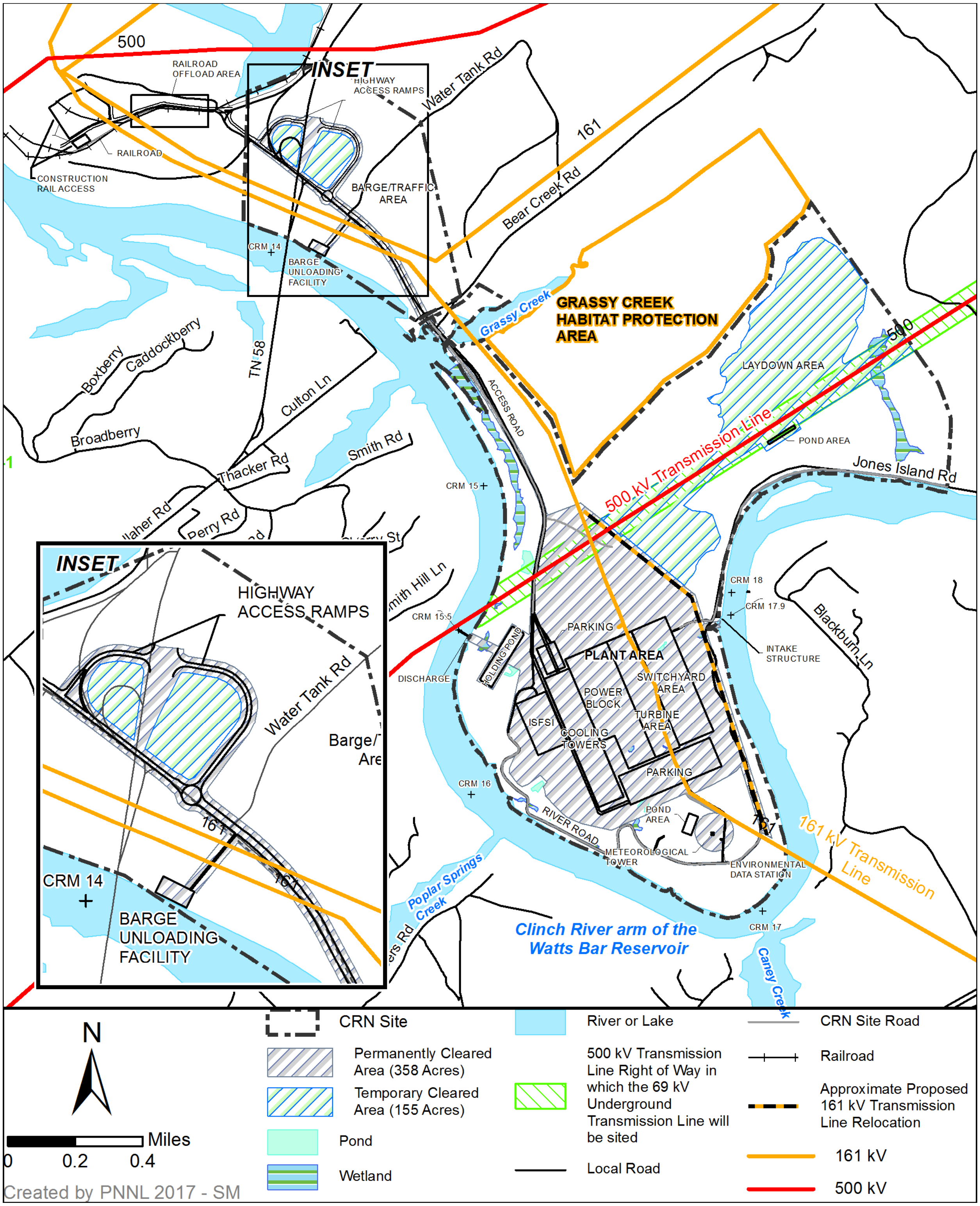


Figure 3-1. Project Layout

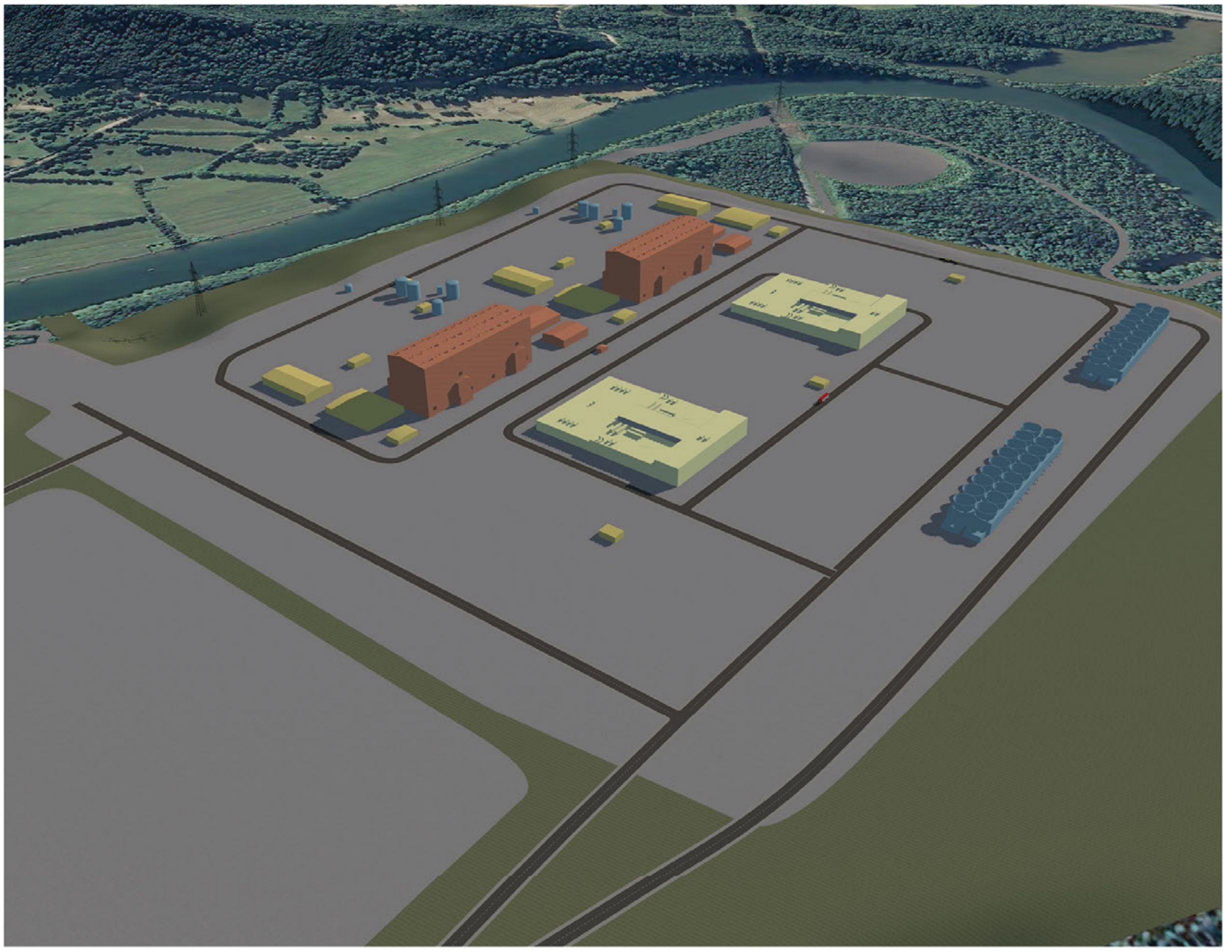


Figure 3-2. Architectural Rendering of Two SMR Units Superimposed on the CRN Site (looking to the southeast) (Source: TVA 2017-TN4921)

not relevant to the review under the National Environmental Policy Act of 1969, as amended (NEPA; 42 U.S.C. § 4321 *et seq*.-TN661). However, such internal processes would be considered in the design certification documentation for a specific reactor design, and in future NRC safety reviews of a COL application. This section describes only those structures that have a significant plant-environment interface.

The remaining structures are discussed in Section 3.2.3 to the extent that they may be relevant to the review team's consideration of construction and preconstruction impacts in Chapter 4.

3.2.2.1 Landscape and Stormwater Drainage

Landscaping and the stormwater-drainage system would affect the recharge to the subsurface and the rate and location at which precipitation drains into adjacent waterbodies. TVA installed a stormwater-management system on the CRN Site after dismantling the CRBRP structures, backfilling most of the deep excavation, and regrading the land surface at the end of the CRBRP. The current system consists of a regraded land surface and piping to direct runoff to five stormwater-retention ponds. The current system would be modified as needed to support the proposed project on the CRN Site.

For the new plant on the CRN Site, the modified ground surface and surrounding areas (about 494 ac) would be graded to direct stormwater runoff to storm drains, swales, and existing or new stormwater-management ponds before ultimately discharging to the surrounding land or the Clinch River arm of Watts Bar Reservoir. The stormwater system would also be used to manage effluent from excavation dewatering. Other than the ponds used to settle out solids, TVA does not expect to install other stormwater treatment systems such as settling tanks or oil/water separators. TVA would develop a stormwater pollution prevention plan (SWPPP) incorporating best management practices (BMPs) to minimize erosion and stabilize the land surface. BMPs would likely include methods described in the State of Tennessee Erosion and Sediment Control Handbook (TDEC 2012-TN4889). "BMPs are to be implemented in accordance with existing TVA BMPs and the Construction Stormwater Permit, and may include one or more of the methods described in the State of Tennessee Erosion and Sediment Control Handbook (Reference 3.6-5)." This handbook serves as the primary reference for the development and implementation of the SWPPP, as required by the Tennessee General National Pollutant Discharge Elimination System (NPDES) Permit for Discharges Associated with Construction Activities and individual NPDES permits.

3.2.2.2 Cooling System

The cooling system generally represents the largest interface between a nuclear plant and the environment. Cooling water is typically obtained from a surface-water source, heat in the cooling water is typically rejected to the atmosphere, and blowdown and liquid effluents are typically discharged to the environment. For the surrogate plant at the CRN Site, the source of cooling water would be surface water from the Clinch River arm of the Watts Bar Reservoir. A portion of the makeup water would be returned to the environment by discharging it to surface water in the Clinch River arm of the Watts Bar Reservoir, approximately 2.5 mi downstream of the cooling-water intake. The remaining portion of the water would be released to the atmosphere via evaporative cooling through mechanical draft cooling towers. This section describes the components of the cooling system based on the information provided by TVA in its ER (TVA 2017-TN4921) and SSAR (TVA 2017-TN5387).

3.2.2.2.1 Cooling-Water Intake Structure

The intake structure would be located north-northeast of the main plant area on the west bank of the Clinch River arm of the Watts Bar Reservoir near Clinch River mile (CRM) 17.9 (Figure 3-1). TVA anticipates that the intake structure would be approximately 50 ft long and 50 ft wide, and have four intake channels leading to four pump bays (Figure 3-3). Bar screens would prevent debris from entering the intake channels and dual-flow traveling screens would prevent smaller debris from reaching the pumps in the pump bays. The vertical height of the structure would be approximately 25 ft and the top deck elevation would be above the 100-year flood elevation. The riverbed near the shore would need to be deepened slightly to form a forebay between the face of the intake and the main channel of the river so that water would enter the intake system below the minimum water level of the reservoir (Figure 3-4). The intake design features are intended to keep the water velocity through the dual-flow traveling screens less than 0.5 fps to minimize impingement of fish or other aquatic biota (TVA 2017-TN4921).

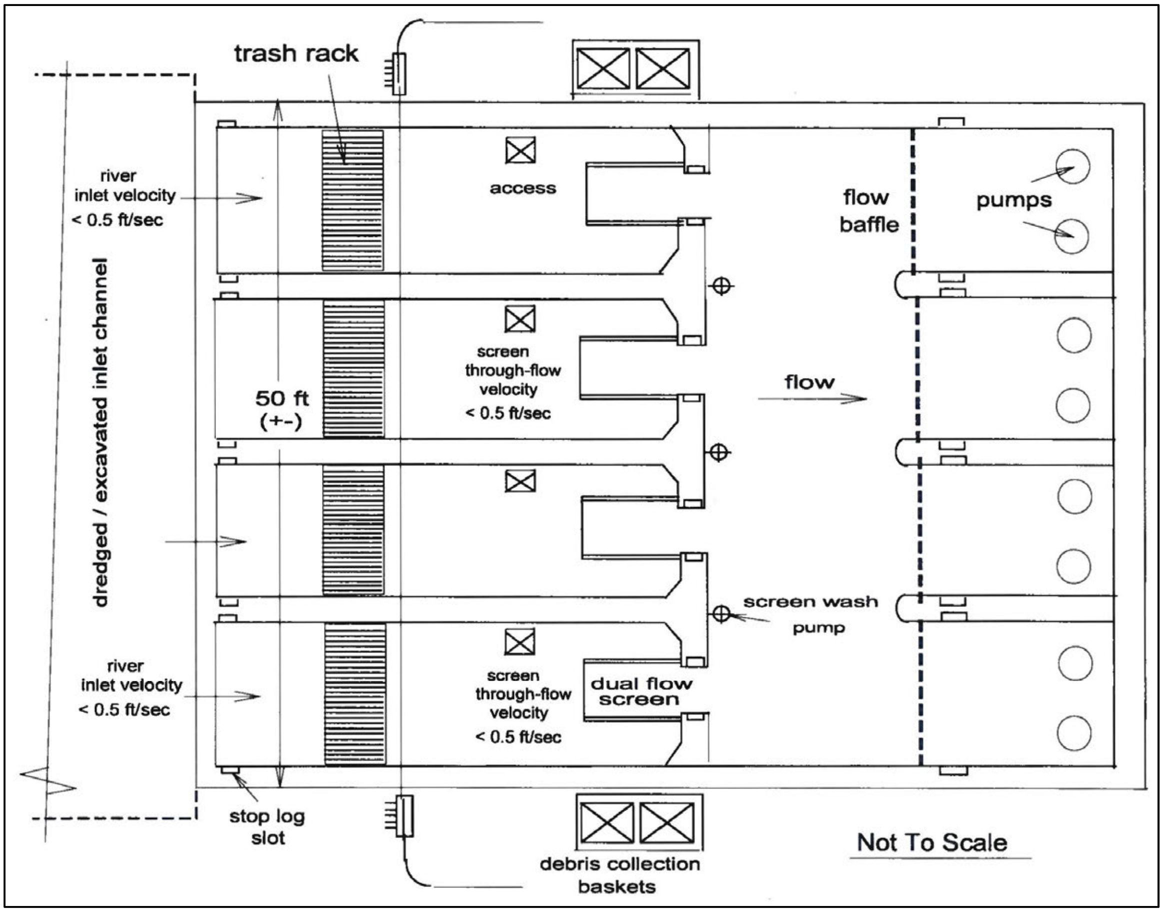


Figure 3-3. Conceptual Plan View of the Cooling-Water Intake Structure (Source: TVA 2017-TN4921)

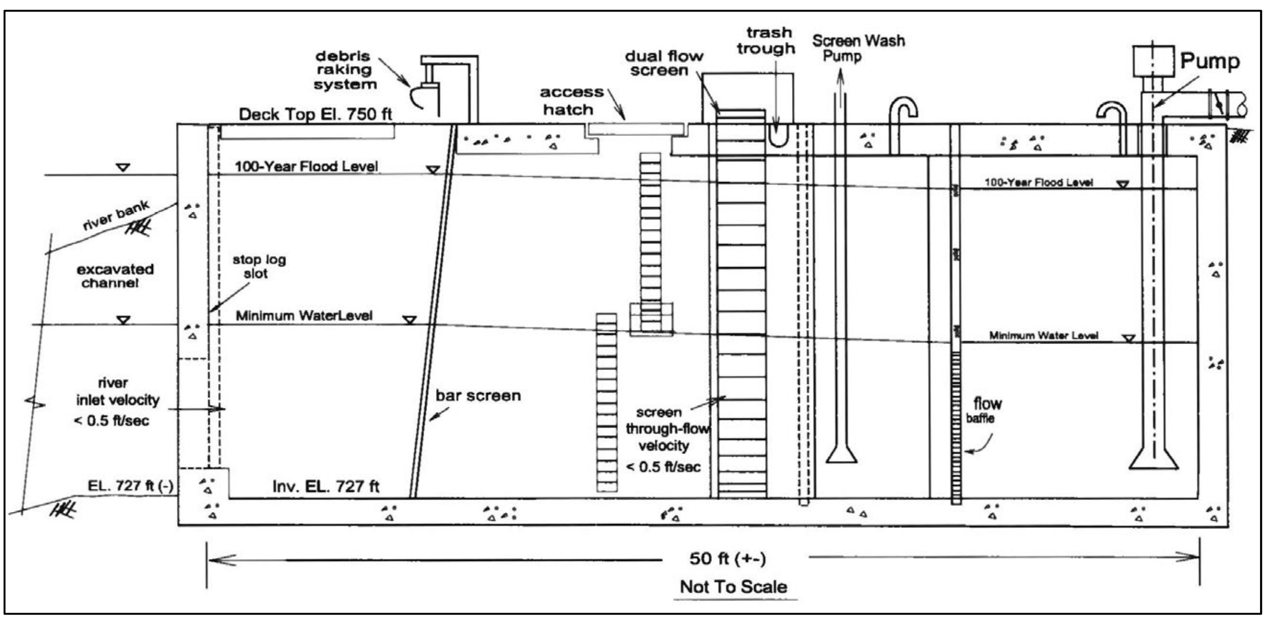


Figure 3-4. Conceptual Side View of the Cooling-Water Intake Structure (Source: TVA 2017-TN4921)

3.2.2.2.2 Cooling-Water Discharge Structure

Liquid effluents from the plant would be transported via pipeline to a holding pond located between the main plant area and the discharge structure, then to the discharge structure on the Clinch River arm of the Watts Bar Reservoir at CRM 15.5, west of the main plant area (Figure 3-1). The holding pond would be at an elevation of 763 ft above mean sea level (MSL); it would be approximately 980 ft long, 230 ft wide, and 13 ft deep. The pond would have a surface area of approximately 5 ac (225,400 ft^2) and volume of approximately 67 ac-ft. The discharge pipeline would be split into two parallel, 3-ft-diameter pipes that extend into the river at an elevation of about 720 ft MSL, or 4 ft above the bottom at the offshore end (Figure 3-5). A vault containing instruments to monitor effluent flow and temperature would be located upstream of the split. The conceptual design would have diffuser ports on the downstream side of the last 12 to 15 ft of each pipe in order to effect a discharge velocity of 8 to 10 fps. Each pipe would be valved so that discharge flow could be controlled for mixing or exit velocity, or be directed to one pipe if needed for maintenance (TVA 2017-TN4921).

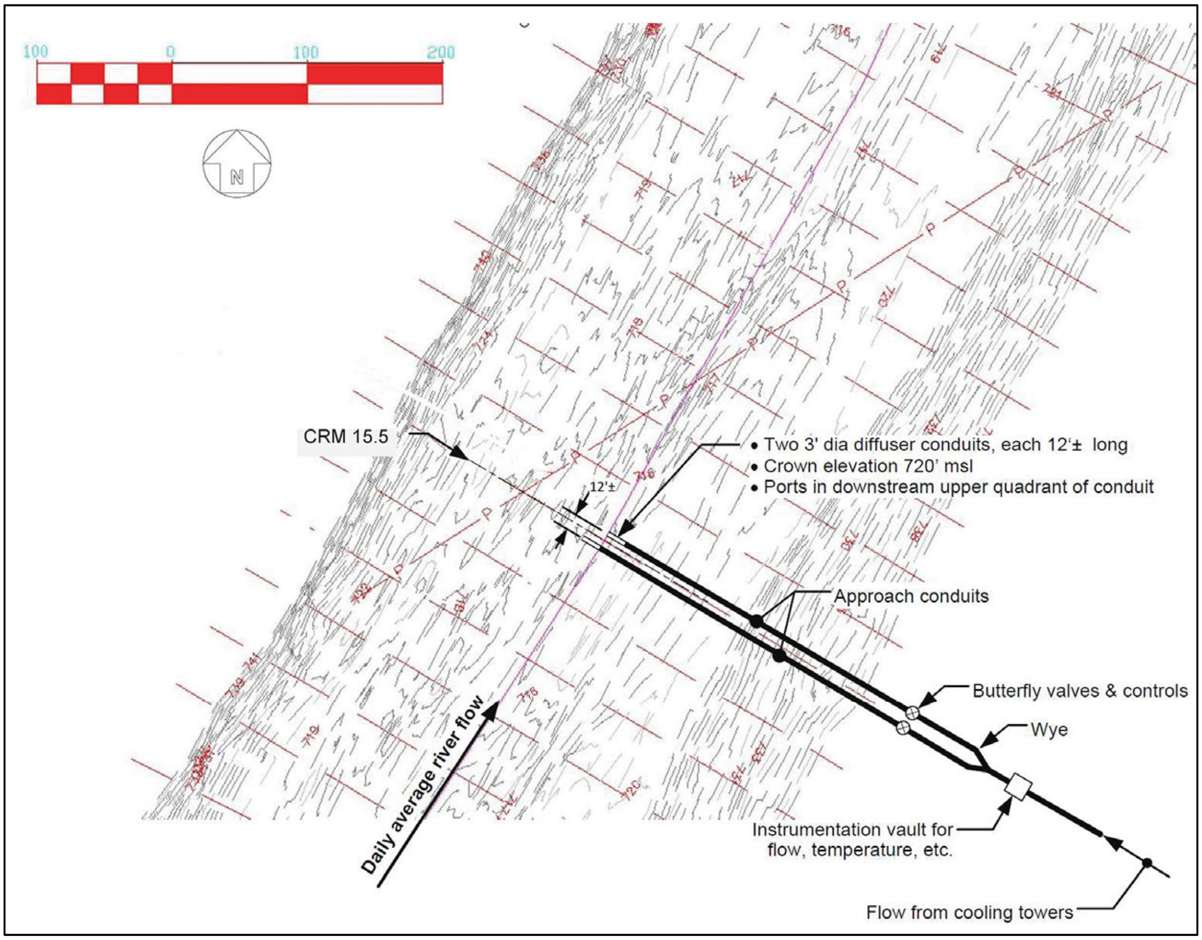


Figure 3-5. Conceptual Plan View of the Cooling-Water Discharge Structure (Source: TVA 2017-TN4921)

3.2.2.2.3 Cooling Towers

TVA's conceptual design calls for mechanical draft cooling towers to dissipate heat. The mechanical draft cooling towers would be 65 ft or less in height and would occupy approximately 21 ac in the main plant area adjacent to the power block (Figure 3-1).

3.2.2.3 Other Structures with a Permanent Environmental Interface

Many of the structures and features needed to support the surrogate plant would have a permanent environmental interface on or off the CRN Site. These structures and features include local transportation facilities, buildings, ISFSI, parking lots, fill source areas, spoils disposal areas, and the transmission system.

3.2.2.3.1 Barge-Unloading Facility

TVA proposes to refurbish an existing but inactive barge terminal at CRM 14.1, near the entrance to the Clinch River site and Bear Creek Road (Figure 3-3). Materials or equipment shipped by barge to the CRN Site would be offloaded at this terminal. Anticipated refurbishment activities would be improvements to the existing retaining wall, and installation of bollards or mooring cells to secure barges at the terminal.

3.2.2.3.2 Rail Lines/Railway Improvements

The EnergySolutions Heritage Railroad is an existing, privately owned, 11.5-mi rail line between a Norfolk Southern Railway line and the East Tennessee Technology Park, north-northwest of the CRN Site. A spur of the EnergySolutions Heritage Railroad ends at an offload area just west of the State Route (SR) 58 and Bear Creek Road interchange (Figure 3-1). TVA anticipates using the EnergySolutions Railroad for building material, equipment, and component deliveries to the CRN Site. Use of the railroad would primarily occur during the construction and preconstruction period, but it could be used for delivery of large parts or components during operation. To meet this anticipated purpose, the railroad would require refurbishment of the lines in the offload area and possibly elsewhere on the line (TVA 2017-TN4922).

3.2.2.3.3 Roads

Several road improvements would be necessary to support construction and operation of a nuclear plant on the CRN Site. Site access is via SR 95 northeast of the site and SR 58 (Oak Ridge Turnpike) west of the site. Both highways intersect Bear Creek Road, which provides access to the CRN Site. Construction-related traffic is anticipated to use SR 58 to access the rail and barge-unloading facilities and Bear Creek Road. The SR 58 access ramps at Bear Creek Road would be improved, roadways would be widened, and turn lanes and traffic signals would be added. Bear Creek Road would be widened and upgraded to create a heavy-haul road between the rail delivery area and the CRN Site entrance, passing the barge-unloading facility (Figure 3-1). The CRN access road would also be upgraded to a permanent heavy-haul road from the site entrance to the plant area. The entire heavy-haul route is expected to be approximately 2.5 mi long and require 5 ac of land. Other roads on the CRN Site would be located within the disturbed area footprint and would use existing roadways to the extent possible (TVA 2017-TN4921).

3.2.2.3.4 Spoils Areas

Spoils areas would be established to manage soils and woody debris cleared, grubbed, or excavated during CRN Site preparation. TVA anticipates that excavated material could be reused onsite. Establishment of spoils areas would occur within the areas designated as disturbed (temporarily or permanently) in Figure 3-1. Any excavated material not suitable for fill would be disposed of in accordance with TVA's waste-management program and regulatory requirements or, if appropriate, in the onsite landfill.

In Tennessee, borrow areas are subject to permitting under the State's stormwater pollution prevention regulations and may be subject to aquatic resource alteration regulations or mining regulations depending on their proximity to aquatic resources and the material being excavated (TVA 2017-TN4921, TVA 2017-TN4922).

3.2.2.3.5 Melton Hill Dam Bypass

TVA proposes to add a bypass flow system (conduit) through an existing part of the Melton Hill Dam structure to maintain a minimum flow of 400 cfs independent of the hydroelectric generating system.

3.2.2.3.6 Power Transmission System

Existing transmission lines serving the area of the CRN Site are 161 kV and 500 kV lines. In Section 3.7 of its ER (TVA 2017-TN4921), TVA described the power transmission system that would connect a potential 800-MW(e) plant at the CRN Site to the grid that distributes power to the TVA service territory. Anticipated changes and additions to that system to ensure that National Electrical Safety Code (NESC) (IEEE 2007-TN1087) standards are met are as follows:

- new onsite switchyards, 161 kV and 500 kV, adjacent to the main plant area looped into existing lines
- a new 69-kV underground line within the existing 500-kV corridor, from the CRN Site to the Bethel Valley Substation and related expansion of the Bethel Valley Substation
- relocation of the existing 161-kV Kingston FP-Fort Loudon HP #1 line outside the main plant area but within CRN Site boundary (see Figure 3-1)
- offsite upgrades in many locations within the existing TVA transmission right-of-ways.

<u>New 161-kV and 500-kV Switchyards and Connecting Loops on CRN Site</u>

The new 161-kV and 500-kV switchyards would house the transformers, breakers, metering, communications, and other equipment needed to connect the power plant with the existing transmission system. The switchyards would occupy approximately 26 ac located adjacent to the main plant area.

The 500-kV line connection would be a double-circuit loop, or two separate lines spaced 125 ft apart. Typical 500-kV line right-of-way width is 175 ft. Approximately 10 lattice steel tower structures spaced about 1,000 ft apart would be needed to support the lines over the estimated loop length of 0.7 mi. Tower heights are expected to be between 85 and 125 ft tall depending on the clearance needed above final grade and land use (TVA 2017-TN4921).

The 161-kV line connection would be a double-circuit loop supported by a combination of single- or double- (H-frame) pole structures. TVA estimated that three pole structures spaced 600 ft apart would be required to support the lines over the 0.2-mi loop length. The typical width of the 161-kV line right-of-way is 100 ft. As with the 500-kV towers, 161-kV pole heights are expected to vary depending on grade and land use, between 80 and 110 ft tall (TVA 2017-TN4921).

<u>New 69-kV Line from CRN Site to Bethel Valley Substation</u>

The new 69-kV line would be approximately 5 mi long and would be placed underground in the existing right-of-way for the 500-kV Watts Bar NP-Bull Run FP line (Figure 3-6). It would consist of 3 parallel conductors placed 12 in. apart and 36 in. deep underground. The northwest side of the 161-kV Bethel Valley Substation would be expanded approximately 60 ft to accommodate the 69-kV line (TVA 2017-TN4921, TVA 2017-TN4922).

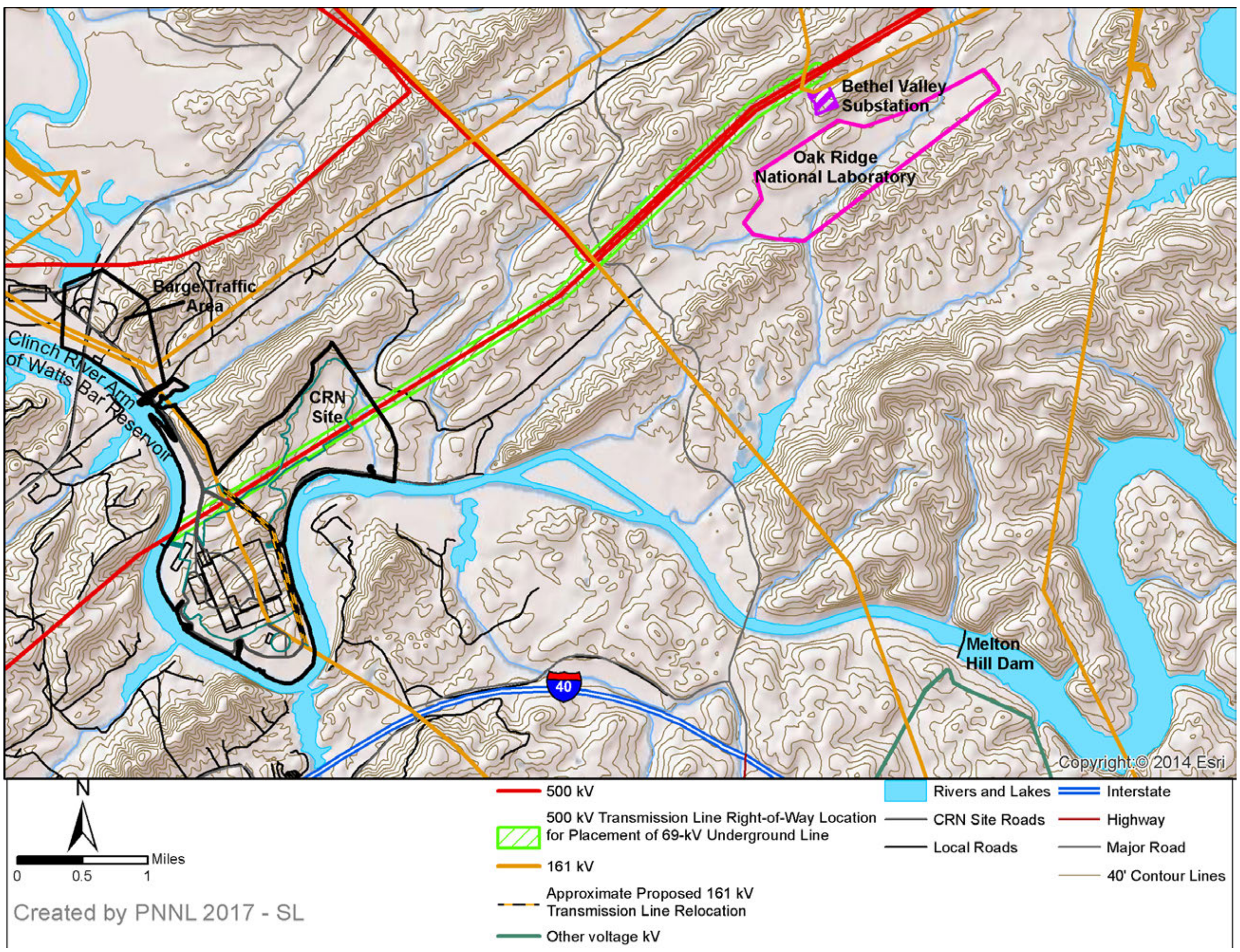


Figure 3-6. Existing 161-kV and 500-kV Transmission Lines and Proposed New Underground 69-kV Transmission Line in the Vicinity of the CRN Site

Relocate 161-kV Kingston FP-Fort Loudon HP #1 Line

The existing 161-kV Kingston FP-Fort Loudon HP #1 line traverses the portion of the CRN Site where the power plant would be built. The 161-kV line would be relocated to skirt the perimeter of the main plant area where it would not interfere with building or operating the new plant (Figure 3-1).

Offsite Transmission Upgrades

TVA identified many segments of existing 161-kV transmission lines that would need to be uprated, reconductored, or rebuilt to accommodate the additional load from an 800-MW(e) power plant (Figure 2-8). In its ER, TVA tabulated the total length of segments to be uprated, reconductored, or rebuilt as approximately 191 mi, 122 mi, and 13 mi, respectively (TVA 2017-TN4921). However, TVA also provided spatial data that indicated the segment lengths to be uprated or reconductored could be up to 215 and 212 mi, respectively (TVA 2017-TN4920). TVA noted that "an 'uprate' can be performed at a single point or at multiple locations along the transmission line," and that the exact nature and location of uprate or reconductoring activity within each line segment is not yet known and would depend on the final configuration and capacity of the new plant (TVA 2017-TN4921, TVA 2017-TN4922).

3.2.2.4 Other Structures with a Temporary Environmental Interface

Anticipated temporary plant-environment interfacing structures include a concrete batch plant and dewatering systems.

3.2.2.4.1 Concrete Batch Plant

A concrete batch plant would be located near the main plant area. The concrete batch plant would use an estimated average 34 gpm of water supplied by the City of Oak Ridge municipal water system (TVA 2017-TN4922).

3.2.2.4.2 Dewatering Systems

Dewatering is expected to be a localized activity associated with excavation. Dewatering systems would be installed for the excavation for the nuclear island. Dewatering techniques include directing water to sumps via horizontal drains in excavated surfaces and grouting to prevent inflow of groundwater. Surface-water and groundwater seepage would be removed by sump pumps and discharged to the construction-stormwater management system (TVA 2017-TN4921).

3.2.3 Structures with a Minor Environmental Interface

The structures described in the following sections would have minimal environmental interface during plant operation.

3.2.3.1 Power Block and Other Buildings in the Main Plant Area

The "main plant area" is used to describe the area that would be occupied by the power block, turbine building(s), switchyard(s), and other buildings associated with nuclear power generation such as a radioactive waste management and diesel generator buildings. The main plant area is located on the southern portion of the CRN Site (Figure 3-1), primarily in the area that was previously disturbed during the CRBRP. TVA's PPE value for the height of the tallest power block structure is 160 ft above plant grade. The power block would also be where the deepest excavation occurs; the PPE value for the depth of the deepest excavation is 138 ft below plant grade (TVA 2017-TN4922).

3.2.3.2 Cranes and Footings

Several large cranes would be needed to install reactors on the CRN Site. The largest would be a 638-ft heavy-lift crane used in the main plant area (TVA 2017-TN4922).

3.2.3.3 Pipelines

Approximately 0.5 mi of new pipeline would be laid to convey water from the intake structure to the main plant area; approximately 0.4 mi of new pipeline would be laid to convey water from the main plant area to the discharge pipe (TVA 2017-TN4920). A new pipeline would also be installed to bring water to the site from the City of Oak Ridge supply line near the Bear Creek Road entrance to the CRN Site. This municipal water would be used for potable, sanitary, some construction purposes (e.g., concrete batch plant, and possibly for fire protection). If a separate line from the City of Oak Ridge is required for fire protection water, that line would be placed in the same right-of-way. A new pipeline would also be needed to convey sanitary wastewater to the existing City of Oak Ridge wastewater pumping station on Bear Creek Road north of the Grassy Creek embayment. The new municipal water and wastewater lines would be approximately 1.4 and 1.7 mi long, respectively (TVA 2017-TN4920). TVA anticipates that all new pipelines would follow existing roadways or other cleared areas in the permanently disturbed portion of the CRN Site (Figure 3-1) (TVA 2017-TN4922).

3.2.3.4 Support and Laydown Areas

Construction-support and laydown areas would be established to support fabrication and installation activities and might be maintained as laydown areas for future maintenance of the plant. Several construction-support areas totaling approximately 150 ac would be located within the areas of disturbance (permanent or temporary) identified in Figure 3-1 (TVA 2017-TN4922).

3.2.3.5 Parking

Parking areas would be created to support the construction workforce and some parking would be retained for the operating workforce once plant installation is completed. The rest of the temporary parking areas would be revegetated. Parking areas would be in the vicinity of the plant and laydown areas identified in Figure 3-1.

3.2.3.6 Fill Source (Borrow) Areas

In addition to reusing material excavated from the CRN Site, TVA anticipates obtaining fill material from existing, permitted offsite sources. TVA identified nine such sources located within 50 mi of the CRN Site (Figure 2-9) (TVA 2017-TN4921, TVA 2016-TN5145).

3.3 Construction and Preconstruction Activities

This section describes the construction and preconstruction activities associated with building SMRs represented by the PPE on the CRN Site.

The NRC's authority is limited to construction activities that have a reasonable nexus to radiological health and safety or common defense and security (72 FR 57416-TN260). Examples of construction activities defined in Title 10 of the *Code of Federal Regulations* (CFR) 50.10(a)(1) [TN249]) include pile driving, subsurface preparation, placement of backfill, concrete, or permanent retaining walls within an excavation; installation of foundations; or in-place assembly, erection, fabrication, or testing of specified structures, systems, or components.

Other activities related to building the plant that do not require NRC approval may occur before, during, or after NRC-authorized construction activities (as defined by 10 CFR 50.10(a)(2) [TN249]). These activities are termed "preconstruction" in 10 CFR 51.45(c) (TN250) and are typically regulated by local, State, Tribal, or Federal agencies other than the NRC. Preconstruction includes activities such as site preparation (e.g., clearing, grading, and installation of erosion control, and other environmental mitigation measures), erection of fences, excavation, erection of support buildings or facilities, building service facilities (e.g., roads, parking lots, rail lines, transmission lines, sanitary-treatment system, potable water system), and procurement or fabrication of components occurring at a location other than the final, in-place location at the site. Further information about the delineation of construction and preconstruction activities is presented in Chapter 4 of this draft EIS.

This section describes the structures and activities associated with building SMRs with the bounding design characteristics represented by the PPE on the CRN Site. Table 3-1 provides general definitions and examples of activities that would be performed when building the new units. This section characterizes the potential activities associated with the principal structures to provide requisite background for the assessment of environmental impacts; it is not a complete discussion of every activity or a detailed engineering plan.

Table 3-1. Definitions and Examples of Activities Associated with the Proposed Project

Activity	Definition	Examples
Clearing	Removing vegetation or existing structures from the land surface.	Cutting vegetation in an area to be used for construction laydown.
Grubbing	Removing roots and stumps by digging.	Removing stumps and roots of trees or shrubs from the construction laydown area.
Grading	Reforming the elevation of the land surface to facilitate operation of the plant and drainage of precipitation.	Leveling the site of the reactors and cooling towers.
Hauling	Transporting material and workforce along established roadways.	Transporting components from the barge-unloading area to the plant area on the new heavy-haul route.
Paving	Laying impervious surfaces, such as asphalt and concrete, to provide roadways, walkways, parking areas, and site drainage.	Paving a parking area.
Shallow excavation	Digging a hole or trench to a depth reachable with a backhoe. Shallow excavation may not require dewatering.	Placing pipelines; setting foundations for small buildings.
Deep excavation	Digging an open hole in the ground. Deep excavation requires equipment with greater vertical reach than a backhoe. Deep excavation generally requires dewatering systems to keep the hole from flooding.	Excavating for the basemat for the reactor.

Table 3-1. (contd)

Activity	Definition	Examples
Excavation dewatering	Pumping water from wells or pumping water directly to keep excavations from flooding with groundwater or surface runoff.	Pumping water from sumps at the base of an excavation.
Grouting	Installing low-permeability material in the subsurface around deep excavations to minimize movement of groundwater.	Installing slurry wall around the excavation for the reactor building.
Spoils placement	Emplacing construction (earthwork) or dredged material in an upland location.	Relocating excavated material from the holding pond area to an upland disposal area.
Erection	Assembling reactor SMR units into their final positions, including all connections between modules.	Using a crane to assemble the SMR units.
Fabrication	Creating an engineered material from the assembly of a variety of standardized parts. Fabrication can include conforming native soils to some engineered specification (e.g., compacting soil to meet an engineered fill specification).	Preparing and pouring concrete; laying rebar for the basemat.
Vegetation management	Thinning, planting, trimming, and clearing vegetation.	Maintaining the switchyard free of vegetation.
Diversion	Altering the course of a waterway (stream or ditch)	Modifying the course of a stream for structures.
Filling a wetland or waterbody	Discharging dredge and/or fill material into waters of the United States, including wetlands.	Placing fill material into wetlands to bring it to grade with the adjacent land surface.

3.3.1 Major Activity Areas

3.3.1.1 Landscape and Stormwater Drainage

Large portions of the CRN Site would be cleared and graded during site preparation. Therefore, drainage runoff controls would be established early in the site preparation process. Activities related to installing site drainage would include grading, creation of berms around temporary spoils disposal areas, and shallow trenching for ditches, drain pipes, and culverts. Slopes, swales, ditches, and pipes would direct runoff to aboveground stormwater-management ponds. TVA plans to use the existing retention pond locations, but would redesign and rebuild the drainage and ponds to accommodate excavation dewatering effluent and runoff from the future plant design. Establishing the redesigned stormwater-management ponds would involve shallow excavation and emplacement of geotextile fabric, drain pipe, rock, cover material, and riprap. Post-construction activities would include regrading temporary features and stabilizing the surface by reseeding vegetation or paving (depending on use) (TVA 2017-TN4921).

3.3.1.2 Main Plant Area

Preparing the locations of the power block, 161-kV and 500-kV switchyards, and CWS cooling towers would involve clearing, grubbing, grading, deep excavation, excavation dewatering, placement of structural fill, fabrication, and module staging activities. The switchyard area would be paved with gravel and fenced, and electrical switching structures would be erected. As noted in Section 3.2.2.4.2 above, excavation dewatering would be used in the nuclear island excavation and could include horizontal drains in excavated surfaces to direct water to sumps, grouting to prevent inflow of groundwater, and pumping water from sumps to the construction-stormwater management system (TVA 2017-TN4921). TVA noted that, depending on the size and depth of the excavation area, a number of temporary dewatering wells could be needed, and that each could have a flow rate of up to 15 gpm during the construction period. Dewatering is not anticipated once nuclear island construction is completed (TVA 2017-TN4921, TVA 2017-TN4987).

3.3.1.3 Cooling-Water Intake Structure

Preparing the intake structure location would require clearing, grubbing, and grading the structure location; placement of a temporary cofferdam; and shallow excavation along the shoreline to form the forebay for the intake structure. The river bank would be excavated to provide a short intake channel, approximately 50 ft wide, using BMPs to control bank erosion and transport of suspended sediment. Excavated material from the Watts Bar Reservoir would be treated as "potentially contaminated," sampled and analyzed for hazardous or radioactive constituents, and dispositioned based on the results of those analyses. If needed, TVA would, in accordance with its NPDES permit and SWPPP, establish an area on the CRN Site to receive the excavated material. Fabrication of the concrete intake and pump bay structure would occur after excavation to allow placement of the base at approximately 727 ft MSL. Pumps, piping, debris exclusion, screen wash, and necessary electrical systems would be installed to create an operational intake system (TVA 2017-TN4921, TVA 2017-TN4922).

3.3.1.4 Cooling-Water Discharge System

Installing the discharge pipeline, holding pond, and outfall diffuser would require clearing, shallow excavation, and backfilling. As noted in Section 3.3.1.3 above, any excavated material would be disposed of appropriately depending on characterization of the material (TVA 2017-TN4921, TVA 2017-TN4922).

3.3.1.5 Roads

Building the main access and onsite roads would require clearing and grading of land along the proposed routes. TVA identified several locations along Bear Creek Road where filling would be needed to accommodate the wider roadway (TVA 2017-TN4921, TVA 2016-TN5145). A new culvert would be needed where the access road crosses the outlet of Grassy Creek. On the CRN Site, existing roads would require some clearing and resurfacing to accommodate the level of use.

3.3.1.6 Barge-Unloading Facility

Refurbishing the barge-unloading facility would involve reinforcing or rebuilding the retaining wall; clearing, grading, and paving the upland area; and installing moorings and pilings. TVA does not anticipate any dredging would be necessary (TVA 2017-TN4921).

3.3.1.7 Rail Lines

If used, the rail spur between Bear Creek Road and the main Norfolk Southern rail line would involve minor refurbishment within the existing right-of-way and developed rail terminal areas (TVA 2017-TN4922).

3.3.1.8 Pipelines

Pipeline installation would require the clearing of land along the pipeline corridor, shallow excavation (trenching), and backfilling. TVA indicated that pipelines would be placed in existing road right-of-ways or cleared areas (TVA 2017-TN4922).

3.3.1.9 Concrete Batch Plant

Erecting the temporary concrete batch plant would occur on graded fill near the main plant area (TVA 2017-TN4922).

3.3.1.10 Laydown and Parking Areas

Establishing and preparing laydown areas would be necessary for staging of activities. Prior to and during construction and preconstruction, materials would be brought to the site and stored in laydown areas. TVA expects to clear and grade laydown areas in various locations on the CRN Site. Normally only limited vegetation is allowed in laydown areas (TVA 2017-TN4921). Parking areas would be cleared, filled if necessary, graded, and paved.

3.3.1.11 Cranes and Crane Footings

Fabrication of concrete footings and assembly of cranes would be necessary to build the larger plant structures (TVA 2017-TN4921).

3.3.1.12 Miscellaneous Buildings

Excavation for shallow foundations would be needed prior to fabrication and erection of miscellaneous buildings. Fill may be needed to create a stable base and to bring the area up to an appropriate final grade.

3.3.1.13 Transmission Lines

Installation of new transmission lines and relocation of the existing 161-kV line on the CRN Site would involve the removal of trees and shrubs along portions of the transmission line corridor and access roads, movement of construction equipment, and shallow excavation for the foundations of the transmission line towers. Temporary dewatering may be needed to build footings for transmission towers. Placement of the new 69-kV underground line within the existing 500-kV transmission corridor would involve vegetation removal, shallow excavation or trenching, and backfilling over the buried lines. Expansion of the Bethel Valley Substation would also involve clearing and grading (TVA 2017-TN4921, TVA 2017-TN4922).

Offsite transmission line upgrades would occur over numerous segments of existing lines (Figure 2-8). The activities associated with these upgrades are as follows:

- moving structures located in the right-of-way that interfere with safe operation of the lines;
- replacing or modifying (e.g., extending) existing support structures and/or adding surcharge (supportive material) around footings of affected structures, and adding new or replacing undersized support structures in segments where the line needs to be rebuilt;
- modifying the conductor (wire) to increase its ground clearance;
- replacing undersized conductor (reconductoring); and
- modifying or rerouting local distribution lines where they cross TVA transmission lines.

These activities would involve access by standard transmission line equipment (e.g., bulldozers, bucket trucks, boom trucks, forklifts) in existing right-of-ways. Structure replacement or new structure installation would involve limited clearing and shallow excavation, usually within 100 ft of the structure location. Conductor modification would involve using a bucket truck to access an existing conductor, generally at a structure. Related disturbance would be minimal. Conductor replacement, or stringing new wire, would involve placement of temporary poles to minimize interference with traffic, staging reels of the conductor, connecting the new conductor to the existing one, and using a bulldozer and line tensioning equipment to pull the conductor to the proper tension. The "pull points" where equipment would be operated would generally be located along an existing access point in the right-of-way. TVA estimated 200 to 300 ft of typical disturbance along the right-of-way at each pull point (TVA 2017-TN4921; NRC 2018-TN5386).

3.3.1.14 Melton Hill Dam Bypass

The Melton Hill Dam bypass would involve modifying the existing structure by installing a conduit that allows a continuous flow of 400 cfs.

3.3.2 Summary of Resource Parameters during Construction and Preconstruction

Table 3-2 provides a list of the significant resource commitments associated with construction and preconstruction. The values in the table combined with the affected environment described in Chapter 2 provide the basis for the construction and preconstruction impacts assessed in Chapter 4. These values were stated in the ER or supplemental information submitted by the applicant.

Table 3-2. Summary of Parameters and Resource Commitments Associated with Construction and Preconstruction of the Proposed Project

Resource Areas	Value	Parameter Description
All Resource Areas	72 mo (6 yr)	Duration of construction and preconstruction activities
Land Use, Terrestrial Ecology, Cultural and Historic Resources (Site and Vicinity)	494 ac	Disturbed area footprint onsite; 167 ac temporarily disturbed, 327 ac permanently disturbed of which approximately 100 ac would be main plant area
	45 ac	Disturbed area offsite but in vicinity (Barge/Traffic Area); 15 ac temporarily disturbed, 30 ac permanently disturbed
Land Use, Terrestrial Ecology, Cultural and Historic Resources (Offsite, Transmission Lines)	4,157 ac	Total area for offsite transmission line activities, temporary disturbance only; 210 ac for 69-kV underground line 3,947 ac for offsite rebuild, reconductor, and uprate
Hydrology – Groundwater	138 ft below grade, elevation 683 ft NAVD88	Maximum excavation depth (containment and auxiliary buildings)
Hydrology – Surface Water, Socioeconomics	231,660 gpd (161 gpm, 0.233 Mgd)	Construction water (e.g., concrete batch plant) and potable/sanitary water from City of Oak Ridge municipal system
	5,000 gpd (3.5 gpm, 0.005 Mgd)	Construction water use, e.g., for dust control; source would be surface water from the Clinch River arm of the Watts Bar Reservoir

Table 3-2. (contd)

Resource Areas	Value	Parameter Description
Socioeconomics, Transportation	2,200 workers	Workforce onsite during construction (maximum single shift workforce expected during 4th year of 6-year period); 400 workers during site preparation and excavation
	3,300 workers	Peak construction and preconstruction workforce across all shifts
Terrestrial Ecology, Socioeconomics	638 ft (crane)	Height of tallest structure or equipment during construction and preconstruction
Terrestrial Ecology, Nonradiological Health, Socioeconomics	101 dBA at 50 ft	PPE value for maximum expected noise level from construction activities
	102 dBA at 50 ft 84 dBA at 400 ft	Noise level with distance from activity

NAVD88 = North American Vertical Datum of 1988; PPE = plant parameter envelope.

Sources: TVA 2017-TN4921, TVA 2017-TN4922.

3.4 Operational Activities

The operational activities considered in the review team's environmental review are those associated with structures that have a major interface with the environment, as described in Section 3.2.2 of this chapter. Examples of operational activities include withdrawing water for the cooling system, discharging blowdown water, and discharging waste heat to the atmosphere. Activities within the plant are discussed by TVA in the SSAR portion of its application (TVA 2017-TN5387) and are reviewed by the NRC in its Safety Evaluation Report.

3.4.1 Description of Cooling System Operational Modes

The full power operation of the plant is the operational mode that uses the maximum amount of cooling water. The PPE provides the bounding cooling system parameters, including water flow rates and heat transfer characteristics, for full power operation. Water use and heat transfer characteristics for other operational modes, such as shutdown or outage conditions are significantly less than the full power parameter. Therefore, the PPE values are used in the evaluation of impacts. The other operational modes are not evaluated further because their impact is bounded by the impact of full power operation.

3.4.2 Plant-Environment Interfaces during Operation

This section describes the operational activities related to structures that have an interface with the environment.

3.4.2.1 Stormwater-Management System

TVA plans to install a site drainage system that uses the locations of existing retention ponds and outfalls, but redesigns and rebuilds the components of the system to accommodate the volume of runoff expected from the new plant design. Runoff would be directed to stormwater-management ponds where the sediment in the runoff would settle out prior to runoff being discharged to surface water. Maintenance activities would include inspecting and clearing culverts, cleaning catch basins and ponds, and keeping paved areas clear of debris (TVA 2017-TN4921; NRC 2018-TN5386).

3.4.2.2 Circulating-Water System

3.4.2.2.1 Cooling-Water Intake Structure

During normal plant operation with the CWS operating at four cycles of concentration, 18,423 gpm (41.0 cfs) of water would be withdrawn from the Clinch River arm of the Watts Bar Reservoir at the intake structure. The maximum withdrawal rate of 30,708 gpm (68.4 cfs), would occur if the CWS operates at two cycles of concentration. Most of this water would be pumped to the cooling-tower basins for use in the plant cooling system; the rest would go to other plant uses as shown in Figure 3-7. TVA does not anticipate any dredging to maintain the intake structure because it is located on a reach where little to no sediment accumulation occurs (TVA 2017-TN4922).

3.4.2.2.2 Cooling Towers

Excess heat in the cooling water would be transferred to the atmosphere by evaporative and conductive cooling in the cooling towers. In addition to evaporative losses, a small percentage of water would be lost in the form of droplets (drift) from the cooling towers. Water lost to evaporation and drift is considered consumptive use because the water is not available for reuse. The PPE values for both the normal and maximum evaporation rates of the CWS would be 12,800 gpm; the CWS drift rate would be 8 gpm, because the heat load would be the same under normal and maximum operating conditions.

3.4.2.2.3 Discharge Structures

Cooling-tower blowdown and most other plant liquid effluents would be discharged to the Clinch River arm of the Watts Bar Reservoir. Plant discharges would be mixed in a holding pond located between the main plant area and the outfall diffuser in the river (Figure 3-1). The expected discharge rate during normal operation (cooling system operating at four cycles of concentration) is 4,270 gpm from cooling-tower blowdown and 445 gpm from other plant uses, for a total of 4,715 gpm. The maximum discharge rate (occurring when the cooling system is operating at two cycles of concentration) would be 12,800 gpm cooling-tower blowdown and 4,200 gpm from other plant uses, for a total of 17,000 gpm. Another 900 gpm of effluent associated with the liquid radioactive waste system would be injected into the discharge pipeline between the holding pond and the outfall diffuser. The plant discharge system and holding pond would be operated in accordance with a NPDES permit. Sanitary wastewater would not be mixed with other plant effluents, but would be discharged to the City of Oak Ridge wastewater-treatment system (TVA 2017-TN4921, TVA 2017-TN4922).

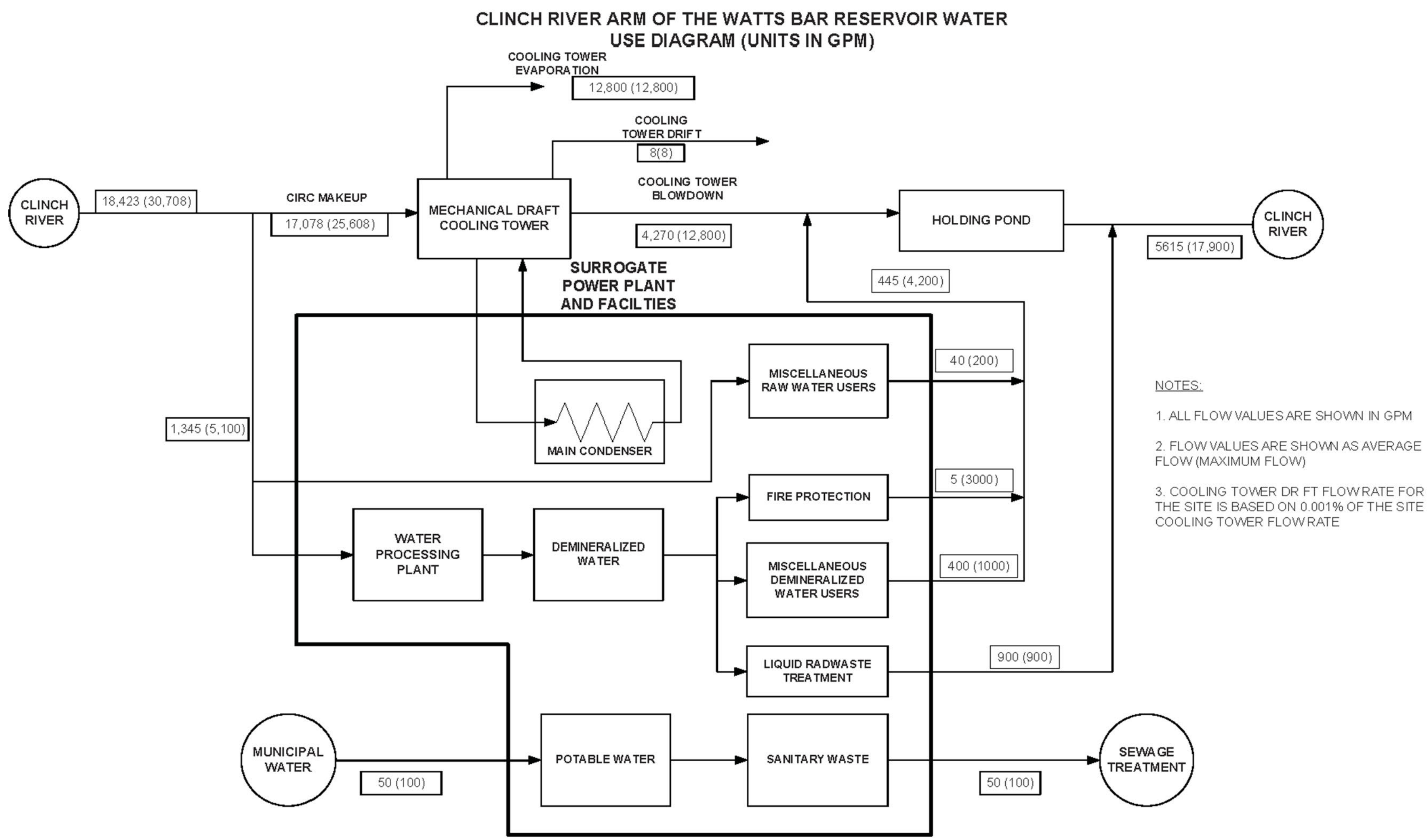
3.4.2.3 Other Environmental Interfaces during Operation

3.4.2.3.1 Water Systems Other Than CWS

Under normal operating conditions, 1,345 gpm would be diverted for plant water uses other than the CWS. Most of this water would be treated for use in plant systems that require demineralized water (Figure 3-7). Potable water would be supplied by the City of Oak Ridge; this municipal water would not be used for other plant systems. As noted above, potable and sanitary effluent discharges would be to the City of Oak Ridge wastewater-treatment system (TVA 2017-TN4921, TVA 2017-TN4922).

3.4.2.3.2 Melton Hill Dam Bypass

The Melton Hill Dam bypass flow system would be operated continuously during plant operations (TVA 2017-TN4921, TVA 2016-TN5008).



1 **Figure 3-7. Plant Water-Use Diagram (Source: TVA 2017-TN4921)**

3.4.2.3.3 Power Transmission System

Transmission lines and corridors are considered to interface with the environment during plant operation, because there are potential continuing impacts from electric fields, noise, and corridor inspection and maintenance. Regular inspection of the structures, insulators, and access areas would be performed by TVA using trucks and aircraft (either airplanes or helicopters). Corridor maintenance includes controlling woody vegetation and maintaining access roads. TVA has established procedures for maintenance of transmission line corridors using both chemical (herbicides or growth regulators) and mechanical (trimming, mowing, and hand-clearing) means of vegetation control. Growth regulators and herbicides would be required to be used in a manner that meets Federal, State, and local regulations (TVA 2013-TN4996).

3.4.3 Radioactive Waste-Management System

Liquid, gaseous, and solid radioactive waste-management systems would be used to collect and treat the radioactive materials produced as byproducts of operating SMRs on the CRN Site. These systems would process radioactive liquid, gaseous, and solid effluents to maintain their releases within regulatory limits and to levels as low as is reasonably achievable before releasing them to the environment. Waste processing systems would be designed to meet the design objectives of 10 CFR Part 50 (TN249), "Domestic Licensing of Production and Utilization Facilities," Appendix I ("Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion 'As Low as is Reasonably Achievable' for Radiological Material in Light-Water-Cooled Nuclear Power Reactor Effluents"), and 10 CFR Part 20 (TN283), "Standards for Protection Against Radiation."

Radioactive material in the reactor coolant is the primary source of gaseous, liquid, and solid radioactive wastes in light water reactors. Radioactive fission products build up within the fuel as a consequence of the fission process. These fission products are contained in the sealed fuel rods, but small quantities escape from the fuel rods and into the reactor coolant. Neutron activation of the primary coolant system is also responsible for coolant contamination and for induced radioactivity in reactor components.

TVA has not identified specific radioactive waste-management systems for SMRs on the CRN Site. The PPE concept was used to provide an upper bound on liquid radioactive effluents, gaseous radioactive effluents, and solid radioactive waste releases. Design information from each of the vendors was used to estimate PPE liquid and gaseous radioactive effluents. Bounding liquid and gaseous effluent releases per unit and per site are found in Tables 3.5-1 to 3.5-4 of the TVA ER (TVA 2017-TN4921). The bounding releases in these tables are a composite of all four reactor designs assuming the highest activity of any individual isotopes as provided by the SMR vendors.

Solid radioactive wastes produced by the operation of a new plant would be either dry or wet solids. The solid radioactive waste-management system would receive, collect, and store solid wastes before storing them onsite or shipping them offsite. The estimated bounding annual volume of radioactive solid waste is 5,000 ft^3 per year with an estimated bounding radioactive material activity of 57,200 Ci per year, as provided in TVA ER Section 3.5.3 (TVA 2017-TN4921).

3.4.4 Nonradioactive Waste-Management Systems

The following sections describe the nonradioactive waste-management systems proposed for the CRN Site, including systems for solid waste, liquid waste, gaseous waste, hazardous waste, and mixed waste.

3.4.4.1 Solid-Waste Management

Solid waste expected to be generated during building and operation activities at the proposed CRN Site would include nonhazardous nonradioactive wastes such as construction and demolition waste, wood, metal, paper, municipal solid waste, and debris collected on trash screens at the water-intake structure. TVA estimated that up to 290 tons per month of nonradioactive, nonhazardous waste could be generated during building and/or operation of a new plant at the CRN Site. This estimate was based on the average waste generated at the Watts Bar Nuclear (WBN) site during 3 years when WBN Unit 2 was under construction and WBN Unit 1 was operating. WBN Units 1 and 2 are larger reactors and require more personnel than would SMRs at the CRN Site (TVA 2017-TN4922). TVA stated that a waste-minimization program would be established (TVA 2017-TN4921), and that the standard procedures related to the management of nonradioactive solid waste that are used at other TVA plants would be implemented at the CRN Site. Solid waste would generally be managed by a solid-waste disposal vendor and disposed of at a State-approved sanitary landfill in accordance with TVA standard procedures. The applicant stated they would comply with all applicable Federal, State, and local requirements and standards for handling, transporting, and disposing of solid waste (TVA 2017-TN4921, TVA 2017-TN4922).

3.4.4.2 Liquid-Waste Management

Nonradioactive liquid effluents, such as surface water pumped from excavations and stormwater during construction, would ultimately be discharged to the Clinch River arm of Watts Bar Reservoir (TVA 2017-TN4921). Nonradioactive wastewater discharges during operations include cooling-tower blowdown; wastewater from the demineralized water system; wastewater from floor drains, sinks, and plant laboratories; and stormwater runoff (TVA 2017-TN4921). Estimates for chemical constituents present in cooling-tower blowdown are presented in Table 3-3. Additional liquid-waste streams may include raw cooling water, air-conditioning condensate, steam generator blowdown, and high-pressure fire protection water.

Most liquid-waste streams, with the exception of sanitary wastes and some stormwater discharges, would be routed to a holding pond on the western side of the CRN Site. This holding pond would serve as the collection point for most process waste streams and would discharge to the Clinch River arm of the Watts Bar Reservoir through one or more diffusers located at CRM 15.5. All wastewater discharges would be regulated by the Tennessee Department of Environment and Conservation (TDEC) under an NPDES permit, which would include discharge limits (for temperatures and chemical concentrations) established to protect receiving waters, and required monitoring to ensure compliance within those limits (TVA 2017-TN4921).

An existing stormwater-management system at the CRN Site consists of stormwater-retention ponds and piping that would be modified to support the project as needed. TVA would manage stormwater in accordance with a site-specific SWPPP, and BMPs would be implemented to control stormwater runoff. The stormwater-management system may include use of existing ponds and/or construction of one or more new ponds, depending on the facility configuration and the technology chosen. Stormwater management may include settling of solids, but would not involve any additional treatment, oil/water separators, or settling tanks (TVA 2017-TN4921).

Table 3-3. Projected Blowdown Constituents and Concentrations

Constituent	Maximum Potential Concentration (ppm)[(a)]
Chlorine demand	1,000
Free available chlorine	0.5
Chromium	--
Copper	6
Iron	3.5
Zinc	0.6
Phosphate	7.2
Sulfate	3,500
Oil and grease	< 10
Total dissolved solids	17,000
Total suspended solids	150
Biological Oxygen Demand, 5-day	< 5
Calcium	260
Magnesium	85
Sodium	990
Manganese	0.1
Alkalinity as $CaCO_3$	150
Nitrate (NO_3)	52
Silicon dioxide (SiO_2)	150
pH Range	7.5-8.5

(a) Assumes CWS operating at four cycles of concentration.

Source: TVA 2017-TN4921.

Water pumped from excavations during construction would also be managed through the stormwater-management system. Flow from de-watering would be routed to either an existing retention pond or to a new pond. The water would be managed under the same SWPPP and using the same BMPs as for stormwater (TVA 2017-TN4921).

Sanitary waste generated during both construction and operation would be conveyed to one of two City of Oak Ridge Public Works Department wastewater-treatment plants, both of which operate under TDEC NPDES permits. The expected effluent flow from the potable/sanitary water system is an average daily flow of 72,000 gpd, and a maximum daily flow of 144,000 gpd (TVA 2017-TN4921).

3.4.4.3 Gaseous Waste Management

Operation of SMRs emits nonradioactive gaseous and particulate emissions to the air primarily from cooling towers and auxiliary systems (i.e., auxiliary boilers, standby diesel generators, emergency standby gas turbine generators, or other engine-driven emergency equipment). Operation and testing of auxiliary systems would typically be intermittent and for short periods of time. Auxiliary boilers would be designed to exhaust at grade and would be used for heating buildings, primarily during the winter months, and for generating process steam during reactor startups. The standby diesel generators would be designed to exhaust at an elevation of 25 ft above grade. Emissions from emergency gas turbine generators would be discharged at a design elevation of 50 ft above grade. Estimated emissions for auxiliary boilers, standby diesel generators, and emergency standby gas turbines are provided in Table 3-4. Once a technology selection has been made for these systems, the applicant stated they would consult with TDEC about air permit requirements to ensure compliance (TVA 2017-TN4921).

Table 3-4. Projected Maximum Annual Emissions from Auxiliary Boilers, Standby Diesel Generators, and Gas Turbines

	Emissions (lb/yr)		
Pollutant	**Auxiliary Boilers[(a)]**	**Diesel Generators[(b)]**	**Gas Turbines[(c)]**
Particulates	7,700	281	Not Available
Sulfur oxides	41,575	Not Available	25
Carbon monoxide	5,930	3,124	584
Hydrocarbons	465	740	15
Nitrogen oxides	33,875	38,983	2,280

(a) Assumed one auxiliary boiler without "low NO_x" burners operating at 100 percent load; operation at startup, 36 d/yr or 864 hr/yr.
(b) Assumed generators operating at 100 percent load.
(c) Operating 4 hr/mo.

Source: TVA 2017-TN4921.

3.4.4.4 Hazardous- and Mixed-Waste Management

TVA maintains procedures for management of hazardous and mixed waste at their facilities, and any hazardous waste generated at the proposed CRN Site would be managed in accordance with the Resource Conservation and Recovery Act of 1976, as amended (RCRA) (42 U.S.C. § 6901 *et seq*.-TN1281) and the regulations under which the TDEC Hazardous Waste Management Program operates (TVA 2017-TN4921). The proposed CRN facility is expected to be a Small Quantity Generator of Hazardous Wastes. TVA maintains procedures for management of hazardous and mixed waste at their facilities, and these procedures would be followed for hazardous wastes generated at the CRN Site.

Small amounts of mixed waste (waste containing radioactive and nonradioactive material) would be generated during routine maintenance, refueling, radiochemical lab activities, and health protection activities. Although specific hazardous- and mixed-waste management practices, treatment methods, and storage areas have not been established for the CRN Site, industry standards and regulatory-compliant measures would be applied during all forms of handling hazardous and mixed wastes at the CRN Site. All hazardous and mixed waste would be shipped offsite for treatment and/or disposal at licensed facilities.

TVA would implement a waste-minimization plan for the CRN Site that would be similar to those developed for other TVA nuclear power facilities. BMPs that could be elements of a CRN waste-minimization plan could include (TVA 2017-TN4921) the following:

- Inventory identification and control that uses a tracking system to manage waste-generation data and waste-minimization opportunities.
- Work planning to reduce mixed-waste generation. (An example of work planning is pre-task planning to determine what materials and equipment are needed to perform the anticipated work.)
- Mixed-waste reduction, recycling, and reuse methods that maximize opportunities for reclamation and reuse of waste materials are used whenever feasible.
- Training and education of employees on the principles and benefits of waste minimization.

3.4.5 Summary of Resource Parameters during Operation

Table 3-5 sorts the plant parameter values by resource area for the project during its operation.

Table 3-5. Resource Parameters Associated with Operation of the Proposed Project

Resource Areas	Value	Parameter Description
Hydrology-Surface Water, Aquatic Ecology	18,423 gpm (41.0 cfs, 26.5 Mgd)	Normal water withdrawal rate
	30,708 gpm (68.4 cfs, 44.2 Mgd)	Maximum water withdrawal rate (from Clinch River arm of the Watts Bar Reservoir)
Hydrology-Surface Water, Meteorology-Air Quality	12,800 gpm	Normal and maximum CWS evaporation rate
Meteorology-Air Quality, Terrestrial Ecology	8 gpm	Normal and maximum CWS drift rate
Hydrology-Surface Water	12,808 gpm (28.5 cfs)	Normal and maximum consumptive-use rate
Hydrology-Surface Water, Aquatic Ecology	5,615 gpm (12.5 cfs)	Normal effluent discharge rate (90% cooling-tower blowdown)
	17,900 gpm (39.9 cfs)	Maximum effluent discharge rate (to Clinch River arm of the Watts Bar Reservoir)
Hydrology-Surface Water, Aquatic Ecology	90° F	Maximum blowdown temperature
Hydrology-Surface Water, Socioeconomics, Nonradioactive Waste	50 gpm	Normal demand for municipal water; normal discharge rate to municipal sewer
	100 gpm	Maximum demand for municipal water; maximum discharge rate to municipal sewer
Terrestrial Ecology, Meteorology-Air Quality	65 ft	CWS cooling-tower height
Terrestrial Ecology	160 ft	Tallest building height in power block
Socioeconomics, Transportation, Radiological Health, Nonradiological Health	500 workers	Normal operating workforce
	1,000 workers	Additional temporary workforce during refueling outages occurring every 2 years, lasting 30 to 60 days
Terrestrial Ecology, Nonradiological Health, Socioeconomics	70 dBA	Peak cooling-tower sound level 1,000 ft from towers
Uranium Fuel Cycle	2,420 MW(t)	Gross thermal output for site
Uranium Fuel Cycle, Transportation	800 MW(e)	Gross electrical output for site
Uranium Fuel Cycle, Transportation	90% to 98%	Expected SMR annual capacity factor

Sources: TVA 2017-TN4921 and TVA 2017-TN4922.

4.0 CONSTRUCTION IMPACTS AT THE PROPOSED SITE

This chapter examines the environmental issues associated with building two or more small modular reactors (SMRs) at the Clinch River Nuclear (CRN) Site as described in the application for an early site permit (ESP) submitted by the Tennessee Valley Authority (TVA) to the U.S. Nuclear Regulatory Commission (NRC). Although an ESP would not provide NRC authorization to conduct construction activities, as part of its application, TVA submitted (1) an Environmental Report (ER) (TVA 2016-TN4637), which discusses the environmental impacts of building, operating, and decommissioning two or more SMRs, and (2) a Site Safety Analysis Report (SSAR) (TVA 2017-TN5387), which addresses safety aspects of building and operating two or more SMRs.

As discussed in Section 3.3 of this draft environmental impact statement (EIS), the NRC authority related to building new nuclear units is limited to construction "activities that have a reasonable nexus to radiological health and safety and/or common defense and security" (72 FR 57416 -TN260). The NRC has defined "construction" within the context of its regulatory authority. Many of the activities required to build a nuclear power plant do not fall within the NRC regulatory authority and, therefore, are not "construction" as defined by the NRC. Such activities are referred to as "preconstruction" activities in Title 10 of the *Code of Federal Regulations* (CFR) 51.45(c) (TN250). The NRC staff evaluates the direct, indirect, and cumulative impacts of the construction activities that would be authorized if the holder of an ESP applied for and was issued a construction permit (CP) or a combined license (COL) for the site. The environmental effects of preconstruction activities (e.g., clearing and grading, excavation, and erection of support buildings) are included as part of this EIS in the evaluation of cumulative impacts.

Most proposed nuclear power plants require a permit from the U.S. Army Corps of Engineers (USACE), where impacts are proposed to waters of the United States, in addition to a license from the NRC. As described in Section 1.1.6 of this EIS, the USACE is a cooperating agency on this EIS consistent with the updated Memorandum of Understanding signed with the NRC (USACE and NRC 2008-TN637). The NRC and USACE established this cooperative agreement because both agencies concluded it is the most effective and efficient use of Federal resources in the environmental review of a proposed new nuclear power plant. The goal of this cooperative agreement is the development of one EIS that provides all the environmental information and analyses needed by the NRC to make a license/permit decision and all the information needed by the USACE to perform analyses, draw conclusions, and make a permit decision in the USACE Record of Decision documentation. To accomplish this goal, the environmental review described in this EIS was conducted by a joint NRC-USACE team. The review team was composed of the NRC staff and its contractors and staff from the USACE.

The USACE is responsible for ensuring that the information presented in this EIS is adequate to fulfill the requirements of the USACE regulations; the U.S. Environmental Protection Agency's (EPA's) 404(b)(1) "Guidelines for Specification of Disposal Sites for Dredged or Fill Material" (40 CFR Part 230-TN427), hereafter the 404(b)(1) Guidelines, which contain the substantive environmental criteria used by the USACE in evaluating discharges of dredged or fill material into waters of the United States; and the USACE public interest review process. If TVA submits a Department of the Army permit application at a future date, the USACE will decide whether to issue a permit based on an evaluation of the probable impact including cumulative impacts of the proposed activity on the public interest. By guidelines, no discharge of dredged or fill material shall be permitted if there is a practicable alternative to the proposed discharge that would have a less adverse impact on the aquatic ecosystem provided the alternative does not have other significant adverse consequences. That USACE decision will reflect the national concern for both protection and use of important resources. The benefit that reasonably may be expected to accrue from the proposal must be balanced against its reasonably foreseeable detriments. Factors that may be relevant to the proposal will be considered including the cumulative effects thereof; among those are conservation, economics, aesthetics, general environmental concerns, wetlands, historic and cultural resources, fish and wildlife values, flood hazards, floodplain values, land use, navigation, shore erosion and accretion, recreation, water supply, water quality, energy needs, safety, food and fiber production, mineral needs, considerations of property ownership, and, in general, the needs and welfare of the people.

Many of the impacts the USACE must address in its analysis are the result of preconstruction activities. Also, most of the activities conducted by a COL applicant that would require a permit from the USACE would be preconstruction activities. TVA plans to submit an application to the USACE for a permit to conduct the following activities: filling, dredging, grading, and building structures.

While both the NRC and the USACE must meet NEPA requirements (42 U.S.C. § 4321 et seq. - TN661), both agencies also have mission requirements that must be met in addition to the NEPA requirements. The NRC regulatory authority is based on the Atomic Energy Act of 1954, as amended (42 U.S.C. § 2011 et seq.-TN663). The USACE regulatory authority related to the proposed project is based on Section 10 of the Rivers and Harbors Appropriations Act of 1899 (33 U.S.C. § 401 et seq.-TN660), which prohibits the obstruction or alteration of navigable waters of the United States without a permit from the USACE, and Section 404 of the Clean Water Act (CWA, 33 U.S.C. § 1344-TN1019), which prohibits the discharge of dredged or fill material into waters of the United States without a permit from the USACE. Therefore, the applicant may not commence preconstruction or construction activities in jurisdictional waters, including wetlands, without a USACE permit. The USACE will complete its evaluation of the proposed project after it fully considers the recommendations of the USACE staff; Federal, State, and local resource agencies; and members of the public and assesses the cumulative impact of the total project and after the following consultations and coordination efforts are completed: Section 106 of the National Historic Preservation Act (54 U.S.C. § 300101 et seq.-TN4157), including, as appropriate, development and implementation of any Memoranda of Agreement; the Endangered Species Act of 1973 (16 U.S.C. § 1531 et seq.-TN1010); State forest conservation plans; and State water-quality certifications.

The collaborative effort between the NRC and the USACE in presenting the discussion of the environmental effects of building two or more SMRs at the CRN Site, in this chapter and elsewhere, must serve the needs of both agencies. Consistent with the Memorandum of Understanding, the NRC and USACE staffs collaborated in the (1) review of the ESP application and information provided in response to requests for additional information (developed by the NRC and the USACE) and (2) development of this EIS. The NRC regulations (10 CFR 51.45(c) [TN250]) require that the impacts of preconstruction activities be addressed by the applicant as cumulative impacts in its ER. Similarly, the NRC analysis of the environmental effects of preconstruction activities on each resource area would be addressed as cumulative impacts, normally presented in Chapter 7 of the EIS. However, because of the collaborative effort between the NRC and the USACE in the environmental review, the combined impacts of construction activities that require NRC approval, and preconstruction activities associated with the project are presented in this chapter. For each resource area, the NRC also provides an impact characterization solely for construction activities that meet the NRC definition of construction at 10 CFR 50.10(a) (TN249). The combined impacts of construction and preconstruction activities are also considered in the description and assessment of cumulative impacts in Chapter 7 of this EIS.

For some environmental resource areas (e.g., socioeconomics), the impacts are not solely the result of either preconstruction or construction activities. Rather, the impacts are attributable to a combination of construction and preconstruction activities. For most resource areas, the majority of the impacts would occur as a result of preconstruction activities.

This chapter is divided into 12 sections. In Sections 4.1 through 4.11, the review team evaluates the potential impacts on land use, water use and quality, terrestrial and aquatic ecosystems, socioeconomics, environmental justice, historic and cultural resources, meteorology and air quality, nonradiological health effects, radiological health effects, nonradioactive waste, and applicable measures and controls that would limit the adverse impacts of building a new nuclear power plant. An impact category level—SMALL, MODERATE, or LARGE—of potential adverse impacts has been assigned by the review team for each resource area using the definitions for these terms established in Chapter 1 of this EIS. In some resource areas, for example, in the socioeconomic area where the impacts of taxes are analyzed, the impacts may be considered beneficial and would be stated as such. The review team determination of the impact category levels is based on the assumption that the mitigation measures identified in the ER or activities planned by various State and county governments, such as infrastructure upgrades (discussed throughout this chapter), would be implemented. Failure to implement these upgrades might result in a change in the impact category level. Possible mitigation of adverse impacts, where appropriate, is presented in Section 4.11. A summary of the construction impacts is presented in Section 4.12. The technical analyses provided in this chapter support the results, conclusions, and recommendations presented in Chapters 7, 9, and 10 of this EIS.

4.1 Land-Use Impacts

This section provides information about land-use impacts associated with construction and preconstruction of the project at the CRN Site. Topics discussed in this section include land-use impacts at the CRN Site and in the site vicinity (EIS Section 4.1.1) and at offsite areas where TVA proposes various offsite transmission line reconductoring, uprating, and rebuilding activities needed for the grid to handle power generated by the new reactors (EIS Section 4.1.2).

4.1.1 Site and Vicinity

As discussed in Section 2.2.1 of this draft EIS, TVA's property includes approximately 1,200 ac, of which TVA has identified approximately 935 ac as the CRN Site. The proposed project would not encroach into the remainder of the TVA property, which comprises the Grassy Creek Habitat Protection Area. Elements of the proposed project would extend into the barge/traffic area (BTA), including highway interchange improvements, rail spur refurbishments, barge slip improvements, and rebuilding a site access road connecting local highways and rail facilities with the CRN Site. Impacts of building a 69-kV underground transmission line from the CRN Site to the Bethel Valley Substation on the U.S. Department of Energy (DOE) Oak Ridge Reservation (ORR) are also discussed in this section.

Land-use impacts associated with building the project on the CRN Site would result from land disturbance and changes in land use during both construction and preconstruction activities. Preconstruction activities would include clearing, grubbing, grading and excavating, stockpiling soils, and onsite disposal of construction-related debris. Materials excavated on the CRN Site would be stockpiled and/or used as fill onsite. TVA expects to construct and operate an onsite landfill for construction, site clearing, and grading debris. The landfill would be sized to accommodate the anticipated materials and would be located in the permanently cleared laydown area north of the main plant area. TVA has stated (TVA 2017-TN4921) that the landfill would be constructed in accordance with relevant permits and licenses. No hazardous or municipal waste would be disposed of in this landfill. The landfill would be closed at the end of the construction period (TVA 2017-TN4921). Construction for safety-related structures, systems, or components is discussed in more detail in Chapter 3 in this EIS, but would include driving piles; subsurface preparation; placing backfill, concrete, or permanent retaining walls within an excavation; installing foundations; or assembling, erecting, fabricating, or testing those structures in place.

As described by TVA, the anticipated construction and preconstruction activities would disturb approximately 494 ac on the CRN Site and 45 ac in the BTA, for a total footprint of approximately 539 ac. Of this, approximately 357 ac would be permanently disturbed to support developed or industrial land uses (including approximately 327 ac on the CRN Site and 30 ac for transportation improvements in the BTA), and approximately 182 ac would be temporarily disturbed for laydown and other temporary construction areas (approximately 167 ac on the CRN Site and 15 ac for the nearby barge facilities) (TVA 2017-TN4921).

The 494 ac that would be disturbed on the CRN Site includes approximately 303 ac identified as forest land, approximately 19 ac identified as woody wetlands, and the remainder as non-forest vegetation, water, or as previously developed (Table 4-1 and Figure 4-1 and Figure 4-2). Actually, no land on the CRN Site is currently developed; most of the land identified as other than forest comprises land previously disturbed in the 1980s to build the unfinished Clinch River Breeder Reactor Project (CRBRP) and was subsequently redressed and allowed to become revegetated (DOE et al. 1984-TN5221). Figure 4-1 identifies a few small areas on the CRN Site as “developed”, but these are unpaved roadways or other lightly vegetated areas are are not truly developed areas.

Additional land-use changes are expected in the BTA. Land would be cleared for building new highway access ramps for State Route (SR) 58 to facilitate site access for the expected construction workforce and related heavy truck deliveries. Bear Creek Road would be improved to handle heavy loads, and nearby barge and rail loading/unloading facilities would be refurbished and possibly expanded (TVA 2017-TN4921). TVA anticipates that approximately 30 ac of land, mostly forest and open spaces at the edges of roadways, would be permanently altered by roadway improvements and barge-landing refurbishment, and approximately 15 ac would be temporarily altered from these activities. The specific land-use impacts from these activities also are summarized in Table 4-1. Note that Table 4-1 is based on an overlay of the footprint of disturbance provided by TVA in their application (TVA 2017-TN4921) over the existing land-cover data presented in EIS Section 2.2.1, which are updated data superior to the existing land-cover data presented by TVA in the application.

Approximately 182 ac on the CRN Site and BTA would be temporarily disturbed during construction for use as laydown areas for staging materials, assembling project components, and installation of the onsite portion of the 69-kV underground transmission line. These areas would be cleared and graded. As described in EIS Section 4.1.1, TVA anticipates being able to revegetate temporarily cleared areas with native vegetation and allowing natural succession to take hold and return the areas to forested cover (TVA 2017-TN4921).

Table 4-1. Land-Use Changes as a Result of Construction and Preconstruction Activities on the CRN Site

Land Cover	CRN Site						Barge/Traffic Area					
	Permanent (ac)	(%)	Temporary (ac)	(%)	Total (ac)	(%)	Permanent (ac)	(%)	Temporary (ac)	(%)	Total (ac)	(%)
Barren	3.2	1.0	1.3	0.8	4.6	0.9	0.0	–	0.0	–	0.0	–
Deciduous Forest	132.3	40.5	112.5	67.4	244.8	49.6	9.0	29.9	9.0	60.0	18.0	39.9
Evergreen Forest	19.1	5.8	15.2	9.1	34.2	6.9	0.2	0.8	0.4	2.9	0.7	1.5
Mixed Forest	11.5	3.5	12.7	7.6	24.2	4.9	0.0	–	0.0	–	0.0	–
Grass/Hay	99.6	30.5	16.5	9.9	116.1	23.5	2.8	9.4	0.9	5.7	3.7	8.2
Shrubland	5.6	1.7	2.7	1.6	8.3	1.7	0.0	–	0.0	–	0.0	–
Woody Wetlands	14.5	4.4	4.7	2.8	19.2	3.9	0.2	0.8	0.9	5.7	1.1	2.4
Developed/Open Space	16.5	5.0	0.0	–	16.5	3.3	4.3	14.2	1.3	8.6	5.5	12.3
Developed/Low Intensity	15.6	4.8	0.9	0.5	16.5	3.3	6.6	22.0	1.3	8.6	7.9	17.6
Developed/Med Intensity	3.5	1.1	0.0	–	3.5	0.7	6.6	22.0	1.3	8.6	7.9	17.6
Developed/High Intensity	0.4	0.1	0.0	–	0.4	0.1	0.0	–	0.0	–	0.0	–
Open Space	4.5	1.4	0.0	–	4.5	0.9	0.0	–	0.0	–	0.0	–
Open Water	0.6	0.2	0.4	0.3	1.1	0.2	0.2	0.8	0.0	–	0.2	0.5
Totals	327.0	100.0	167.0	100.0	494.0	100.0	30.0	100.0	15.0	100.0	45.0	100.0

Source: National Agricultural Statistics Service (NASS 2017-TN5144).

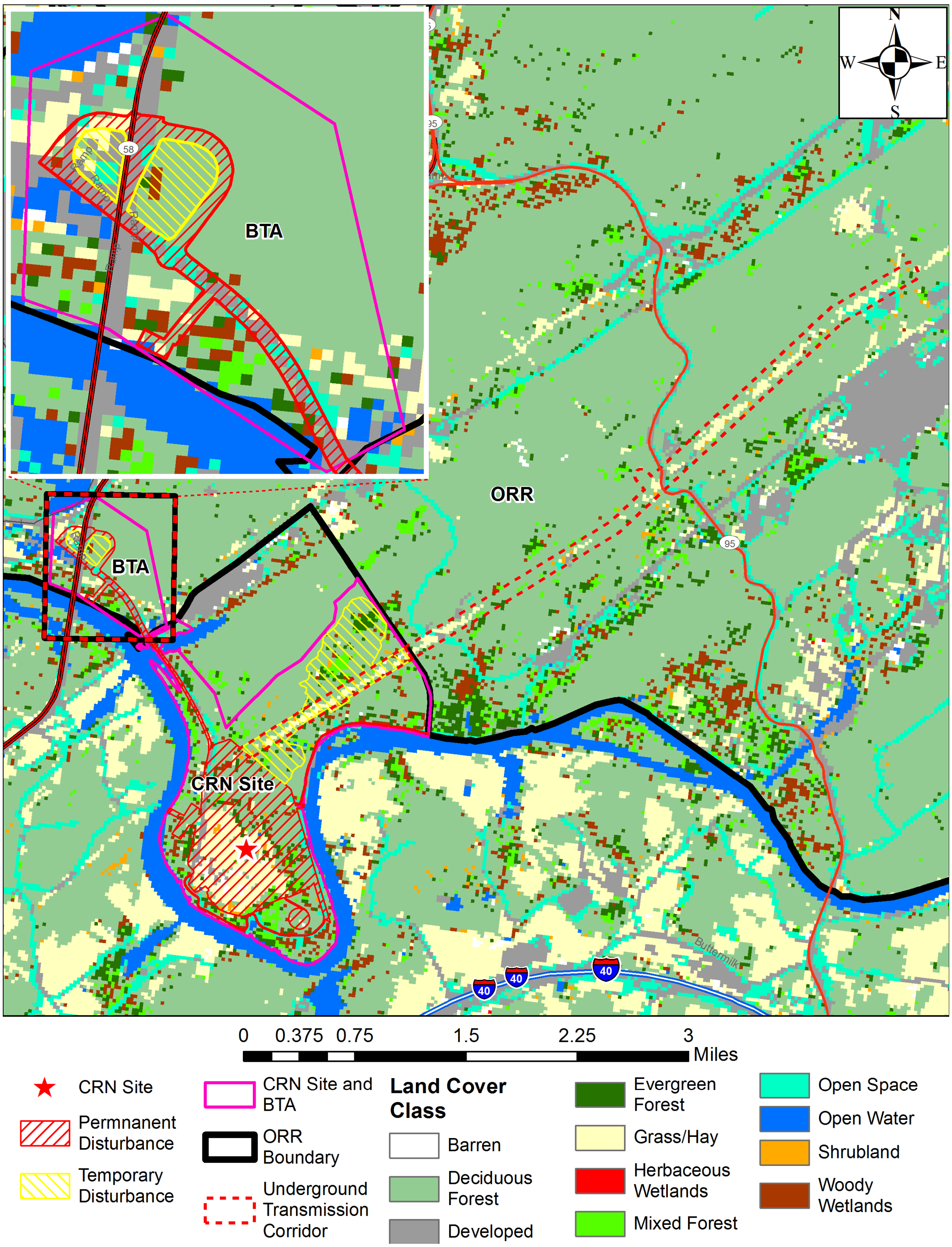


Figure 4-1. Construction and Preconstruction Impacts on Land Use/Land Cover at the CRN Site (land-use data from NASS 2017-TN5144)

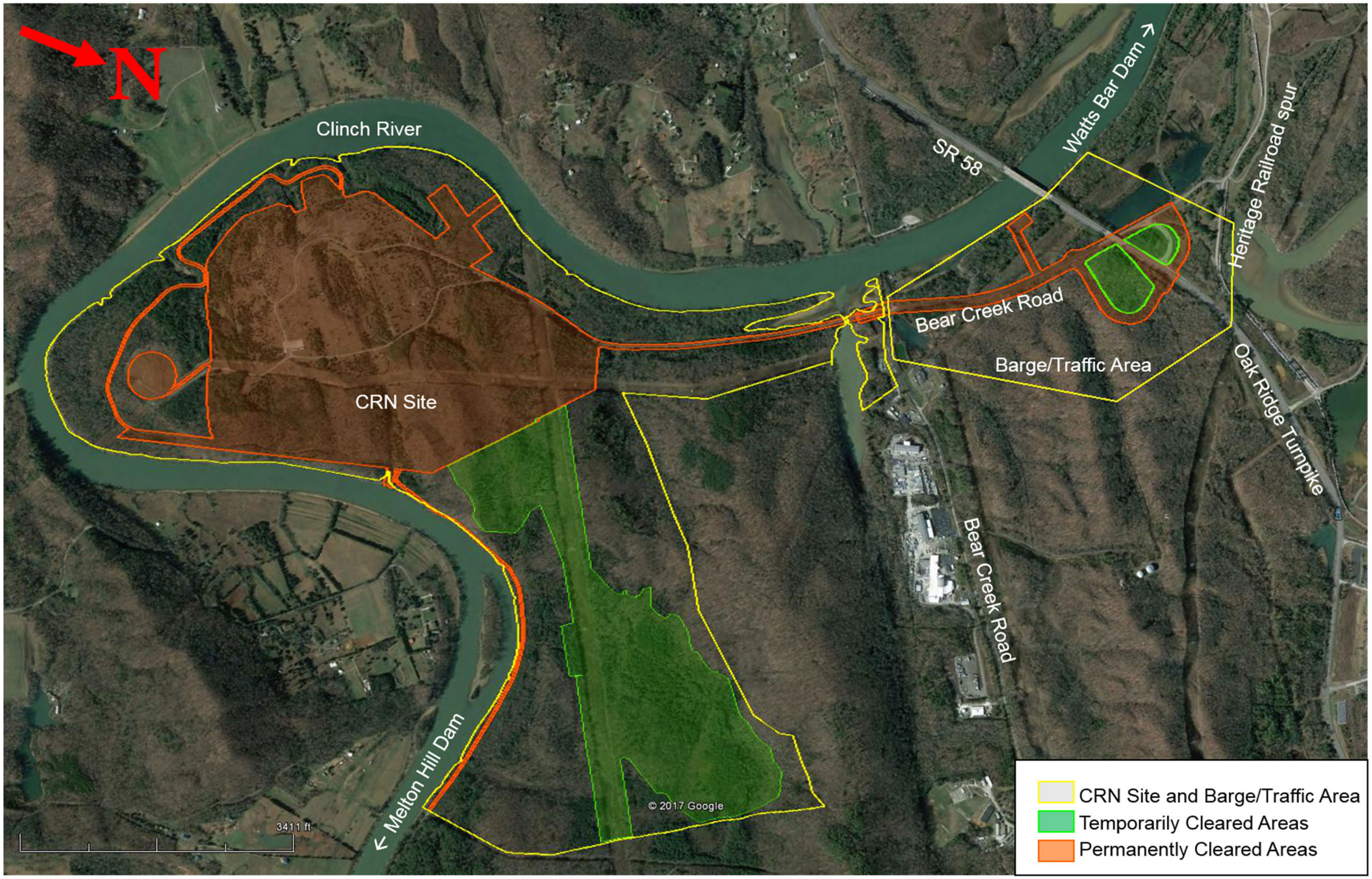


Figure 4-2. Aerial Overview of Expected Land-Use Impacts of Construction and Preconstruction at the CRN Site (Google Earth image captured 3/7/2017)

Overall, the land-use impacts of building a new nuclear power plant on the CRN Site would be sufficient to alter noticeably, but not to destabilize, important attributes of existing land uses on and surrounding the site. Part of the land disturbance would be temporary, and the land would revegetate once construction and preconstruction activities were completed. Years or decades would be required to return the temporarily cleared lands to their current state of vegetation, although the land could again be suitable for some of its existing recreational uses even before natural forest vegetation could reestablish. Permanent disturbance including land-cover classification changes from natural vegetation to developed industrial use would occur on approximately 357 ac of the site and BTA, as the proposed facilities would be constructed. TVA indicates that best management practices (BMPs) would be used and that established procedures would comply with all relevant land-use regulations (TVA 2017-TN4922).

In Section 2.2.1 of this draft EIS, the review team identified prime farmland as being present at the CRN Site. TVA completed a Farmland Conversion Impact Rating (Form AD-1006) in consultation with the U.S. Department of Agriculture's Natural Resources Conservation Service to quantify the potential impacts on prime farmland (TVA 2017-TN4921). The impact rating score considers the acreage of prime farmland to be converted, the relative abundance of prime farmland in the surrounding county, and other criteria such as distance from urban support services and builtup areas, potential effects of conversion on the local agricultural economy, and compatibility with existing agricultural use. Based on the U.S. Department of Agriculture form, loss of sites with a total score of at least 160 has the potential to adversely affect prime farmland. The impact rating score for the CRN Site was 102 points (TVA 2017-TN4921). Because the impact score was below the threshold for adverse impacts on prime farmland, the review team concludes that no noticeable impacts on prime farmland would result from the proposed project.

As noted in TVA's ER, there are no known commercial mineral resources on the CRN Site, in the BTA, or in nearby areas of the ORR whose exploitation could be adversely affected by building the proposed facilities (TVA 2017-TN4921). The CRN Site and BTA are situated in the City of Oak Ridge, but comprise only Federal land to which City of Oak Ridge zoning ordinances do not apply (City of Oak Ridge 2013-TN4999). TVA has designated most of the CRN Site as Zone 2 – Project Operations, but has designated a narrow strip of low-lying land along the reservoir shoreline as Zone 3 – Sensitive Resource Management. Nearly all of the land potentially disturbed by proposed project activities lies in Zone 2 and is therefore compatible. However, the intake and discharge structures would have to be built in Zone 3 to access the reservoir, and pipelines connecting to those structures would have to traverse narrow strips of land crossing Zone 3. The review team believes that these encroachments into Zone 3 would be too small (less than 5 ac) to adversely affect the conservation purposes inherent in the Zone 3 designation.

A minor intrusion into the Clinch River 100-year floodplain would be disturbed by clearing and grading activities necessary to building the proposed intake and blowdown structures, and installing the makeup and blowdown lines. Most impacts would be temporary, except for building and operating the CRN plant intake and discharge structures. The review team therefore expects that less than 5 ac of land in the floodplain would be permanently disturbed. Current City of Oak Ridge ordinances regarding floodplain construction (City of Oak Ridge 2013-TN4999) would be followed to minimize impacts (TVA 2017-TN4922).

As indicated by the above discussion, the review team believes that the area of land on the CRN Site that would have to be dedicated to the project is noticeable, but that impacts on other land-use issues such as zoning, prime farmlands, and floodplains would be minimal. Impacts on wetlands are addressed as part of terrestrial ecology in EIS Section 4.3.1.

4.1.2 Offsite Areas

Building the proposed units at the CRN Site would potentially require upgrades (in the form of rebuilds, uprates, or re-conductoring of portions of TVA's transmission system. TVA has identified multiple specific transmission line corridor segments that could require upgrades (see Figure 2-9). TVA has identified one transmission corridor segment in the northern suburbs of Knoxville for a possible rebuild of the towers and conductors (TVA 2017-TN4921). For that transmission line corridor segment (approximately 12.7 mi long), the activities of vegetation clearing and installation of new towers, including hardened footings, would be locally noticeable, but of short duration. These activities would take place entirely within existing transmission line corridors previously disturbed to install the existing transmission lines (TVA 2017-TN4921). Access across this right-of-way while rebuild work is taking place could be temporarily disrupted for brief periods.

TVA also anticipates uprating an additional 215 mi of transmission line corridor and uprating or reconductoring another 212 mi of corridor (Table 2-2). The effects of these activities on the land surface would be similar to normal line maintenance activities, which cause only minimal or no ground disturbance. Personnel, vehicles, and equipment used to uprate and/or reconductor transmission lines would be present for only temporary periods. Work would be carried out entirely within existing right-of-ways and would follow established procedures and BMPs to avoid land-use impacts (TVA 2017-TN4921, TVA 2017-TN4922). Land-use impacts from potential improvements to the affected transmission line corridors including uprating and reconductoring would be minor and of short duration.

The review team considered TVA's anticipated transmission line impacts to be representative of general land-use impacts that would be expected from such upgrade activities. TVA has not identified the specific upgrades that would be necessary (TVA 2017-TN4921). Thus, the specific land-use impacts expected from the actual required upgrades may need to be revisited at the COL application stage.

In general, the review team expects that none of the possible transmission line rebuild, uprate, or reconductoring activities would substantially conflict with adjoining land uses. None of the affected transmission line corridors are in the coastal zone. None traverse any National Parks, forests, or wildlife refuges, Tribal lands, or wild or scenic rivers. One potentially affected line terminates at a substation located within Rock Island State Park. The review team expects that uprating and reconductoring activities anticipated for corridors crossing park lands would be conducted using TVA's BMPs for transmission line work and would be consistent with relevant park management plans. Some work may have to be conducted in floodplains where the affected right-of-ways cross rivers and streams, but would not likely alter the ground surface properties or flood flow patterns. The review team concludes that overall the offsite transmission line upgrades would not have more than minor land-use impacts. Potential impacts on wetlands are discussed in EIS Section 4.3.1.2.

4.1.3 Summary of Land-Use Impacts

The review team concludes that noticeable land-use impacts from construction and preconstruction would result from the proposed project, primarily because of the conversion of substantial areas of undeveloped naturally vegetated land to a developed condition, and because of the long-term dedication of a 935-ac tract of Federally owned land in an industrial setting that would have otherwise been available for other industrial or urban uses. The review team's conclusion also reflects noticeable land-use impacts from highway interchange reconstruction in the BTA, as well as brief but locally noticeable land-use impacts from rebuilding a 12.7-mi transmission line segment, especially where the right-of-way traverses residential landscapes. However, because the changes would take place in an area where energy generation and development projects are common and would not be incompatible with existing land uses, and because the changes would not substantially interfere with anticipated regional growth, the review team does not believe that the land-use impacts would be destabilizing to land resources in the region.

Based on the information provided by TVA and the review team's independent review, the review team concludes that the combined land-use impacts would be MODERATE. Because the land-use impacts specifically attributable to NRC-authorized construction activities would contribute to the changes to existing land uses for the expected license period, the NRC staff concludes that the land-use impacts of the NRC-authorized construction also would be MODERATE.

4.2 Water-Related Impacts

Water-related impacts associated with building a nuclear plant on the CRN Site are similar to impacts that would be associated with the development of any large industrial site. Prior to initiating onsite activities, including any site preparation work, TVA would be required to obtain the appropriate authorizations regulating alterations to the hydrologic environment. These authorizations would likely include, but not be limited to, the following:

- Section 404 of the Clean Water Act (33 U.S.C. § 1251 *et seq*.-TN662). This permit would be issued by the USACE, which governs discharge of dredged and/or fill material into waters of the United States.
- Section 10 of the Rivers and Harbors Appropriation Act of 1899 (33 U.S.C. § 401 *et seq*.-TN660) Permit. This permit would be issued by the USACE to regulate any structure or work in, over, under, or affecting waters of the United States (e.g., construction and maintenance of intake and discharge structures in navigable waters of the Clinch River arm of the Watts Bar Reservoir).
- Clean Water Act Section 401 Water Quality Certification (33 U.S.C. § 1251 *et seq*.-TN662). This certification is issued by the Tennessee Department of Environment and Conservation (TDEC) and ensures that the project does not conflict with State and Federal water-quality management programs.
- Clean Water Act (33 U.S.C. § 1251 *et seq*.-TN662) Section 402(p) National Pollutant Discharge Elimination System (NPDES) Permit. This permit would regulate limits of pollutants in liquid discharges to surface water. The EPA has delegated the authority for administering the NPDES program in the State of Tennessee to the TDEC. An erosion and sediment control plan would be required as part of the NPDES permit.
- Water Quality Control Act (T.C.A. § 69-3-101 *et seq*.-TN4914) Aquatic Resource Alteration Permit. This permit is issued by the TDEC to authorize physical alterations to waters of the state (stream, river, lake, or wetland), e.g., dredging or excavation, bank stabilization, water diversions or withdrawals, flooding or draining/filling a wetland. This permit would be part of the TDEC 401 Certification (above).

- Ports and Waterways Safety Act (33 U.S.C. § 1221 *et seq*.-TN4314) Private Aids to Navigation Permit. This permit is issued by the U.S. Coast Guard; it would be needed for construction of the discharge pipeline into navigable waters.
- Spill Prevention, Control and Countermeasures rule (40 CFR Part 112-TN1041), Appendix F, Sections 1.2.1 and 1.2.2, and EPA Facility Response Plan (40 CFR Part 9-TN5322 and 40 CFR Part 112-TN1041), and the EPA Hazardous Waste Contingency Plan. These regulations require pollution prevention and response plans for spills of oil and other hazardous materials. TVA would develop an Integrated Pollution Prevention Plan (IPPP) to implement these regulations.
- Water and sewer connection permits typically issued by a city, county, or municipal district. A DOE permit may be needed if construction along Bear Creek Road is required for an upgrade to the wastewater-treatment plant pumping facility.

Additional detail regarding the items listed above is contained in Appendix H of this EIS (Volume 2).

Section 4.2.1 discusses the expected hydrologic alterations in surface water and groundwater related to building a nuclear reactor on the CRN Site. Sections 4.2.2.1 and 4.2.2.2 discuss water-use impacts from building activities for surface water and groundwater, respectively. Sections 4.2.3.1 and 4.2.3.2 discuss water-quality impacts from building activities for surface water and groundwater, respectively. Section 4.2.4 discusses water monitoring during plant building. These sections draw on information presented in Section 2.3 of this EIS and TVA's ER (TVA 2017-TN4921).

4.2.1 Hydrologic Alterations

This section (1) identifies and describes proposed building activities, including site preparation, onsite activities, and offsite activities that could result in hydrologic alterations; (2) describes and analyzes the resulting hydrologic alterations and the physical effects of these alterations; (3) analyzes the practices proposed to minimize hydrologic alterations having adverse impacts; and (4) assesses compliance with applicable standards and regulations.

Activities associated with building at the CRN Site are described in detail in Section 3.3 of this draft EIS. Activities that could produce hydrologic alterations include the following:

- clearing and grading at the project site and building infrastructure (e.g., roads, laydown areas, parking lots, and stormwater-conveyance and -retention systems)
- building and refurbishing transportation corridors in the vicinity of the site (e.g., highway interchanges, barge-unloading area, main plant access road)
- building new structures at the site (e.g., power-block structures, cooling towers, switchyard, and subgrade piping and systems)
- installation of a 5-mi-long underground 69-kV transmission line from the CRN Site to Bethel Valley Substation, and various offsite transmission system uprates and upgrades
- installing pipelines from the intake structure to the cooling towers and from the cooling towers to the holding pond and discharge structure
- excavating the nearshore area of the Clinch River arm of the Watts Bar Reservoir for the cooling-water-intake structure forebay and building the intake structure on the shoreline

- excavating a holding pond between the main plant area and the Clinch River arm of the Watts Bar Reservoir shoreline, excavating the nearshore area for the blowdown discharge line, and placing the diffuser in the river
- excavation dewatering for construction of the nuclear island
- installation of a flow bypass system at the Melton Hill Dam.

Groundwater is expected to be affected by surface modifications that alter the rate and spatial distribution of local recharge, and by excavation dewatering.

4.2.1.1 Surface Water

Building activities would affect surface waterbodies on and near the CRN Site, including the Clinch River arm of the Watts Bar Reservoir, Grassy Creek, and small streams and ponds on the CRN Site, in the BTA, and in the transmission line right-of-way (Figure 2-19).

4.2.1.1.1 Small Streams and Ponds

About 494 ac onsite and 45 ac in the BTA would be affected during development of the project. This includes clearing and grading land for buildings, roads, parking lots, and laydown areas; shallow excavation and backfilling for pipeline and structure placement, as well as for installing the new 69-kV underground transmission line; and completion of other plant facilities such as the discharge holding pond. These building activities would affect a number of ponds, streams and wetlands on the CRN Site, the BTA, and the existing offsite transmission corridor, as described in EIS Section 4.3. The six small ponds on the CRN Site were constructed for stormwater management purposes. Two of these ponds would be filled and graded during building (TVA 2017-TN4921).

A perennial stream in the area of the CRN Site intake structure (S01 in Figure 2-19) would be filled as part of building the intake structure and the associated pipeline (TVA 2017-TN4921). Two small intermittent streams in the BTA would be affected by building activities: Stream S09 (see Figure 2-19) would be temporarily affected by road improvements, and Stream S10 (Figure 2-19) would be filled. Alterations to these streams are expected to be subject to USACE jurisdiction (TVA 2017-TN4921). Six ephemeral streams on the CRN Site and six ephemeral streams in the BTA are expected to be filled during building activities. Alterations to existing streams would affect runoff from the streams' drainage areas. Runoff from the affected areas would be managed as part of the CRN Site stormwater-management requirements (discussed in the following section), and would be subject to TDEC permitting.

Effects on streams crossed by the installation of the new 69-kV underground transmission line are expected to be temporary because the stream bed would only be affected during the time required to install the line across it. In addition, the effects would be localized to the small area required for the trench itself and for the excavation equipment. The review team expects that these building activities will be subject to USACE and TDEC permitting.

Impacts on wetlands are described in Section 4.3.1 of this chapter.

4.2.1.1.2 Clinch River

During building activities, the power block and other structures for a new plant would be located in the central portion of the CRN Site, with drainage directed away from the facilities.

Modifications to the land surface made during building activities would alter the local hydrology and site drainage. The CRN Site land surface would be developed to include surface-water drainage ditches and stormwater-retention ponds to handle stormwater flows and allow suspended solids to settle prior to being discharged to the Clinch River arm of Watts Bar Reservoir. These land-surface modifications would alter surface-water runoff flow patterns and the infiltration properties of the land surface. Runoff would increase by replacing vegetated surfaces with buildings and relatively impervious ground surface. Although a detailed design of the stormwater management system has not been determined, a stormwater pollution prevention plan (SWPPP) would be in place for erosion protection and stormwater management. A SWPPP would be required to meet TDEC stormwater NPDES permit discharge requirements (TVA 2017-TN4921). Stormwater runoff from the CRN Site would be controlled via engineered structures, collected in engineered retention ponds, and infiltrated to the ground, or released to the Clinch River in a controlled manner. The SWPPP would incorporate BMPs to minimize erosion and stabilize the land surface (TVA 2017-TN4921). BMPs would include methods described in the State of Tennessee Erosion and Sediment Control Handbook (TDEC 2012-TN4889). These plans and controls are a requirement for obtaining an NPDES construction stormwater permit. TVA would obtain the required NPDES permit prior to any building activities at the site (TVA 2017-TN4921).

Stormwater runoff from the CRN Site during building would drain primarily to the Clinch River arm of the Watts Bar Reservoir. Clinch River flows at the CRN Site result from drainage over a large basin (approximately 3,400 mi^2), of which the CRN Site area is a very small fraction (less than 0.1 percent). Because of this, any alteration in runoff at the CRN Site is not expected to noticeably affect the hydrologic conditions in the Clinch River arm of the Watts Bar Reservoir. Because CRN Site runoff would be a small fraction of Clinch River flow at the site, and stormwater would be managed in accordance with the NPDES permit and BMPs would be used during building activities, the review team concludes that the quantity and quality of the runoff due to land-surface modifications at the CRN Site would have minor effects on the Clinch River.

Building the intake and discharge structures would not require any dredging of Clinch River sediments, but would require some nearshore underwater excavation. These activities will produce temporary and localized effects on patterns of river flows in the immediate area of the building activities. Therefore, the review team determined that the effects of building activities on Clinch River flows would be minor. Excavation activities are anticipated to produce a temporary, localized degradation in water quality due to the disturbance of sediment. Intake structure and discharge pipeline/diffuser installation, and any associated excavation would comply with USACE and TDEC permit requirements and with procedures of the Watts Bar Interagency Working Group agreement, intended to ensure protection of the water resource and the proper disposition of sediments (TVA 2017-TN4922). TVA stated that the interagency agreement could require the use of BMPs (such as silt fences or cofferdams) to contain and control sediments, and may require additional restrictions based on the characteristics of the sediments at the site (TVA 2017-TN4922). In addition, TVA stated that excavated materials would be sampled and characterized for hazardous and radioactive contamination, and properly disposed of based on the results of this analysis and according to any applicable State and Federal requirements for managing such materials (TVA 2017-TN4922). Because the building activities for the intake and discharge structures would be localized and temporary, and would comply with applicable permit requirements, the review team determined that effects on Clinch River water quality would be minor.

4.2.1.1.3 Floodplains

TVA identified areas of the CRN Site subject to inundation during flooding using the flood insurance rate maps provided by the U.S. Federal Emergency Management Agency. Flooding potential in the Clinch River along the CRN Site exists up to an elevation of 752 ft (North American Vertical Datum of 1988 [NAVD88]), which generally limits the floodplain to land close to the river except where tributary streams exist and in the BTA (TVA 2017-TN4922). As shown in Figure 2-5, CRN Site building activities would be conducted outside the floodplain, with the exception of small areas of the floodplain that would be affected by building the intake and discharge structures and pipelines, and the BTA transportation corridor (TVA 2017-TN4922). Because the floodplain area that would be altered during building activities is a minor fraction of the existing floodplain in the CRN Site area, the review team concludes that the effects of this alteration on the capacity of the floodplain would be minor.

4.2.1.2 Groundwater

Land-surface modifications would result in local alterations to groundwater recharge, in particular a reduction in recharge where vegetated surfaces are replaced by buildings and paved surfaces, and a potential increase in recharge from stormwater-retention ponds or cleared areas where forest cover was converted to grassland or shrubby vegetation. These activities are expected to noticeably alter the spatial and temporal pattern of infiltration and recharge and groundwater flow directions in the shallow aquifers on the site. However, effects on infiltration, recharge, and groundwater flow would be negligible off the CRN Site.

Building the main plant facilities would require excavation of the surface fill, residuum, and weathered rock to reach competent bedrock on which foundations can be placed. After building is completed, groundwater hydrology is expected to be altered within the excavations by the placement of fill materials that have hydraulic properties different than the native materials removed during excavation. The review team expects that the fill would have a minor and localized effect on groundwater flow directions in the immediate vicinity of the excavations.

Power-block excavation may extend to a depth of about 140 ft bgs, to an elevation of 683 ft NAVD88 (TVA 2017-TN5387). At this depth, the bottom of the excavation would be about 40 ft below the bed of the Clinch River at the CRN Site. Because the groundwater at the CRN Site is in communication with the Clinch River (as described in EIS Section 2.3), dewatering of the power-block excavation is expected to be required. TVA anticipates that dewatering would be accomplished using a gravity-type system: water that drains into the excavation under gravity would be collected at the bottom of the excavation and pumped out to a stormwater-retention basin for eventual infiltration or discharge to the Clinch River (TVA 2017-TN5387, TVA 2017-TN4987). Horizontal relief wells drilled into the excavation walls may be used to reduce hydrostatic pressure behind the walls (TVA 2017-TN5387). Dewatering would lower groundwater levels in the area of the excavation. To minimize this effect and reduce the need for dewatering, TVA would block off or grout fractures and cavities transmitting large amounts of water (TVA 2017-TN5387). TVA would also assess the effects of dewatering by monitoring groundwater levels surrounding the excavation and water levels in potentially affected surface waterbodies.

TVA provided a qualitative evaluation of the effects of excavation dewatering on the surrounding groundwater levels and ponds, streams, and wetlands on the CRN Site (TVA 2017-TN4987). TVA reported that the surface-water feature closest to the power-block excavation area is approximately 500 ft away (excluding two wetlands planned for removal). TVA stated that this feature is unlikely to be affected by dewatering because its distance from the excavation is much greater than the radius of influence for the aquifer pump test (described in EIS Section 2.3), reported by TVA to be 150 ft (TVA 2017-TN4987). In addition, TVA stated that exceeding the maximum pumping rate of about 15 gpm in the aquifer test well resulted in the water level in the pumped well dropping from its steady-state value of about 65 ft bgs to a level of about 170 ft bgs (i.e., the well dewatered as described in EIS Section 2.3). TVA attributed this to the decrease in or near absence of fractures below an elevation of about 720 ft NAVD88 (about 82 ft bgs) (TVA 2017-TN4987). TVA also reported that no continuous seepage was observed through the floor of the CRBRP excavation, which was at an elevation of 714 ft NAVD88 (TVA 2017-TN4987).

As described in EIS Section 2.3, the review team determined that groundwater flow at the CRN Site occurs predominantly within the secondary porosity of the rock (e.g., fractures), and that flow over significant distances requires the presence of connected fractures over that distance. The observed decrease in fractures with depth in CRN Site boreholes indicates that most groundwater flow occurs within the weathered rock and at shallow depths within the competent rock where fractures are more frequent. Groundwater flow occurs at greater depth, but a continuous flow at depth requires a fracture of sufficient size to conduct water, and a continuous connection to a source of recharge. During the site audit, the review team observed large road cuts in the Chickamauga and Knox Groups. The review team observed that groundwater seepage from the face of the rocks occurred in isolated fractures, while the vast majority of the fractures appeared to be dry. Based on the hydrogeological characterization of the CRN Site and the reported experience with seepage into the CRBRP excavation, the review team expects that seepage into the CRN Site excavation would be similar. Namely, the review team expects that the weathered rock and highly fractured rock would readily dewater, but seepage from deep fractures would be limited to a relatively small number of locations. This would act to limit the extent of the effects of dewatering on the surrounding groundwater. Because seepage is expected to be reduced at greater depths and because the site is surrounded on three sides by the Clinch River, the review team expects that the effects of dewatering would not extend beyond the Clinch River boundary of the CRN Site. In addition, the northeast-southwest strike of the geologic units would limit the effects of dewatering north of the excavation. The review team assumes that the mitigation measures identified by TVA to reduce seepage (grouting fractures contributing seepage to the excavation) and the groundwater monitoring that TVA has stated it would conduct to evaluate the effects of dewatering would be carried out and would act to reduce further the minor dewatering effects.

4.2.2 Water-Use Impacts

This section evaluates the impacts on the use of surface water and groundwater arising from the activities described above in EIS Section 4.2.1 associated with building activities at the CRN Site, including proposed practices to minimize adverse impacts on water use from these activities. The impacts on the use of surface water and groundwater are discussed in Sections 4.2.2.1 and 4.2.2.2, respectively.

4.2.2.1 Surface-Water Use

Most of the water for building activities (e.g., concrete batch plant, potable, fire protection, and sanitary water systems) would be supplied by the City of Oak Ridge Public Works Department at a rate of 161 gpm (0.23 Mgd) (TVA 2017-TN4921, TVA 2017-TN4922). The City of Oak Ridge water system withdraws water from the Melton Hill Reservoir upstream of the CRN Site. The system has a capacity of 15 Mgd; average demand on the system was about 7 Mgd in

2016, with a peak daily demand of 13.8 Mgd (TDEC 2017-TN5032). TVA (2017-TN4921) reported an average daily demand of 7.7 Mgd for the City of Oak Ridge Public Works Department water system. The system has an existing excess capacity of at least 1 Mgd. As noted above, the supply rate to the CRN Site during the building period is expected to be 0.23 Mgd, which represents about 3 percent of the existing excess capacity based on average demand and about 20 percent of the excess capacity based on peak demand. This use rate would be limited to the building period (approximately 6 years).

Surface water withdrawn from the Clinch River arm of the Watts Bar Reservoir could be used for dust suppression. TVA estimates a use rate of 5,000 gpd during the construction and preconstruction period (TVA 2017-TN4922). Under the current reservoir operations plan, the minimum daily flow in the Clinch River arm of the Watts Bar Reservoir is 400 cfs and the average daily flow is 4,670 cfs (TVA 2017-TN4921). The total use of surface water for building activities at the CRN Site would thus be less than 0.1 percent of the minimum daily flow. This use rate would also occur for a limited period of time (approximately 6 years).

Because of the small proportion of water used relative to the available supply from both the City of Oak Ridge and the Clinch River arm of Watts Bar Reservoir, the review team concludes that the surface-water-use impacts of building a plant at the CRN Site would be SMALL.

4.2.2.2 Groundwater Use

Groundwater would not be used during building activities at the CRN Site. However, as noted previously in EIS Section 4.2.1, groundwater would be extracted as a consequence of dewatering for the power-block excavation. The review team determined in Section 4.2.1 that the effects of dewatering would be limited to the shallow groundwater of the CRN Site and not be noticeable at the locations of offsite groundwater users. Because groundwater flow alterations would be temporary and limited to the CRN Site, the review team concludes that the groundwater-use impacts of building a plant at the CRN Site would be SMALL.

4.2.3 Water Quality

4.2.3.1 Surface-Water Quality

As described above in EIS Section 4.2.1, the site preparation and building activities that could affect surface-water quality include land-surface clearing and grading, road improvements, and building structures on the CRN Site. Land-surface modifications and road improvements would also occur in the BTA and offsite transmission corridors. These activities would alter the land surface, the surface cover, and surface-drainage patterns and increase the potential for runoff and erosion. As noted in EIS Section 3.4.2.2, TVA plans to redesign and rebuild the existing site drainage system to accommodate the level of runoff expected from the new design. Runoff from the CRN Site would be regulated under the NPDES permit, which would include TVA's SWPPP and the use of BMPs to minimize erosion and stabilize the land surface (TVA 2017-TN4921). BMPs would also include spill prevention measures to minimize the occurrence of accidental releases of contaminants associated with equipment or building materials that could affect surface-water quality (TVA 2017-TN4921).

Work occurring on the shoreline of the Clinch River arm of Watts Bar Reservoir would disturb sediment containing contaminants from historical practices or spills that occurred offsite at upstream locations. As described above, intake structure and discharge pipeline/diffuser installation, and any associated underwater excavation, would comply with USACE and TDEC permit requirements and with procedures of the Watts Bar Interagency Working Group agreement, intended to ensure protection of the water resource and the proper disposition of sediments (TVA 2017-TN4922). The interagency agreement could require the use of BMPs (such as silt fences or cofferdams) to contain and control sediments, and may require additional restrictions based on the contaminant characteristics of the sediments at the site (TVA 2017-TN4922). Sediment disturbed during excavation would settle after the completion of the activity and is expected to have a temporary impact on water quality in the vicinity of the building activity. Excavated sediments would be managed as potentially contaminated, and would be disposed in accordance with applicable State and Federal regulations based on the results of analyses for hazardous or radioactive contaminants (TVA 2017-TN4921, TVA 2017-TN4922). Because the building activities for the intake and discharge structures would be localized and temporary, and would comply with applicable permit requirements, the review team determined that effects on Clinch River water quality would be minor.

Because engineering controls (e.g., BMPs, silt fences/curtains, detention/retention basins, cofferdam) regulated by a combination of TDEC and USACE permitting, and the Watts Bar interagency agreement, would be in use during building activities, the building-related impacts would be controlled, localized, and temporary. Therefore, the review team concludes that the impact on surface-water quality would be SMALL.

4.2.3.2 Groundwater Quality

During building, gasoline, diesel fuel, hydraulic lubricants, and other similar products would be used for construction equipment. Inadvertent spills of these fluids have the potential to contaminate groundwater. Pursuant to 40 CFR Part 112 (TN1041) and 40 CFR Part 9 (TN5322), TVA would implement an IPPP at the CRN Site, which would include the use of BMPs to minimize the occurrence of spills and limit their effects (TVA 2017-TN4921). These BMPs include actions such as proper vehicle and equipment maintenance, containment for fuel or oil storage tanks, and the maintenance of spill response equipment and materials (TVA 2017-TN5176). Based on implementation of an IPPP and the use of BMPs, the review team concludes that the effect on groundwater quality of inadvertent chemical spill would be localized and temporary. As a result, the impacts on groundwater quality would be minor.

Dewatering of the power-block excavation would alter the shallow groundwater flow patterns, but is not anticipated to alter groundwater quality. Minor changes in groundwater chemistry may occur in the vicinity of the excavation, but these changes are expected to be localized and temporary because the groundwater will equilibrate with the undisturbed rocks as it flows away from the excavations. Groundwater withdrawn during dewatering will be discharged to a stormwater-retention basin and ultimately infiltrated or discharged to the Clinch River. The shallow groundwater at the CRN Site, which would be dewatered, currently discharges to the Clinch River. In addition, discharge of groundwater withdrawn during dewatering would be regulated as part of the NPDES permit issued by TDEC.

Because the groundwater-quality impacts identified above would be localized and temporary, and because groundwater discharges would be regulated by the NPDES permit and BMPs would be used to minimize and control inadvertent spills, the review team concludes that the groundwater-quality impacts from activities related to construction and preconstruction at the CRN Site would be SMALL.

4.2.4 Water Monitoring

TVA described the construction monitoring programs for hydrologic and chemical monitoring in Sections 6.3 and 6.6 of the ER (TVA 2017-TN4921).

4.2.4.1 Surface-Water Monitoring

Water discharges during building activities would be monitored in accordance with applicable NPDES permit requirements and TDEC water-quality requirements. Typical requirements of an NPDES permit include monitoring of stormwater and dewatering discharges. A SWPPP would be required as part of the NPDES permit and would identify required inspection methods and BMPs used to detect and limit erosion and provide effective sediment control. Other monitoring may be required as determined by TDEC. Requirements for monitoring the Clinch River during building of the intake structure and the discharge pipeline and diffuser would be specified as part of the USACE Section 404 permit and the Section 401 water-quality certification issued by TDEC. Additional sediment monitoring may be required under the procedures of the Watts Bar interagency agreement.

4.2.4.2 Groundwater Monitoring

Groundwater heads would be monitored during building to detect changes in recharge and groundwater flows as well as the effects of excavation dewatering. Two years of quarterly water-quality monitoring would be completed to provide a preoperational baseline. TVA plans to sample 19 existing wells, including 8 wells that will be redeveloped due to high turbidity. Groundwater-quality monitoring would be used to detect the presence of new contaminants and to evaluate changes in groundwater-quality parameters from current values.

4.3 Ecology

This section describes the potential impacts on terrestrial and aquatic ecological resources from construction and preconstruction activities. The section is divided into two subsections: terrestrial and wetland impacts and aquatic impacts.

4.3.1 Terrestrial and Wetland Impacts

Preconstruction activities would start with land clearing and site preparation work on the CRN Site and development of the barge facility and haul road in the BTA. Most preconstruction work would take place in the first year, during which most impacts on terrestrial habitats, including wetlands, would occur. Construction-phase impacts would occur over a subsequent period of 4 to 5 years and include building safety-related structures (TVA 2017-TN4921).

4.3.1.1 Site and Vicinity

The terrestrial ecology impacts presented in this section are based on the plant parameter envelope (PPE) defined by TVA in the application; the actual areas of disturbance may ultimately differ once TVA completes a design to support a COL (or CP) application.

4.3.1.1.1 Terrestrial Habitats

Approximately 494 ac of the CRN Site and 45 ac of the BTA (approximately 539 ac total) would be disturbed by construction and preconstruction activities (Table 4-2). This includes approximately 327 ac on the CRN Site and 30 ac in the BTA that would be permanently occupied by facilities over the life of the project (Table 4-2). This also includes about 167 ac on the CRN Site and about 15 ac in the BTA that would be temporarily disturbed (Table 4-2) (TVA 2017-TN4920).

TVA would revegetate or otherwise restore temporarily disturbed acreage using native or noninvasive species. Revegetating using native plant species would reduce competition from invasive species and facilitate forest succession (the process by which vegetation changes naturally over time). Over several decades, some of these areas likely would gradually transition physically and functionally from herbaceous/grassland to forest habitat (TVA 2017-TN4921). Nevertheless, reestablishment of temporarily disturbed forest, especially mature deciduous forest, could require several decades to more than a century. Temporary disturbance of deciduous forest constitutes a loss of many ecological forest services for the foreseeable future, especially when considering suitability for forest interior wildlife. However, some other wildlife may be able to inhabit the younger successional forests that regenerate in the years immediately following a disturbance. Other temporarily disturbed areas may be replanted in trees (TVA 2017-TN4921), which is expected to facilitate and accelerate forest succession. However, in areas of permanent habitat conversion (e.g., forest to herbaceous/grassland or shrubland such as in the corridor of the relocated 161-kV onsite transmission line or intake and discharge water pipeline corridors [Figure 4-3]), TVA would maintain habitat in its converted state (e.g., using herbicides or by mechanical means), and the prior functional value of the former forest communities would not be restored.

Terrestrial habitats and wetlands on the CRN Site and in the BTA are depicted in Figure 2-27 and Figure 2-19 in Section 2.4.1.1 of this draft EIS. The proposed structures and affected areas are shown in Figure 3-1, and described in EIS Sections 3.2 and 3.3. An overlay of the areas to be permanently and temporarily cleared relative to terrestrial and wetland habitats on the CRN Site and in the BTA is provided in Figure 4-3. By making the maximum possible use of the previous clearing and excavations for the CRBRP footprint, TVA has designed the construction footprint to minimize impacts on forest and wetlands. Approximate affected acreages by habitat/land cover on the CRN Site and in the BTA are provided in Table 4-2.

The subsections below address potential impacts on specific habitats.

<u>Impacts on Forest</u>

Upland forest on the CRN Site consists mostly of mixed evergreen-deciduous forest and deciduous forest (Table 2-9) that occurs mostly in the northern part of the site and along the Clinch River surrounding the CRBRP footprint (Figure 2-27). Clearing would remove about 196 ac of mixed evergreen-deciduous forest from the CRN Site and none from the BTA (Table 4-2). This loss of mixed evergreen-deciduous forest represents about 15 percent of this forest type within the 6-mi vicinity (Table 2-1). Clearing would remove about 72 ac of deciduous forest from the CRN Site and 23 ac of deciduous forest from the BTA (Table 4-2). This loss of 95 ac of deciduous forest represents about 0.2 percent of this forest type within the 6-mi vicinity (Table 2-1). About 20 ac of evergreen forest would be cleared from the CRN Site and none in the BTA (Table 4-2). This loss of evergreen forest represents about 1 percent of this forest type within the 6-mi vicinity (Table 2-1). The potentially affected evergreen forest consists of remnant loblolly pine (*Pinus taeda*) and white pine (*Pinus strobus*) plantations (EIS Section 2.4.1.1) (Cox et al. 2015-TN5193), perhaps planted when the CRBRP footprint was redressed (DOE 1984-TN5282). Loss of this type of forest does not constitute loss of regionally indigenous evergreen forest habitat.

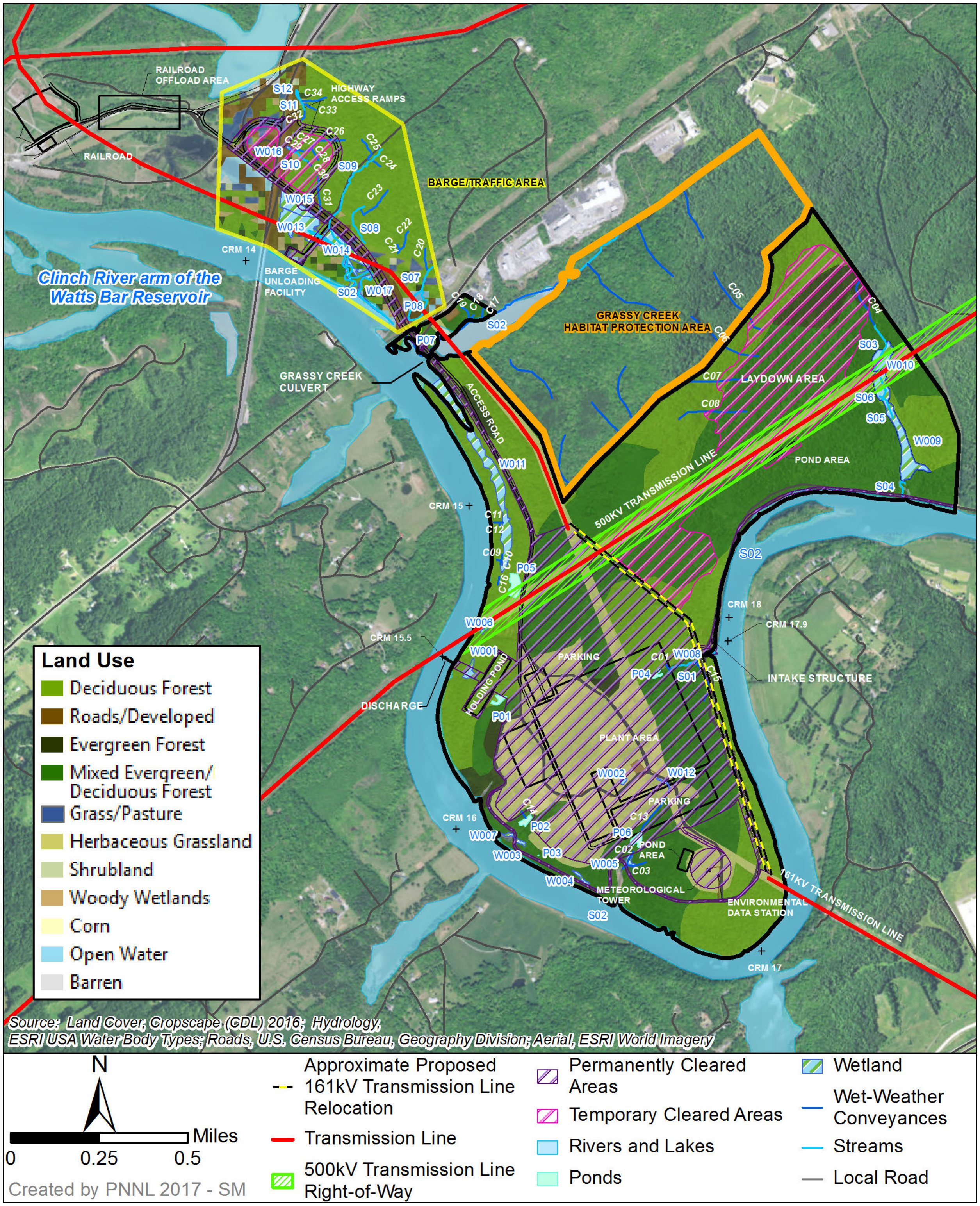


Figure 4-3. CRN Site and BTA Development Footprint Overlaid on Terrestrial Habitats and Wetlands

Table 4-2. Habitat and Land-Cover Types that Would Be Disturbed by Developing the CRN Site and BTA. Obtained from information provided by TVA (2017-TN4920)

Location/Habitat Types/ Land-Cover Types	Approximate Acreage Permanently Affected	Approximate Acreage Temporarily Affected	Total Acreage Affected
CRN Site			
Herbaceous/Grassland	152	41	193
Mixed Evergreen-Deciduous Forest	106	90	196
Deciduous Forest	53	19	72
Roads/Developed Areas (Existing)	13	--	13
Evergreen Forest	3	17	20
Total	327	167	494
Barge Traffic Area			
Herbaceous/Grassland	1	1	2
Deciduous Forest	9	14	23
Roads/Developed Areas (Existing)	20	--	20
Total	30	15	45

Riparian forest on the CRN Site is situated along the reservoir shoreline (Clinch River). The habitat impact acreages in Table 4-2 include the small amount of riparian vegetation that would be removed for construction of the intake and discharge structures (Figure 4-3). No riparian vegetation would be cleared to reactivate the existing barge facility, and improvements to that facility would not require substantial additional clearing of shoreline riparian vegetation (TVA 2017-TN4921).

Overall forest impacts, totaling 311 ac (Table 4-2 and Figure 4-3), would reduce the extent of and fragment the three forest interior parcels on the CRN Site (see EIS Section 2.4.1.1 and Figure 4-4). The impacts would reduce the number of forest interior parcels from three to two and would reduce forest interior cover by approximately 175 ac (Figure 4-4). There are, however, many other parcels of interior forest on the ORR (Parr et al. 2015-TN5151), including just north of the CRN Site and northeast of the BTA (Figure 4-4).

Impacts on Non-Forest Vegetation

Approximately 195 ac of herbaceous/grassland and old field vegetation on the CRN Site and in the BTA would be disturbed (Table 4-2), mostly within the footprint of the former CRBRP. This area represents only about 2 percent of the total acreage of similar vegetation within the 6-mi vicinity (Table 2-1). Areas of temporary loss would be revegetated and allowed to revert to their former condition (which would likely require about 2–10 years) and continue the process of succession to forest. Old field/successional habitat is considered a priority habitat in the State of Tennessee (TWRA 2015-TN5042). However, in the Ridge and Valley Ecoregion (as well as in other areas of the state) the old field/successional habitat type is ranked relatively low in its need for conservation based on the habitat preferences of wildlife species of greatest conservation concern in the State (TWRA 2015-TN5042).

Additionally, up to 210 ac of scrub-shrub/grassland would be temporarily disturbed beyond the CRN Site by installation of the proposed 69-kV underground line within the existing Watts Bar NP–Bull Run FP 500-kV corridor, which crosses the CRN Site and ties into the existing Bethel Valley Substation (see Figure 3-6). This area is currently a maintained right-of-way and would

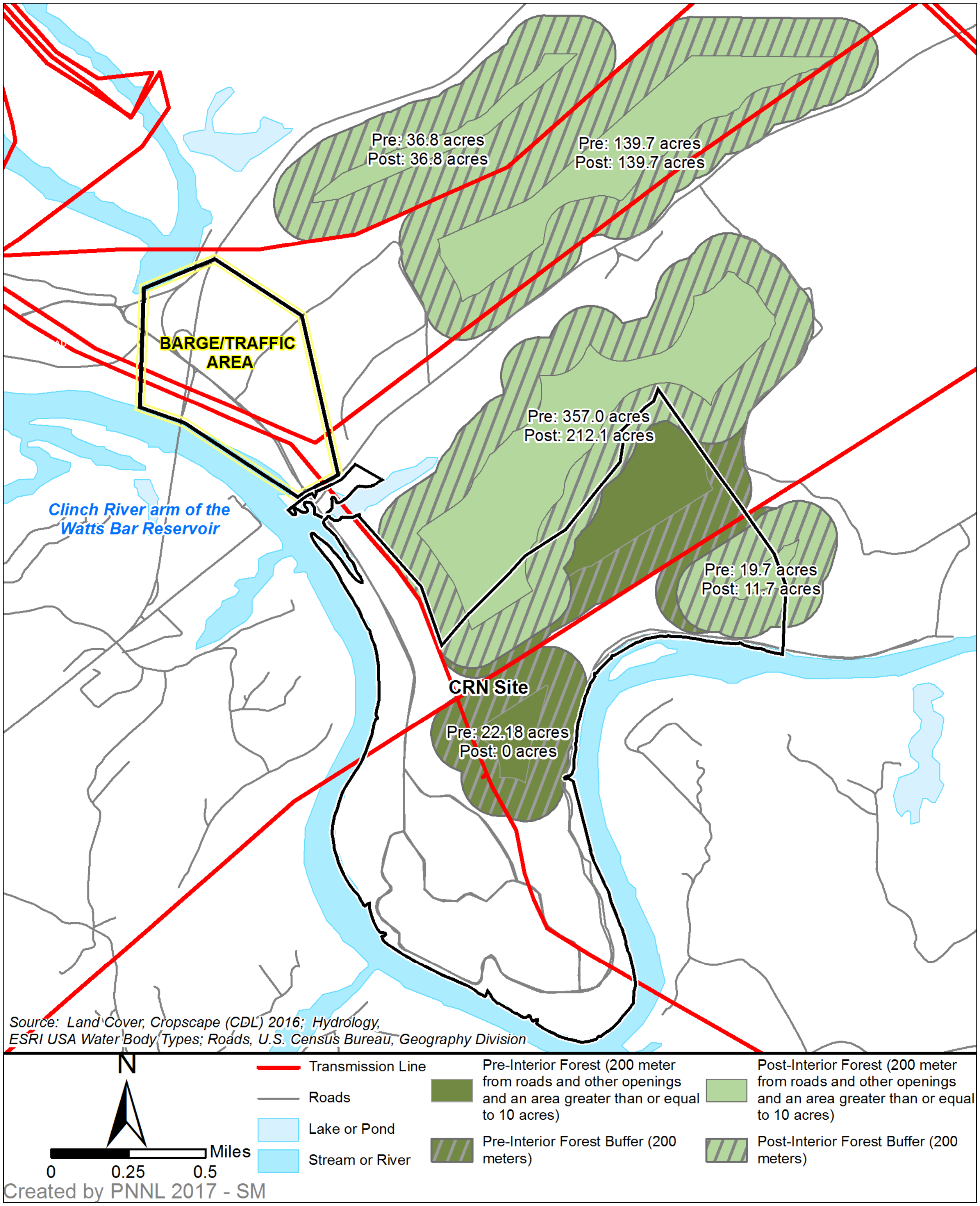


Figure 4-4. Pre- and Post-Construction Forest Interior Parcels on the CRN Site and near the BTA

continue to be so maintained after installation of the underground transmission line. Disturbed areas would be seeded after installation of the underground conductors and would be expected to regenerate typical right-of-way vegetation in a few years. There would be little or no long-term change in this right-of-way vegetation community. An additional 0.33 ac of scrub-shrub/grassland would be permanently removed by expansion of the Bethel Valley Substation. No other habitat would be disturbed to expand the substation.

4.3.1.1.2 Wetlands and Floodplains

Impacts on Wetlands

Four wetlands (W001, W002, W008, and W012) totaling about 1.2 ac would be filled to build the new facilities on the CRN Site. The type, location, size, and condition of these four wetlands are provided in Table 4-3. The condition of the affected wetlands ranges from degraded to moderate. In most instances, at least one field indicator (hydrology, hydric soils, connectivity to surface water) is lacking for these wetlands, possibly due to extensive site disturbance during the 1970s during site preparation for the CRBRP (Pilarski-Hall 2015-TN5185). The functions of these wetlands, including their function as wildlife habitat, would also be lost.

The other wetlands on the CRN Site listed in Table 2-10 would be avoided and thus not directly affected by construction and preconstruction activities. Indirect effects on these wetlands would be reduced by the use of BMPs to prevent erosion and sedimentation. TVA has stated that it would stabilize soil stockpiles and disturbed areas using BMPs such as revegetation required by applicable soil erosion and sediment control permits (TVA 2017-TN4921). According to TVA, drainage control measures for the spoils piles may include berms, riprap, sedimentation filters, and detention ponds. TVA would manage construction-related discharges in accordance with a SWPPP and NPDES permit for discharges of stormwater. TVA would use existing and additional stormwater-retention ponds to manage the increased runoff from impervious structures and allow infiltration to reduce runoff. This would limit stormwater discharges during high-intensity precipitation events. According to TVA, these measures would also largely eliminate the potential for soil erosion and sedimentation of down-gradient wetlands outside the footprint of development (TVA 2017-TN4921).

Table 4-3. Affected Wetlands on the CRN Site

Wetland Number	Wetland Type[(a)]	Location	Impact	TVA Condition Category[(b)]	Size (ac)
W001	PF01E	Water discharge pipeline corridor on a terrace of the Clinch River	Fill	2	0.67
W002	PEM1E	Power-block area	Fill	1	0.13
W008	PF01E	Water intake pipeline corridor	Fill	2	0.23
W012	PEM1E	Power-block and parking areas	Fill	1	0.13
Total					1.16

(a) Classification codes as defined by Cowardin et al. (1979-TN5186): PEM1E = palustrine emergent, persistent vegetation, seasonally flooded/saturated; PFO1E = palustrine forested, broad-leaved deciduous vegetation, seasonally flooded/saturated; PSS1E = palustrine scrub-shrub, broad-leaved deciduous vegetation, seasonally flooded/saturated; PSSHh = palustrine scrub-shrub, broad-leaved deciduous vegetation, permanently flooded, diked/impounded.

(b) Category 1 = degraded; Category 2 = moderate quality; Category 3 = high quality.

As discussed in EIS Section 4.2, dewatering of groundwater within the power-block excavation would be necessary during construction of the below-grade nuclear island structures and foundations. TVA would install drainage sumps at the bottom of the excavation to pump surface drainage and/or accumulated groundwater to an established and, if necessary, permitted release point. These activities could affect the surrounding water table and three nearby wetlands: W003 (0.18 ac), W004 (0.24 ac), and W007 (0.17 ac) (Figure 2-19) (Table 2-10) (TVA 2017-TN4921). These three wetlands (as well as the other wetlands on the CRN Site and in the BTA) are associated with surface water (streams or the Clinch River) and their association with groundwater is assumed, but the extent of the connection is unknown (TVA 2017-TN4921). As stated in EIS Section 4.2, the review team expects that the weathered rock and highly fractured rock would readily dewater, but seepage from deep fractures would be limited to a relatively small number of locations. This would act to limit the extent of the effects of dewatering on the surrounding groundwater. However, because the dependence of wetlands on groundwater is uncertain, the likelihood of wetland drawdown and extent, if any, are unknown. As stated in Section 4.2, the review team expects that the effects of dewatering would not extend beyond the Clinch River boundary of the CRN Site. If the design for the project ultimately submitted for a COL may substantially alter groundwater elevations outside the construction footprint, then those impacts would have to be evaluated at the COL stage.

The review team estimates that approximately 0.5 ac of W013, W014, W015, and W017 in the BTA would be affected. In addition, 0.11 ac (W016) may be filled (TVA 2017-TN4921, TVA 2016-TN5145). The approximately 0.6 ac, along with the approximately 1.2 ac on the CRN Site, represent about 0.2 percent of the total acreage of wetlands within the 6-mi vicinity (Table 2-1), suggesting only a minor reduction in wetlands in the surrounding landscape. However, the nature and magnitude of these wetland impacts cannot be determined at the current stage of project development, but would be determined at the COL application stage upon finalization of facility design and specific plans for development in the BTA (TVA 2017-TN4921, TVA 2016-TN5145) and any mitigation that may be imposed by the USACE or TDEC.

In addition, the review team assumes that the entirety of the estimated 2 ac of wetlands within the existing 500-kV transmission line corridor where the proposed new 69-kV underground transmission line is to be buried (see EIS Section 2.4.1.1) would be disturbed. The review team recognizes, however, that it might be possible to install the conductors under wetlands and other surface-water features without disturbing the surface. For conservatism, TVA is assessing impacts as if open trench installation would be used along the entire route and would disturb wetlands across the entire width of the corridor. TVA would install the 69-kV line in accordance with its wetland clearing, construction, and restoration BMPs that are specific to construction in transmission line corridors (TVA 2012-TN4911) in order to avoid and reduce impacts to the extent practicable. However, the nature and magnitude of impacts cannot be determined at the current stage of project development, but would be determined at the COL stage after wetland delineation, and finalization of the routing of the buried line, the offsetting effects of TVAs BMPs, and any mitigation that may be imposed by USACE or TDEC.

Impacts on Floodplains

Building the new facilities on the CRN Site and in the BTA would encroach into about 5 ac of the current floodplain of the Clinch River based on reservoir operations (Figure 2-5). The floodplain impacts would occur in low-lying areas along the reservoir shoreline or along connecting streams and associated wetlands near their confluence with the reservoir (Figure 2-5 and Figure 2-19). Because of their limited spatial extent, the review team views floodplain impacts as minor.

4.3.1.1.3 Wildlife

<u>Impacts Related to Habitat Changes</u>

Some wildlife present in the construction footprint would suffer direct mortality, disturbance, and displacement. In general, less-mobile animals (e.g., amphibians, reptiles, small burrowing mammals, and unfledged birds) would incur greater direct mortality than those that are more mobile (e.g., adult birds and large mammals). For example, habitats would be subject to clearing any time of year and, if cleared during the nesting season, migratory birds using the affected habitats could incur loss of one year's reproduction.

Disturbances below lethal levels may adversely affect wildlife behaviors (such as movement, feeding, sheltering, and reproduction). By using the CRBRP footprint to the extent possible, TVA has minimized necessary encroachment into surrounding forests, thereby reducing potential impacts on forest wildlife.

Some individuals of wetland wildlife species (e.g., amphibian species) would be lost because of impacts in and around the wetlands discussed above. Some individuals of riparian species would be lost as a result of disturbance of riparian vegetation within the intake and discharge structure footprints along the Clinch River and along the fringes of affected streams. Upland forest and scrub-shrub/grassland wildlife, and wildlife associated with a mosaic of these two habitats (e.g., eastern wild turkey [*Meleagris gallopovo*], white-tailed deer [*Odocoileus virginianus*]), would be lost because of the reduction in such habitats (Table 4-2). However, some mobile wildlife in these various habitats may disperse into similar habitats in nearby areas (see EIS Section 2.4.1.3). Resources in nearby similar habitats, if suitable, may already be occupied by such species, and would then need to be partitioned among a greater number of individuals, which may lead to increased competition resulting in increased predation, decreased fecundity, and population declines. In such cases, some population declines may be permanent because, as noted above, there would be a net permanent loss of upland and riparian forest, scrub-shrub/grassland, and wetland habitats on the CRN Site and in the BTA. However, the mosaic of forest and scrub-shrub/grassland and associated edge habitats may increase as a result of forest fragmentation, providing areas into which populations of edge species could later expand. In such cases, population declines may be temporary.

The most deleterious type of habitat loss results from permanent land-use change, which is one of the primary causes of wildlife species declines in Tennessee (TWRA 2015-TN5042). Perhaps equally deleterious as direct habitat loss is the indirect loss of the quality of the remaining habitat due to fragmentation and isolation (TWRA 2015-TN5042). One parcel of forest interior habitat would be lost from the CRN Site and two others would be substantially reduced in size (see above text and Figure 4-4). Forest interior habitats on the ORR have been documented to support wildlife species, especially birds, that are uncommon in or absent from surrounding areas (Parr et al. 2015-TN5151). Fragmentation creates disjunct habitat patches that may isolate wildlife communities from each other, thereby impeding colonization of or use of areas that are required to satisfy life-cycle requirements, and hindering gene flow between populations. In addition, fragmented habitat is vulnerable to non-native invasive plants and animals that may encroach from disturbed edges and replace native species. Fragmentation impacts on animal and plant communities extend beyond the area of direct habitat loss, and edge effects have been observed to extend up to 200 m (650 ft) into the forest from the forest edge on the ORR (Parr et al. 2015-TN5151). Thus, the CRN Site would likely continue to support deep forest wildlife, such as forest interior birds, but less so compared to preconstruction conditions. A narrow forested riparian zone would be retained along most of the Clinch River (Figure 4-3), which likely would continue to function as a wildlife travel corridor.

Even temporarily affected forest habitat may require several decades following revegetation before reacquiring former functionality and colonization and use by similar wildlife (e.g., the CRBRP footprint disturbed in the early 1980s is currently in a state of early forest succession). Thus, even temporarily affected areas of the CRN Site and BTA could contribute to local wildlife population declines for the foreseeable future.

Physical Impacts

An osprey (*Pandion haliaetus*) nest is located on a tower supporting the 161-kV transmission line on the CRN Site. Monitoring of this or other such nests would be conducted in advance of construction activities in the vicinity. Nests would be monitored to determine if they are active and likely to remain active at the time of scheduled construction in the area of the nest. Nests that do not contain eggs or young may be removed and their rebuilding deterred during the site preparation and construction periods. If necessary to avoid the loss of eggs or young present in a nest, construction schedules would be modified where practicable. TVA has stated that it would coordinate with the U.S. Fish and Wildlife Service (FWS) in the event that impacts on active nests cannot be avoided (TVA 2017-TN4920).

Collision Impacts on Avian Species

Migratory bird collisions with tall construction equipment are possible. Studies of avian collisions with elevated construction equipment are lacking in the literature. Communication towers are the structures most similar to elevated construction equipment (e.g., cranes) and pose the greatest threat of collision mortality. The towers that appear to cause the most problems are tall, especially those that exceed 305 m (1,000 ft), are illuminated at night with solid or pulsating incandescent red lights (e.g., Federal Aviation Administration lights), are guyed, are located near wetlands and in major songbird migration pathways or corridors, and have a history of inclement weather during spring and fall migrations (Kerlinger 2004-TN3871; Manville 2005-TN893). Lighting may function as an attractant for nocturnally migrating birds, especially in weather conditions that create poor visibility, and collisions typically occur with guy wires (Kerlinger 2004-TN3871). Published accounts of kills at short towers and other short structures are limited, and are usually associated with inclement weather and poor visibility (Manville 2005-TN893).

Terrestrial avian species such as songbirds have been shown to not follow the same migratory pathways used by larger birds such as waterfowl and shorebirds (La Sorte et al. 2014-TN5152). Terrestrial birds are not tied to waterways, fly routes based on advantageous wind conditions, and may satisfy temporary stopover habitat needs over much broader land areas (La Sorte et al. 2014-TN5152). The CRN Site is not within a major waterbird (birds that inhabit or depend on waterbodies or wetland areas) migratory flyway (Bellrose 1968-TN5150; TVA 2017-TN4921). In the eastern United States there is a spring flyway and fall flyway for songbirds. The spring flyway passes through Tennessee and the fall flyway passes through the East Coast States (La Sorte et al. 2014-TN5152). The CRN Site is within the songbird spring flyway, because at least 15 songbird species are known to be migrants from the ORR (Roy et al. 2014-TN5154). Notwithstanding the likely presence of songbirds in spring, substantial migratory bird collisions with construction equipment are unlikely because of the equipment's relatively low stature (maximum crane height of 638 ft [TVA 2017-TN4922]) compared to communication towers, and its being not guyed and being unlit. Thus, both migratory waterbird and songbird collision is not likely to be a substantial source of avian mortality.

Impacts of Noise

The following discussion of noise related to wildlife differs from that found in EIS Section 4.8 related to humans, both in terms of the source data and its use in evaluating impacts. TVA stated its maximum expected noise level due to construction activities is 101 dBA measured at 50 ft from the source (TVA 2017-TN4921), which comports with the high end of average maximum noise levels at 50 ft that range from about 73 to 101 dBA for non-impact heavy equipment (WSDOT 2017-TN5313). TVA stated that some infrequent or nighttime construction activities could generate temporary noise levels at or above 60 to 90 dBA at a distance of 100 ft from the source (TVA 2017-TN4921). TVA also noted use of impact equipment (TVA 2017-TN4921), which may generate noise levels from 79 to 110 dBA at 50 ft from the source (WSDOT 2017-TN5313). TVA would also use stationary equipment (TVA 2017-TN4921), which generally produces noise levels that can range from 68 to 88 dBA 50 ft from the source (WSDOT 2017-TN5313). TVA stated that periodic blasting would occur during construction and preconstruction activities (TVA 2017-TN4921), which may produce noise levels that reach 126 dBA (WSDOT 2017-TN5313). TVA has stated that background sound levels in the project area are about 46 to 48 dBA during the day and between 41 and 49 dBA during the night (TVA 2017-TN4921).

Assuming noise decreases by approximately 7.5 dBA per doubling of distance from the source over soft ground (WSDOT 2017-TN5313), project construction noise could travel as little as 400 ft (starting as 60 dBA at 100 ft from the source) up to 51,200 ft (roughly 9.6 mi) (starting at 126 dBA at 50 ft from the source) before it attenuates to 45 and 51 dBA, respectively (i.e., approximate background sound levels). These noise-intensity levels may represent episodic highs and lows. Heavy construction equipment more typically generates an estimated noise level of approximately 85 decibels adjusted (dBA) at 50 ft from the source (WSDOT 2017-TN5313) and would thus travel up to 1,600 ft before it attenuates to 47.5 dBA. This noise-intensity level may be more representative of typical bouts of noise. Sound attenuation rates that take into account only the soft-site factor (excluding topography, vegetation, and atmospheric conditions, which may also attenuate noise but are highly variable and therefore not typically included in evaluations), likely predict noise levels that are higher than actual noise levels. Given the various attenuation distances to background noise levels and their likely overestimation and the noise-reduction methods proposed by TVA (e.g., mufflers on heavy equipment, erecting earthen berms, placing vegetation between noise sources and receptors [TVA 2017-TN4921]), the review team assumes construction-noise-related effects on wildlife may generally be experienced up to about 0.5 mi from the CRN Site boundary, BTA, and the route of the 69-kV transmission line, all of which are considered potential sources of the noise.

Prediction of noise effects on wildlife is limited by the lack of information linking sound levels to effects on individual species (Caltrans 2016-TN5155; Ortega 2012-TN5153; USDOT 2004-TN5156). Wildlife (especially bird) responses to noise are variable and may range from habituation to varying degrees of avoidance (leaving habitat unoccupied) and even minor injury. For example, birds and small mammals may be startled or frightened around the 80- to 85-dBA threshold (Golden et al. 1979-TN3873), and sound pressure levels at or above 93 dBA may cause temporary threshold shift (temporary hearing loss that recovers over a period of minutes to days from the end of noise exposure) in birds (Caltrans 2016-TN5155). Noise can affect wildlife by inducing physiological changes, nest or habitat abandonment, or behavioral modifications, or it may mask or cause the inability to detect environmental cues or communications required for breeding or defense. It is also not unusual for wildlife to habituate to noise (AMEC 2005-TN901; Larkin 1996-TN772). The review team anticipates that some wildlife may experience such effects and that the risk of such effects would be higher within than beyond the site boundary. Most effects would likely be intermittent and temporary during periods of building activities, because it is anticipated there would be periods of relative quiet between bouts of noise and between building phases.

Traffic-Related Impacts

Construction worker vehicles, delivery trucks, and other traffic needed to build the proposed new facilities on the CRN Site would increase traffic on the local roadway network, particularly Bear Creek Road and the site access road (described in EIS Section 2.5.2.3). The additional workforce commuting and truck traffic would likely increase traffic-related wildlife mortalities. Local wildlife populations could suffer declines if roadkill rates were to exceed the rates of reproduction and immigration. However, while roadkill is an obvious source of wildlife mortality and would likely increase during the construction period, traffic mortality rates rarely limit population size (Forman and Alexander 1998-TN2250). Consequently, the review team expects that the overall impact on local wildlife populations from increased vehicular traffic during the construction period would be minor.

4.3.1.2 Offsite Areas

As discussed in EIS Section 3.2.2.3.5, TVA identified overhead transmission lines outside the CRN Site that may require upgrades by uprating, reconductoring, or rebuilding (Figure 2-9 and Table 2-2). These activities would occur within existing corridors of these lines and no new corridors would be developed or expanded (TVA 2016-TN5145). An uprate may be performed at a single point or at multiple locations along a transmission line. Likewise, reconductoring can occur along a specific line segment or along the entire length of a transmission line. The total length of transmission lines that would require uprating, reconductoring, or rebuilding is approximately 440 mi (see Table 2-2). TVA estimated that that the land areas subject to potential disturbance from uprating, reconductoring, and rebuilding would be approximately 2,608 ac, 2,566 ac, and 152 ac (totaling about 5,327 ac), respectively, all within existing right-of-ways (TVA 2017-TN4921, TVA 2016-TN5145). Uprating, reconductoring, and rebuilding activities include the following:

- Removal of structures that interfere with clearance (due to increased electrical load increasing line temperature and sag).
- Replacement or modification of existing structures or installation of intermediate structures – performed with standard transmission line equipment such as bulldozers, bucket trucks, boom trucks, and forklifts to raise the existing conductor to provide proper ground clearance. Disturbance would typically be limited to a radius of about 100 ft around the work structure.
- Conductor modification – would include conductor slides, cuts, or floating dead-ends to increase ground clearance (described in TVA 2016-TN5145). These improvements require the use of a bucket truck; disturbance would be minimal and confined to the immediate area of the clearance issue.
- Conductor replacement (reconductor) (described in TVA 2016-TN5145) – bucket trucks would be used for access and stringing equipment. A bulldozer and specialized tensioning equipment would be used to pull conductors to the proper tension. Wire pulls would be limited to a maximum of 5 mi. Pull points would typically be located along the most accessible path on the right-of-way (adjacent to road crossings or existing access roads). The area of disturbance at each pull point would typically range from 200 to 300 ft along the right-of-way.

- Addition of surcharge – involves adding a stone base and rock or dirt (surcharge) to structure footings. Typical installation of surcharge would be performed with tracked equipment with minimal ground disturbance.

- Modification of local power company transmission lines – if a local utility crossing does not have adequate clearance, TVA would request that the local utility lower or re-route the crossing.

- Rebuild – installing intermediate structures between existing structures for added structural support and/or clearance, and/or tearing down existing structures and replacing with more robust structures (TVA 2017-TN4921, TVA 2016-TN5145).

Terrestrial resources within the transmission line corridors are listed in Table 2-11, and include wetlands, wildlife management areas, habitat protection areas, parks, and species congregations. TVA would identify, delineate, and map wetlands, establish a minimum 50-ft wetland buffer, implement wetland and wetland buffer avoidance strategies, and create and work to a site-specific wetland clearing, construction, and restoration plan with appropriate BMPs (e.g., to control erosion and sedimentation) (TVA 2012-TN4911). If other sensitive resources (e.g., wildlife management areas, habitat protection areas, heron rookeries) are identified by desktop or field review, they would be mapped and a buffer and BMPs would be established on a case-by-case basis by TVA's Environmental Permitting and Compliance Biological and Cultural staff (TVA 2012-TN4911). Implementation of BMPs, as indicated above, should facilitate avoidance and reduction of impacts to the extent practicable.

Based on the above description of upgrade activities, it is likely that much less than the entirety of the 5,327 ac would be disturbed, but neither the activity locations nor areal extent of habitat disturbance (especially in relation to the resources listed in Table 2-11) have been identified. Consequently, notwithstanding implementation of BMPs, impacts on the resources listed in Table 2-11 cannot be predicted or described. Impacts will need to be described at the COL stage when more definitive information is available about the locations and areal extent of habitat disturbance in relation to terrestrial resources within the transmission line corridors. Even though TVA has not explicitly stated so, the review team expects that, based on its reading of the application, the transmission line upgrades would be limited to uplands and would not involve physical disturbance of the ground surface in wetlands. The review team likewise expects that TVA would not remove any mature trees or forest cover as part of the transmission line upgrades, including trees from forested wetlands. If such disturbance is found to be necessary, then these impacts would also have to be evaluated at the COL stage. The transmission line segments that would be uprated, reconductored, or rebuilt were identified by TVA based on an initial interconnection system impact study of projected future transmission system conditions. TVA has stated it used available information about transmission and generation additions and upgrades that may subsequently change. TVA also stated that given the dynamic nature of its transmission system and the time between the ESP and anticipated COL, the planning assumptions are anticipated to change (depending on the final configuration and additional electrical capacity of the specific reactors ultimately proposed) along with associated changes in the corridor segments and to engineering solutions (TVA 2017-TN4921, TVA 2016-TN5145). Thus, the exact corridor segments, modifications, terrestrial resources, and impacts would be identified at the COL stage.

4.3.1.2.1 Offsite Borrow Areas

The combined volume of fill material currently present in the nine offsite borrow pits described in Section 2.2.2.3 and Figure 2-9 in this draft EIS is anticipated to meet the volume of fill material that would be needed for the project. Therefore, it is unlikely that existing borrow areas would need to be expanded beyond currently permitted boundaries or that new borrow areas would need to be opened to accommodate the proposed project (TVA 2017-TN4921, TVA 2016-TN5145). Assuming no expansion and no new borrow areas, there would be no impacts on vegetation or wildlife from acquiring borrow materials.

4.3.1.3 Important Species and Habitats

This section describes the potential impacts of construction on the important terrestrial species and habitats, identified in the correspondence with Federal and State agencies. The design of the construction footprint reduces impacts on potential habitat for important species (e.g., forest and wetlands). This factor is considered in the assessment below. A more detailed assessment of impacts on Federally listed species and critical habitats is provided in NRC's biological assessment (BA) (see Appendix M).

4.3.1.3.1 Indiana Bat (Myotis sodalis) – Federally Endangered (FE)

Forest habitat on the CRN Site and in the BTA is suitable roosting habitat for the Indiana bat (Section 2.4.1.11). Potential direct adverse effects on roosting bats by tree removal could include (1) harm (injury or death) if occupied roost trees are felled (there are currently no seasonal tree harvest restrictions) and (2) harassment from tree felling noise resulting in displacement. Displaced bats may be forced to locate new roosts, increasing energy expenditure that could result in reduced fitness. Bats could also encounter increased intra-specific or inter-specific competition (e.g., with the NLEB) in locating and establishing alternative roost sites, which could also result in reduced fitness. Increased energy expenditure and competition may also affect nutrition (FWS 2005-TN5382). Reduced fitness and nutrition could result in reduced survivorship and a decline in local population abundance and viability.

Potential indirect adverse effects on bats could include (1) removal of foraging habitat and (2) avoidance of noise and increased human activity and light levels, both of which may result in a need to find alternate foraging and roosting areas. Intermittent streams and riparian areas are often preferred foraging habitats for the species (FWS 2005-TN5382). One of the primary effects of the project on the Indiana bat would be the loss of foraging habitat due to the loss of forested habitat and streams. This habitat loss would possibly eliminate some preferred foraging areas, as well as bat flyways and watering areas. The forested habitat remaining in the project area would become more isolated (Figure 4-4) and perhaps less suitable to support the Indiana bat.

Noise (as well as increased human activity and light levels) would also result in a decrease in the quality of the remaining habitat on the CRN Site and in the BTA. Because noise would be generated day and night, roosting and foraging bats could frequently be disturbed. Some studies suggest that bats may be able to tolerate loud noises while other studies suggest that bats avoid noisy areas (FWS 2005-TN5382). The review team concludes that noise and vibrations (due to blasting) related to building and operation activities could result in bats abandoning roosts. Limited data are available about how far away from noise tree-roosting bats need to be for these effects to be avoided (FWS 2005-TN5382). In the absence of these data, the review team assumes noise and ground vibrations may affect bats up to 0.5 mi from the CRN Site, BTA, and buried 69-kV transmission line. Energy expended to find habitat in which bats could resume roosting or foraging activities in calm conditions could result in reduced fitness, which could adversely affect survivorship and reproduction and cause a decline in local population abundance and viability.

A more detailed evaluation of potential effects on the Indiana bat is found in NRC's BA in Appendix M.

4.3.1.3.2 Northern Long-Eared Bat (Myotis septentrionalis) – Federally Threatened (FT)

NLEB roost sites have been documented to occur about 0.04 to 3.0 mi from foraging areas (80 FR 17974 -TN4216). Thus, roost sites should be assumed to occur on the CRN Site and in the BTA because of the presence of suitable habitat. The suitable habitat for the Indiana bat on the CRN Site and in the BTA is also suitable for the NLEB for spring, summer, and fall roosting and foraging (Section 2.4.1.11). Potential direct adverse effects on roosting bats by tree removal could include (1) harm (injury or death) if occupied roost trees are felled (there are currently no seasonal tree harvest restrictions) and (2) harassment from tree felling noise resulting in displacement. Displaced bats may be forced to locate new roosts, increasing energy expenditure that could result in reduced fitness. Bats could also encounter increased intra-specific or inter-specific competition (e.g., with the Indiana bat) in locating and establishing alternative roost sites, which could also result in reduced fitness. Reduced fitness could result in reduced survivorship and a decline in local population abundance and viability. However, because NLEBs may roost in younger roost trees (down to 3 in. in DBH), the species may have greater roost tree availability, which could lessen the effects of locating and establishing alternate roost sites relative to the Indiana bat. Timber harvest alone has not to date had significant, population-level effects on the NLEB (80 FR 17974 -TN4216); this has not been the case for the Indiana bat. Thus, unlike the Indiana bat, effects on the fitness, including reproductive fitness or survivorship, of individual NLEBs likely would not rise to the level of affecting population abundance and viability except when overlaid on the effects of WNS (Section 2.4.1.3).

Potential indirect adverse effects on bats could include (1) removal of foraging habitat and (2) avoidance of noise and increased human activity and light levels, both of which may result in a need to find alternate foraging areas. Unlike the Indiana bat, NLEB foraging habitat is largely confined to under the forest canopy. Thus, mature forest habitat not only provides suitable roosting habitat, but is also an important habitat type for foraging NLEBs, because it provides prey that accommodate the gleaning part of the species' foraging lifestyle, e.g., snags and downed logs that provide insects (80 FR 17974 -TN4216). Mature forest habitat would remain elsewhere on the CRN Site and in the BTA after building, and exists offsite, more on the ORR than south of the Clinch River (Parr et al. 2015-TN5151). NLEBs whose foraging areas occur within an affected area of suitable habitat onsite or whose foraging areas would be disconnected (i.e., loss of a suitable travel corridor), may expend an increased amount of energy to establish new commuting patterns to alternate foraging areas, which could decrease their fitness. NLEBs may also be subject to increases in inter- and intra-specific competition (Indiana bat, little brown bat, and to a lesser extent the tri-colored bat) if available foraging habitat is limited, which could also result in decreased fitness. Because the foraging habitat preferred by the NLEB is more specialized than that preferred by the Indiana bat, the effects of foraging habitat removal may be greater for the NLEB.

The indirect impacts of noise (as well as increased human activity and light levels) on the NLEB would be similar to those of the Indiana bat and are thus not repeated here. The effects of noise and ground vibration (due to blasting) are unlikely to adversely affect the NLEB hibernaculum located about 9 mi from the CRN Site (Section 4.3.1.1.3).

A more detailed evaluation of potential effects on the NLEB is found in NRC's BA in Appendix M.

4.3.1.3.3 Gray Bat (Myotis grisescens) – Federally Endangered (FE)

Because no caves are known to be located on the CRN Site or in the BTA, gray bats likely use these areas for foraging but do not roost there. However, Rennies Cave and 2-Batteries Cave are located within the Grassy Creek Habitat Protection Area, and there are three additional caves/karst openings near Grassy Creek (LeGrand et al. 2015-TN5188). Although these caves have not been surveyed, they may be occupied by gray bats because the species typically roosts in caves within 1 km of foraging areas (Clinch River) (FWS 1982-TN929).

Because gray bats do not roost on the CRN Site or in the BTA, there would be no direct effects on species (as for the Indiana bat and NLEB), but there likely would be indirect effects from forest removal and noise, human activity, and light. All gray bats fly in the protection of forest canopy between caves and over-water foraging areas. Gray bat feeding areas have not been found over rivers or reservoirs where adjacent areas of forest have been cleared (FWS 1982-TN929). It is unknown whether and where any occupied caves are located nearby; thus, routes taken by gray bats in the area of building on the CRN Site and in the BTA to forage along the river and associated wetlands, ponds, and streams are unknown. However, notwithstanding the lack of forest in the CRBRP footprint, gray bats use the nearby river environment. It is uncertain whether removal of more forest in the northern part of the CRN Site and in the BTA (Figure 4-3) would disrupt existing commuting routes to the river environment or use of it as a foraging area. This could necessitate finding alternate forested commuting corridors to the same or a more distant foraging area along the river, which could result in reduced fitness. One factor that may facilitate possible continued use of the river near the developed area for foraging is that a strip of forest would remain along the river after development of the CRN Site and the BTA (Figure 4-3). However, it is uncertain whether this strip of forest is currently used to access the river environment and whether it would be used after building, especially because it would become much narrower in places after site development (Figure 4-3).

Gray bats may avoid noise during the day (and possibly during the night, depending on the location of occupied caves) and may avoid increased human activity and light levels during nighttime. These factors could reduce the quality of remaining forested areas on and around the CRN Site and in the BTA for use as commuting corridors, and/or reduce the quality of the existing foraging areas in the river environment near the developed area. Avoidance could disrupt use of existing commuting routes to the river environment and/or use of these as a foraging area, and necessitate finding alternate forested commuting corridors to the same or a more distant foraging areas in the river environment. Depending on the energy expended to find new commuting corridors and/or foraging areas, and the increase in distance between caves and foraging areas, these activities could result in reduced fitness.

A more detailed evaluation of the potential effects on the NLEB is found in NRC's BA in Appendix M.

4.3.1.3.4 Tri-colored Bat (Perimyotis subflavus) – Petitioned for Listing under the ESA, State Status Rare (S2/S3)

The tri-colored bat likely uses the CRN Site and BTA for roosting and foraging. Recordings of the species in the fall may indicate a possible hibernaculum in the vicinity of the CRN Site or BTA. One tri-colored bat was observed in Rennies Cave in the Grassy Creek Habitat Protection Area by archaeologists in April 2011 (Section 2.4.1.11), but the cave has not been surveyed for bats. The same general direct adverse impacts (harm [injury or death] if occupied roost trees are felled and harassment from tree felling noise resulting in displacement) and indirect adverse effects (removal of foraging habitat and avoidance of noise and increased human activity and light levels) noted above for the Indiana and NLEB, with the exception of species-specific details, would also apply to the tri-colored bat. Thus, these effects are not repeated here. The potential effects of noise and vibrations due to blasting may be more likely for the tri-colored bat than for the Indiana bat or NLEB, because there is at least some evidence that tri-colored bats may occupy Rennies Cave.

A more detailed evaluation of potential effects on the tri-colored bat is found in NRC's BA in Appendix M.

4.3.1.3.5 Little Brown Bat (Myotis lucifugus) – Petitioned for Listing under the ESA, No State Status

The little brown bat likely uses the CRN Site and BTA for roosting and foraging. Recordings of the species in the fall may indicate a possible hibernaculum in the vicinity of the CRN Site or BTA. The same general direct adverse impacts (harm [injury or death] if occupied roost trees are felled and harassment from tree felling noise resulting in displacement) and indirect adverse effects (removal of foraging habitat and avoidance of noise and increased human activity and light levels) noted above for the Indiana and NLEB, with the exception of species-specific details, would also apply to the little brown bat. Thus, these effects are not repeated here.

A more detailed evaluation of the potential effects on the tri-colored bat is found in NRC's BA in Appendix M.

4.3.1.3.6 Eastern Small-Footed Myotis (Myotis leibii) – State Status Rare (S2/S3)

The species likely uses the CRN Site for roosting (in hollow trees under bark) and foraging in spring and summer (Section 2.4.1.11). Thus, the species could noticeably be directly and indirectly affected in a manner similar to the Indiana bat or NLEB by forest removal, noise, and increased human activity and light levels.

4.3.1.3.7 Sharp-Shinned Hawk (Accipiter striatus) – Rare (S3B)

The sharp-shinned hawk may occur year-round in the area where building activities would occur on the CRN Site (Cornell 2015-TN4433), but it was only observed in winter (LeGrand et al. 2015-TN5188). The species is known to breed on the ORR but most observations are also during winter (Roy et al. 2014-TN5154). The species breeds in dense woods and during the nonbreeding season hunts along forest edges (Cornell 2015-TN4433). Although the species was observed only during winter in the area of the CRN Site, it may be assumed to potentially breed there due to plentiful suitable habitat. Forest reduction on the CRN Site and in the BTA would noticeably reduce suitable nesting habitat for this species.

4.3.1.3.8 Bald Eagle (Haliaeetus leucocephalus) – Rare (S3)

Bald eagles were observed flying over the CRN Site and in the BTA in spring, summer, and fall but were not observed on these two sites. Numerous nests occur along Watts Bar Reservoir. The closest documented nest is approximately 8 mi from the CRN Site on Watts Bar Reservoir (LeGrand et al. 2015-TN5188). There are no documented roosting or important foraging areas on the CRN Site or in the BTA. However, bald eagles could in the future roost and forage and potentially nest on the CRN Site or in the BTA. The only impacts that would occur along the river shoreline would be associated with building the intake and discharge structures, which would only affect a small amount of shoreline (Figure 4-3). Based on the National Bald Eagle Management Guidelines (FWS 2007-TN780), these activities are too far distant to have any effect on eagles nesting at the above location. This stretch of river shoreline at the CRN Site could be readily avoided by eagles seeking to roost or forage in favor of other areas along the river with less human presence or disturbance. Thus, the review team expects that there would be no noticeable impacts on the bald eagle.

4.3.1.3.9 Eastern Slender Glass Lizard (Ophisaurus attenuatus longicaudus) – Rare (S3)

The eastern slender glass lizard inhabits dry upland areas including brushy, cut-over woodlands and grassy fields (TDEC 2017-TN5217) and thus could inhabit herbaceous/shrubby upland areas of the CRN Site and/or BTA, and the 500-kV transmission line corridor extending from the CRN Site to the Bethel Valley Substation (where the new 69-kV transmission line would be buried). However, the species was not observed on the CRN Site or in the BTA (LeGrand et al. 2015-TN5188) and the species is not known to occur on the ORR (Giffen et al. 2009-TN5184). Thus, effects on the species from development of herbaceous/shrub areas on the CRN Site, in the BTA, or in the 500-kV transmission line corridor are unlikely.

4.3.1.3.10 Shining Ladies'-Tresses (Spiranthes lucida)--Rare (S1S2)

Shining ladies'-tresses was located in 2000 at the southern end of the BTA (TVA 2017-TN4921), but was not observed in recent surveys (Cox et al. 2015-TN5193) and would thus not be affected by road improvements and barge terminal refurbishment in the BTA.

4.3.1.3.11 Spreading False-Foxglove (Aureolaria patula)—Rare (S3)

The only part of the Clinch River property where spreading false-foxglove has been found is the calcareous forest within the Grassy Creek Habitat Protection Area (Section 2.4.1.11) and it would thus not be affected by development of the CRN Site.

4.3.1.3.12 American Ginseng (Panax quinquefolius) – Rare (S-CE)

The only part of the Clinch River property where American ginseng has been found is the calcareous forest within the Grassy Creek Habitat Protection Area (Section 2.4.1.11) and it would thus not be affected by development of the CRN Site.

4.3.1.3.13 Important Terrestrial Habitats

Important terrestrial habitats within 2 mi of the CRN Site or in the BTA are listed in Table 2-13, depicted in Figure 2-28, and discussed in EIS Section 2.4.1.11. The 100-ac area of "very high biological significance" located on the CRN Site (Figure 2-28) would be permanently disturbed over most of its extent, except for a narrow strip near the Clinch River arm of Watts Bar Reservoir (compare Figures 2-28 and Figure 4-3). Possible occurrence of Appalachian bugbane (*Actaea rubifolia*), a species considered rare on the ORR, may also be affected by disturbing this area. Further, potential habitat area 2 (PH2) would be directly disturbed by development of the road interchange in the BTA (compare Figures 2-28 and Figure 4-3). Note that shining ladies'-tresses and spreading false-foxglove were previously known to occur in the BTA (likely in the PH2 portion) but were not observed in recent surveys (EIS Section 2.4.1.11). Indirect effects may occur on the following important habitats due to disturbance in adjacent areas of the project footprint: Grassy Creek Habitat Protection Area due to development of laydown areas on the CRN Site (Figure 4-3) (project activity would be on the south side of a ridge that separates the CRN Site from the Grassy Creek Habitat Protection Area), natural area 49 (Table 2-13) due to development of the road interchange in the BTA (compare Figure 2-28 and Figure 4-3), natural area 33 (Table 2-13) due to development of the access road between the BTA and the CRN Site (compare Figures 2-28 and Figure 4-3), and research area 22 (Table 2-13) due to development of the laydown area in the northeastern part of the CRN Site (compare Figure 4-2 and Figure 4-3). The above important habitats may also be affected by noise.

Disturbing land adjacent to or near an important habitat may increase the spread of invasive plant species (such as those discussed in EIS Section 2.4.1.11) into such areas, where they may replace native species and reduce floral biodiversity. Such effects on plant and animal communities extend beyond the area of direct habitat loss and have been observed up to 656 ft into the forest from the forest edge on the ORR (Parr et al. 2015-TN5151). Other more distant important habitat areas would likely be only negligibly affected, if at all, by development on the CRN Site and in the BTA.

4.3.1.3.14 Offsite Transmission Line Corridors

Important Terrestrial Species

The important species that may occur within 0.125 mi of the offsite transmission lines that would be upgraded (reconductored, rebuilt, uprated) are indicated in Tables 2-14 and 2-15 in this EIS. It is likely that much less than the total transmission line corridor area (5,327 ac) would be disturbed by upgrades, and neither the upgrade locations nor areal extent of habitat disturbance within the 5,327 ac have been identified. Also, although there are some known occurrences of some important species within 0.125 mi of the offsite transmission lines (Table 2-15), occurrences of these species within the corridor are largely unknown. Consequently, notwithstanding implementation of BMPs, impacts on important species cannot be predicted or described. Impacts will need to be described at the COL stage when more definitive information is available about the locations and areal extent of habitat disturbance in relation to occurrences of important species within the transmission line corridors. Further discussion of Federally listed species known to occur within 0.125 mi of the offsite transmission lines and which could occur or are unlikely to occur within the corridors is provided in NRC's BA (Appendix M).

Important Terrestrial Habitats

There are no important terrestrial habitats, including critical habitats for Federally listed terrestrial species, within 0.125 mi of the offsite transmission lines that would be upgraded (reconductored, rebuilt, uprated) (see NRC's BA in Appendix M).

4.3.1.4 Monitoring

TVA does not propose additional monitoring of terrestrial plant and animal communities during construction and operations (TVA 2017-TN4921). However, TVA has indicated that it plans to repeat field studies performed during the site preparation monitoring program for the period following construction in order to collect at least 1 year of preoperational and/or operational data for comparison to the baseline data. TVA later indicated it would perform monitoring as required by other Federal agencies (TVA 2017-TN4920); any such requirements are not known at this stage of the review but would be described by TVA if it applies for a COL or CP.

4.3.1.5 Mitigation

The USACE and TDEC would determine wetland mitigation requirements for unavoidable wetland impacts under their separate jurisdictions once TVA submits a Joint Permit Application to those agencies. The review team expects that any eventual wetland mitigation would be completed in accordance with the 2008 USACE Mitigation Rule (33 CFR Part 332-TN1472), which calls for the mitigation to be designed to address losses of wetland functions and provides for adaptive management to ensure the mitigation's ultimate success. Because TVA is applying for an ESP, the review team does not expect that TVA will submit a detailed wetland mitigation plan to USACE and TDEC at this time.

4.3.1.6 Summary

TVA has indicated that site preparation and development of project facilities would be conducted according to Federal and State regulations, permit conditions, and established BMPs. The site preparation and development-related impacts would affect a total of approximately 539 ac of terrestrial habitats, as well as additional lands in various existing transmission line corridors. These impacts would be spatially extensive, noticeably alter the terrestrial ecology of the local landscape, and may affect several adjacent important habitats on the ORR. Habitat loss and fragmentation would reduce the quality of mature forest for the Federally listed Indiana bat, NLEB, and gray bat, as well as the tri-colored bat and little brown bat, which are petitioned for listing under the ESA, and one other bat species considered rare in Tennessee, and forest interior birds.

Based on information provided by TVA and the review team's independent evaluation, the review team concludes that the impacts of construction and preconstruction activities on terrestrial ecological resources would be MODERATE. This impact level is driven primarily by noticeable impacts on upland forests and other terrestrial habitats on and adjacent to the CRN Site and BTA and associated impacts on wildlife, particularly Federally listed and rare species. TVA stated it would revegetate temporarily disturbed areas. Wetland impacts would be mitigated in accordance with a wetland mitigation plan developed by TVA and accepted by USACE at the time of any COL application. All of the NRC-authorized construction would occur in areas disturbed as part of site preparation and development of the CRN Site. However, the NRC-authorized construction would continue to introduce substantial noise and human activity into a predominantly natural surrounding landscape. Therefore, the NRC staff concludes that the terrestrial ecological impact associated with NRC-authorized construction activities would also be MODERATE. Mitigation would be implemented as noted above and discussed in EIS Section 4.3.1.5, but the practicable mitigation opportunities available to TVA would primarily address the preconstruction impacts, not the NRC-authorized impacts.

4.3.2 Aquatic Impacts

This section describes potential impacts on the existing aquatic ecosystems, biota, and threatened and endangered species from building the proposed project. The review team's analysis of the potential impacts on the aquatic biota of the Clinch River and the streams and ponds located on the CRN Site and in the BTA are based on the ER (TVA 2017-TN4921); the review team's onsite observations; discussions and information provided by TVA, the FWS, Oak Ridge National Laboratory, and the State of Tennessee; and peer-reviewed articles or other documents obtained directly by the review team.

4.3.2.1 Site and Vicinity

4.3.2.1.1 Ponds and Streams

The proposed locations for the new facilities and structures have been sited to avoid, to the extent possible, impacts on streams and other waterbodies. However one perennial stream (S01) and six ephemeral streams/wet-weather conveyances (WWCs) (C01, C02, C03, C13, C14, C15) lie within the TVA's estimated construction footprint. Two freshwater ponds (P04 and P06) also lie within the footprint (TVA 2017-TN4921). Five additional ephemeral streams located in the northeast section of the CRN Site (C04, C05, C06, C07, and C08) may be temporarily disturbed and then restored. The streams and ponds affected by development of the site and BTA are small in size and contain only limited habitat and biota.

TVA indicates that installing a pipeline to the cooling-water intake and building activities in the vicinity of the intake would result in the loss of the entire 925-ft channel composing Stream S01. Stream S01 is an unnamed tributary of the Clinch River arm of Watts Bar Reservoir and is likely subject to USACE jurisdiction because it runs through a wetland. As discussed in EIS Section 2.4.2 of this EIS, sampling of Stream S01 indicated only limited aquatic communities and revealed no fish and only a few crayfish that were too small to identify. Stream S01 is fed by a spring and a small pond (P04), which will be graded and filled to build the switchyard. Pond P04 was constructed as a stormwater-retention basin for the CRBRP. It is characterized as a shallow pond (TVA 2017-TN4921).

A second pond, P06 would be also be graded and filled to build a parking lot. Like Pond P04, it was constructed as a stormwater-retention basin. It has only intermittent connections during heavy rainfall with the Clinch River arm of Watts Bar Reservoir (TVA 2017-TN4921).

Within the BTA, two intermittent streams (S09 and S10) and six ephemeral streams (C26, C27, C28, C29, C30, and C31) would be affected by building improvements related to Bear Creek Road, the CRN Site entrances, and development of a new intersection and access ramps on SR 58. Stream S10 and the six ephemeral streams would be permanently altered through grading and filling as part of the road development (TVA 2017-TN4921). Stream S10 was not sampled during the stream survey study conducted in 2011 because it was deemed to not have the same potential to support aquatic communities as other streams such as S01 and S09. Stream S09 is described as a first-order stream. Its substrate consists of gravel and cobble. This stream would only be affected where it is crossed by Bear Creek Road, as a result of road widening and other improvements (TVA 2017-TN4921). The sampling reported only a single crayfish (upland burrowing crayfish, *Cambarus dubius*) and no fish. The review team expects that these impacts would be temporary and minor. Both intermittent streams are likely to be subject to USACE jurisdiction. The jurisdictional status of the ephemeral streams is more difficult to predict (TVA 2017-TN4921).

The two ponds within the BTA near the entrance to the CRN Site are not expected to be affected by development activities, and the proposed stormwater BMPs would prevent or minimize sediment transport and erosion to these ponds (TVA 2017-TN4921).

TVA has stated that they would use BMPs to minimize erosion and transport of sediments in the streams. TVA uses BMPs specifically directed toward avoiding or minimizing adverse impacts on streamside management zones (SMZs) and the waterbodies. TVA also indicated they would follow a SWPPP that sets controls to manage runoff during clearing and building activities

(TVA 2017-TN4921). TVA stated that they would subsequently revegetate and restore any temporarily disturbed aquatic habitats (TVA 2017-TN4921).

The project would also include installing a 5-mi underground 69-kV transmission line connecting the CRN Site to the Bethel Valley Substation and the CRN Site. Installation of the buried 69-kV line would take place entirely within an existing right-of-way and not require clearing of forested land. However, the installation would cross six streams that flow roughly perpendicularly across the right-of-way, as discussed in EIS Section 2.4.2.1. TVA has indicated that they would attempt to tunnel under the streams where practicable (TVA 2017-TN4921). TVA expects to employ BMPs to reduce the impacts from sediment during the installation of the underground conductors. TVA has committed to restoring any disturbance to streams immediately after work is completed (TVA 2017-TN4921). The review team expects that the USACE would require TVA to restore surface disturbances to jurisdictional streams as part of any Department of the Army permit issued under the Clean Water Act.

4.3.2.1.2 Clinch River Arm of Watts Bar Reservoir

Aquatic habitats and organisms in the Clinch River could be affected by installation of the intake structure, discharge structure, improvements to the barge facility, and installation of a new culvert under the road in the Grassy Creek embayment (that is part of the Clinch River arm of the Watts Bar Reservoir).

The proposed cooling-water intake and discharge structures are described in EIS Section 3.2.2.2. As described by TVA, the intake structure would likely be 50 ft long and situated so that the front of the intake structure would be flush with the shoreline, as shown in Figures 3-3 and 3-4. The riverbed near the shore would need to be deepened slightly to form a forebay between the face of the intake and the main channel of the river. This would allow water to enter the intake below the minimum water level of the reservoir. The intake would be placed at Clinch River mile (CRM) 17.9, on the east side of the CRN Site. However, the precise location of the intake and the depth and amount of riverbed excavated would be included in any future CP or COL application (TVA 2017-TN4921).

The discharge would be built at approximately CRM 15.5 on the west side of the CRN Site. Installation of the discharge would require placement of two parallel 3-ft-diameter pipes that extend into the river at an elevation of about 720 ft, or 4 ft above the bottom at the offshore end (Figure 3-5). The diffuser pipe would be partially buried, requiring in-water excavation of the river bottom. Installation of the discharge might also require excavation near the shoreline (TVA 2017-TN4921).

TVA indicates that “these activities would affect only small areas of the reservoir” (TVA 2017-TN4921). In addition, these activities would require a Department of the Army permit from the USACE, and TVA would need to conduct activities in accordance with the requirements of the permit. TVA has indicated that no in-stream dredging would be required for activities to build the intake or place the discharge, although shoreline excavation or underwater excavation would be necessary (TVA 2017-TN4921). TVA anticipates using BMPs to prevent erosion and sediment transport. The review team expects that TVA would use a temporary cofferdam during placement of the intake structure, and TVA may use temporary silt curtains or cofferdams when building the discharge structure (TVA 2017-TN4921).

Installation of the intake would result in temporary and localized loss of aquatic habitats for benthic organisms. As discussed in EIS Section 2.4.2.1, the benthic community in the vicinity of the site is considered to be relatively diverse in terms of species richness. The benthic macroinvertebrates that would be displaced by installation of the intake and discharge are not considered rare and can be expected to reestablish in the area of disturbance, with the likely exception of native mussel species. As discussed previously, invasive zebra mussels are out-competing the freshwater mussels for space and food.

TVA would install a new culvert in the Grassy Creek embayment of the Clinch River arm of the Watts Bar Reservoir as part of the roadway improvements to the access road as discussed in Chapter 3 of this EIS. This would cause temporary disturbance to the aquatic biota in a small portion of the embayment. TVA would use BMPs such as silt curtains and cofferdams to minimize erosion and prevent the transport of sediments into the reservoir (TVA 2017-TN4921).

As described in EIS Section 3.2.2.3, TVA would refurbish the existing inactive barge terminal at CRM 14.2 near the entrance to the CRN Site and Bear Creek Road. TVA can be expected to repair or enlarge the existing retaining wall and install steel or wooden pilings or mooring posts to secure the barges. Dredging activities are not anticipated; however, piles could be used during the barge facility improvements. Placement of piles would affect small areas of habitat within the footprint of the piles (TVA 2017-TN4921). Although most fish species can be expected to avoid the underwater noise of pile driving, some species such as Lake Sturgeon (*Acipenser fulvens*) could be affected by the noise and the associated pressure wave. The Lake Sturgeon has not been observed in recent surveys or telemetry studies, but they have been released in past years and in the future they may be more common in this area. The review team does not anticipate that TVA would disturb much river bottom area when building the subject facilities.

TVA would conduct barging activities while building the project. However, TVA indicated that most deliveries of modules and components would occur via road or rail (TVA 2017-TN4921).

Other than at the proposed locations for the features noted above, TVA indicates in figures in its application that a buffer of undisturbed riparian forest vegetation would be left between disturbed lands and the river (TVA 2017-TN4921). This buffer, combined with BMPs to prevent erosion and sedimentation from disturbed soils, would effectively prevent sedimentation of aquatic habitats in the river and would preserve shaded aquatic habitats at the edge of the river.

4.3.2.1.3 Melton Hill Dam Bypass

The bypass that TVA proposes to build at the Melton Hill Dam would be built inside the existing dam; therefore, building it would not affect aquatic life or disturb sediments (TVA 2017-TN4921).

4.3.2.2 Offsite Areas

The review team does not expect TVA to disturb aquatic habitats during offsite work, such as upgrading (uprating, reconductoring, and rebuilding) the offsite overhead transmission line segments identified as possibly necessary to support the project, or by using offsite borrow sources. This expectation is based on an explanation of the upgrade processes by TVA representatives at the May 2017 Site Audit (NRC 2018-TN5386). If TVA submits an application for a COL or CP that involves physical disturbance of aquatic habitat to upgrade transmission lines, then it will be necessary to evaluate impacts on those habitats at that time.

All ground disturbance for the transmission lines would be confined to existing right-of-ways. TVA maintains SMZs, as discussed in EIS Section 2.4.2.1, and uses other BMPs to minimize sedimentation and erosion. BMPs include erosion control methods such as silt fencing or hand clearing in sensitive areas to prevent or minimize impacts on streams. TVA allows only minimal construction activities within most SMZs and State regulations allow only minimal surface disturbance where ephemeral streams intersect with perennial or intermittent streams (TVA 2017-TN4921). The review team expects that TVA would extend new conductors across waterways within the existing right-of-ways without conducting in-water work or disturbing shorelines, and without clearing additional trees to the extent possible. Impacts on aquatic habitats would be localized and temporary.

4.3.2.3 Important Species and Habitats

As discussed in EIS Section 2.4.2.3, the review team determined that Federally listed species (specifically the pink mucket [*Lampsilis abrupta*], sheepnose mussel [*Plethobasus cyphyus*], and Spotfin Chub [*Erimonax monachus*]) are likely not present at or in the vicinity of the CRN Site and BTA. The review team has determined that building the new facilities at the CRN Site would not likely affect Federally listed species, and would not substantially affect the commercial and recreational species and other important species described in EIS Section 2.4.2.3. Furthermore, building activities would not likely affect the hellbender (*Cryptobranchus alleganiensis*) because it is unlikely to be present in the areas subject to disturbance.

Refurbishing the existing inactive barge terminal could affect the State-Endangered Lake Sturgeon during placement of pilings, depending on when this activity occurs and whether Lake Sturgeon are present in the vicinity. Further, installing and burying the 69-kV underground transmission line in the existing 500-kV transmission line corridor where it crosses Ish Creek could affect the Tennessee Dace, which TDEC has designated as being “In Need of Management.” The Tennessee Dace has been sighted in Ish Creek as recently as 2016. The Tennessee Dace prefers undercut banks in shallow pools and likely does not preferentially inhabit the parts of the stream that cross the right-of-way. If TVA can install the underground transmission line by tunneling under Ish Creek, there would be little potential for adverse effects on any Tennessee Dace inhabiting that stream. Because this fish species is motile, most individuals can be expected to evade disturbance activity.

The review team assumes that the anticipated transmission line upgrades would not involve any physical disturbance of rivers, streams, ponds, shorelines, or other aquatic features. The review team furthermore expects that TVA’s BMPs for streamside protection during transmission line work would effectively protect aquatic features from runoff and sedimentation from the transmission line upgrades. Considering also that the upgrade work would be brief and temporary, the review team considers it unlikely that Federally listed aquatic species would be adversely affected by the upgrades.

4.3.2.4 Aquatic Monitoring

TVA has not proposed any further monitoring of aquatic ecological resources, and the review team does not anticipate that further monitoring requirements would be required by Federal, State, or other regulatory agencies.

4.3.2.5 Mitigation

The review team expects that three major forms of reasonably foreseeable mitigation would be implemented by TVA to address impacts on aquatic ecological resources. First, TVA has designated a footprint of disturbance that avoids encroachment into aquatic habitats to the maximum extent possible, limiting disturbance to a few small streams and ponds on the CRN Site and BTA, perpendicular crossings of streams traversed by the underground 69-kV transmission line, and small areas of disturbance to reservoir sediments where intake and outfall structures would be built into the Clinch River. Any land disturbance extending outside of this proposed footprint would require further analysis at the time of COL application. Second, TVA would implement BMPs to minimize soil erosion and minimize sedimentation into streams, the Clinch River arm of the Watts Bar Reservoir, and other aquatic habitats in the affected area. These BMPs would be required by internal TVA policy and would have to meet State requirements. Third, TVA would perform compensatory mitigation as required by the conditions established by the USACE as part of a Department of the Army permit. The USACE would require that TVA demonstrate specific avoidance and minimization measures and implement specific compensatory mitigation measures in accordance with USACE's 2008 Mitigation Rule established in 33 CFR Part 332 (TN1472). Mitigation for impacts on aquatic habitats in streams and ponds, which USACE regulates as a type of aquatic habitat, overlaps with the wetland mitigation presented in EIS Section 4.3.1.5.

4.3.2.6 Summary

Based on its review of TVA's ER and other relevant information, the review team concludes that the impacts of building the project facilities (construction and preconstruction) on aquatic resources would be SMALL. The conclusion reflects the expectation that TVA would minimize the footprint of disturbance and implement appropriate BMPs to minimize sedimentation, erosion, and other disturbances to the reservoir, ponds, and streams. The conclusion also reflects an expectation that TVA would implement mitigation requirements established by the USACE as part of a Department of the Army permit for any physical disturbance of streams and other aquatic habitat on the CRN Site and any streams crossed by building the proposed 69-kV underground transmission line to the Bethel Valley Substation. The conclusion also rests on an assumption that work on offsite overhead transmission lines would be limited to existing right-of-ways. Based on the above analysis and because NRC-authorized construction activities represent only a portion of the analyzed activities, and the above mitigation is reasonably foreseeable, the NRC staff concludes that the impacts of NRC-authorized construction activities would be also SMALL.

4.4 Socioeconomic Impacts

Construction and preconstruction activities (the review team will refer to these as building activities in this subsection) at the CRN Site could affect individual communities and the surrounding region. This section assesses the impacts of these building-related activities on the general public and the associated workforce in the demographic and economic regions. The review team assessed the TVA ER (TVA 2017-TN4921) and verified the data sources used in its preparation by examining cited references and independently confirming data in discussions with community members and public officials (NRC 2018-TN5386). To verify data in the ER, the review team requested clarifications and additional information from TVA as needed. Unless otherwise specified in the sections below, the review team has relied upon verified data from TVA (TVA 2017-TN4921). Where the review team used different analytical methods or additional information for its own analysis, the sections include explanatory discussions and citations for the additional sources.

Although the review team considered the entire region within a 50-mi radius of the CRN Site when assessing socioeconomic impacts, because of expected commuter patterns, the distribution of residential communities in the area, and the likely socioeconomic impacts, the review team identified a primary economic region composed of the four counties nearest to the site—Anderson, Loudon, Knox, and Roane—as the area with the greatest potential for economic impacts, hereinafter referred to as the “economic region.”

Section 4.4.1 presents a summary of the physical impacts of the project. Section 4.4.2 provides a description of the demographic impacts. Section 4.4.3 describes the economic impacts, including impacts on the local and State economy and tax revenues. Section 4.4.4 describes the impacts on infrastructure and community services. Section 4.4.5 summarizes the socioeconomic impacts of building activities at the CRN Site.

4.4.1 Physical Impacts

Building activities can cause temporary and localized physical impacts such as noise, fugitive dust, air emissions, and visual aesthetic disturbances. The review team expects these impacts would be mitigated by compliance with all applicable Federal, State, and local environmental regulations and site-specific permit conditions. All of the mitigation activities discussed below are identified in the TVA ER (TVA 2017-TN4921). This section discusses potential impacts on people, buildings, and roads from building activities.

4.4.1.1 Workers and the Local Public

This section discusses potential impacts of air emissions, noise, and vibrations on workers, nearby residents, and transient visitors to the immediate area around the CRN Site. The proposed CRN Site is located adjacent to DOE’s ORR in Roane County, Tennessee. The site is located on a peninsula or “goose neck” of the Clinch River arm of the Watts Bar Reservoir. The site is approximately 10 mi south of Oak Ridge, Tennessee; 16 mi west of Knoxville, Tennessee; and 7 mi east of Kingston, Tennessee.

The nearest residences to the CRN Site are located across the Clinch River, approximately 1,900 ft to the south of the expected location of the CRN Site cooling towers (TVA 2017-TN4921). The closest recreational areas include the Gallaher Recreation Area, located on the south bank of the Clinch River, just west of the site boundary; the Melton Hill Dam Reservation, which includes 2,578 ac of land surrounding the Melton Hill Reservoir, upstream from the CRN Site; and several private boat ramps providing access to the Clinch River from residences along the south bank of the river, along the entire stretch bordering the site (TVA 2017-TN4921).

Because physical impacts attenuate rapidly with distance, onsite workers involved in building activities for a new plant would experience the most direct exposure to physical impacts and the impacts experienced by people offsite would be less. Further discussion of the health impacts on construction workers can be found in Section 4.8.1.2 of this chapter. Because the review team determined the nonradiological health impacts on construction workers and the public would be minimal, the review team determined the socioeconomic component of the physical impacts on onsite workers and the public would also be minimal and no additional mitigation beyond what TVA has identified in its ER would be warranted.

Workers involved in building the proposed offsite facilities such as road and rail improvements and transmission line upgrades would be less likely to experience the effects of fugitive dust, emissions, noise, and vibrations because less equipment and fewer materials would be involved in these efforts and most of the work would occur away from the CRN Site. In addition, contractors involved in these activities would use the BMPs discussed by TVA to minimize impacts on the workforce (TVA 2017-TN4921). The closest residences are directly across the

Clinch River from the CRN Site. Physical impacts attenuate less with distance across water than they do over land. Therefore, the review team determined that given the close proximity to the site of numerous residences on the other side of the Clinch River, physical impacts from emissions, noise, and fugitive dust during construction activities would be more noticeable to nearby residents than is typical for nuclear power plant construction, but that impact would be temporary, and not destabilizing. Periods of noticeable physical impacts would be expected throughout the duration of the construction period.

The review team determined the physical impacts on the workers and the local public from building activities for offsite facilities would be of short duration and would be considered a minor annoyance or nuisance, and no further mitigation beyond that identified by the applicant in its ER would be warranted.

4.4.1.1.1 Noise

The socioeconomic portion of the physical impacts of noise are related to the health effects produced by loud and prolonged noise. As discussed in Section 4.8.2 of this chapter, the review team determined the noise related to building activities associated with the CRN Site would be minor to noticeable and mitigation would be required to reduce noise levels to at or below the NRC's 65 dBA threshold for a minor impact. Therefore, the review team expects minimal to noticeable socioeconomic impacts due to building-related noise, as well.

4.4.1.1.2 Air Quality

The socioeconomic aspect of air-quality impacts relates to the costs incurred by individuals who experience health-related problems due to increased air pollution (e.g., medical costs, lost work impacts, etc.). As discussed in Section 4.7 of this chapter, the review team determined air-quality degradation due to building activities for the CRN Site would be minimal and, therefore, any associated socioeconomic impact from the degradation of human health would also be minimal. Further discussion about air quality in this EIS is in Section 4.7 of this chapter.

4.4.1.2 Structures

Building activities on the CRN Site should not affect any offsite structures, because of the distance separating the site from other development. As noted previously, the nearest residences are located across the Clinch River from the site. The nearest industrial and commercial buildings are located adjacent to the site, but are separated from the area of construction by a ridgeline and are not likely to be affected by onsite building activities (TVA 2017-TN4921).

The structures that have the greatest potential to be affected by building activities associated with a new nuclear power plant at the CRN Site would be the existing facilities at the Clinch River Industrial Park, which is located less than a mile from the CRN Site. The park could experience vibration-related impacts associated with pile-driving activities and some surface fouling from building-related dust. TVA indicates that building activities would be planned, reviewed, and conducted in a manner that ensures no adverse effect on the operations of nearby facilities (TVA 2017-TN4921). The review team expects that these measures would minimize impacts on existing structures outside the CRN Site. Offsite construction activities such as roadway and rail line improvements and transmission line upgrades are not expected to require the removal of existing buildings, and the review team expects that the required work activities in these locations would not generate significant vibrations or other physical impacts.

In summary, the review team concludes that building-related activities associated with a new nuclear power plant on the CRN Site (including offsite facilities) would not affect offsite structures and that impacts on buildings on the CRN Site would be minimized through design and construction practices. Thus, the impact of building-related activities on onsite and offsite structures would be minimal, and no mitigation beyond that identified by the applicant in its ER would be warranted.

4.4.1.3 Transportation

4.4.1.3.1 Roads

Building activities at the CRN Site would affect existing road conditions and traffic volumes in two ways: the modification of the SR 58 interchange with Bear Creek Road would alter traffic patterns in the area, and construction workers and other traffic related to a new nuclear power plant would increase traffic on the local roadway network. Section 2.5.2.4.1 of this draft EIS describes the local transportation network around the CRN Site, and Figure 2-11 depicts the road and highway system in the vicinity of the CRN Site. This section discusses the impact of physical changes to local roads and highways due to increased traffic related to building-related activities. EIS Section 4.4.4.1 discusses the socioeconomic impacts from additional vehicular traffic volumes, road and intersection capacities, and the level of service due to building-related activities.

The primary physical effects of the proposed interchange improvements on the SR 58 to Bear Creek Road would be changes in local traffic patterns and volumes. Vehicular traffic volumes in the area would increase due to construction workers and delivery trucks driving to and from the CRN Site each day. Given the size of the increases in traffic volumes, it is likely that building activities at the CRN Site would increase the rate of degradation on some roads in the economic region, particularly SR 58 and Bear Creek Road in Roane County. These impacts could warrant increased road repairs and maintenance and cause additional traffic congestion in some areas. Most road degradation would occur in Roane County. Therefore, the review team determined the physical impacts on roads would be noticeable but not destabilizing, and mitigation beyond that which TVA has identified in its ER would not be warranted.

4.4.1.3.2 Water

As discussed in EIS Section 2.5.2.4.4, there is an existing barge facility near the CRN Site. To support delivery of large components and equipment for building, TVA indicated that the existing barge facility would need to be refurbished. In addition, TVA states there would need to be a cooling-water intake structure and a discharge structure to take water from and discharge water into the Clinch River arm of the Watts Bar Reservoir. Construction of the barge slip and the cooling-water intake and discharge structures would be conducted under project plans permitted by the USACE, and TVA expects minimal disturbance to the local environment—including recreational uses. TVA also expects deliveries of construction materials by barge to have a negligible impact on river traffic and recreation on the Clinch and Tennessee Rivers (TVA 2017-TN4921).

4.4.1.3.3 Rail

As described in EIS Section 2.5.2.4.2, TVA has indicated that it would recondition an existing rail spur to the rail offloading area near the BTA. The review team expects only minor impacts along that rail spur because reconditioning activities may temporarily disrupt existing service to nearby DOE facilities. Any service disruptions would be coordinated with other customers of the rail spur.

4.4.1.4 Aesthetics

Because of the distance to occupied areas, activities associated with building a new nuclear power plant at the CRN Site would be visible primarily to workers on the site and local residences on the south bank of the Clinch River. Aesthetic impacts on offsite areas would occur mainly as a result of the introduction of large new structures, including cooling towers, a reactor building, and a new highway interchange, into the visual environment.

Boaters on the Clinch River and residents and recreationists near the Clinch River in Roane County would be able to clearly see most of the facilities on the CRN Site. Residents of other nearby portions of Roane County would likely have views of the facilities at the CRN Site from various roadway vantage points. EIS Figure 3-1 shows the expected layout of the CRN Site (TVA 2017-TN4921).

The majority of building activities would not be visible from offsite. However, building a new nuclear power plant at the CRN Site would eventually add to the industrial character of the CRN Site. The principal visual features added by a new nuclear power plant would be the power-block structure (up to 160-ft tall), cooling towers, and the new highway interchange. A heavy-lift crane (up to 638 ft tall) would be used during much of the construction period and would be visible when in close proximity to the site and from local roadways (TVA 2017-TN4921). Under Federal Aviation Administration regulations, the tallest plant structures would be appropriately marked with lighting, making them visible during nighttime hours. The other facilities would not be widely visible, except when in close proximity to the site.

Because of the topographic isolation of the CRN Site and the limited areas of viewshed interruption, along with the existing industrial presence of the ORR, the review team determined the aesthetic impacts from building-related activities at the CRN Site would be noticeable for areas in close proximity to the site and would be minimal elsewhere. Any mitigation beyond what TVA has indicated in their ER would not be warranted.

4.4.1.5 Summary of Physical Impacts

Based on the information provided by TVA and the review team's independent evaluation and outreach, the review team concludes that the physical impacts of building-related activities on workers and the local public; air quality; and on structures would be SMALL. Physical impacts including noise and visual aesthetics would be SMALL to MODERATE, and no mitigation beyond that proposed by TVA would be warranted. SMALL impacts would be expected at distances beyond close proximity to the CRN Site, while MODERATE impacts would be experienced by local residences and businesses directly across the Clinch River from the site. The physical impacts on the road network during building would be MODERATE due to more frequent road maintenance and repair activities related to increased traffic volumes and heavy-haul loads, especially on Bear Creek Road. The building of structures at onsite and offsite locations for the CRN Site would have SMALL to MODERATE physical impacts on aesthetic resources, depending on distance, and those impacts would not be amenable to mitigation.

Based on the above information, the review team determined the impacts of NRC-authorized construction activities on the physical aspects of the affected environment for impact categories (noise, roadways, and visual aesthetics) also would be SMALL to MODERATE.

4.4.2 Demography

TVA estimates that preconstruction activities associated with a new nuclear power plant, including site preparation work and building the proposed highway interchange, would begin in the third quarter of 2020 and last about 72 months (until the second quarter of 2026) (TVA 2017-TN4921).

For analytical purposes, TVA plans to begin preconstruction activities in the third quarter of 2020 and would run them for a full year before beginning safety-related construction. The NRC-authorized construction activities on a new nuclear power plant would begin in the third quarter of 2021 and be completed in the second quarter of 2026 (TVA 2017-TN4921). TVA has not selected a reactor technology, but estimates that 3,300 workers would be required during peak employment period—a 6-month period (months 42–47) (TVA 2017-TN4921). Table 4-4 presents the number of workers that would be required during each month of the construction period. For most socioeconomic resources, the review team analyzed only the impacts of the peak construction employment period as an upper bound for potential impacts, recognizing that impacts would likely be smaller during the rest of the building period. The average monthly workforce size over the 72-month construction period would be 1,764 workers (TVA 2017-TN4921).

Table 4-4. Estimated Construction Workforce Requirements by Construction Month

Construction Month	Total	Percent of Peak Workforce
1	100	3
3	150	5
6	225	7
9	300	9
12	400	12
15	700	21
18	1,000	30
21	1,400	42
24	1,775	54
27	2,150	65
30	2,475	75
33	2,650	80
36	2,950	89
39	3,200	97
42	3,300	100
45	3,300	100
48	3,200	97
51	2,550	77
54	2,150	65
57	2,150	65
60	2,000	61
63	1,800	55
66	1,500	45
69	800	24
72	200	6

Source: TVA 2017-TN4921.

TVA reports in its ER that 77 percent of the labor force for the construction of a conventional pressurized water reactor is skilled craft labor, including civil, mechanical/piping, electrical, and support personnel, and the remaining 23 percent is composed of field management and supervisory, engineering, quality control, safety and health, and administrative staff (TVA 2017-TN4921). Of the 3,300 workers required at peak employment, TVA estimates 25 percent of the skilled craft workforce would represent civil/architectural trades (635 workers), 24 percent mechanical and piping trades (610 workers), and 14 percent each electrical trades and site support workers (356 workers each). TVA estimates that most of the nontrade workers would be employed during the construction period in the areas of management, supervision, field engineering, quality assurance/quality control, environmental safety and health, administration, and startup preparation (TVA 2017-TN4921). The review team finds the worker assumptions in TVA's ER to be reasonable and has incorporated them into the analyses in this section of the EIS.

Based on TVA's and DOE's experience in nuclear and energy facility construction, TVA relied upon several assumptions to bound the construction workforce composition with respect to workforce commuting and relocation. TVA made the following assumptions regarding plant construction:

- Construction workers commute up to 50 mi, thus workers within 50 mi of the CRN Site are considered local.
- 80 percent of field craft laborers would be available within 50 mi of the CRN Site.
- 20 percent of the field craft laborers would relocate to within 50 mi of the CRN Site and seek temporary housing.
- 80 percent of the non-manual field laborers would relocate to within 50 mi of the CRN Site and seek permanent housing.
- 20 percent of the non-manual field laborers would be available within 50 mi of the CRN Site.

The review team found these assumptions to be consistent with worker location assumptions for other recent NRC licensing actions and incorporated them in its assessment. The review team also developed additional information about the likelihood of a higher proportion of locally supplied labor and materials, given that the economic region already supports DOE's ORR.

Substantial local expertise and supply chain businesses exist in the economic region as well, which may mitigate some of the need for both labor, support services, and materials acquisition from outside the region.

The review team assessment of construction worker location and economic impacts of construction is based on two recent studies covering the local area and additional review team analysis.

- In cooperation with the University of Tennessee, the East Tennessee Economic Council (ETEC 2014-TN4963) completed a study of the 2013 economic impact of DOE operations on the State of Tennessee.
- DOE (2015-TN4964) estimates the localized economic impact of the operation of DOE's Oak Ridge Environmental Management program in Federal fiscal year 2014. This study also was performed by the University of Tennessee.

These studies characterize the economic impacts accruing locally and to the rest of the State from DOE-related employment at the ORR and from DOE direct non-labor (goods and services) expenditures tied to activities at the ORR. The referenced studies, DOE's workforce location estimates, and the review team's outreach to the affected communities and economic researchers form the basis for determining the economic region to be the four-county area (Anderson, Knox, Loudon, and Roane). Thus, the review team expects most of the workers required to build a new nuclear power plant would be drawn from the labor force within the economic region, rather than from the wider 50-mi radius. This assumption is based on the large labor force available within the economic region of the CRN Site and the expertise of TVA and DOE related to nuclear and energy facility construction. These workers would maintain their current residences and commute daily to the CRN Site. Labor with specialized skills or capabilities is typically in high demand and TVA may need to hire these workers from other regions in Tennessee or other states. Table 4-5 summarizes the labor requirements expected for the CRN Site, including estimates of the number of skilled craft workers that would need to be recruited from outside the economic region.

Table 4-5. Projected Peak Construction Onsite Labor Requirements

Labor Category	Installation Items/Responsibility	Estimated Percent of Total Workforce	Peak Workforce Need	Needed from Outside the Economic Region
Civil/ Architectural Workforce	Earthwork, Yard Pipe, Piling, Concrete and Reinforcing Steel, Rigging, Structural/Miscellaneous Steel, Fire Proofing, Insulation, Coatings/Painting	25	825	165
Mechanical/ Piping Workforce	Nuclear Steam Supply System; Turbine Generator; Condenser; Cooling Towers, Process Equipment; Heating, Ventilation, and Air-Conditioning; Piping; Tubing; Valves; Hangers/Supports	24	792	158
Electrical Workforce	Electrical Equipment, Cable Tray, Conduit, Supports, Cable and Wire, Connections and Terminations	14	462	92
Site Support Workforce	Scaffolding, Equipment Operation, Transport, Cleaning, Maintenance, etc.	14	462	92
Non-manual Workforce	Management, Supervision, Field Engineering, Quality Assurance/Quality Control, Environmental/Safety and Health, Administration, and Startup	23	759	607
	Total	**100**	**3,300**	**1,114**

TVA assumed that at peak construction, 1,114 of the 3,300 workers, or about 34 percent, would relocate into the economic region in proportion to the existing DOE Oak Ridge-related workforce residency pattern (TVA 2017-TN4921). The review team found these assumptions to be consistent with worker location assumptions for other recent NRC licensing actions and incorporated them in its assessment along with an additional assumption that all in-migrating workers would relocate with their families. The average household size (includes single-person households) in Tennessee is 2.53 people (USCB 2016-TN4965). Table 4-6 summarizes the expected residency of the in-migrating construction workers and families.

Table 4-6. Estimated Population Increase and Employment in the Economic Impact Region during the Peak Construction Period

County	In-Migrating Workers	Population Increase	Projected 2025 Population	Percent Increase	Local Resident Workers	Total Project Employment
Anderson	301	762	80,713	0.9	590	891
Knox	557	1,409	516,603	0.3	1,093	1,650
Loudon	67	170	62,151	0.3	131	198
Roane	189	478	56,805	0.8	372	561
Total	**1,114**	**2,819**	**714,968**	**0.4**	**2,186**	**3,300**

Source: For projected 2025 population see Table 2-24 in this EIS.

Of the 2,186 workers that already live in the economic region, some would have been unemployed prior to being hired for building activities at the CRN Site. The 2016 national annual average unemployment rate for the construction industry was 6.3 percent (BLS 2017-TN4992). Of the workforce that would already live in the economic region, the review team assumes 138 would have been unemployed and would find construction jobs at the CRN Site, and an additional 1,114 jobs would be filled by in-migrating workers, for a total of 1,252 new jobs in the economic region because of building activities at the CRN Site.

The review team calculates an in-migrating workforce of 1,114 workers and their families would cause a 0.4 percent increase in population because of worker relocation. The increase would not noticeably affect the demographic character of the economic region or any of its counties and therefore the impact would be SMALL.

4.4.3 Economic Impacts on the Community

This section evaluates the economic and tax impacts of building activities at the CRN Site, focusing primarily on the economic region of Anderson, Knox, Loudon, and Roane Counties. The evaluation assesses the impacts of project-related expenditures at the CRN Site as well as workforce income and spending impacts. As indicated in EIS Section 4.4.2, the review team assumes 1,114 workers (about 34 percent of the peak construction workforce) would migrate into the economic region. Assuming a family size of 2.53, the review team assumes about 2,819 people would move into the economic region.

4.4.3.1 Economy

Direct employment for large industrial or infrastructure projects typically benefits the local economy. Each direct job stimulates spending on goods and services, resulting in the creation of indirect and induced jobs.

TVA has not selected a specific reactor technology, but for the purposes of this analysis, the review team assumes the SMR PPE electrical capacity of 800 megawatts electric (MW(e)) discussed in Section 3.2.2.3.5 of this EIS. Reliable studies of first-of-a-kind SMR power plant construction costs are not available. Most studies addressing SMR costs assume a mature market for the technology has already been established, and the costs reported reflect nth-of-a-kind implementation. TVA did not assume any cost values for the SMR technology for the proposed project in its ER (TVA 2017-TN4921). To estimate the economic impacts that might be expected for purposes of the ESP, the review team assumed a range of potential SMR costs that would require substantial refinement in the event of a COL application to the NRC. The review team assumed that SMR costs reported in the literature would not be representative of first-of-a-kind SMR applications. Instead, the review team assumed that the high end of any ranges reported would be more likely to represent the expected construction experience.

The DOE Office of Nuclear Energy relies upon a study that suggests SMR overnight costs could range from $3,000-$7,000 per kW(e) (EPI 2010-TN4966). Thus, for the assessment of economic impacts at the ESP stage, the review team used a range of $5,000-$7,000 per kW(e) (2010$), which translates to total overnight costs (excluding costs of loans) of $4.0–$5.6 billion. The inflation-adjusted amount would be $5,183–7,256 per kW(e) in 2016 dollars, using the Bureau of Economic Analysis (BEA) Gross Domestic Product Implicit Price Deflator for Nonresidential Structures and Nonresidential Equipment (BEA 2017-TN4967). Using these assumptions, the review team assumes the PPE bounding capacity of 800 MW(e) would cost about $4.1–$5.8 billion in 2016 dollars. The Energy Policy Institute (2010) also estimated that for SMRs, 87 percent of the costs are allocated to offsite modular manufacturing and the remaining 13 percent are allocated to onsite installation of the units. Thus, $533–$728 million (2016$) would be expected to be spent locally to construct facilities and install the SMR units (average of $89–$121 million per year). These costs do not explicitly include site preparation and balance-of-plant construction costs, for which no estimate is available at the ESP stage. Given the highly specialized nature of nuclear power plant components, a large portion of the project's materials and equipment would be imported from outside the region, with no benefit to the economic region. However, a new nuclear power plant would require substantial amounts of generic materials and supplies (including concrete, steel piping, wiring, and electrical components), much of which could be procured locally. These locally obtained materials and supplies would have a beneficial economic effect on the economic region.

Expenditures during building would support employment in other sectors of the local economy at vendors and shops that provide materials and supplies for the building phase. BEA's Economics and Statistics Division provides Regional Input-Output Modeling System (RIMS II) regional multipliers for industry employment and earnings (TVA 2017-TN4921). TVA obtained and the review team reviewed multipliers from the BEA for the economic region. For every construction job created at the CRN Site, an additional 0.742 jobs would be created in the rest of economic region (TVA 2017-TN4921). For each dollar of earnings paid to newly hired workers, 0.6998 additional dollars in labor income would be generated in the economic region (TVA 2017-TN4921). That means that an estimated 2,450 indirect and induced jobs in the economic region would be expected during the peak construction period (months 42–47).

The types of construction workers that would be used on the project and the number of construction workers in the economic region are discussed in EIS Section 4.4.2. The annual mean wage in May 2016 for a Construction and Extraction worker (U.S. Department of Labor, Bureau of Labor Statistics, Standard Occupational Classification code 470000) in the Knoxville Metropolitan Statistical Area was $40,920 (BLS 2017-TN5389). The size of the building workforce and associated payroll spending would vary each year, depending on the building schedule and mobilization. Assuming an average of 1,764 workers per year, the review team estimates that an average of $71.2 million (2016$) annually would be spent on CRN construction labor wages and salaries. At peak construction, this number would rise to $135 million.

As discussed in EIS Section 4.4.2, most of these wages would be paid to construction workers residing in the economic region. A total of 1,114 workers are expected to move into the economic region at peak construction. These 1,114 workers would receive an estimated annual total of $45.6 million in compensation. About 138 previously unemployed construction workers would be hired and receive annual compensation of approximately $5.6 million. Total wage and salary compensation for construction labor would be $51.2 million for the 1,252 newly hired workers in the economic region during peak construction activities.

Using the RIMS II economic multipliers TVA obtained, the aggregate impact supported by the proposed project includes approximately 5,750 direct, indirect, and induced jobs and $229 million annually in direct, indirect, and induced labor income during peak construction activities. The peak employment impact generated by the infusion of 1,252 new construction workers would result in an additional 929 indirect and induced jobs in the economic region, for a net employment impact of 2,181 jobs. The economic impact of the labor income generated by the newly hired workers would create $31.9 million in additional labor income in the economic region, for a net income impact of $75.5 million. Though in absolute terms these numbers appear substantial, the net impacts represent relatively minor new economic impacts in the context of the wider economy of the economic region. The impacts generated by workers hired from existing employment within the economic region are assumed to reflect no net change in employment or income to the economic region because workers would simply change jobs.

4.4.3.2 Taxes

The tax structure for the economic region is discussed in EIS Section 2.5.2.3. Primary tax revenues associated with building activities at the CRN Site would be from (1) State sales taxes on worker expenditures, (2) worker property taxes, (3) State sales taxes on some purchases of materials and supplies, and (4) TVA payments in lieu of taxes based on the location and construction of power-generation facilities.

4.4.3.2.1 State Sales Taxes on Worker Expenditures

Workers would spend some of their income on goods and services that may be taxed. Tennessee imposes a 7.0 percent sales tax (4 percent on food). Each county in the economic region levies local option use taxes in addition to the base sales tax (see Table 2-23). Because Tennessee's 2016 revenue from sales taxes was more than $686 million and the net economic impact of the proposed project is expected to be relatively minor, the review team expects a minimal, beneficial impact on State sales tax revenue from in-migrating, previously unemployed, and indirect worker expenditures during peak construction activities.

4.4.3.2.2 Property Taxes

Property taxes that would be paid during the building phase by construction workers that are already living in economic region are a part of the baseline and not relevant to this analysis. In-migrating workers would most likely move into existing houses rather than construct new houses. Thus, the in-migrating workforce would result in a transfer of property taxes instead of an increase in local property tax revenues. Based on the above assessments, the review team determined there would be minimal property tax impacts from relocating construction workers.

4.4.3.2.3 State Sales Taxes on Materials and Supplies

EIS Section 4.4.3.1 discusses the review team's estimates of CRN-related expenditures in the economic region and beyond during building. Some expenditures may be subject to sales taxes. Tennessee imposes a 7.0 percent sales tax (4 percent on food). Each county in the economic region levies local option use taxes in addition to the base sales tax (see Table 2-32). Neither the distribution of expenditures across the localities, nor the expected sales of goods not exempt from sales tax are known at the ESP stage. In the event of a COL application, the review team would refine these impact estimates. During building, the review team estimates, at a minimum, about $89–$121 million year would be spent in the economic region during peak construction activities, of which a minor portion likely would be subject to sales and use taxes. If all the local expenditures were subject to sales and use taxes, the maximum impact would be $8.5 million per year and would account for a 1.2 percent increase in Tennessee's sales tax revenues, based on 2016 collections. As indicated in EIS Section 2.5.2.3, TVA is not subject to sales tax, and the expected revenues from project purchases would be much lower. Therefore, the review team believes that there would be a minimal, positive impact on sales tax revenues during building.

4.4.3.2.4 TVA Payments in Lieu of Taxes

As indicated in EIS Section 2.5.2.3, TVA makes payments in lieu of taxes to jurisdictions affected by power plant construction activities. In addition, payments are made to affected counties (as summarized in Table 2-31). TVA indicates that estimates of impact-related payments are not possible to provide at the ESP stage (TVA 2017-TN4921). Such estimates would be based on estimated costs for the proposed project, which also are not available. The review team will need to revisit these impacts if the NRC receives a COL application regarding the proposed project. If the estimated payments were known, the review team expects that the additional payments to the counties of the economic region affected by the proposed project would be minor in relation the other existing revenue streams currently available.

4.4.3.3 Summary of Economic Impacts on the Community

Based on the information provided by TVA and the review team's independent evaluation and outreach, the review team concludes that the economic and tax impacts would be SMALL and beneficial for the economic region during the peak construction period. The increased benefits would result from the hiring of currently unemployed workers or workers relocating to the economic region and from CRN-related expenditures on locally supplied goods and services. Minor tax revenue impacts on local jurisdictions would accrue through sales and property taxes, and from TVA's anticipated payments in lieu of taxes for construction-affected communities.

Information about the specific costs of the proposed project is not available to the review team at the ESP stage. The review team will need to revisit these impacts if the NRC receives a COL application regarding the proposed project, because the impact level could change depending on the specific project costs and allocation of local expenditures.

4.4.4 Infrastructure and Community Service Impacts

This section provides the estimated impacts on infrastructure and community services, including transportation, recreation, housing, public services, and education.

4.4.4.1 Traffic

Existing transportation routes would be affected by the transportation of equipment, materials, supplies, and the construction workforce to the CRN Site. The CRN Site can be accessed via roads, rail, and the Clinch River, and all transportation modes likely would be used during building activities. Large components and equipment would be transported by barge via the Tennessee and Clinch Rivers or by rail. TVA plans to refurbish the existing DOE barge facility in the BTA adjacent to the CRN Site (EIS Section 3.3.1). Building-related road traffic would primarily use the proposed upgraded highway interchange and Bear Creek Road to access the site (TVA 2017-TN4921). Personal vehicles and trucks on roadways would be the primary transportation mode for the construction workforce and would affect the level of service (LOS) on local roadways, particularly during the peak building period.

The road system in the economic region is described in EIS Section 2.5.2.4.1. Physical impacts on the local transportation network from building are discussed in EIS Section 4.4.1.5. The size of the workforce would vary over an estimated 72-month building period from a minimum of 100 workers to a maximum of 3,300 workers at peak employment. During shift changes at peak employment, up to 2,412 worker vehicles would be expected to use local roads to access or exit the CRN Site (AECOM 2015-TN5000). TVA expects, on average, 90 vehicles per day to deliver construction materials, equipment, and supplies to the site (TVA 2017-TN4921).

TVA conducted a traffic impact analysis (TIA) to determine traffic impacts around the CRN Site (AECOM 2015-TN5000). The TIA analyzed deterioration of the LOS on roads and intersections in Roane County using the following assumptions: (1) the maximum anticipated construction workforce of 3,300, plus 366 operations workers simultaneously; (2) peak construction in 2024; (3) use of existing access routes; and (4) traffic load based upon a combination of peak construction workers, (5) three staggered shifts at the CRN Site, (6) baseline background traffic (which incorporates current ORR site employees), and (7) deployment of mitigation measures (TVA 2017-TN4921).

The TIA indicated that by 2024, six intersections in Roane County would have traffic levels that deteriorated below Tennessee acceptable standards (LOS B or better) (AECOM 2015-TN5000). The intersections are:

- SR 58 at Bear Creek Road Ramp
- SR 58 at SR 327
- SR 95 at Bear Creek Road
- Bear Creek Road at U.S. Government Property Road
- Bear Creek Road at Site Driveway
- Bear Creek Road at Bear Creek Road North Bound Ramp (Proposed).

The TIA indicated the most effective mitigation strategies for these intersections would be the following (AECOM 2015-TN5000):

- adding a northbound access ramp between SR 58 and Bear Creek Road
- widening of Bear Creek Road to three lanes, including a reversible traffic lane between SR 58 and the CRN Site Driveway
- signalizing the intersection of West Bear Creek Road, Bear Creek Road, and the Site Driveway
- adding a two-lane roundabout at the intersection of the proposed northbound ramp and Bear Creek Road
- adding a northbound exit and entry lanes on SR 58 for accessing and exiting the proposed ramp to Bear Creek Road.

The TIA indicated that, without mitigation measures, the LOS would deteriorate. The suggested mitigation measures in the TIA may improve the LOS; however, some intersections would remain below Tennessee's acceptable standard. The traffic metrics for determining impacts are reported in Table 4-7. Figure 4-5 illustrates the conceptual design of the mitigation measures anticipated for the CRN Site access.

As discussed above, the TIA is based on a combination of peak construction employment, operations workforce, and baseline background traffic. The peak construction workforce is assumed to occur during construction months 42 through 47. Without mitigation, the review team expects the traffic impacts from building would be destabilizing, because the LOS would deteriorate to level F, and inbound traffic delays could exceed 15 minutes at some intersections during several hours of the work day for a period of 6 months. If the mitigation activities recommended in the TIA were undertaken, the review team expects the local impact on traffic would be reduced, but adverse impacts on access routes in the ORR would still be noticeable during peak construction activities and estimated delays at SR 95 and Bear Creek Road would still exceed 7 minutes during the afternoon peak commute time. Such substantial delays could be destabilizing, and without additional mitigation, commuters would need to temporarily adapt to the deteriorated conditions during afternoon commutes during peak construction.

Table 4-7. Impacts on Roadways around the CRN Site during Peak Building

	AM Peak		PM Peak		
Intersection	**LOS**	**Delay (sec)**	**LOS**	**Delay (sec)**	**Expected Effect**
1. SR 58 at Bear Creek Road Ramp					
2013 Existing	B	10.1	C	15.2	
2024 Background	B	10.7	C	19.2	
2024 No Mitigation	F	900+	F	900+	Destabilizing
2024 With Mitigation*	C	20.5	C	23.2	Noticeable
2. SR 58 at SR 327					
2013 Existing	A	9.5	A	6.9	
2024 Background	B	11.1	A	7.5	
2024 No Mitigation	B	14.2	A	8.9	Minor
2024 With Mitigation	B	14.2	A	8.9	Minor
3. SR 95 at Bear Creek Road					
2013 Existing	B	10.5	C	24.9	
2024 Background	B	10.8	F	54.3	
2024 No Mitigation	F	57.9	F	435	Destabilizing
2024 With Mitigation	F	57.9	F	435	Destabilizing
4. Bear Creek Road at U.S. Government Property Road					
2013 Existing	A	9.3	A	8.6	
2024 Background	A	9.5	A	8.6	
2024 No Mitigation	F	563	B	14.9	Destabilizing
2024 With Mitigation	D	31.9	A	10.0	Noticeable
5. Bear Creek Road at Site Driveway					
2024 No Mitigation	F	900+	F	900+	Destabilizing
2024 With Mitigation	D	42.0	B	10.5	Noticeable
6. Bear Creek Road at Bear Creek Road NB Ramp (Proposed)					
2024 No Mitigation	B	19.6	B	15.0	Minor
2024 With Mitigation	B	15.7	A	7.0	Minor

AM Peak (NB Diverge), PM Peak (SB Merge).

Adapted from TVA 2017-TN4921.

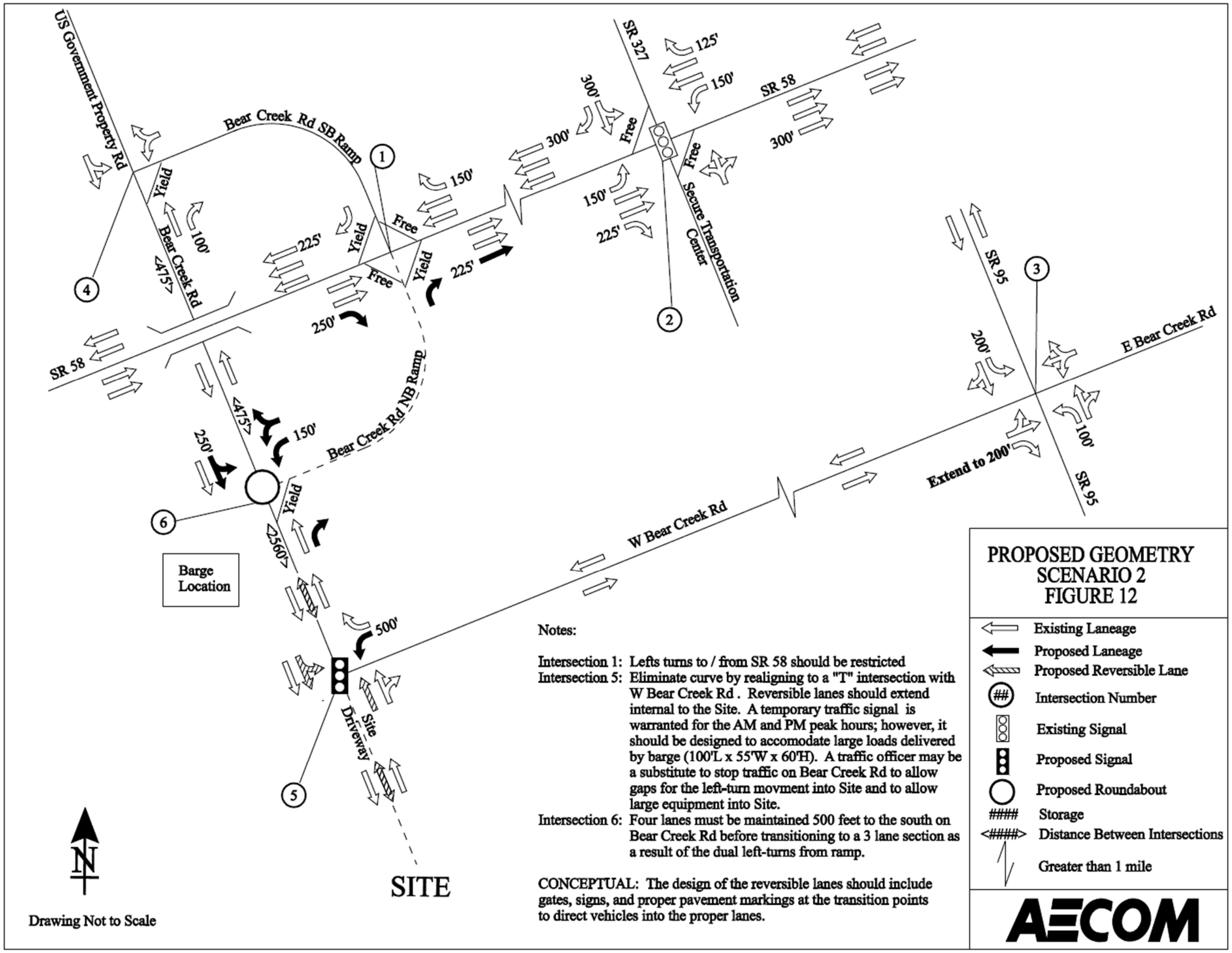


Figure 4-5. Conceptual Traffic Flow and Mitigation Design for 2024 Access to the CRN Site (Source: AECOM 2015-TN5000)

4.4.4.2 Recreation

Recreational resources in the economic region may be affected by building activities at the CRN Site. Impacts may include (1) increased user demand associated with the projected increase in population as a result of the in-migrating workforce and their families, (2) impaired recreational experience associated with the views of the in-progress facility construction, and (3) possible access delays associated with increased traffic on local roadways. Increased user demand as a result of the in-migrating population may include increased competition for camping spaces at campgrounds, which could be used for temporary housing for some of the workforce.

As discussed in EIS Section 4.4.1, there would be some aesthetic impacts at recreational areas that have an unobstructed view of the CRN Site. These areas are typically across the Clinch River. The building activities at the CRN Site would transform the undeveloped nature of the site to industrial development. Also, people using recreational facilities in Roane County could experience traffic congestion on the roads during the morning and afternoon commutes of the construction workforce.

Because 34 percent of the construction workforce would be expected to relocate either temporarily or permanently to the economic region, the review team expects some minor stresses to be placed upon the capacity of recreational facilities near the CRN Site. Local campgrounds may experience increased occupancy, especially during weekdays, to accommodate temporary workers.

The economic region and the local parks and recreational facilities have sufficient capacity to accommodate in-migrating workers and their families, and the review team expects minimal impacts at the affected recreation sites. The review team expects the impacts on recreational activities in the vicinity to be minimal except for a noticeable but not destabilizing aesthetic impact on users of the Clinch River from building activities at the site that cannot be reduced through mitigation.

4.4.4.3 Housing

EIS Section 2.5.2.6 discusses housing information for the economic region. According to Table 2-30, there are 27,397 vacant housing units available for purchase or rent in all counties of the economic region, and every county has a significant supply of vacant units. As discussed in EIS Section 4.4.2, 1,114 workers and their families would move into the economic region from outside the economic region. The rest of the peak construction workforce is expected to come from within the economic region and commute daily to the site, therefore having no impact on the housing stock.

The in-migrating workers and families may choose to buy available vacant housing or rent, or they may bring temporary housing with them such as recreational vehicles. Table 4-8 shows the estimated impact on housing availability for the in-migrating families, assuming all in-migrating families would acquire local housing. Comparisons are made to 2015, but in reality, the housing stock will continue to develop between now and the expected peak of construction activities. Thus, the minimal impacts suggested would be even smaller by 2024.

In addition to the housing stock for owner-occupied housing and rental units, there is also sufficient stock of temporary housing in the economic region, if workers decide to stay in hotels, motels, or campgrounds. Construction workers are more likely to take advantage of the temporary housing stock because they are expected to be at the CRN Site for a relatively short time period.

Table 4-8. Estimated Housing Impacts in the Economic Regional at Peak Employment

County	Peak Construction In-Migrating Families	2015 Vacant Units	2015 Total Housing Units	2015 Vacancy Rate	Proposed Project Vacant Units	Proposed Project Vacancy Rate
Anderson	301	4,155	34,767	12.0	3,854	11.1
Knox	557	17,390	198,119	8.8	16,883	8.5
Loudon	67	2,135	22,144	9.6	2,068	9.3
Roane	189	3,717	25,604	14.5	3,528	13.8
Total	1,114	27,397	280,634	9.8	26,333	9.4

Source: Table 2-35 of this EIS.

Given the large supply of vacant housing relative to the in-migrating workforce during peak building employment and the availability of short-term accommodations, the review team expects sufficient housing to be available for workers relocating to the area and that there would be minimal impacts on the housing supply or prices in the local area. In addition, given the large supply of vacant housing, the short-term accommodations, and the temporary nature of the construction workforce in the area, the review team does not expect the in-migrating workers and families would stimulate new housing.

Based on the information provided by TVA, interviews with local officials, and its own independent review, the review team expects there would be minimal impacts in the economic region on the price and availability of housing related to construction activities at the CRN Site.

4.4.4.4 Public Services

This section discusses the impacts on existing water supply, wastewater-treatment, police, fire protection, and healthcare services in the economic region.

4.4.4.4.1 Water Supply and Wastewater-Treatment Services

About 66 percent of the project workforce would be local workers who currently reside in the region. The majority of these workers would commute from their homes to the project site and would not relocate. Therefore, the majority of workers are currently served by the water supply and wastewater-treatment facilities within the communities in which they reside.

At peak employment, the review team expects 1,114 workers and their families to move into the economic region. This would constitute a total of 2,819 people moving into the economic region at peak construction. These relocating workers would increase the demand on the water supply and wastewater-treatment services within the communities where they would reside.

The review team calculated the increase in demand for residential water based on the increase in people, using the Tennessee per capita demand for water of 145 gpd (Bohac and Bowen 2012-TN5026). Table 4-9 shows the impact of the increased population on the excess water supply capacity within each county of the economic region. As shown in Table 4-9, the projected increase in water demand is less than 2 percent of the current excess capacity in Anderson and Roane Counties, and is 0.4 percent of current excess capacity in Knox County. Loudon County does not have appreciable excess capacity based on the 2016 peak daily demand; however, the county has 3.2 Mgd of excess capacity based on 2016 average demand (TDEC 2017-TN5032). Table 4-9 shows that in the four-county area, the overall increase in projected demand is 0.6 percent of the current excess capacity.

Table 4-9. Estimated Water Supply Impacts in the Economic Region

County	Current Excess Capacity (Mgd)[(a)]	Increase in Population[(b)]	Estimated Increase in Water Demand (Mgd)[(c)]	Increase in Demand as Percent of Excess Capacity
Anderson	5.9	762	0.110	1.9
Knox	55.7	1,409	0.204	0.4
Loudon	-0.2	170	0.025	---
Roane	3.8	478	0.069	1.8
Total	65	2,819	0.41	0.6

(a) Source: EIS Table 2-36, based on 2016 peak daily demand.
(b) Source: EIS Table 4-6.
(c) Increase in population multiplied by 145 gpd.

Given the small increase in demand that would result from the in-migrating workers and their families compared to the existing supply, the review team determined that impacts on water supply in the economic region would be minimal, and mitigation would not be warranted.

The review team calculated the increase in demand for wastewater based on the increase in people and using a per capita demand for wastewater of 75 gpd (TDEC 2016-TN5041). Table 4-10 shows the impact of the increased population on the excess wastewater capacity within each county of the economic impact area. As shown in Table 4-10, the projected increase in demand is 1.4 percent of the current excess capacity in Roane County, 3.2 percent in Loudon County, and less than 1 percent in Anderson and Knox Counties. Table 4-10 shows that in the four-county area, the overall increase in projected demand is 0.6 percent of the current excess capacity.

Table 4-10. Estimated Wastewater Supply Impacts in the Economic Region

County	Current Excess Capacity (Mgd)[(a)]	Increase in Population[(b)]	Estimated Increase in Wastewater Demand (Mgd)[(c)]	Increase in Demand as Percent of Excess Capacity
Anderson	8.1	762	0.057	0.7
Knox	21.9	1,409	0.106	0.5
Loudon	0.4	170	0.013	3.2
Roane	2.6	478	0.036	1.4
Total	33	2,819	0.211	0.6

(a) Source: EIS Table 2-37.
(b) Source: EIS Table 4-6.
(c) Increase in population multiplied by 75 gpd.

Given the small increase in demand for wastewater treatment that would result from the in-migrating workers and their families compared to the existing capacity, the review team determined that impacts on wastewater treatment in the economic region would be minimal, and mitigation would not be warranted.

TVA indicates that the City of Oak Ridge Public Works Department would supply the construction site with potable and sanitary water, fire protection water, and water for miscellaneous construction uses such as concrete batch plant supply. TVA indicates that it would need about 231,660 gpd (0.23 Mgd) onsite (TVA 2017-TN4922). As shown in Table 2-

36, the City of Oak Ridge water system has excess capacity of 1.2 Mgd (with respect to 2016 peak daily demand); current excess capacity is 7.4 Mgd with respect to the 2016 average demand (TDEC 2017-TN5032). During the period of building, the increased water demand from the CRN Site would be about 3 percent of the average excess capacity (and as much as 19 percent of the excess capacity based on peak daily demand). During discussions with the review team, City of Oak Ridge Public Works Department staff stated that the existing water distribution, not the water availability, would be the limiting factor in serving water to the CRN Site, and that existing storage tanks located north of Bear Creek Road would be sufficient to meet the CRN Site demand (NRC 2018-TN5386).

TVA also indicated that CRN Site sanitary wastewater would be discharged to the City of Oak Ridge Rarity Ridge Wastewater-Treatment Plant (WWTP). TVA estimated a peak wastewater treatment demand of 165,000 gpd (0.165 Mgd) based on a per capita demand of 50 gpd for the peak workforce of 3,300 workers. During the period of building, the increased wastewater demand from the CRN Site would be about 41 percent of the Rarity Ridge WWTP excess capacity of 0.4 Mgd (Table 2-37). During discussions with the review team, City of Oak Ridge Public Works Department staff stated that the existing pumping capacity would need to be increased to deliver CRN Site wastewater to the treatment plant, but that they did not see any issues with increasing the pump capacity or obtaining the required permit from DOE to do so (NRC 2018-TN5386).

The review team concluded from the information provided by TVA and interviews with City of Oak Ridge staff that building at the CRN Site would have minimal impacts on the local water supply and on wastewater treatment facilities and no mitigation would be warranted.

4.4.4.4.2 Police, Fire Protection, and Healthcare Services

The building workforce at the CRN Site would increase the demand on police, fire protection, and healthcare services within the communities where workers reside and at the CRN Site.

About 66 percent of the project workforce would be local workers who currently reside in the economic region. The majority of these workers would commute from their homes to the project site and would not relocate. Therefore, the existing police, fire protection, and healthcare services in the economic region already serve the majority of the proposed project's construction workers within the communities in which they reside.

At peak employment, the review team expects 1,114 workers and their families to move into the economic region for a total of 2,819 people (workers plus their families). These in-migrating workers and their families would be widely dispersed into the four counties and would cause a minimal increase the demand on the police, fire protection, and healthcare services within the communities where they would reside.

No county in the economic region has a projected population increase at peak employment of more than 1 percent. In discussion with local officials of the localities closest to the site, the review team found that such minimal increases in population should not have any noticeable effect on the performance of police, fire protection, and healthcare services at peak employment in the economic region (NRC 2018-TN5386).

Because of their proximity to the site, first responders in Anderson County, City of Oak Ridge, and Roane County likely would receive the greatest impacts from construction worker injuries or accidents on the roads leading to the site and at the site. When responding to calls, these personnel could encounter traffic congestion on local roadways when the building workforce is commuting to the site, especially during peak employment periods. However, the area around the CRN Site is sparsely populated, so there would not be a high demand for these personnel near the site. In addition, measures to mitigate traffic delays have been recommended and are discussed in EIS Section 4.4.4.1. These measures could reduce the impacts on emergency responders as well as on members of the general public using local roadways.

Based on discussions with local officials and its own independent analysis, the review team expects a minimal impact on police, fire protection, and healthcare services from building activities at the CRN Site, and no mitigation would be warranted.

4.4.4.5 Education

The building workforce at the CRN Site would increase the demand for educational services within the communities where workers reside. About 66 percent of the project workforce would be local workers who currently reside in the region. The majority of these workers would commute from their homes to the site and would not relocate. Therefore, the majority of workers are currently served by the educational services within the communities where they reside.

As shown in Table 4-11, during peak building there would be an estimated increase of 668 students in the economic region. The review team determined this to be a minor increase compared to the existing enrollment in the economic region (more than 86,000 students, as shown in Table 2-39). No county in the economic region would experience a noticeable increase in the number of students per teacher. The greatest increase in student-to-teacher ratios would be in Roane County, where the increase would be 0.24 students per teacher.

Table 4-11. Estimated Number of School-Aged Children Associated with In-Migrating Workforce Associated with Building at the CRN Site

County	Estimated Increase in Population	Percent of Population Between 5 and 18 Years Old[(a)]	Estimated Increase in School-Age Children	Student/Teacher Ratio Existing Conditions[(b),(c)]	Student/Teacher Ratio During Peak Building[(c)]
Anderson	762	23.4	178	13.11	13.31
Knox	1,409	24.7	348	14.94	15.02
Loudon	170	21.9	37	15.51	15.59
Roane	478	21.9	105	15.49	15.73
Total	**2,819**	**24.1**	**668**	**14.74**	**14.91**

(a) U.S. Census Bureau (USCB 2017-TN4934).
(b) Derived from Table 2-39.
(c) Public school estimates only.

Because of these estimates and discussions with local officials, the review team expects minimal impacts on local school districts and schools in the economic region resulting from project construction activities, and no mitigation would be warranted.

4.4.4.6 Summary of Community Service and Infrastructure Impacts

Based on the information provided by TVA and the review team's independent evaluation and outreach, the review team concludes that the building-related impacts on all infrastructure and community services would be SMALL for the economic region, with the exception of traffic and recreation impacts in close proximity to the CRN Site. The review team expects LARGE adverse impacts on traffic for routes near the CRN Site without mitigation. These impacts could be reduced by further planning and mitigation measures similar to those discussed by TVA, but the review team expects the mitigated impacts would still be MODERATE to LARGE. The review team concludes that recreation impacts would be SMALL to MODERATE in close proximity to the site as a result of the expected aesthetic impacts of adding structures to the CRN Site.

Based on the above information, the review team determined the impacts of NRC-authorized construction activities on infrastructure and community services for MODERATE-to-LARGE traffic impacts are integrally related to the period of maximum construction workforce and therefore would also be MODERATE-to-LARGE. The recreation impacts of the changes in aesthetics also would be related to NRC-authorized construction activities and would remain SMALL to MODERATE.

4.4.5 Summary of Socioeconomic Impacts

The review team has assessed the activities related to building a new nuclear power plant at the CRN Site and the potential socioeconomic impacts in the economic region. The above discussion includes scenarios with and without mitigation. However, given that where possible the applicant identified specific mitigation actions for each category, which are consistent with industry standards or required by local ordinances and which would reduce negative impacts, the review team finds it reasonable to assume for this summary that those mitigating actions would be successfully implemented. Therefore, for clarity, the summary discussion below refers strictly to the expected level of impacts following the implementation of applicant-identified mitigation.

Physical impacts on workers and the general public would include those related to noise levels, air quality, existing buildings, transportation resources, and aesthetics. The review team concludes most physical impacts from building at the CRN Site would be SMALL, with the exception of MODERATE impacts from noise, roadway degradation, and changes to visual aesthetics. Physical impacts from noise would be mitigated with standard noise mitigation practices required by local ordinances, but still would affect the local residents in close proximity to the site, directly across the Clinch River from the CRN Site. The increased pace of roadway degradation would require more frequent maintenance activities to mitigate the impacts. Impacts on visual aesthetics also would affect those living in close proximity to the site, those transiting local roadways, and recreationists using the Clinch River and other nearby recreation sites. These impacts would not be mitigated.

On the basis of information supplied by TVA and the review team interviews conducted with public officials, the review team concludes that impacts on the demographics of the economic region from building at the CRN Site would be SMALL. Economic impacts throughout the economic region would be SMALL and beneficial. Tax impacts would be SMALL and beneficial throughout the economic region.

Infrastructure and community services impacts span issues associated with traffic, recreation, housing, public services, recreation resources, and education. Impacts from building at the CRN Site on housing, public services, and education would be SMALL. Traffic impacts are expected to be localized, temporary, MODERATE-to-LARGE, and adverse. LARGE impacts on traffic would be expected without the identified mitigation measures. With mitigation, the traffic impacts would be MODERATE-to-LARGE.

4.5 Environmental Justice Impacts

The review team evaluated whether minority or low-income populations would experience disproportionately high and adverse human health or environmental effects from building a new nuclear power plant at the CRN Site. To perform this assessment, the review team (1) identified (through U.S. Census Bureau and American Community Survey demographic data, the TVA ER, and site visit assessments) minority and low-income populations of interest; (2) identified all potentially significant pathways for human health, environmental, physical, and socioeconomic effects on those identified populations of interest; and (3) determined whether the characteristics of the pathway or special circumstances of the minority or low-income populations would result in a disproportionately high and adverse impact.

To perform this assessment, the review team followed the method described in EIS Section 2.6.1. In the context of building activities at the CRN Site, the review team considered the questions outlined in Section 2.6.1. For all three health-related questions, the review team determined that the level of environmental emissions projected is well below the protection levels established by the NRC and EPA regulations and would not impose a disproportionate and adverse effect on minority or low-income populations.

4.5.1 Health Impacts

EIS Section 4.8 assesses the nonradiological health effects for construction workers and the local population from fugitive dust, noise, occupational injuries, and transport of materials and personnel. In Section 4.8, the review team concludes that nonradiological health impacts would be SMALL. The review team's investigation and outreach did not identify any unique characteristics or practices among minority or low-income populations that might result in disproportionately high and adverse nonradiological health effects.

EIS Section 4.9 assesses the radiological doses to construction workers and the local population and concludes that the doses would be within the NRC and EPA dose standards. Section 4.9 concludes that radiological health impacts on the construction workforce at the CRN Site would be SMALL. In addition, there would be no radioactive material on the construction site except for very small sources such as those commonly used by radiographers; therefore, there would be minimal radiation exposure to members of the public from building at the CRN Site. Based on this information, the review team concludes that there would be no disproportionately high and adverse impact on low-income or minority populations.

4.5.2 Physical and Environmental Impacts

For the physical and environmental considerations described in EIS Section 2.6.1, the review team determined through literature searches and consultations that (1) the impacts on the natural or physical environment would not significantly or adversely affect a particular group, (2) no minority or low-income population would experience an adverse impact that would appreciably exceed or be likely to appreciably exceed those of the general population, and (3) the environmental effects would not occur in groups affected by cumulative or multiple adverse exposure from environmental hazards.

The review team determined that in most cases the physical and environmental impacts from onsite building activities at the CRN Site would attenuate rapidly with distance, intervening foliage, and terrain. There are four primary exposure media in the environment: soil, water, air, and noise. The following sections discuss each of these pathways in greater detail.

4.5.2.1 Soil

Building activities on the CRN Site represent the largest source of soil-related environmental impacts. The site is well-defined, and access is restricted. Soil-disturbing activities are localized on the site, sufficiently distant from surrounding populations, and have little ability to migrate, resulting in no noticeable offsite impacts. Soil migration would be minimized by adherence to regulations, permits, and the use of BMPs. As discussed in EIS Section 2.6, none of the block groups exceeding low-income thresholds used for environmental justice impact assessment are in close proximity (10 mi) to the CRN Site. Because of the distance between the site and the closest minority or low-income population, the review team did not identify any disproportionately high and adverse impacts from soil-related pathways.

4.5.2.2 Water

Water-related environmental impacts from erosion-related degradation of surface water and the introduction of anthropogenic substances into surface and groundwater would occur, but the impacts would be mitigated through adherence to permit requirements and BMPs. Increased water turbidity during dredging activities could affect nearshore water quality, but the effect would be minimized through adherence to permit requirements and BMPs. Consumptive use of surface water for building activities would also occur but would have only a minimal effect because the water supply for building would be obtained from the Clinch River. The water-related impacts of building activities associated with the proposed project would be of limited magnitude, localized, and temporary. Furthermore, because of the distance between the site and the closest minority or low-income population, the review team did not identify any disproportionately high and adverse impacts from water-related pathways.

4.5.2.3 Air

Air emissions are expected from increased vehicle traffic, construction equipment, and fugitive dust from building activities. Emissions from vehicles and construction equipment would be unavoidable but would be temporary and minor in nature and subject to management under State and Federal air regulations and permits and the use of BMPs. Furthermore, because of the distance between the site and the closest minority or low-income population, the review team did not identify any disproportionately high and adverse impacts from air-related pathways.

4.5.2.4 Noise

Noise would result from clearing; moving earth; preparing foundations; pile-driving; concrete mixing and pouring; erecting steel structures; and various stages of facility equipment fabrication, assembly, and installation. TVA would, however, use standard noise control measures for construction equipment, limit the types of building activities during nighttime and weekend hours, notify all potentially affected neighbors of planned activities, and establish a construction-noise monitoring program. The review team also expects only minor and temporary noise activities from any offsite building activities. The review team determined that noticeable noise impacts on the public would occur in close proximity to the CRN Site, affecting local residents living across the Clinch River from the CRN Site. However, because of the distance between the site and the closest minority or low-income population, the review team did not identify any disproportionately high and adverse impacts from noise-related pathways.

4.5.2.5 Summary of Physical and Environmental Impacts

The review team's investigation and outreach did not identify any unique characteristics or practices among minority or low-income populations that might result in physical or environmental impacts on them that were different from those on the general population.

As discussed in EIS Section 2.6, the census block groups classified as minority or low-income are located several miles from the CRN Site. The closest block groups to the site are about 8 mi north of the CRN Site in the City of Oak Ridge. The census block groups would not be affected by any physical or environmental impacts because of the distance from the site.

On the basis of information provided by TVA and the review team's independent review, the review team found no pathways from soil, water, air, and noise that would lead to disproportionately high and adverse impacts on minority or low-income populations.

4.5.3 Socioeconomic Impacts

Socioeconomic impacts (discussed in EIS Section 4.4) were reviewed to evaluate whether there would be any building activities that could have a disproportionately high and adverse impact on minority or low-income populations. Except for effects on traffic, all adverse socioeconomic impacts associated with building activities at the CRN Site are expected to be SMALL for the general public. The review team found that there could be adverse MODERATE-to-LARGE impacts on traffic in Roane County; however, these impacts are not expected to disproportionately affect the low-income and minority populations, nor are these populations in close proximity to the expected impacts.

4.5.4 Subsistence and Special Conditions

The NRC method for conducting environmental justice assessments includes assessment of populations that have unique characteristics, such as minority communities exceptionally dependent on subsistence resources or identifiable in compact locations such as Native American settlements, or high-density concentrations of minority populations.

4.5.4.1 Subsistence

Access to the CRN Site is restricted; such restricted access reduces any impact on plant-gathering, hunting, and fishing activities at the site. TVA and the review team independently interviewed community leaders in the economic region and found that no such practices were identified in the vicinity of the CRN Site nor any documented subsistence fishing in the Clinch River. As discussed, in EIS Section 2.6.3.2, hunting, plant-gathering, and fishing are all done for recreational purposes within the economic region.

From the information provided by TVA, interviews with local officials, and the review team's independent evaluation, the review team concludes that there would be no building-related disproportionately high and adverse impacts on subsistence activities on minority or low-income populations.

4.5.4.2 High-Density Communities

As discussed in EIS Section 2.6.3.1, there are no high-density communities in the economic region. From its own independent evaluation and interaction with local officials, the review team does not expect any impacts on the communities in Oak Ridge, Kingston, or other towns nearby from building activities at the CRN Site. Because of the distance between the site and the closest minority or low-income population, the review team did not identify any pathways leading to disproportionately high and adverse impacts.

4.5.5 Migrant Labor

As discussed in EIS Section 2.6.4, minor numbers of migrant workers are used in the agriculture and residential construction industries of the economic region and no impact pathways have been identified that would affect these workers. Therefore, from the information provided by TVA, interviews with local officials, and the review team's independent evaluation, the review team concludes that there would be no disproportionately high and adverse impacts on minority or low-income migrant laborers.

4.5.6 Summary of Environmental Justice Impacts

The review team evaluated the impacts of building activities at the CRN Site on environmental justice populations. The review team did not identify any potential environmental pathways by which the identified minority or low-income populations in the economic region would likely experience disproportionately high and adverse human health, environmental, physical, or socioeconomic effects as a result of building activities.

Based on the preceding analysis, and because the NRC-authorized construction activities represent only a part of the analyzed activities, the review team concludes that there would be no disproportionately high and adverse impacts on minority and low-income populations resulting from building activities at the CRN Site.

4.6 Historic and Cultural Resources

NEPA (42 U.S.C. § 4321 *et seq*.-TN661) requires Federal agencies to take into account the potential impacts of their proposed actions on the cultural environment, which includes archaeological sites, historic buildings, and traditional cultural places important to a community. The National Historic Preservation Act of 1966, as amended (NHPA; 54 U.S.C. § 300101 *et seq*.-TN4157) requires Federal agencies to consider the impacts on those resources if they are eligible for listing in the *National Register of Historic Places* (NRHP). Such resources are referred to as "historic properties" in NHPA. As outlined in 36 CFR 800.8 (TN513), "Coordination with the National Environmental Policy Act of 1969," the NRC is coordinating compliance with Section 106 of NHPA by fulfilling its responsibilities under NEPA. Because the USACE has no action as part of the ESP, the USACE will defer its consultation on NHPA Section 106 impacts until the COL stage of the application process and will define its permit area at that time.

Building (refers to both construction and preconstruction activities) two or more SMRs may affect either known or previously unidentified historic and cultural resources located within the onsite and offsite direct- and indirect-effects area of potential effect (APE). In accordance with 36 CFR Part 800 (TN513), NRC is required to make a reasonable and good faith effort to identify historic properties in the APE and, if such properties are present, determine whether significant impacts are likely to occur. If there are potentially adverse impacts, the NRC shall consult with the State Historic Preservation Office (SHPO), Federally recognized American Indian Tribes, and interested members of the public as necessary, to address mitigation and/or avoidance measures. Even if no historic properties (i.e., places eligible for listing in the NRHP) are present or affected, the NRC is still required to notify the SHPO before proceeding. If it is determined that historic properties are present, the NRC and SHPO are required to assess and resolve any adverse effects of the undertaking.(1)

For a description of historic and cultural resources and historic properties located within the onsite and offsite indirect-effects APE, see EIS Section 2.7.

4.6.1 Onsite Impacts on Historic and Cultural Resources

Building-related activities would result in significant impacts on historic and cultural resources located within the onsite and direct- and indirect-effects APE. As discussed in EIS Section 2.7.3, TVA is a Federal land-managing agency, and as such, is required to comply with other Federal historic and cultural resources compliance requirements in addition to those required by NHPA Section 106 and NEPA. TVA initiated its NHPA Section 106 consultation and has executed a Programmatic Agreement (PA) to resolve any potential adverse effects of building-related activities on historic properties (TVA and TSHPO 2016-TN5298). In this PA, TVA committed to following the NHPA Section 106 compliance process in consultation with the Tennessee Historical Commission and American Indian Tribes for building-related activities within the direct and indirect APEs at the CRN Site (TVA and TSHPO 2016-TN5298; TVA 2017-TN4922).

The PA also contains commitments made by TVA to amend its APE as needed, and conduct identification and evaluation (e.g., NRHP eligibility) of historic properties. If historic properties are identified within amended APEs, TVA plans to pursue avoidance of historic properties. If avoidance is not possible, TVA will seek ways to minimize or mitigate adverse effects. Mitigation options would vary depending upon the type of resource being affected (i.e., architectural, archaeological, or traditional cultural property) (TVA and TSHPO 2016-TN5298). The PA also outlines NHPA Section 106 requirements and Native American Graves Protection and Repatriation Act (25 U.S.C. § 3001 *et seq.*-TN1686) inadvertent discovery procedures, in the event archaeological resources or human remains are discovered during building-related activities, which include stop work and notification provisions (TVA and TSHPO 2016-TN5298; TVA 2017-TN4922). In addition, TVA has also committed to keep the NRC informed of updates regarding its ongoing NHPA Section 106 consultation for the proposed project (TVA 2017-TN4922).

Building-related ground-disturbing activities with the potential to impact historic and cultural resources within the onsite direct-effects APE include the installation of cooling-water intake and discharge pipelines, relocation of the onsite transmission line, installation of a new 69-kV underground line within an existing right-of-way, and improvements to the BTA. These activities could impact an unknown number of the 16 potentially NRHP-eligible archaeological resources, NRHP-eligible archaeological resources, and deeply buried archaeological deposits located within the onsite direct-effects APE (TVA and TSHPO 2016-TN5298). In its ER, TVA stated that six potentially NRHP-eligible archaeological sites (40RE107, 40RE0595, 40RE0549, 40RE104,

(1) According to 36 CFR 800.5(a)(1) (TN513), an adverse effect will occur when "an undertaking may alter, directly or indirectly, any of the characteristics of a historic property that qualify the property for inclusion in the National Register in a manner that would diminish the integrity of the property's location, design, setting, materials, workmanship, feeling, or association. Consideration shall be given to all qualifying characteristics of a historic property, including those that may have been identified subsequent to the original evaluation of the property's eligibility for the National Register. Adverse effects may include reasonably foreseeable effects caused by the undertaking that may occur later in time, be farther removed in distance, or be cumulative"

40RE105, and 40RE138) and one NRHP-eligible site (40RE233), will be potentially impacted by building activities (TVA 2016-TN5318). As project plans are finalized, the number of historic and cultural resources impacted could change and would be addressed as part of TVA's PA and NRC's COL review.

Pursuant to TVA's PA, if impacts cannot be avoided or minimized, TVA will conduct data recovery to mitigate adverse effects on NRHP-eligible archaeological sites (TVA and TSHPO 2016-TN5298). If building activities result in ground disturbance that exceeds 80 cm in depth, in areas with the potential for deeply buried cultural deposits, TVA would amend its APE to include deposits not previously investigated (see Step I.A of the PA (TVA and TSHPO 2016-TN5298). It is possible that deeply buried archaeological deposits and NRHP-eligible archaeological resources within the onsite direct-effects APE will be irretrievably damaged by building activities if in situ stabilization is not possible and data recovery is required. Despite being a form of mitigation, archaeological data recovery results in the irretrievable loss of historic and archaeological information.

As discussed in EIS Section 2.7, there is one historic cemetery (Hensley Cemetery) located within the onsite direct-effects APE. Building-related impacts on the Hensley Cemetery are expected to be negligible because building-related activities will avoid the cemetery. Indirect visual impacts are expected to be minimized because the cemetery is surrounded by vegetation and trees affording visual screening. TVA has protection procedures in place which include marking the location of cemeteries on construction drawings and fencing the perimeter of these sites to avoid impacts (TVA 2017-TN4922). TVA must also comply with the State of Tennessee's Cemetery and Burial Site laws (Tennessee Code Ann. Title 46).

No impacts are expected to occur on traditional cultural properties of significance to American Indian Tribes because none have been identified in the onsite direct- or indirect-effects APE at the time of publishing this draft EIS. See EIS Section 2.7.4 for additional information about consultation with American Indian Tribes.

No architectural resources are located within the onsite direct-effects APE; therefore, there would be no impacts on these resources from onsite building activities (i.e., installation of 65-ft tall cooling towers, relocation of the onsite transmission line, and the temporary use of cranes up to 638-ft tall needed to install reactors). Building activities would not visually impact the two extant unevaluated architectural resources (RE1439 and Structure 3) located within the onsite indirect-effects APE due to the presence of vegetative screening.

4.6.2 Offsite Impacts on Historic and Cultural Resources

Building activities occurring in offsite areas have the potential to impact offsite historic and cultural resources. These activities include installation of a new 69-kV underground line within an existing TVA transmission line right-of-way, upgrades to existing TVA transmission rights-of-way, borrow area developments, and installation of a bypass at the Melton Hill Dam. Specific plans for these activities have not yet been finalized. Offsite building activities are expected to result in impacts on the NRHP-eligible Melton Hill Dam District (TVA 2016-TN5318). Building activities also have the potential to directly and indirectly impact historic and cultural resources (i.e., archaeological resources, architectural resources, and traditional cultural properties) located within other offsite areas. TVA has not completed historic and cultural resource investigations of the offsite areas because project plans have not been finalized. At the time of publishing this draft EIS, it is unknown whether any significant resources are located in these areas. However, as stipulated in Steps I–VI of its PA, TVA is committed to following the NHPA

Section 106 compliance process for all future project activities associated with the building of two or more SMRs at the CRN Site (TVA and TSHPO 2016-TN5298; TVA 2017-TN4922: page E3-1-E3-2). TVA will avoid, minimize, or mitigate potential building-related impacts on historic and cultural resources located in these offsite project areas (TVA and TSHPO 2016-TN5298).

4.6.3 Summary

For the purposes of the review team's NEPA analysis, the review team concludes that the combined impacts from construction and preconstruction activities on historic and cultural resources located within the onsite and offsite direct- and indirect-effects APE would be MODERATE to LARGE. Preconstruction activities constitute the primary contribution to this impact determination.

This NEPA finding was based on (1) NRC's ongoing consultation with 20 American Indian Tribes and Tennessee Historical Commission; (2) TVA's executed PA describing its ongoing NHPA Section 106 compliance including commitments to avoid, minimize, mitigate, and resolve adverse effects on NRHP-eligible resources that cannot be avoided and NHPA and Native American Graves Protection and Repatriation Act inadvertent discovery and notification provisions; (3) potential irretrievable damage to 16 NRHP potentially eligible archaeological sites, 1 NRHP-eligible archaeological site, and deeply buried archaeological deposits if in situ stabilization is not possible; (4) potential impacts on the NRHP-eligible Melton Hill Dam Historic District and on other historic and cultural resources that could be located in other offsite areas (i.e., transmission lines and borrow areas).

The NRC staff concludes that the potential impacts on historic and cultural resources from NRC-authorized construction activities occurring within the onsite direct- and indirect-effects APE would be SMALL because all impacts would have occurred during preconstruction.

For the purposes of NHPA 106 consultation pursuant to 36 CFR 800.8 (TN513), the NRC staff concludes that there would be no effect on historic properties from NRC-authorized construction activities because impacts on historic properties would already have occurred as a result of preconstruction activities.

While preconstruction impacts are not within NRC's regulatory authority, NRC staff has reviewed TVA's NHPA Section 106 compliance activities. TVA has concluded that its undertaking to obtain an ESP for future demonstration of the suitability of the CRN Site for potential future building and operation of two or more SMRs has the potential to adversely affect an unknown number of the 16 potentially NRHP-eligible properties and 1 NRHP-eligible site (40RE233) and has executed a PA to address its ongoing NHPA Section 106 responsibilities because specific plans have not been finalized.

4.7 <u>Meteorological and Air-Quality Impacts</u>

EIS Section 2.9 discusses the meteorological characteristics and air quality at and around the CRN Site. The primary impacts on local meteorology and air quality of constructing a new nuclear power plant at the CRN Site would be from dust generated by land-clearing and building activities, emissions from heavy equipment and machinery, concrete batch plant operations, and emissions from vehicles used to transport workers and deliver materials to and from the site. Air-quality impacts directly associated with these activities are described below in Section 4.7.1; air-quality impacts associated with transportation of construction workers are addressed in Section 4.7.2.

4.7.1 Construction and Preconstruction Activities

Construction and preconstruction activities (sometimes referred to jointly as building activities) at the CRN Site would result in temporary impacts on local air quality. Potential air emission activities listed in Section 4.4.1.2 of the ER (TVA 2017-TN4921) include:

- land clearing and material processing, handling, and removal
- material replacement (e.g., subsurface preparation and concrete pouring and paving)
- driving piles and erecting structures
- machinery operation and maintenance
- truck deliveries of supplies and materials
- soil transport and temporary stockpiling
- workforce commute.

Equipment and vehicle emissions from these activities would contain carbon monoxide, oxides of nitrogen, volatile organic compounds, and oxides of sulfur to a lesser extent. Fugitive emissions of dust particles (such as PM_{10} and $PM_{2.5}$; that is, particulate matter with a mean aerodynamic diameter of less than or equal to 10 and 2.5 μm, respectively) would be generated during windy periods, earthmoving, and movement of vehicular traffic over recently disturbed or cleared areas.

Emissions of fugitive dust and construction equipment engine exhaust are generally limited in duration, infrequent, and localized to the project area. The air quality impacts are therefore expected to be limited to the area within 6 mi of the CRN Site. As discussed in EIS Section 2.9.2, Roane County, where the CRN Site is located, is in attainment for all criteria pollutants.

Authorizations for construction, preconstruction, and operation activities are listed in Table 1.2-2 of the ER (TVA 2017-TN4921). Air permits under Tennessee and Federal laws will address the impact of air emissions on sensitive receptors, located across the Clinch River arm of the Watts Bar Reservoir (TVA 2017-TN4921). Additionally, the applicant plans to implement an emissions mitigation plan (TVA 2017-TN4921). Section 4.4.1.2 of the ER (TVA 2017-TN4921) lists air emissions mitigation measures that may be used, including the following:

- phasing activities and equipment use
- minimizing the idling time of vehicles
- using properly maintained equipment in compliance with applicable regulations
- minimizing speeds on unpaved roads
- watering roads and exposed areas
- minimizing soil storage piles
- locating stationary equipment (e.g., generators and compressors) away from sensitive receptors
- minimizing dust-generating activities during high winds.

Construction and preconstruction activities, such as operation of on-road construction vehicles, commuter vehicles, nonroad construction equipment, and marine engines, would also result in greenhouse gas (GHG) emissions, principally carbon dioxide (CO_2). Although the ER assumes a 6-year period for construction and preconstruction activities and a maximum electrical output of 800 MW(e) (TVA 2017-TN4921), GHG emissions for construction and preconstruction equipment are derived from NRC Interim Staff Guidance COL/ESP-ISG-026, *Interim Staff Guidance on Environmental Issues Associated with New Reactors* (NRC 2014-TN3768). This guidance estimates GHG emissions of 39,000 MT CO_2 equivalent (CO_2e)[2] for a reference 1000-MW(e) reactor with a 7-year construction and preconstruction duration. This value would not significantly differ for a new nuclear power plant at the CRN Site based on the fact that the staff used an 80 percent capacity factor for the 1,000-MW(e) reference nuclear power plant and the applicant used a 90 to 98 percent capacity factor for the 800-MW(e) CRN SMR; therefore, the estimated emissions are comparable. The estimate from the 1,000-MW(e) reference reactor is expected to be comparable relative to the CRN Site, based on the duration of activities and reactor size. This GHG emission mass translates to an emission rate of about 5,570 MT CO_2e annually, averaged over the 7-year period of construction/preconstruction, which amounts to about 0.006 percent of the total estimated GHG emissions in Tennessee (100,000,000 MT of gross[3] CO_2e) in 2015 (EPA 2015-TN4925). This also equates to about 0.00008 percent of the total U.S. annual emission rate of 6.6 billion MT CO_2e in 2015 (EPA 2017-TN4924). Appendix K of this EIS provides the details of the review team estimate for a reference 1,000-MW(e) nuclear power reactor.

Based on its assessment of the relatively small construction equipment GHG footprint compared to total Tennessee and U.S. annual GHG emissions, the review team concludes that the atmospheric impacts of GHGs from construction and preconstruction activities would not be noticeable and additional mitigation would not be warranted.

In general, emissions from construction and preconstruction activities, including GHG emissions, would vary based on the level and duration of a specific activity, but the overall impact is expected to be temporary and limited in magnitude. TVA stated in ER Section 4.4.1.2 (TVA 2017-TN4921) that emission-specific strategies and measures would be developed and implemented to ensure compliance with the applicable regulatory limits defined by the National Primary and Secondary Ambient Air Quality Standards (40 CFR Part 50-TN1089). Additionally, a dust control program would likely be implemented by TVA. Considering the information provided by TVA and its stated intent to develop and implement strategies to reduce emissions to ensure compliance with Federal, State, and local regulations, the review team concludes that the impacts on air quality from CRN Site construction and preconstruction activities would not be noticeable and appropriate mitigation measures would be adopted.

4.7.2 Traffic (Emissions)

During building activities, additional commuter vehicles, trucks, and other construction vehicles would daily pass through Bear Creek Road, leading into the CRN Site. This traffic would include the passenger cars and light-duty trucks of the construction and preconstruction workforce and truck traffic for delivery of construction materials and heavy equipment used to support development (e.g., excavators, bulldozers, heavy-haul trucks, cranes). The review team determined that increases in emission levels are expected to be minimal and temporary, and would have a minimal impact on air quality from criteria pollutants (TVA 2017-TN4921).

The overall impact caused by increased traffic volume and congestion would be localized and temporary. In the ER, TVA identifies mitigation measures that would be developed before building activities begin. These traffic mitigation measures would reduce the impact of increased traffic on air quality. Potential mitigation measures involve additional traffic ramps

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(2) A measure to compare the emissions from various greenhouse gases (GHGs) on the basis of their global warming potential, defined as the ratio of heat trapped by one unit mass of the GHG to that of one unit mass of CO_2 over a specific time period.

(3) Total GHG emissions estimate is based on twice the reported emissions from large emitting facilities.

and changes to intersections to reduce congestion. Workers may carpool to the site to minimize the number of added vehicle traffic.

Workforce transportation would also result in GHG emissions, principally CO_2. Assuming a 7-year period for construction and preconstruction activities and a typical workforce size, the review team estimates that the total workforce GHG emission footprint for building a new 1,000-MW(e) nuclear power plant at the CRN Site would be on the order of 43,000 MT CO_2e (NRC 2014-TN3768). As noted in EIS Section 4.7.1, this estimate is comparable for the anticipated 6-year construction and preconstruction period for the 800-MW(e) project. This total emission quantity translates to a rate of about 6,100 MT CO_2e annually, averaged over the 7-year period of construction/preconstruction. This amounts to about 0.006 percent of the total estimated GHG emissions in Tennessee (100,000,000 MT of gross[4] CO_2e) in 2015 (EPA 2015-TN4925) and 0.00009 percent of the total U.S. annual emission rate of 6.6 billion MT CO_2e in 2015 (EPA 2017-TN4924). Appendix K of this EIS provides the details of the review team estimate for a reference 1,000-MW(e) nuclear power reactor.

Based on its assessment of the relatively small construction and preconstruction workforce GHG footprint compared to the Tennessee and U.S. annual GHG emissions, the review team concludes that the atmospheric impacts of GHGs from workforce transportation would not be noticeable, and additional mitigation would not be warranted. Based on the limited increase in local vehicle traffic and the applicant's stated intent to develop mitigation measures listed in the ER (TVA 2017-TN4921), the review team concludes that the impact on the air quality related to construction and preconstruction activities, including the effect of GHG emissions, would be temporary and would not be noticeable if the applicant's proposed mitigation measures are adopted.

4.7.3 Summary

The review team evaluated potential impacts on air quality associated with criteria pollutants and GHG emissions during CRN Site building activities. The review team determined that the impacts would be minimal. On this basis, the review team concludes that the impacts on air quality from emissions of criteria pollutants and GHGs during CRN Site construction and preconstruction would be SMALL and that no further mitigation would be warranted. Because the NRC-authorized construction activities represent only a portion of the analyzed activities, the NRC staff concludes that the air-quality impacts of the NRC-authorized construction activities would also be SMALL, and no further mitigation beyond those mitigation measures that the applicant has committed to implement would be warranted. Appendix K of this EIS provides the details of the review team estimate for a reference 1,000-MW(e) nuclear power reactor. As was noted in EIS Section 4.7.1, use of the Appendix K values is bounding compared with the anticipated 6-year construction and preconstruction period for the proposed 800-MW(e) project at the CRN Site.

4.8 <u>Nonradiological Health Impacts</u>

The CRN Site is located on the northern bank of the Clinch River arm of Watts Bar Reservoir in rural Roane County, Tennessee, between CRM 14.5 and CRM 19 (TVA 2017-TN4921). The closest communities to the center of the proposed CRN Site are Kingston (7.2 mi west) and Lenoir City (8.9 mi southeast). The property is mostly undeveloped land (>90 percent) composed of mixed forests, grasslands, and other vegetative cover. The topography consists of

(4) The total GHG emissions estimate is based on twice the reported emissions from large emitting facilities.

steep slopes and flat meadows. Previous development on the site to support the CRBRP effort was limited to approximately 7 percent of the CRN Site (TVA 2017-TN4921).

Nonradiological health impacts on the public and workers from building the proposed SMR units and supporting structures at the CRN Site are described in this section, including impacts on public and occupational health (Section 4.8.1), the impacts of noise (Section 4.8.2), and the impacts of transporting construction materials and personnel to and from the proposed site (Section 4.8.3). Nonradiological health impacts are summarized in Section 4.8.4.

4.8.1 Public and Occupational Health

This section discusses the impacts of building activities on the nonradiological health of the public and the impacts from site preparation and development on the nonradiological health of workers. EIS Section 2.10 provides background information and baseline conditions of the affected environment at and near the vicinity of the proposed CRN Site.

4.8.1.1 Public Health

The physical impacts on the public from building activities at the proposed CRN Site would include fugitive dust and vehicle exhaust (including exhaust from haul vehicles) as sources of air pollution during site preparation (TVA 2017-TN4921). TVA stated that operational controls would be imposed to mitigate dust emissions, using methods such as watering unpaved roads and exposed soils (when surface is dry), stabilizing construction roads and spoil piles, and phasing grading activities and ceasing them during high winds and during extreme air pollution episodes (TVA 2017-TN4921).

Engine exhaust would be minimized by maintaining fuel-burning equipment in good mechanical order and by phasing building activities to minimize daily emissions. TVA (2017-TN4921) stated that applicable Federal, State, and local emission requirements would be followed as they relate to operation of fuel-burning equipment. The appropriate Federal, State, and local permits and operating certificates would be obtained as required. For a more detailed description of the baseline air quality for the proposed CRN Site, please refer to EIS Section 2.9.2.

The public would have access close to the proposed CRN Site during all phases of the project. The nearest publicly accessible area is approximately 0.36 mi (1,900 ft) from the planned cooling-tower location (TVA 2017-TN4921; AECOM 2014-TN5004). TVA also stated that procedures developed for the proposed CRN Site to limit adverse impacts during building activities would be based on similar procedures already established for existing units at the Watts Bar Nuclear Power Plant site (TVA 2017-TN4921). Given that TVA will employ mitigation measures discussed above, the review team concludes that the impacts on nonradiological public health from building activities would be negligible. No further mitigation beyond the actions identified above would be warranted.

4.8.1.2 Construction Worker Health

In general, human health risks to construction workers and other personnel working onsite are dominated by occupational injuries (e.g., falls, electrocution, asphyxiation, and burns). The Tennessee Department of Labor and Workforce Development protects workers from adverse conditions by requiring employers to comply with occupational health and safety regulations (TOSHA 2017-TN5388; 29 CFR Part 1926-TN4455). TVA has a comprehensive safety program for all aspects of construction and operation that applies to all employees and staff at TVA facilities (NRC 2018-TN5386; TVA 2017-TN4921). For specific managed tasks during construction, contractors to TVA are responsible for their own safety programs and TVA monitors compliance to ensure practices are aligned with TVA safety procedures (NRC 2018-TN5386). Safety plans would be prepared and construction staff would receive appropriate training in applicable safety procedures for all work activities and a safety/environmental officer would oversee and inspect all construction activities (TVA 2017-TN4921).

In addition to onsite building activities, TVA has planned for new facilities and line upgrades to connect the proposed plant to the existing transmission system, which are fully described in Section 3.2.2.3.5 of this draft EIS (TVA 2017-TN4921). All new transmission lines and switchyards would be built in accordance with the National Electrical Safety Code and applicable construction standards and codes (TVA 2017-TN4921).

According to the U.S. Bureau of Labor Statistics (BLS), incidence rates for "utility system construction" have been reduced by more than 50 percent in the last 10 years, from a rate of 5.4 injury/illnesses per 100 full-time equivalent employees (FTEs) in 2006 to 2.4 injury/illnesses per 100 FTEs in 2015 (BLS 2017-TN4906). The State of Tennessee also reports incidence rates for "utility system construction." In 2015, the rate was 7.0 injury/illnesses per 100 FTEs (BLS 2017-TN4906).

The peak onsite construction workforce at the proposed CRN Site and related facilities would be 3,300 (TVA 2017-TN4921). Based on the BLS incidence rates provided above, during six months of the 5-year building phase, there could be a maximum of 231 recordable cases (mostly injuries due to slips and falls) per year (BLS 2017-TN4905; TVA 2017-TN4921). Before and after the peak employment period, the number of recordable cases would be proportional to the changes in total employees. These numbers, based on rates in Tennessee, would yield 79.2 recordable cases during building activities. TVA has stated that all contractors and subcontractors would be required to comply with safety procedures to prevent and/or minimize recordable cases during all phases of building activities (TVA 2017-TN4921).

The review team has determined that the nonradiological impacts of building activities on construction worker health would be minor. Application of mitigation measures identified in Table 10-1 of this EIS (and discussed in this subsection), adherence to permits and authorizations required by State and local agencies, and safety training that would be conducted by TVA could further reduce incidence rates. Further mitigation beyond that described would not be warranted.

4.8.2 Noise Impacts

Development of a nuclear power plant project is similar to other large industrial projects, and it involves many noise-generating activities. Regulations governing noise from building activities are generally limited to worker health. Federal regulations governing noise are found in 29 CFR Part 1910 (TN654) and 40 CFR Part 204 (TN653). 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 construction equipment including compressors.

The ER indicates that activities associated with building of new SMR units at the CRN Site would include the use of

- hand tools
- pneumatic equipment

- generators
- cranes
- pile-drivers
- earthmoving equipment
- blasting operations.

As discussed in EIS Section 2.10.2, TVA measured baseline noise levels in 2014. Measurements at the nearest sensitive receptors (within 0.61 mi) at Locations 1, 2, and 3 were day-night average sound level (Ldn) values of 49.7 dBA, 55.2 dBA, and 57.6 dBA, respectively (AECOM 2014-TN5004). Locations 5, 6, and 7, all within 0.75 mi of the center of the proposed CRN Site, had day-night average sound level (Ldn) values of 59.2 dBA, 51.7 dBA, and 63.9 dBA, respectively, during ambient measurements (AECOM 2014-TN5004). Locations 8 and 9, located 1.07 mi and 4.73 mi from the center of the proposed CRN Site had Ldn values of 57.3 dBA and 60.1 dBA, respectively (AECOM 2014-TN5004). It is important to note that the ambient noise levels measured in 2014 during the baseline noise study will no longer be applicable once site clearing activities are carried out. As stated by AECOM Technical Services Inc. (AECOM) in their study:

> Ambient noise conditions were sampled within and outside of the Site for baseline purposes only. These levels may be used at a later date as a comparison to assess construction and/or operational noise at the Site. No recommendations are presented at this time.

Therefore, the review team performed the analysis below making conservative assumptions regarding attenuation by distance alone.

The ER indicates the loudest piece of equipment listed above (a bulldozer) has a peak noise level of 102 dBA measured 50 ft from the source (TVA 2017-TN4921). At a distance of 400 ft, the bulldozer's peak noise level would decrease to no more than 84 dBA, estimated by calculating noise attenuation by distance alone (TVA 2017-TN4921). At the closest residence to the proposed site, the bulldozer's noise level would decline to 70.4 dBA, slightly greater than the NRC's 65 dBA noise threshold for impacts. These estimates do not include the noise attenuation associated with weather, vegetation, and topography, which the review team expects would further reduce the estimated sound levels at each distance discussed above.

Most building activities would occur during normal daylight hours; however, in cases where activities are required outside normal working hours, noise levels generated would not be higher than 65 dBA at the CRN Site border (TVA 2017-TN4921). In addition, several measures could also be taken to mitigate the potential adverse effects of noise. Among the mitigation measures are compliance with applicable local regulations and with the Occupational Safety and Health Administration noise exposure limits, implementation of training and use of personal protective equipment, inspection and maintenance of noise-limiting devices on vehicles and equipment, shielding high noise sources near their origin, and restriction of non-routine activities to weekday business hours (TVA 2017-TN4921). TVA has also suggested the use of several sound mitigating BMPs, including:

- using noise reduction devices (i.e., mufflers) on heavy equipment
- limiting driving speeds, use of "Jake brakes" and tail-gate slamming
- constructing earthen berms
- placing foliage or ground cover between the noise source and receptors.

According to NUREG-1555 (NRC 1996-TN288),[(5)] noise levels below 65 dBA are considered to be of small significance. As stated in the above subsection, the anticipated noise levels (1) are expected to be higher than baseline conditions at each of the nearest sensitive receptors, (2) exceed NRC's 65 dBA threshold, and (3) could exceed the City of Oak Ridge noise ordinance regarding levels and duration without mitigation. However, TVA has stated they would adhere to city ordinances for noise during building activities, and therefore, the review team concludes that noise impacts from building would be minor and mitigation beyond what TVA has described would not be warranted.

4.8.3 Transportation Impacts

This EIS assesses the impact of transporting workers and construction materials to and from the CRN Site from the perspective of three areas of impact: the socioeconomic impacts, the air-quality impacts of dust and particulate matter emitted by vehicle traffic, and potential health impacts due to additional traffic-related accidents. Human health impacts are addressed in this section, while the socioeconomic impacts are addressed in EIS Section 4.4.1.3, and air quality impacts are addressed in EIS Section 4.7.2. The impacts evaluated in this section for new SMR units at the CRN Site are appropriate for characterizing the alternative sites discussed in EIS Section 9.3. Alternative sites evaluated in this EIS include ORR Site 2 and ORR Site 8 in Roane County, and Redstone Arsenal Site 12 in Madison County, Alabama. There is no meaningful differentiation among the proposed and alternative sites regarding the nonradiological environmental impacts from transporting construction materials and personnel to the CRN Site and the alternative sites, and these issues are not discussed further in Chapter 9 of this draft EIS.

The general approach used to calculate the nonradiological impacts of fuel and waste shipments is the same as that used for transportation of construction materials and construction personnel to and from the CRN Site and alternative sites. The assumptions made to provide reasonable estimates of the parameters needed to calculate nonradiological impacts are discussed below.

The applicant's ER did not provide estimates for construction material shipment capacities to use in calculations for transporting materials. Therefore, numbers provided in the *DOE NP2010 Nuclear Power Plant Construction Infrastructure Assessment* (DOE 2005-TN5335) were used as the basis for SMR construction material amounts:

- The review team assumed that shipment capacities are approximately 460,000 yd^3 of concrete, 71,000 T of rebar and structural steel, and 690,000 ft of piping and 8,960,000 ft of cable, conduit, wire, and tubing per shipment. For the purposes of this analysis, the review team assumed these materials would be transported to the site in a levelized manner (i.e., evenly distributed) over a 6-year period based on the schedule provided by TVA.
- The number of construction workers at peak employment is 3,300 in a 24-hour period (TVA 2017-TN4921). A total of 2,539 vehicles were estimated to enter and leave the CRN Site daily, based on 1.3 people per car. Therefore, the impacts of transporting workers were estimated based on 2,539 vehicles entering and leaving the CRN Site daily. Each person was assumed by the review team to travel to and from the site 365 days per year.

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(5) NUREG-1437 was originally issued in 1996 (NRC 1996-TN288). Addendum 1 to NUREG-1437 was issued in 1999 (NRC 1999-TN289). All references to NUREG-1437 include NUREG-1437 and its Addendum 1.

- The review team assumed the average one-way shipping distance for construction materials to be 50 mi one way.
- The review team assumed the average commuting distance for construction workers to be within 50 mi of the CRN Site (TVA 2017-TN4921).
- To develop representative commuter and construction material-traffic impacts, Tennessee-specific accident, injury, and fatality rates from the Tennessee Department of Transportation were used for the years 2010 to 2014.

The estimated nonradiological impacts of transporting construction materials to the proposed CRN Site and transporting construction workers to and from the site are listed in Table 4-12. Based on Table 4-12, the nonradiological impacts are dominated by transport of construction workers to and from the CRN Site. The total annual construction fatalities related to building the facility represent an approximate 7.5 percent increase over the average 10 traffic fatalities per year that occurred in Roane County from 2012 to 2016 (TDOSHS 2017-TN5351). This percentage represents negligible increases relative to the current traffic fatality risks in the areas surrounding the proposed CRN Site and alternative sites. Increases for the alternative sites were the same for ORR Sites 2 and 8, and similar for the Redstone Arsenal Site12 in Madison County, Alabama (ALDOT 2016-TN5352).

Table 4-12. Annual Nonradiological Impacts of Transporting Workers and Materials to and from the Proposed CRN Site

	Accidents per Year per Site	Injuries per Year per Site	Fatalities per Year per Site
Workers	1.4×10^{2}	3.8×10^{1}	7.5×10^{-1}
Materials			
Concrete	1.4	3.8×10^{-1}	7.6×10^{-3}
Rebar; Structural Steel	2.6×10^{-1}	7.0×10^{-2}	1.4×10^{-3}
Cable, Conduit, Wire & Tubing	1.1×10^{-1}	3.0×10^{-2}	5.9×10^{-4}
Piping	8.4×10^{-3}	2.3×10^{-3}	4.5×10^{-5}
Total – Materials	3.7×10^{-1}	1.0×10^{-1}	2.0×10^{-3}
Total – Construction	1.4×10^{2}	3.8×10^{1}	7.5×10^{-1}

Based on information provided by TVA, the review team's independent evaluation, and considering the number of shipments of construction materials and workers that would be transported to the CRN Site and alternative sites, the review team concludes that the nonradiological health impacts of building activities from transporting building materials and personnel to the CRN Site and alternative sites would be negligible, and no further mitigation would be warranted.

4.8.4 Summary of Nonradiological Health Impacts

As part of its evaluation of nonradiological health impacts, the review team considered the mitigation measures identified by TVA in its ER and relevant permits and authorizations required by State and local agencies for building activities at the CRN Site. The review team evaluated nonradiological impacts on public health and construction workers from fugitive dust, occupational injuries, noise, and transport of materials and personnel to and from the CRN Site. No significant impacts related to the nonradiological health of the public or workers were identified from air quality or transportation and noise during the course of this review. Based on information provided by TVA and the review team's independent evaluation, the review team concludes that the nonradiological health impacts of building activities associated with the proposed CRN Site would be SMALL for all categories with the exception of noise, which would be MODERATE. NRC-authorized construction activities are a significant contributor to all findings.

4.9 Radiological Health Impacts

Potential sources of radiation exposure for construction workers during the site preparation and construction phases of building two or more SMRs at the CRN Site would include any SMR(s) that are already operational. The multiple SMR units for three of the four design options under consideration are assumed to be constructed within separate shielded structures adjacent to any initial units already constructed and operational. The NuScale SMR differs in that a single reactor building is designed to contain multiple reactor units and any subsequent reactor units would be installed within the same structure in which the initial reactor(s) are already operational.

Because the SMRs would be manufactured at an offsite location and large fabricated components would be delivered to the CRN Site, the onsite time required for installation and construction of the SMRs is expected to be less than that for a large light water reactor employing traditional construction methods. This offsite manufacturing process reduces radiation exposures to construction workers by reducing the amount of time working near operating units.

For the SMR designs of BWXT, Holtec, and Westinghouse, TVA considered the construction workers to be members of the public, both before and after any units become operational. Construction worker doses would remain below the radiation dose limit for individual members of the public (100 mrem/yr [10 CFR 20.1301 (TN283)]). Therefore, the dose estimates for these construction workers are compared to the dose limits for members of the public, pursuant to 10 CFR Part 20, Subpart D (TN283), "Radiation Dose Limits for Individual Members of the Public."

For the NuScale SMR design, multiple units would be sequentially installed and made operational within a single structure. Because the operating NuScale units are within the same structure as the units being constructed, it can be assumed the workers installing subsequent units would be getting doses above 100 mrem/yr; therefore, the impacts on workers installing additional units after startup of the initial unit(s) would be compared to the dose limits for radiation workers, pursuant to 10 CFR Part 20, Subpart C (TN283), "Occupational Dose Limits." As a result, NRC staff assumed the construction phase for the NuScale design ends when the first unit becomes operational. Impacts on workers associated with installation of subsequent units are addressed in EIS Section 5.9, Radiological Impacts of Normal Operations.

The SMRs are pressurized water reactor units, allowing multiple units to collectively function as a larger nuclear power plant. Thus, they would be constructed and installed in series where construction would occur on subsequent units during operation of those previously completed. TVA estimates it would take 6 years from the start of site preparation activities to fuel loading of the final unit. TVA also assumed a gap of at least 1 year between the construction schedules of each additional SMR unit, indicating that one or more units would have been operating for 1 year while construction continues on a subsequent unit. Therefore, the potential radiation dose to construction workers was calculated assuming that one less than the maximum total number of SMR units for each design are operating for the duration of construction of the final SMR unit.

4.9.1 Direct Radiation Exposures

The only source of direct radiation exposures, above background, would be from the operational SMR units. The first SMR unit would be placed in service during construction of subsequent units, so direct radiation from the operational units must be considered. The distances from Oak Ridge National Laboratory and other nearby locations that house nuclear-related activities to the CRN Site is too far for any resulting direct radiation exposures to exceed natural background levels.

Sources of direct radiation exposure in the operating SMRs would be shielded. TVA indicated that when completed, the entire SMR facility is anticipated to produce 800 MW(e) or less (TVA 2017-TN4921). In the absence of design-specific information, TVA conservatively estimated direct radiation doses to construction workers next to operational SMRs based on measured dose rates at perimeter fences surrounding the larger 3,625-MW(t) pressurized water reactor s at the Vogtle Nuclear Power Plant. The direct radiation doses were then scaled to adjust for CRN Site-specific worker occupancy times, number of reactors, and distances to reactors. Based on thermoluminescent dosimeter data collected for 1 year (365 days, which is 8,760 hours) at the Vogtle Nuclear Power Plant, TVA used the average measured dose rate of 66.9 mrem/yr at the nearest location on the Vogtle perimeter fence (located 410 ft from an operating reactor) as the starting point for estimating the direct annual doses. This rate was used to estimate doses from two operating 800 MW(t) reactor units to SMR construction workers during construction of a third unit. Because a construction worker would only work about 2,080 hours in a year onsite (calculated from 40 hours per week and 52 weeks per year [2080 hr/yr]), the bounding external dose rate would be 15.9 mrem/yr from one operating unit. TVA further adjusted the estimated dose rate to account for actual SMR separation distances of 387 ft and 1,162 ft to two operating 800 MW(t) reactor units, yielding a bounding annual direct dose of 24 mrem/yr. Because the estimated annual direct dose rate for each operational SMR unit is based on actual data from larger operational power plants, the NRC staff agrees that 24 mrem/yr is a conservative and bounding value. Direct sources of radiation would be monitored, either individually or in the general area, to ensure that construction worker doses remain within regulatory limits.

In addition, at certain times during construction, TVA would receive, possess, and use specific radioactive by-product, source, and special nuclear material in support of construction and preparations for operation. These sources of low-level radiation are required to be controlled by the applicant’s radiation protection program, with physical protections if necessary, and have very specific uses under controlled conditions. Therefore, these sources are expected to result in a negligible contribution to construction worker doses.

4.9.2 Radiation Exposures from Gaseous Effluents

Because a specific design has not yet been selected, the exhaust point and vent configuration is uncertain. As discussed in ER Section 2.7.5, TVA assumed ground-level releases in the development of dispersion coefficients (TVA 2017-TN4921) because the ground-level releases are more conservative. Likewise, NRC staff evaluated impacts assuming the exhaust points to be at ground level. The design has not matured to where details on gaseous effluent release points and treatment are available.

Because SMR construction will occur in proximity to operating unit(s), the impact of gaseous effluents on workers needs to be considered. TVA used the GASPAR II computer code (Strenge et al. 1987-TN83) to estimate the dose to construction workers resulting from routine gaseous releases from onsite operational units considering inhalation of effluents, external exposure to the effluents, and external exposure to ground contaminated by the effluents. As discussed in ER Section 2.7.6, routine diffusion and dispersion estimates were modeled using the XOQDOQ computer program (Sagendorf et al. 1982-TN280) using 1 year's worth of site-specific validated meteorological data.

The GASPAR II input parameters are discussed in EIS Section 5.9. All estimates assumed the construction workers would be located at the center of the power block under construction while all the other proposed units are already operational. This approach assumes the worker is exposed to normal effluents from multiple operational units. The worker is also assumed to spend 2,080 hours in a year at that location. TVA concluded that the GASPAR II results suggest that construction workers could receive a total body dose of 28 mrem/yr from routine gaseous effluents, with a maximum organ (skin) dose of 51 mrem/yr. In accordance with NRC guidance, the total effective dose equivalent value was estimated by weighting the thyroid dose (48 mrem/yr) by 0.03 and summing with the total body dose of 28 mrem/yr to obtain 29 mrem/yr.

4.9.3 Radiation Exposures from Liquid Effluents

Typically, liquid radioactive effluents discharged to the Clinch River arm of the Watts Bar Reservoir would have been evaluated for their contribution to the total effective dose equivalent to construction workers. However, because the City of Oak Ridge Public Works Department would supply potable water to the construction force, there would be no dose contributions from drinking water. The City of Oak Ridge water supply is withdrawn from Melton Hill Lake, upstream of both the Clinch River arm of the Watts Bar Reservoir and the proposed effluent release location for the CRN Site.

4.9.4 Total Dose to Construction Workers

TVA estimated the maximum total effective dose equivalent to a construction worker to be about 53 mrem/yr based on a 2,080-hour work year (TVA 2017-TN4921), which is the sum of the following sources: (1) direct exposure from operating units (24 mrem/yr), (2) routine gaseous effluents (29 mrem/yr), and (3) routine liquid effluents (0 mrem/yr) (TVA 2017-TN4921). This estimate is well below the radiation dose limit for individual members of the public (100 mrem in a year) found in 10 CFR 20.1301 (TN283). The occupational dose limit for a radiation worker is 5,000 mrem in a year, found in 10 CFR 20.1201 (TN283). The maximum estimated annual collective dose to the construction workforce, based on an annual individual dose of about 53 mrem and an estimated peak workforce of 3,300 (assumed to last for 1 year) would be about 170 person-rem per year (person-rem/yr) (TVA 2017-TN4921). Over the duration of construction, the average estimated annual collective dose to the construction workforce, based on the average annual workforce of 2,200 (TVA 2017-TN4921) would be about 117 person-rem/yr.

4.9.5 Summary of Radiological Health Impacts

The NRC staff concludes that the estimated doses to construction workers during site preparation and construction activities for the BWXT mPower, Holtec SMR-160, NuScale SMR, and Westinghouse SMR designs do not exceed the regulatory limit of 100 mrem/yr designed to protect the health of individual members of the public (10 CFR 20.1301 [TN283]). The NRC staff assumes that the construction phase for the NuScale design ends when the first unit becomes operational. Impacts on workers associated with installation of subsequent units are addressed in EIS Section 5.9, Radiological Impacts of Normal Operations. Based on information provided by TVA and the NRC staff's independent evaluation, the NRC staff concludes that the radiological health impacts on workers conducting NRC-authorized construction activities at the CRN Site would be SMALL, and no further mitigation would be warranted.

4.10 Nonradioactive Waste Impacts

The following sections provide descriptions of the potential environmental impacts from the generation, handling, and disposal of nonradioactive waste during the building activities at the proposed CRN Site. Section 3.4.4 of this draft EIS provides descriptions of the proposed CRN nonradioactive waste systems. Potential types of nonradioactive wastes expected to be generated, handled, and disposed of include construction debris, spoils, stormwater runoff, municipal and sanitary waste, dust, and air emissions. The assessment of potential impacts resulting from these types of wastes is presented in the following sections.

4.10.1 Impacts on Land

Building activities related to the proposed project could result in solid waste materials like construction debris from excavation, land clearing, and dredge spoils. TVA would construct and operate an onsite landfill to accommodate construction debris created by excavation and land clearing at the CRN Site (TVA 2017-TN4921). The construction debris and other nonhazardous wastes (including municipal solid waste) not placed in the onsite landfill would be shipped to one of four licensed offsite disposal landfills, such as the Sanitary Chestnut Ridge Landfill (TVA 2017-TN4921). Hazardous solid waste would also be disposed of at a licensed facility in accordance with Tennessee solid-waste regulations (TVA 2017-TN4921).

Spoils (dredge material) generated as a result of dredging the Clinch River for building activities associated with the intake and discharge structures for the new units, would be placed in an upland dredged-material dewatering pond (see EIS Sections 3.2.2.1 and 3.2.2.2) (TVA 2017-TN4921). Spoils would remain in the dewatering pond until they were dry enough to be used as clean fill on the CRN Site, disposed of in the onsite landfill, or transported offsite to an approved landfill (TVA 2017-TN4921). Once all dredge material is dried and moved out of the dewatering pond, the dewatering pond site would be re-graded if necessary and vegetation would be re-seeded for stabilization (TVA 2017-TN4921).

Based on TVA plans to manage solid wastes in accordance with all applicable State and local requirements and standards, and implement recycling and minimizing waste practices, the review team expects the impacts on land from nonradioactive wastes generated during the building activities for CRN units would be minimal, and no further mitigation would be warranted.

4.10.2 Impacts on Water

Surface water and groundwater have the potential to be affected due to the building activities at the CRN Site. TVA must obtain a NPDES General Permit for Stormwater Discharges from Large and Small Construction Activities to minimize potential impacts on surface water and groundwater. As part of the permit, a Storm Water Pollution Prevention Plan will be required. In addition, an erosion and sediment control plan would be a component of the NPDES permit. Water-use impacts and water-quality impacts during the development of the proposed CRN Site are further discussed in EIS Sections 4.2.2 and 4.2.3.

Onsite sanitary wastes generated during the building activities would be discharged to the City of Oak Ridge wastewater treatment system which will be able to accommodate a workforce of up to 3,300 people at a time during building activities (TVA 2017-TN4921). The maximum quantity of sanitary waste expected would be 165,000 gpd (3,300 workers at 50 gpd)

(TVA 2017-TN4921). The onsite wastewater production would only use one-third of the excess capacity of the City of Oak Ridge Rarity Ridge sanitary treatment facility. See EIS Section 4.4.4.4.1 for a detailed discussion of building activities on the wastewater treatment system.

During building activities, stormwater would be managed by controls for runoff. These controls include creation of berms around temporary spoils areas, shallow trenching for ditches, drain pipes, and culverts, and slopes, swales, ditches, and pipes to direct runoff to aboveground retention ponds (TVA 2017-TN4921). BMPs would likely include methods described in the State of Tennessee Erosion and Sediment Control Handbook (TDEC 2012-TN4889).

As stated in EIS Section 3.2.2.4.2, dewatering would be used in the nuclear island excavation and could include horizontal drains in excavated surfaces to direct water to sumps, grouting to prevent inflow of groundwater, and pumping water from sumps to the construction-stormwater management system (TVA 2017-TN4921). TVA noted that, depending on the size and depth of the excavation area, a number of temporary dewatering wells could be needed, and that each could have a flow rate of up to 15 gpm during the construction period. Dewatering is not anticipated once nuclear island construction is completed (TVA 2017-TN4921, TVA 2017-TN4987).

Based on the regulated practices for managing liquid discharges, including wastewater, and the required NPDES permit with an approved SWPPP that TVA plans to implement for managing surface water and groundwater, the review team expects that impacts on water from nonradioactive effluents during building activities at the CRN Site would be minimal, and no further mitigation would be warranted.

4.10.3 Impacts on Air

Although equipment and vehicles used for site preparation and the increase in vehicle traffic of construction workers involved in building activities at the CRN Site would result in increased emissions, TVA would manage fugitive dust and other generated emissions during site development activities. As stated in EIS Section 4.8.1.1, possible mitigation measures could include stabilizing construction roads and spoils piles, covering haul trucks, watering unpaved construction roads to control dust, and conducting routine inspections and maintenance on construction vehicles and equipment (TVA 2017-TN4921). TVA stated they would consult with TDEC on air permit requirements once a technology is chosen (TVA 2017-TN4921).

Based on the regulated practices for managing air emissions from construction equipment and temporary stationary sources, the review team expects that impacts on air from nonradioactive emissions during building activities at the CRN Site would be minimal, and no further mitigation would be warranted.

4.10.4 Summary of Impacts

Solid, liquid, and gaseous wastes generated during building activities at the CRN Site would be handled according to county, State, and Federal regulations. County and State standards and regulations for handling and disposal of solid waste would be obtained and implemented. An NPDES permit that would include a SWPPP for surface-water runoff and groundwater quality, and the use of temporary, portable facilities for sanitary waste systems during the construction period would ensure compliance with the Clean Water Act (33 U.S.C. § 1251 *et seq.*-TN662) and the State of Tennessee standards. Based on this information provided by TVA and the review team's independent evaluation, the review team concludes that nonradiological waste impacts on land, water, and air from building activities would be SMALL and that additional mitigation would not be warranted.

Cumulative impacts on water and air from nonradioactive effluents and emissions are discussed in EIS Sections 7.2 and 7.6, respectively. For the purposes of Chapter 9, the review team expects that there would be no substantive differences between the impacts of nonradioactive waste for the proposed CRN units and the alternative sites and no substantive cumulative impacts that warrant further discussion beyond those discussed for the alternative sites in EIS Section 9.3.

4.11 Measures and Controls to Limit Adverse Impacts during Construction Activities

In its evaluation of environmental impacts during building activities for a new nuclear power plant at the CRN Site, the review team considered TVA's stated intention to comply 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 control, noise control, stormwater management, discharge prevention and response, hazardous material management);
- compliance with applicable requirements of permits or licenses required for construction of a new nuclear power plant at the CRN Site (e.g., DA Section 404 Permit, NPDES permit);
- compliance with existing TVA processes and/or procedures applicable for environmental compliance activities during construction and preconstruction at the CRN Site (e.g., solid-waste management, hazardous waste management, and discharge prevention and response);
- incorporation of environmental requirements into construction contracts; and
- identification of environmental resources and potential impacts during the ESP process and the development of revisions to the TVA ER.

Examples of TVA's stated measures to minimize impacts and protect the environment include the following:

- using BMPs for construction and preconstruction activities;
- implementing plans to manage stormwater and to prevent and appropriately address accidental spills;
- limiting ground disturbance to existing right-of way lands when upgrading offsite transmission lines and when installing the buried 69-kV transmission line;
- considering opportunities to bore underground when installing the buried 69-kV transmission line; and
- adhering to Federal, State, and local permitting requirements including associated mitigation requirements.

The review team considered these measures and controls in its evaluation of the impacts of building two or more SMRs at the CRN Site. Table 4-13, which is based on Table 4.6-1 in the ER (TVA 2017-TN4921) and other information provided by the applicant, summarizes the measures and controls to limit adverse impacts when building a new nuclear power plant. Some measures apply to more than one impact category.

Table 4-13. Measures and Controls to Limit Adverse Impacts when Building a New SMR at the CRN Site

Resource Area	Specific Measures and Controls
Land-Use Impacts	• Use stormwater management plans to control erosion and runoff. • Return temporarily disturbed lands to former uses upon completion of construction. • Offset loss of wetland impacts by mitigation expected to be required by the Department of Army Permit. • Allow temporarily disturbed wetland areas to return to former conditions upon completion of construction. • Limit ground disturbances to the smallest amount of area necessary to construct and maintain the plant. • Perform ground-disturbing activities in accordance with regulatory and permit requirements; use adequate best management practices (BMPs) erosion-control measures to minimize impacts. • Restrict soil stockpiling and reuse to designated areas. • Use BMPs and stormwater management plans to control erosion and runoff, minimize clearing, wetlands impacts, and vegetation impacts. • Limit ground-disturbing activities such as vegetation removal to established transmission line corridors.
Water-Related Impacts	
Water Use	• Comply with applicable regulations, permits, and plans. • Grout fractures, cavities, and solution openings in the excavated rock face. Monitor effects of dewatering using groundwater wells.
Water Quality	• Comply with applicable regulations, permits, and plans. • Establish and implement a stormwater pollution prevention plan. • Use BMPs in addition to TVA, U.S. Army Corps of Engineers, and Tennessee Department of Environment and Conservation controls to protect affected waterbodies. • Apply BMPs as found in stormwater regulations and procedures. • Revegetate construction areas in a timely manner. • Install drainage controls to direct dewatering runoff. • Conduct any excavation along the shoreline in accordance with the terms of the 1991 Watts Bar Interagency Agreement (TVA et al. 1991-TN5345). • Minimize potential spills of chemicals and petroleum materials and hazardous wastes through training, spill prevention plans, and rigorous compliance with applicable regulations and procedures. • Use BMPs to maintain equipment and prevent spills and leaks. • Train appropriate employees in methods for preventing and/or responding to spills. • Establish and implement an Integrated Pollution Prevention Plan for construction practices.

Table 4-13. (contd)

Resource Area	Specific Measures and Controls
Ecological Impacts	
Terrestrial Ecosystems	• In temporarily disturbed areas, revegetate and allow natural succession, resulting in a reduction of long-term ecological impacts in these areas. • To the extent feasible, plan facility construction to take place in previously disturbed areas. • Use BMPs to prevent impacts on adjacent habitats, such as from erosion and runoff of sediment. • To the extent feasible, plan facility locations and construction activities to avoid wetlands. • Limit vegetation removal and construction activities to construction sites, underground transmission line right-of-ways, and access roads. Use established procedures for minimizing erosion and revegetating terrestrial habitats not permanently used for facilities. • Limit ground disturbance to existing right-of-way lands when upgrading offsite transmission lines and when installing the buried 69-kV transmission line.
Aquatic Ecosystems	• Install cofferdams or similar engineering protective measures around the sites when building or installing the intake and discharge. • Employ BMPs to minimize erosion and sedimentation. • Attempt, to the extent feasible, to tunnel under streams when installing the buried 69-kV transmission line. • Restore any disturbance to streams immediately after work is completed. • Install stormwater drainage systems at large construction sites and stabilize disturbed soils. • Maintain streamside management zones appropriately. • Extend new conductors across waterways within the existing right-of-ways without conducting in-water work or disturbing shorelines to the extent possible.
Socioeconomic Impacts	
Physical Impacts	• Manage major high noise construction activities to limit and minimize noise impacts on residences in the vicinity. • Use BMPs for controlling fugitive dust and proper maintenance of construction equipment for controlling emissions. • Train and appropriately protect employees and construction workers to reduce the risk of potential exposure to noise, dust, and exhaust emissions. • To the extent possible, recycle construction wastes with remaining waste disposed in approved landfills. • Stabilize cleared areas, minimize disturbance and visual intrusion, and remove construction debris in timely manner. • Install traffic controls and roadway modifications and additional turning capacity to mitigate traffic delays; construction workforce will work in up to three shifts to spread additional construction traffic volume over a 24-hour period (one 10-hour shift and occasional night and weekend shifts). • Provide onsite services for emergency first aid, and conduct regular health and safety monitoring.
Socioeconomic Impacts	• Install traffic controls and roadway modifications and additional turning capacity to mitigate traffic delays in and around the CRN Site. • Implement up to three shifts for construction workforce to spread additional construction traffic volume over a 24-hour period. • Stagger shifts, encourage carpooling, and time deliveries to avoid shift change or commute times.

Table 4-13. (contd)

Resource Area	Specific Measures and Controls
	• Erect signs alerting drivers of construction and potential for increased construction traffic. • Use procedures and employee training program to reduce potential for traffic accidents.
Environmental Justice	• No disproportionately high and adverse impacts on minority or low-income populations. No mitigation is required.
Historic Properties and Cultural Resources	• TVA has executed a Programmatic Agreement describing its ongoing National Historic Preservation Act (NHPA) Section 106 (54 U.S.C. § 306108-TN4839) compliance including commitments to avoid, minimize, mitigate, and resolve adverse effects to National Register of Historic Places (NRHP)-eligible resources that cannot be avoided and NHPA (54 U.S.C. § 300101 *et seq*.-TN4157) and Native American Graves Protection and Repatriation Act (NAGPRA) (25 U.S.C. § 3001 *et seq*.-TN1686) inadvertent discovery and notification provisions.
Air Quality	• Implement the Construction Air Permit, which includes controls such as watering, minimizing soil storage piles, covering trucks, using properly maintained equipment, minimizing vehicle speeds, and minimizing idling times and the running of inactive construction equipment. • Workforce emissions controls may include staggering shift hours and promoting car/van pooling.
Nonradiological Health	• Comply with Federal, State, and local regulations governing construction activities and construction vehicle emissions. • Comply with Federal, State, and local regulations governing noise from construction activities and increased traffic in the local area. • Comply with Federal and State occupational safety and health regulations; and implement traffic management plan.
Radiation Exposure to Construction Workers	• Train construction workers in radiation safety procedures. • Develop work plans that consider methods for reducing radioactive exposures to levels that are as low as reasonably achievable. • Monitor doses received by construction workers to ensure they are within regulatory limits.
Nonradioactive Waste	• Manage hazardous and nonhazardous solid wastes according to county, State, and Federal handling and transportation regulations. • Implement recycling and BMPs to minimize waste generation. • Establish procedures for, and perform audits to verify, waste disposal according to applicable regulations such as the Resource Conservation and Recovery Act of 1976, as amended (42 U.S.C. § 6901 *et seq*.-TN1281). • Establish a waste minimization program.

4.12 Summary of Construction and Preconstruction Impacts

The impact category levels determined by the review team in the previous sections are summarized in Table 4-14. The impact category levels for the NRC-authorized construction discussed in this chapter are denoted in the table as SMALL, MODERATE, or LARGE as a measure of their expected adverse environmental impacts, if any. Impact levels for the combined construction and preconstruction activities are similarly noted. Some impacts, such as the addition of tax revenue from a new nuclear power plant at the CRN Site on the local economies, are likely to be beneficial and are noted as such in the “Impact Level” columns.

Table 4-14. Summary of Impacts from Building a New Nuclear Power Plant at the CRN Site

Resource Area	Comments	Impact Category Levels for the NRC-Authorized Construction	Impact Category Levels for Construction and Preconstruction
Land-Use Impacts			
Site and Vicinity	Much of the land disturbance associated with building new SMR units on the CRN Site (167 ac of a total of about 494 ac) would be temporary, and the land would be allowed to return to its existing use (primarily forest) once building activities were completed. However, most of the land disturbance (327 ac of a total of about 494 ac) would permanently convert naturally vegetated land to industrial use. Impacts on prime farmland and management of natural resources would be minimal. Work would be in compliance with applicable zoning and land-use plans. Although of very short duration, the land-use impacts of the proposed highway interchange improvements, haul road improvements, barge slip improvements, rail spur reconditioning, and transmission line reconstruction activities would be locally noticeable to area residents and people driving in the vicinity. Local access may be temporarily disrupted during these activities.	MODERATE	MODERATE
Water-Related Impacts			
Water Use			
Surface Water	Most water for building would be obtained from the City of Oak Ridge public water supply system, which is sourced from the Melton Hill Reservoir. This water use would reduce the available excess capacity of the city’s water system. A small amount of water would be obtained directly from the Clinch River for dust suppression and other construction-related activities.	SMALL	SMALL
Groundwater	No groundwater would be used for building. Groundwater extracted as part of excavation dewatering would not affect groundwater use and would be discharged to a stormwater-retention pond.	SMALL	SMALL

Table 4-14. (contd)

Resource Area	Comments	Impact Category Levels for the NRC-Authorized Construction	Impact Category Levels for Construction and Preconstruction
Water Quality			
Surface Water	Potential impacts on surface water from stormwater pollution and inadvertent spills associated with clearing, grading, and other building activities such as pipeline placement. Disturbance of soil and nearshore sediments during excavation for construction of the intake and discharge structures.	SMALL	SMALL
Groundwater	Potential impacts from inadvertent spills of contaminants such as gasoline, diesel fuel, lubricants, and other liquids.	SMALL	SMALL
Ecological Impacts			
Terrestrial and Wetland Resources	Habitat loss due to clearing and grading; wildlife, such as birds and mammals, displaced from the construction site; less mobile animals killed. Wildlife startled or frightened away by construction noises. Potential impacts from bird collisions with man-made structures (cranes, buildings) during construction. Disturbance or destruction of wetlands. Ground disturbance for 69-kV underground transmission line and for offsite transmission line upgrades limited to existing right-of-way lands.	MODERATE	MODERATE
Aquatic Resources	Potential impacts on surface water from stormwater runoff associated with clearing and grading. Disturbance of soil and sediments during excavation along the shoreline for construction at the intake and discharge locations and at the barge facility and installing the Melton Hill bypass. Erosion and sediment transport into nearby waterbodies. Potential impacts on surface water from increased sediment deposition and disturbance.	SMALL	SMALL

Table 4-14. (contd)

Resource Area	Comments	Impact Category Levels for the NRC-Authorized Construction	Impact Category Levels for Construction and Preconstruction
Socioeconomic Impacts			
Physical Impacts	The physical impacts of building-related activities on workers and the local public noise; air quality; and on structures would be minor. However, vehicular traffic for construction worker commuting and building-related deliveries may have noticeable impacts on local roadways. Impacts on the aesthetic qualities of the CRN Site from sensitive viewpoints would be minor to noticeable, depending on distance from the site. These impacts would not be fully amenable to mitigation.	SMALL to MODERATE	SMALL to MODERATE
Demography	The in-migration of workers and their families to support building a new nuclear power plant would increase the population of the economic region by a minor fraction. These levels of population increase would be minor for the any of the counties in the economic region, as well.	SMALL	SMALL
Taxes and Economic Impacts	The economic and tax impacts would be minor and beneficial for the region and the economic region. Tax revenue to local jurisdictions would accrue through sales and property taxes and TVA payments in lieu of taxes.	SMALL (beneficial to the region)	SMALL (beneficial to the region)
Infrastructure and Community Services	The building-related impacts on all infrastructure and community services would be minor for the economic region, with the exception of traffic and recreational impacts near the CRN Site. Noticeable and destablilizing without mitigation adverse impacts on traffic would be experienced on local roadways near the site. These impacts would persist for much of the construction period, but especially during several months of peak construction activities.	SMALL (for all categories except traffic) and MODERATE to LARGE (for traffic)	SMALL (for all categories except traffic) and MODERATE to LARGE (for traffic)
Environmental Justice Impacts	No potential environmental pathways were identified by which the minority or low-income populations in the 50-mi demographic region and four-county economic region would likely experience disproportionately high and adverse human health, environmental, physical, or socioeconomic effects as a result of building activities.	None[(a)]	None[(a)]

Table 4-14. (contd)

Resource Area	Comments	Impact Category Levels for the NRC-Authorized Construction	Impact Category Levels for Construction and Preconstruction
Historic and Cultural Resource Impacts	Historic and cultural resources impacts include potential adverse effects on 16 potentially National Register of Historic Places (NHRP)-eligible archaeological resources, 1 NRHP-eligible archaeological resource (40RE233), deeply buried archaeological deposits, and 1 NRHP-eligible Melton Hill Dam District.	SMALL	MODERATE to LARGE
Air-Quality Impacts	Temporary emissions from construction equipment firing fossil fuels, fugitive dust from soils disturbance and moving of soils, and workforce motor vehicles.	SMALL	SMALL
Nonradiological Health Impacts	Dust emissions, occupational injuries, traffic accidents. Noise levels that exceed the City of Oak Ridge noise ordinance regarding levels and duration. Impacts from construction activities to worker health.	SMALL (for all categories except noise) and SMALL to MODERATE (for noise)	SMALL (for all categories except noise) and SMALL to MODERATE (for noise)
Radiological Health Impacts	Radiation exposures to construction workers that would be within regulatory limits and as low as is reasonably achievable.	SMALL	SMALL
Nonradiological Waste Impacts	Solid, liquid, and gaseous wastes generated when building the CRN units would be handled according to county, State, and Federal regulations. County and State standards and regulations for handling and disposal of solid waste would be obtained and implemented. A National Pollutant Discharge Elimination System permit that would include a stormwater pollution prevention plan for surface-water runoff and groundwater quality, and the use of temporary, portable facilities for sanitary waste systems during the construction period would ensure compliance with the Clean Water Act (33 U.S.C. § 1251 *et seq*.-TN662) and the State of Tennessee standards.	SMALL	SMALL

(a) The entry “None” for Environmental Justice does not mean there are no adverse impacts on minority or low-income populations from the proposed action. Rather, “None” means that, while there may be adverse impacts, they would not affect minority or low-income populations in any disproportionate manner, relative to the general population.

Sources: TVA 2017-TN4921, TVA 2017-TN4922.

5.0 OPERATIONAL IMPACTS AT THE PROPOSED SITE

This chapter examines environmental issues associated with operating two or more small modular reactors (SMRs) with a maximum total electrical output of 800 megawatt electric [MW(e)] at the Clinch River Nuclear (CRN) Site. Although an early site permit (ESP) would not authorize construction or operation of a nuclear power plant, as part of its application for an ESP, the Tennessee Valley Authority (TVA) submitted an Environmental Report (ER) that discusses the environmental impacts of station operation for an initial 40-year period assuming the future issuance of a combined construction permit and operating license (combined license or COL) (TVA 2017-TN4921).

This chapter is divided into 13 sections. Sections 5.1 through 5.12 discuss the potential operational impacts on land use, water, terrestrial and aquatic ecosystems, socioeconomics, environmental justice, historic and cultural resources, meteorology and air quality, nonradiological health effects, radiological health effects, nonradioactive waste, postulated accidents, and applicable measures and controls that would limit the adverse impacts of station operation during an assumed 40-year operating period. Section 5.13 provides a summary of operational impacts.

In accordance with Title 10 of the *Code of Federal Regulations* (CFR) Part 51 (10 CFR Part 51-TN250), impacts have been analyzed, and a significance level of potential adverse impacts (i.e., SMALL, MODERATE, or LARGE) has been assigned by the review team to each impact category. In the area of socioeconomics related to taxes, the impacts may be considered beneficial and are stated as such. The review team's determination of significance levels is based on the assumption that the mitigation measures identified in the ER or activities planned by various State and county governments, such as infrastructure upgrades, would be implemented. Failure to implement these upgrades might result in a change in significance level. Possible mitigation of adverse impacts is also presented, where appropriate.

5.1 Land-Use Impacts

Sections 5.1.1 and 5.1.2 contain information regarding land-use impacts associated with operating new SMRs at the CRN Site. Section 5.1.1 discusses land-use impacts at the site and in the vicinity of the site. Section 5.1.2 discusses land-use impacts at offsite areas.

5.1.1 The Site and Vicinity

Onsite land-use impacts from operating the reactors are expected to be minimal. TVA anticipates that only about 327 ac of the 935-ac CRN Site would be occupied by permanent structures and supporting facilities during operations. An additional area of as much as 30 ac of the barge/traffic area (BTA) would be occupied by permanent road improvements serving the project. The remainder of the site, including lands temporarily disturbed to build the new facilities, would remain in natural vegetation as buffer lands during operations, and would not likely be used for unrelated development activities. The proposed project does not call for any further development of the BTA, although the review team assumes that BTA land outside of the 30 ac permanently occupied by project facilities would be available for other land uses in the future. The 69-kV underground transmission line would be built entirely within an existing overhead transmission line right-of-way, which would continue to be managed as it is currently.

TVA has stated the cooling towers would be located west of the power block as shown in Figure 3-1. Operating the cooling towers has the potential to affect nearby land through fogging, icing, and salt drift. Operation of the cooling towers also generates noise. However, TVA's Seasonal and Annual Cooling Tower Impact (SACTI) modeling of cooling-tower operations indicates that any impacts would be minor and limited to the immediate location of the cooling towers (TVA 2017-TN4921). The SACTI modeling results indicate that salt deposition at rates capable of causing leaf damage (i.e., greater than 10 kg/ha/mo [NRC 2000-TN614]) would not occur off of the CRN Site (TVA 2017-TN4921), suggesting that salt drift would have very little potential of interfering with offsite land uses. Thus, nearby land uses would not be noticeably affected (TVA 2017-TN4921). Adjacent land uses north of the site are limited to undeveloped forested portions of the Oak Ridge Reservation (ORR). The U.S. Department of Energy's (DOE's) management of the adjoining ORR lands for conservation and hunting and as part of a National Environmental Research Park would not be affected (see Section 5.3.1 in this chapter). Immediately across the river from the CRN Site are residences and farmland. However, salt and total dissolved solids (TDS) deposition impacts would be limited to the immediate power-block area of the site, and negligible impacts on land uses beyond that area or in the vicinity are expected (see Section 5.3.1).

As discussed in EIS Section 4.1.1, operating a new nuclear power plant on the CRN Site would be consistent with existing land uses and applicable zoning. TVA reservoir management plans also call for eventual industrial use of the CRN Site (TVA 2009-TN4997). The review team therefore expects that some type of industrial land use would eventually occupy all or most of the CRN Site even if the proposed project were not built.

There would be no further encroachment during operations into prime farmland or other soils of potential future agricultural uses. There are no lands under any other special designation (e.g., wildlife management areas, recreation areas, etc.) on the CRN Site, BTA, or underground transmission line route.

The review team expects that any indirect offsite land-use changes in the 6-mi vicinity of the CRN Site incidental to plant operations, such as conversion of land to housing for operations and outage workers, would be minor. The analysis of housing impacts in Section 5.4.4 in this chapter finds sufficient vacant permanent housing is available to accommodate the projected demand from workers who would operate a new plant. Thus, the review team expects no substantial offsite land-use impacts in the vicinity due to project employment during operations.

As noted in EIS Section 4.1, none of the proposed facilities would be situated in the coastal zone or in close proximity to national or state parks, wildlife areas, or Tribal lands. Operation of the proposed plant would not interfere with anticipated uses of DOE-owned ORR lands to the north of the CRN Site. The highest-elevation lands on a pronounced ridge along the northern part of the CRN Site would remain forested and would buffer the Grassy Creek Habitat Protection Area from operational activities and noise on the CRN Site. There would be no additional encroachment into floodplains or wetlands during operations.

5.1.2 Offsite Areas

The review team expects that offsite land-use impacts from operating a new nuclear power plant would be minimal and primarily associated with transmission line corridor maintenance. EIS Section 4.1.2 discusses the land-use impacts of the permanent land disturbance expected from transmission line upgrades.

Over the operating life of a new plant, periodic maintenance would be required to ensure the associated overhead and underground transmission lines are in safe operational condition. TVA stated that maintenance activities would include repair and maintenance of the right-of-ways (mowing, spraying, and cutting of vegetation and other maintenance activities that follow best management practices [BMPs] for transmission line maintenance and corridor vegetation maintenance) (TVA 2017-TN4921). These include re-clearing methods such as cutting of trees and herbicide application. The presence of underground transmission lines limits some uses of overlying lands, but the only underground transmission line associated with the project would be built within an existing overhead transmission right-of-way and therefore should not interfere with other land uses. The review team therefore expects that land-use impacts of these maintenance activities would be minimal and be limited to lands already disturbed for building the lines.

5.1.3 Summary of Land-Use Impacts

Overall, the land-use impacts of operating a new nuclear power plant on the CRN Site would be minor and would neither destabilize nor noticeably alter any important attributes of existing or expected future land uses on the site or in the vicinity. The review team expects that the land-use impacts from operation and maintenance of the affected transmission lines and in other offsite areas would be minor and would neither destabilize nor noticeably alter any important attributes of existing offsite land uses. Therefore, based on the information provided by TVA and the review team's independent review, the review team concludes that the land-use impacts of operating the proposed new facilities, including associated offsite facilities, would be SMALL.

5.2 Water-Related Impacts

This section discusses water-related impacts on the surrounding environment from operation of a new nuclear power plant at the CRN Site. The primary water-related impacts would be associated with the cooling-water system for a new plant. Details of the operational modes and cooling-water systems associated with operation of a new nuclear power plant are presented in EIS Sections 3.2.2, and 3.4.1, respectively.

Managing water resources requires understanding and balancing the tradeoffs among various, often conflicting, objectives. In the vicinity of the CRN Site, these objectives include navigation, recreation, visual aesthetics, river ecology, and a variety of beneficial consumptive water uses. The Tennessee Department of Environment and Conservation (TDEC) has the primary responsibility for regulating water use and water quality at the CRN Site.

Water-use and water-quality impacts involved with operating a nuclear power plant are similar to the impacts associated with any large thermoelectric power generation facility. Permits and certifications that TVA would be required to obtain, would include the following:

- Clean Water Act (CWA) (33 U.S.C. § 1251 *et seq*.-TN662) Section 401 Certification. This water-quality certification would be issued by TDEC and would ensure that operation of a new nuclear power plant would not conflict with State water-quality management programs. This certification must be obtained before the U.S. Nuclear Regulatory Commission (NRC) could issue a COL to TVA and before USACE would issue a CWA Section 404 permit.
- CWA (33 U.S.C. § 1251 *et seq*.-TN662) Section 402(p) National Pollutant Discharge Elimination System (NPDES) Discharge Permit. This permit would be issued by TDEC and would regulate limits of pollutants in liquid discharges to surface water (stormwater and discharge system). A stormwater pollution prevention plan (SWPPP) would be required.

- CWA (33 U.S.C. § 1251 *et seq*.-TN662) Section 404 Permit. This permit would be issued by the U.S. Army Corps of Engineers (USACE) for the discharge of any dredged and/or fill material during operations into waters of the United States. No dredging during operations is planned.
- CWA (33 U.S.C. § 1251 *et seq*.-TN662) Section 316(a). This section regulates the cooling-water discharges to protect the health of the aquatic environment. The scope would be covered under the NPDES permit.
- CWA (33 U.S.C. § 1251 *et seq*.-TN662) Section 316(b). This section regulates cooling-water intake structures to minimize environmental impacts associated with their location, design, construction, and capacity. The scope would be covered under the NPDES permit.
- Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. § 401 *et seq*.-TN660) Permit. This permit prohibits obstruction or alteration of navigable waters of the United States and would be issued by the USACE for dredging activities that may be needed during operations. No dredging during operations is planned.
- Water Resources Information Act of 2002 (T.C.A. § 69-7-301 *et seq*.-TN4915). State regulation requiring notification and water withdrawal registration for water withdrawals of 10,000 gpd or more. TDEC uses this information to identify water uses and resources that may require management during drought conditions.
- Water Quality Control Act (T.C.A. § 69-3-101 *et seq*.-TN4914) Aquatic Resource Alteration Permit. This permit is issued by the TDEC to authorize physical alterations to waters of the state (stream, river, lake, or wetland), e.g., in the event maintenance dredging is needed.
- Spill Prevention, Control and Countermeasures rule (40 CFR Part 112-TN1041), Appendix F, Sections 1.2.1 and 1.2.2, and U.S. Environmental Protection Agency (EPA) Facility Response Plan (40 CFR Part 9-TN5322 and 40 CFR Part 112-TN1041), and the EPA Hazardous Waste Contingency Plan. These regulations require pollution prevention and response plans for spills of oil and other hazardous materials. TVA would develop an Integrated Pollution Prevention Plan (IPPP) to implement these regulations.
- City of Oak Ridge permits for use of City water and wastewater services.

TVA would also comply with other applicable regional, State, and local regulations as described in ER Chapter 1 (TVA 2017-TN4921).

Section 5.2.1 below discusses the hydrologic alterations associated with operation of a new nuclear power plant at the CRN Site. Water-use impacts from operations are discussed in Sections 5.2.2.1 and 5.2.2.2 for surface water and groundwater, respectively. Water-quality impacts from operations are discussed in Sections 5.2.3.1 and 5.2.3.2 for surface water and groundwater, respectively. Water monitoring during plant operation is discussed in Section 5.2.4. These sections draw on information presented in EIS Section 2.3 and in the ER (TVA 2017-TN4921).

5.2.1 Hydrologic Alterations

This section discusses the hydrological alterations and the resulting effects of the primary activities during operation of a new nuclear power plant at the CRN Site. Site hydrological alterations discussed in Section 4.2.1 of this draft EIS would include a change in the local landscape and drainage patterns, which could cause increased runoff and erosion that would continue during operations. The primary activities during operations at the CRN Site that would produce hydrological alterations are the withdrawal and consumptive use of water from the Clinch River arm of the Watts Bar Reservoir for the plant cooling system, and the discharge of cooling-water blowdown and plant systems wastewater to the same waterbody.

TVA stated that no dredging to maintain the intake and discharge structures is planned, and that dredging of the Clinch River arm of the Watts Bar Reservoir in the area of the CRN Site has not historically been necessary to maintain the navigation channel (TVA 2017-TN4922).

Water for potable and sanitary purposes during operations would be obtained from the City of Oak Ridge public system, with a normal demand of 50 gpm and a maximum demand of 100 gpm. Because the use of City of Oak Ridge water during operations is less than during building, impacts of that use, determined to be SMALL in EIS Section 4.2.2, would be bounding for operations. No onsite or offsite groundwater would be used during operations and no permanent dewatering system is planned (TVA 2017-TN4921).

As described in EIS Section 4.2.1, modifications of the land surface made during building activities would alter the local hydrology and site drainage. These alterations would persist, in part, during operations at the site. The review determined in Section 4.2.1 that because CRN Site runoff would be a small fraction of Clinch River flow at the site, and stormwater would be managed in accordance with the NPDES permit and BMPs would be used during building activities, the quantity and quality of the runoff due to land-surface modifications at the CRN Site would have minor effects on the Clinch River.

Land-surface modification would also alter the pattern and rate of groundwater infiltration because of the increased amount of impervious surface at the CRN Site. These alterations could affect groundwater flow in the shallow groundwater at the site, but the effects are expected to be localized and minor. The existing pattern of groundwater discharge to the Clinch River is not expected to be altered.

As described in EIS Section 3.4.2.2, a plant at the CRN Site would withdraw water from the Clinch River arm of the Watts Bar Reservoir for the cooling-water system and other plant water systems. For water use, TVA defined average (expected) operating conditions as four cycles of concentration and maximum operating conditions as two cycles of concentration. The estimated average and maximum total withdrawal are 18,423 and 30,708 gpm (41.0 cfs and 68.4 cfs), respectively. Evaporation and drift from the cooling towers would consumptively use the majority of the water withdrawn, and the remainder would be returned to the river as blowdown. Because the heat load would be the same under the average and maximum operating conditions defined by TVA, the estimated average and maximum total consumptive use by a plant at the CRN Site would both be 12,808 gpm (28.5 cfs). The primary hydrologic alteration from this water use would be the reduction of flow in the Clinch River arm of the Watts Bar Reservoir, which could affect the availability of water for other uses. The impacts from consumptive water use by a new nuclear power plant are evaluated in terms of the estimated reduction in flow in absolute and relative terms for normal and maximum operational uses and for long-term average flows and low flows in the river, including the 400 cfs minimum flow from the proposed Melton Hill Dam bypass (described in Chapter 3 of this EIS). These impacts are discussed below in Sections 5.2.2 and 5.2.3.

The intake structure would be designed to meet current CWA 316(b) requirements for new facilities, with design through-screen intake velocities less than 0.5 ft/s at the screen. Potential impacts of the intake on aquatic life are evaluated in Section 5.3.2.

As described in EIS Section 3.4.2, plant blowdown and plant wastewater (other than sanitary) would be discharged to the Clinch River arm of the Watts Bar Reservoir. The estimated average and maximum discharge rates are 5,615 gpm and 17,900 gpm (12.5 cfs and 39.9 cfs), respectively, including the contribution from the liquid radioactive waste system. Plant discharge would have potential effects on the thermal, physical, and chemical water quality characteristics of the river. The impacts of plant discharges on the water quality of the Clinch River arm of the Watts Bar Reservoir are evaluated in Section 5.2.3. Potential impacts of the discharge on aquatic life are evaluated in Section 5.3.2.

5.2.2 Water-Use Impacts

This section describes the potential impacts on surface-water and groundwater uses and users resulting from operation of a new nuclear power plant at the CRN Site. Information presented in TVA's ER (TVA 2017-TN4921), other information obtained by the review team, and independent analyses performed by the review team were used to assess the impacts.

5.2.2.1 Surface-Water-Use Impacts

As stated above, the expected average withdrawal and consumptive-use rates are 41.0 and 28.5 cfs, respectively, and maximum withdrawal is 68.4 cfs. The reduction in Clinch River flow at the CRN Site from withdrawal and consumptive use are shown in Table 5-1 for several flow characteristics taken from the Melton Hill Reservoir release data described in Section 2.3.1 in this EIS. Average withdrawal and consumptive use would be less than 1 percent of the mean annual discharge from Melton Hill Reservoir to the Clinch River arm of the Watts Bar Reservoir. Therefore, operation of a plant at the CRN Site would have a minimal effect on average Clinch River flow at the CRN Site. Even the maximum withdrawal would be only 1.5 percent of the mean annual flow. Withdrawal and consumptive use are a much larger fraction of the Clinch River flow during low-flow conditions. For the minimum monthly river flow during the period 2004 to 2013, which occurred during the historically low-flow conditions of 2008, average withdrawal and consumptive use would result in 7.0 and 4.8 percent reductions, respectively, in Clinch River flow at the CRN Site. Maximum withdrawal exceeds 11 percent of the minimum monthly river flow. For the bypass flow (400 cfs, the proposed minimum continuous release from Melton Hill Reservoir), average and maximum withdrawals for a plant at the CRN Site would reduce Clinch River flow by 10.3 and 17.1 percent, respectively (see Table 5-1). Average consumptive use at the CRN Site would be 7.1 percent of the bypass flow. For evaluating water-use impacts, the effect of consumptive use is most relevant because the additional impacts on water resources from withdrawal would only occur between the intake and discharge locations, a region of the Clinch River arm of the Watts Bar Reservoir where there are no active surface-water withdrawals.

Table 5-1. Clinch River Arm of Watts Bar Reservoir Flow Reduction from CRN Site Withdrawal and Consumptive Use (Flows are based on Melton Hill Reservoir release data described in EIS Section 2.3.1.)

Flow Characteristic	Clinch River (cfs)	Flow Reduction from 41.0 cfs Withdrawal (%)	Flow Reduction from 68.4 cfs Withdrawal (%)	Flow Reduction from 28.5 cfs Consumptive Use (%)
Mean Annual Flow	4,670	0.9	1.5	0.6
Minimum Monthly Flow	589	7.0	11.6	4.8
Bypass Flow	400	10.3	17.1	7.1

As described in Section 2.3.2 of this EIS, surface water is the dominant source of water in the lower Clinch River basin, which includes the Clinch River arm of the Watts Bar Reservoir. Total consumptive water use in the lower Clinch River basin was 8.1 Mgd (12.5 cfs) in 2010, and 85 percent of this (6.9 Mgd) was used for public supply purposes. The public supply water systems using surface water that are nearest the CRN Site are located upstream on Melton Hill Reservoir and downstream near Kingston (TVA 2017-TN4921; EPA 2017-TN5147). Because the minimum daily average discharge required at the Melton Hill Dam (400 cfs) would not change with operation of a plant at the CRN Site, operation of Melton Hill Reservoir is not expected to change. As a result, water use for operations at the CRN Site would not have a noticeable effect on water users that obtain water from Melton Hill Reservoir. Consumptive use at the CRN Site would reduce flows downstream of the site. Because the Clinch River below Melton Hill Dam is part of the Watts Bar Reservoir, the availability of water in the Clinch River arm of the Watts Bar Reservoir depends not only on releases from Melton Hill Dam, but also on the much larger releases from Fort Loudoun Dam. The average release from Fort Loudon Dam during 2004 to 2013 was about four times larger than the average release from Melton Hill Dam (TVA 2017-TN4921). As a result, water use for operations at the CRN Site would not have a noticeable effect on water users that obtain water from Watts Bar Reservoir downstream from the CRN Site.

The review team determined that operation of a plant at the CRN Site would consumptively use less than 1 percent of average flow in the Clinch River arm of the Watts Bar Reservoir. During low-flow conditions (e.g., during drought periods), a plant at the CRN Site would consumptively use up to about 7 percent of the release from Melton Hill Reservoir (see Table 5-1). However, because the Clinch River at the CRN Site is an arm of the Watts Bar Reservoir, and existing water users on the Clinch River are located downstream near the confluence with the Tennessee River or upstream on Melton Hill Reservoir, the review team determined that water use for a plant at the CRN Site would not noticeably alter the availability of water supply for upstream or downstream users. Therefore, the review team concludes that the surface-water-use impacts from the operation of a plant at the CRN Site would be SMALL, and no additional mitigation would be required.

5.2.2.2 Groundwater-Use Impacts

No groundwater from onsite or offsite sources would be used during operation of a plant at the CRN Site. Furthermore, no permanent dewatering system is planned for use during operations. Therefore, the review team concludes that the water-use impacts on groundwater from the operation of a plant at the CRN Site would be SMALL.

5.2.3 Water-Quality Impacts

This section describes the potential impacts on surface-water and groundwater quality resulting from operation of a new nuclear power plant at the CRN Site. Surface-water impacts would include those from discharges of thermal, chemical, and radiological wastes as well as physical changes in the Clinch River arm of the Watts Bar Reservoir resulting from effluents discharged by a new plant; these are discussed below in Section 5.2.3.1. The impacts of liquid radiological effluents are discussed in EIS Section 5.9. Groundwater impacts would include those from inadvertent chemical spills that may affect shallow groundwater; these are discussed in EIS Section 5.2.3.2.

5.2.3.1 Surface-Water-Quality Impacts

5.2.3.1.1 Stormwater Runoff

As noted in EIS Section 5.2.1, permanent land-surface alterations would affect stormwater runoff from the CRN Site and the BTA. Runoff would increase with the increased impervious surface area. A stormwater-management system would be built to manage runoff, and operated in accordance with a stormwater NPDES permit. A SWPPP would be in place to manage stormwater runoff and prevent erosion, as well as prevent and manage accidental spills. Because BMPs would be used as required by TDEC under the SWPPP, and because the CRN Site constitutes less than 0.1 percent of the drainage area contributing flow to the Clinch River near the CRN Site, the review team concluded that the surface-water quality of the Clinch River arm of the Watts Bar Reservoir near the CRN Site would be minimally affected by stormwater runoff during operations.

5.2.3.1.2 Plant Effluents

As noted in EIS Section 5.2.1, the estimated average and maximum plant discharge rates are 5,615 gpm and 17,900 gpm (12.5 cfs and 39.9 cfs), respectively. The smaller of these discharge rates is for normal operation with the cooling towers operating at four cycles of concentration. If the cooling towers are operating at two cycles of concentration, then the larger discharge rate is applicable. These rates include contributions from multiple effluent streams. The maximum discharge of 17,900 gpm is composed of 12,800 gpm blowdown from the cooling towers, 4,200 gpm from other plant uses, and 900 gpm from the liquid radioactive waste system (as described in Section 3.4.2.2.3 of this EIS). These effluents would be discharged to the Clinch River arm of the Watts Bar Reservoir via an outfall diffuser at Clinch River mile (CRM) 15.5. The thermal, physical, and chemical impacts of plant discharges to the Clinch River arm of the Watts Bar Reservoir are discussed below.

5.2.3.1.3 Thermal Discharge Effects

During operation of a new nuclear power plant at the CRN Site, blowdown from the circulating-water system (CWS) cooling towers would be discharged to the Clinch River arm of the Watts Bar Reservoir using a discharge pipeline and diffuser. Thermal discharge would be regulated as part of the NPDES permit administered by TDEC. The applicable temperature-related Tennessee water-quality criteria for the CRN Site discharge are applicable at a depth of 5 ft. and include the following (TNSOS 2017-TN5071): (1) a maximum change in river temperature not to exceed 3°C (5.4°F) relative to an unaffected upstream control location; (2) maximum river temperature not to exceed 30.5°C (86.9°F); and (3) maximum river temperature rate of change not to exceed +/- 2°C (3.6°F) per hour. These criteria would be required to be met outside the mixing zone, which would be determined by TDEC and stipulated as part of the NPDES permit along with any monitoring requirements. Tennessee's water-quality criteria specify that mixing zones be restricted in area and not prevent the free passage of fish or cause aquatic life mortality, among other requirements (TNSOS 2017-TN5071).

To evaluate the thermal effects of the discharge and the potential mixing zone requirements, TVA completed a detailed, three-dimensional modeling study. This study modeled flow in the river from CRM 13.5 to CRM 21.0 (i.e., from about 2 mi downstream of the CRN Site discharge to about 3 mi upstream of the intake). TVA evaluated thermal discharge effects using the maximum plant parameter envelope (PPE) values for the withdrawal (25,600 gpm), for the discharge (12,800 gpm), and for the discharge temperature (90°F). Simulation conditions included a maximum temperature difference of 31°F for a winter scenario and 15°F for a summer scenario (extreme winter and summer conditions with the plant at full power). The winter case was found to be bounding. Simulations evaluated the "sloshing" in the Clinch River arm of the Watts Bar Reservoir over a 48-hour period, with one hydropower unit operating at Melton Hill Dam for 1 hour on, 46 hours off, and 1 hour on. TVA determined that a steady 400-cfs release from the Melton Hill Dam bypass was needed to meet water-quality standards. With a river flow of 400 cfs in the downstream direction, TVA's simulation results showed that thermal water-quality criteria would be exceeded outside a 150-ft-diameter mixing zone centered at the discharge diffuser location (Figure 5-1, Hour 24). A 150-ft-diameter mixing zone is about 45 percent of the river width at the discharge location. TVA's simulation results also showed that the unsteady river flows ("sloshing") resulted in local excursions of high-temperature water beyond a 150-ft-diameter mixing zone (Figure 5-1, Hour 13). These excursions exceeded water-quality criteria locally, but were temporary due to the unsteady flow. The simulation results showed that the discharge plume did not circulate upstream to interact with the intake.

The review team assessed the modeling used by TVA to evaluate the thermal effects of plant discharge, including the model setup, boundary conditions, and results. The review team determined that the model simulations provide a sound technical basis for evaluating the characteristics of the thermal plume resulting from plant discharge. Furthermore, the review team determined that the simulations represented bounding conditions with maximum discharge flow rates and temperatures and extreme river temperature and flow conditions. Based on the simulation results, the review team concludes that, with a steady, downstream 400 cfs flow from the Melton Hill Dam bypass, the thermal effects of the discharge would meet the applicable water-quality criteria with a mixing zone about 150 ft in diameter. The review team also concludes that unsteady flow at the discharge location would result in exceedances of the applicable water-quality criteria outside this mixing zone. Based on TVA's simulation results, these exceedances would be temporary and localized to the area immediately surrounding the mixing zone. Therefore, the review team concludes that these exceedances would not affect withdrawals for other water uses.

5.2.3.1.4 Physical Effects of Discharge

Physical impacts on water quality could occur from increased water velocity or dredging activity that could result in sediment erosion, suspension, and transport. The discharge diffuser would be designed to limit scour; the diffuser ports would be in the upper downstream quadrant of the pipe so that effluent would be directed upward into the water column (TVA 2017-TN4921, TVA 2016-TN5008). TVA stated that no dredging to maintain the intake or discharge structures is anticipated during operation, because sediment accumulation is not anticipated. In the event dredging is needed, the activity would need to be included in the CWA Section 404 permit issued by USACE and the Aquatic Resource Alteration Permit issued by TDEC. Dredge spoils would be placed in a permitted disposal area with appropriate containment and stormwater controls. TVA also noted that activities involving the disturbance, resuspension, removal, or disposal of sediments in Watts Bar Reservoir would be subject to oversight by the Watts Bar Interagency Agreement Working Group (TVA 2017-TN4922).

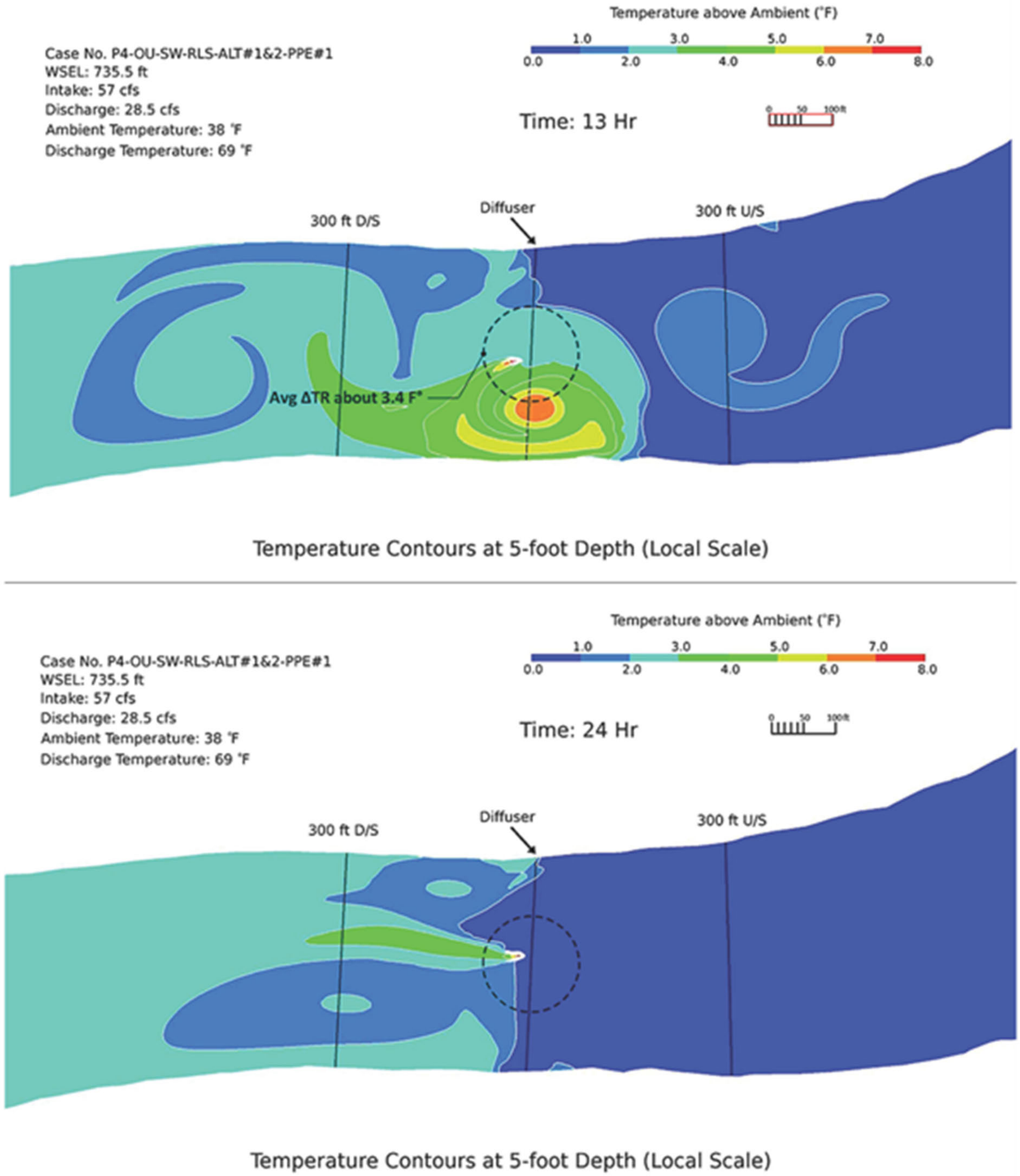

Figure 5-1. TVA Simulation Results of Thermal Discharge Effects under Bounding Winter Conditions at (top) 13 Hours and (bottom) 24 Hours from the Start of the Simulation Period (Source: TVA 2017-TN4921)

5.2.3.1.5 Concentrated Solutes and Residual Chemicals Discharge

As described in Section 3.4 of this EIS, evaporation in the cooling towers would result in the concentration of any solutes present in the makeup water that is withdrawn from the Clinch River arm of the Watts Bar Reservoir. Anticipated constituent concentrations in the blowdown water, assuming the cooling towers are operating at four cycles of concentration, are provided in Table 3-4. The State of Tennessee has established numerical criteria for toxic substances that are intended to protect fish and aquatic life (TNSOS 2017-TN5071). Few of the constituents in Table 3-4 have established numerical water-quality criteria; for those that do (copper, zinc, and manganese), the reported concentrations do not exceed the criteria. The blowdown is not anticipated to contribute any of the constituents that are presently causing water-quality impairment in the Clinch River arm of Watts Bar Reservoir (atmospheric mercury, sediment-associated polychlorinated biphenyl and chlordane), but any of those constituents already occurring in the water could become concentrated in the CRN cooling-water system. In addition to cooling-tower blowdown, liquid effluent from the new plant could contain residual water-treatment chemicals (e.g., scale inhibitors, pH adjusters, biocides, and coagulants) from treating water for various plant uses. Pursuant to 40 CFR Part 423 (TN253), these chemicals would be specifically regulated by the conditions of the NPDES permit.

5.2.3.1.6 Summary of Surface-Water-Quality Impacts

The review team determined that the impacts of operations activities on the quality of surface water in the area would be limited because (1) stormwater and plant wastewater discharges would be subject to NPDES permit requirements, (2) stormwater BMPs would be implemented, and the stormwater runoff from the site would be small compared to the flow of the Clinch River arm of Watts Bar Reservoir, (3) thermal and chemical mixing zones would be established in the NPDES permit for plant wastewater discharges, and (4) maintenance dredging is not anticipated but if needed, would meet permit and oversight requirements. In addition, the effects of the discharge are limited due to the mitigating action of a continuous flow of 400 cfs in the Clinch River arm of the Watts Bar Reservoir provided by the Melton Hill Dam bypass. Based on the information described above and the results of the review team’s independent assessment of TVA’s discharge modeling, the review team concludes that surface-water-quality impacts resulting from the operation of a new nuclear plant at the CRN Site would be SMALL.

5.2.3.2 Groundwater-Quality Impacts

As discussed above in Section 5.2.2.2, no onsite or offsite groundwater would be used during operations at the CRN Site, and no permanent dewatering system is proposed for the site. The review team considered the potential impacts on groundwater quality from inadvertent chemical spills, the stormwater management system, and seepage from the discharge holding pond.

Gasoline, diesel fuel, hydraulic lubricants, and other similar products would be used for equipment during operation. Inadvertent spills of these fluids have the potential to contaminate groundwater. Pursuant to 40 CFR Part 112 (TN1041) and 40 CFR Part 9 (TN5322), TVA would implement an IPPP at the CRN Site, which would include the use of BMPs to minimize the occurrence of spills and limit their effects (TVA 2017-TN4921). These BMPs include actions such as proper vehicle and equipment maintenance, containment for fuel or oil storage tanks, and the maintenance of spill response equipment and materials (TVA 2017-TN5176). The IPPP would minimize impacts on local groundwater quality because spills would be quickly cleaned up and infiltration to groundwater would be minimized.

The stormwater drainage system would direct stormwater to retention basins designed to control the rate, volume, and water quality of runoff that would eventually reach the Clinch River arm of the Watts Bar Reservoir. Stormwater discharge would be regulated under the NPDES permit. Retention basins may increase infiltration over the area of the basin, and increase local recharge to groundwater. Because stormwater quality would conform to the terms of the NPDES permit, the review team concludes that infiltration from stormwater-retention basins would have a minor effect on shallow groundwater quality.

Recharge of the shallow groundwater as a result of seepage from the discharge system holding pond could affect groundwater quality. TVA stated that the detailed design of the holding pond was not currently determined, and that the holding pond would be designed to meet the requirements of the NPDES permit for the discharge system (TVA 2017-TN4922). The review team assumed that the holding pond would be designed to preclude discharge to groundwater during operations at the site. Based on this assumption, the review team concludes that the holding pond would not affect groundwater quality.

Based on the information described above, the review team concludes that the groundwater-quality impacts from operation of a nuclear power plant at the CRN Site would be SMALL.

5.2.4 Water Monitoring

TVA described the operational monitoring programs for thermal, hydrologic, and chemical monitoring in Sections 6.1, 6.3, and 6.6 of the ER (TVA 2017-TN4921).

5.2.4.1 Surface-Water Monitoring

Regular monitoring would be required to ensure that liquid effluent discharges comply with the conditions of the NPDES permit for stormwater and plant wastewater. TVA would develop an operational monitoring program as part of its NPDES permit application. The specific requirements for hydrologic monitoring, water-quality parameters, number of stations, station locations, frequency and method of measurement, and equipment type would be specified in the program. Temperature and contaminant concentration limits would be established, as would any modeling efforts needed to demonstrate compliance. The Clinch River arm of Watts Bar Reservoir would also be monitored as part of the radiological environmental monitoring program described in Section 5.9.6 of this chapter and Section 6.2 of the ER (TVA 2017-TN4921).

5.2.4.2 Groundwater Monitoring

TVA anticipates that the groundwater monitoring wells that would be monitored during operations would be a subset of the wells that exist from preoperational and construction groundwater monitoring. The operational monitoring program would not be defined until a reactor design is selected, but would include water level, radiological, and chemical monitoring as well as modeling to determine changes from the baseline conditions (TVA 2017-TN4921). TVA's Groundwater Protection Program is documented in TVA Procedure NPG-SPP-05.15. This purpose of this program is the prevention, early detection, and mitigation of impacts from potential subsurface or groundwater contamination. As part of the program, a monitoring plan would be developed to specify locations, sampling frequencies, protocols, and procedures for sampling and analysis.

5.3 Ecology

This section describes the potential impacts on terrestrial and aquatic ecological resources from operation of the proposed CRN Site facilities. The section is divided into two subsections: terrestrial and wetland impacts and aquatic impacts.

5.3.1 Terrestrial and Wetland Impacts Related to Operation

Impacts on terrestrial resources related to operation of the proposed facilities may result from cooling-system operations and transmission line operation and maintenance. Operation of the cooling system can result in local deposition of dissolved solids (commonly referred to as salt deposition); increased local fogging, precipitation, or icing; increased local noise levels; risk of avian mortality caused by collision with tall structures; and shoreline alteration. As described below, these effects would all be minimal and localized. Potential impacts on terrestrial and wetland species and habitats from the operation and maintenance of the transmission system include avian collision mortality and electrocution, effects from electromagnetic fields, and the maintenance of vegetation within transmission line corridors. These effects would also be minimal and localized.

As described in Chapter 3 of this EIS, the cooling system at the CRN Site would use mechanical draft cooling towers for heat dissipation. Heat would be transferred to the atmosphere in the form of water vapor and drift. Typically, vapor plumes and drift may affect crops, ornamental vegetation, and native plants, and water losses could affect shoreline habitat. In addition, bird collisions and noise-related impacts are possible with natural draft cooling towers and other tall structures.

5.3.1.1 Site and Vicinity

5.3.1.1.1 Cooling-Tower Impacts on Vegetation

As noted above, the cooling system for the CRN SMRs would be a closed-cycle system using mechanical draft cooling towers to dissipate heat from the CWS. The cooling towers (number and configuration not specified by TVA) would be approximately 65 ft above grade at the maximum and would be located on about 21 ac west of the reactor buildings (Figure 3-1). In each tower, the heat in the CWS water would be transferred to the atmosphere. Cooled CWS water would be recirculated to complete the closed-cycle cooling loop.

Through the process of evaporation, the TDS concentration in the CWS increases. A small percentage of the water in the CWS is released into the atmosphere as fine droplets (i.e., cooling-tower drift) containing elevated TDS levels that can be deposited on nearby vegetation. Vapor plumes and drift are known to be capable of affecting crops, ornamental vegetation, and native plants. Although the cooling towers would be equipped with drift eliminators to minimize the amount of water that is lost via drift, some droplets containing dissolved solids would still be ejected. Operation of the CWS would be based on two cycles of concentration, which means the TDS in the makeup water would be concentrated to approximately two times the ambient concentration in the Clinch River before being released to the atmosphere.

Depending on the makeup source waterbody, the TDS concentration in the drift can contain high levels of salts that, under certain conditions and for certain plant species, can be damaging. Vegetation can be stressed if exposed to drift containing high levels of TDS, either directly by deposition onto foliage or indirectly by accumulation in the soils. TVA modeled salt drift deposition using the Electric Power Research Institute's SACTI (Seasonal and Annual Cooling Tower Impact) model (TVA 2017-TN4921). The modeling addressed all directions from the cooling towers, during all seasons, and annually. Maximum deposition rates took place during summer. Summer deposition rates (TVA 2017-TN4921) were overlaid on the CRN Site vegetation map depicted in Figure 2-27 of this EIS to produce Figure 5-2. Deposition rates at or above the threshold of possible vegetation damage noted in NUREG–1555, the Environmental Standard Review Plan (ESRP) (NRC 2000-TN614), i.e., 1,000 $kg/km^2/mo$, would mostly affect nonforested early successional vegetation in the Clinch River Breeder Reactor Project (CRBRP) footprint, most of which would be permanently cleared and developed prior to operation of the cooling towers (Figure 4-3). However, in the southwest direction, a small parcel of forest would be in the above-threshold salt deposition footprint (Figure 5-2); however, this forest parcel lies within the site development footprint (Figure 5-2) and would be cleared during preconstruction. Thus, the review team expects salt drift impacts to be limited to nonforested early successional vegetation and thus to be minor.

Ground-level fogging occurs when the vapor plume contacts ground-level locations downwind of cooling towers. Icing occurs at temperatures low enough to freeze the vapor plume on ground-level surfaces. The SACTI analysis discussed above demonstrated that due to the relatively small size of the cooling towers (in comparison to cooling towers servicing a large power plant), and the temperature and climate of the area, there would be no hours of fogging or icing (TVA 2017-TN4921). Therefore, the potential impacts of fogging or icing on vegetation in the surrounding area would be negligible.

Withdrawal of water from the Clinch River to operate the cooling towers would have no effect on the surface-water elevation of the Clinch River arm of Watts Bar Reservoir. As indicated in EIS Section 5.2.2, reservoir elevations are controlled by the operation of Watts Bar Dam. Water withdrawals for the proposed nuclear plant at the CRN Site would not be large enough to affect the normal range of operation of the reservoir. Thus, water withdrawals would have no effect on the elevation of the Clinch River arm of Watts Bar Reservoir and its associated riparian habitat and wildlife.

5.3.1.1.2 Transmission Line Corridor Maintenance

TVA maintains the vegetation in its transmission line corridors according to procedures outlined in *A Guide for Environmental Protection and Best Management Practices for Tennessee Valley Authority Transmission Construction and Maintenance Practices* (TVA 2012-TN4911). Maintenance includes routine use of herbicides along with mowing and hand clearing vegetation. These practices are used around wetlands and sensitive biological resources as directed by TVA BMPs (TVA 2012-TN4911).

TVA proposes to limit offsite transmission line work to existing right-of-way lands. Thus, TVA would not have to manage any new or expanded offsite transmission lines and no new vegetation maintenance in offsite corridors would be required. Also, no new or expanded transmission line corridors are proposed for the CRN Site or BTA, with the exception of relocating one section of the existing 161-kV corridor on the CRN Site (Figure 4-3) (TVA 2017-TN4921). New transmission line corridor vegetation maintenance would be required within this relocated section, but would be offset by curtailment of vegetation maintenance in the existing section of the 161-kV corridor. Thus, potential impacts on terrestrial resources due to transmission line corridor maintenance would be negligible.

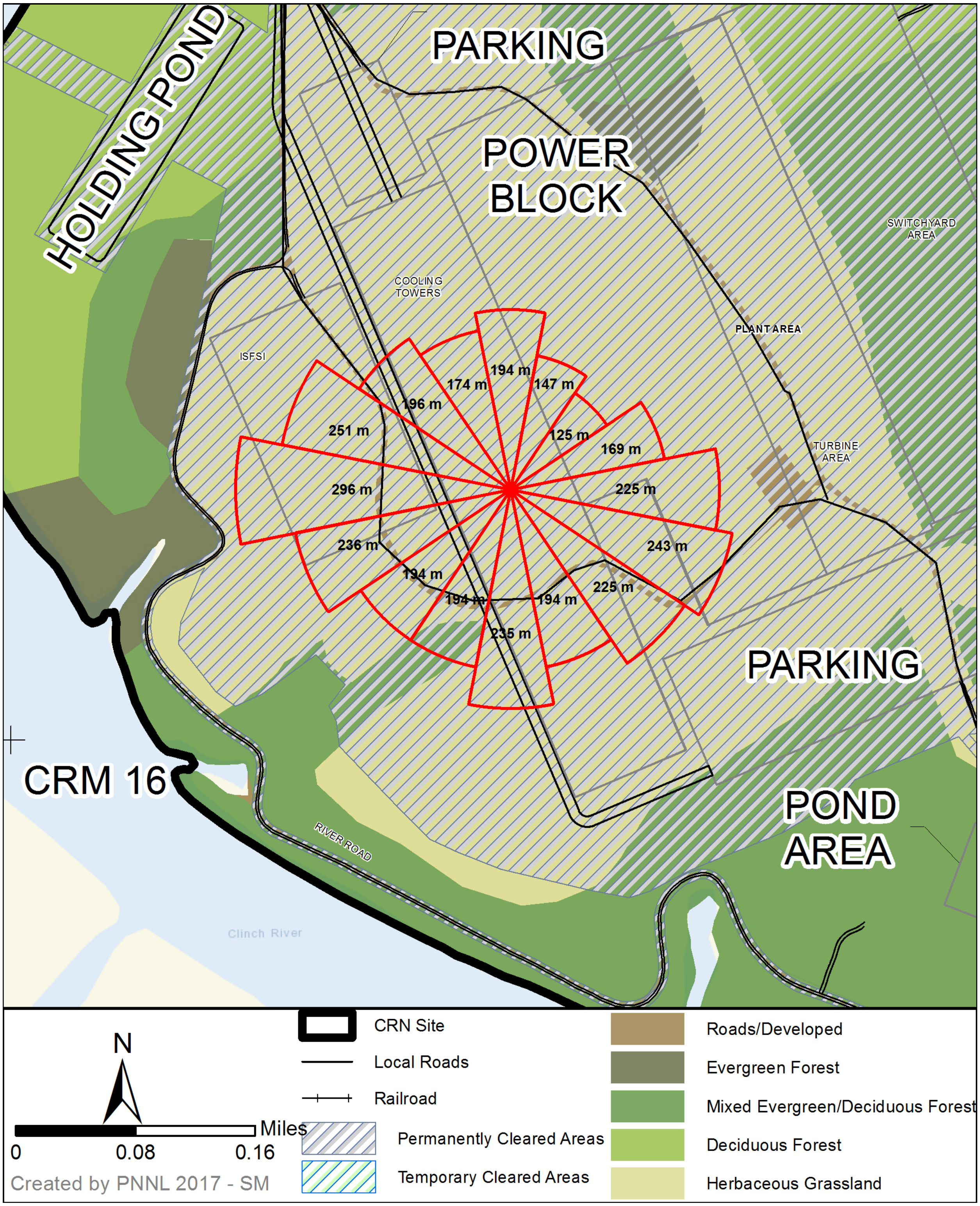

Figure 5-2. Salt Deposition Rates that Exceed the 1,000 kg/km^2/mo Threshold (within Red Segments) Overlaid on Terrestrial Vegetation on the CRN Site.

5.3.1.1.3 Effects of Vehicle Traffic on Wildlife

Increases in traffic generated by the operations workforce would likely be less than those experienced during the construction period (see EIS Section 4.3.1.1). As noted in Section 4.3.1.1, during operations, traffic would also increase on the local roadway network around the CRN Site, particularly Bear Creek Road and the site access road. The additional workforce traffic would likely increase traffic-related wildlife mortalities. Local wildlife populations could suffer declines if roadkill rates were to exceed the rates of reproduction and immigration. However, while roadkill is an obvious source of wildlife mortality and would likely increase during the operation period, except for special situations not applicable to the CRN Site (e.g., ponds and wetlands crossed by roads where large numbers of migrating amphibians would be susceptible), traffic mortality rates rarely limit population size (Forman and Alexander 1998-TN2250). Consequently, the overall impact on local wildlife populations from increased vehicular traffic during the operation period is expected to be minor.

5.3.1.1.4 Avian Mortality from Transmission Lines

The review team is unaware of any issues of avian collision or electrocution at the existing transmission lines. Even if new lines were added, they would not be expected to be a substantial source of additional mortality or injury to local bird populations.

A portion of the 161-kV transmission line on the CRN Site would be relocated from the middle of the site to along the Clinch River (Figure 4-3). The CRN Site is not within a major waterbird migratory flyway (Bellrose 1968-TN5150; TVA 2017-TN4921). Thus, relocation of the 161-kV transmission line to near the river is not expected to result in additional mortality or injury to local waterbird populations.

5.3.1.1.5 Avian Collisions with Cooling Towers

Birds have suffered collision mortality with tall natural draft cooling towers (NRC 1996-TN288). The NRC comparison of natural draft cooling-tower collision mortality to estimated avian collision mortality from all sources (about 200 million to 1.5 billion) suggests that (1) natural draft cooling towers cause only a very small fraction of the total annual bird collision mortality and (2) bird populations are not greatly affected by collisions with natural draft cooling towers (NRC 2013-TN2654). Further, cooling towers of low height such as those proposed for the proposed project (i.e., maximum of 65 ft in height) pose no appreciable collision risk.

5.3.1.1.6 Avian Collisions with the Meteorological Tower

TVA has not provided information regarding the height, lighting, and use of guy wires for the proposed meteorological tower that would be located on the south end of the CRN Site near the Clinch River. This information and the associated evaluation of the potential of avian collisions would be provided at the COL stage.

5.3.1.1.7 Cooling-Tower Noise

The maximum expected sound level produced by the operation of cooling towers, measured at 1,000 ft from the source would be <70 dBA (TVA 2017-TN4921). Noise can affect wildlife by inducing physiological changes, nest or habitat abandonment, or behavioral modifications, or it may disrupt communications required for breeding or defense. It is also not unusual for wildlife to habituate to noise (AMEC 2005-TN901; Larkin 1996-TN772). Prediction of noise effects on wildlife is limited by the lack of information linking sound levels to effects on individual species (Caltrans 2016-TN5155; Ortega 2012-TN5153; USDOT 2004-TN5156). Some wildlife may experience effects similar to those noted for construction noise in EIS Section 4.3.1, and the risk of such effects would be much higher within the site boundary, especially in close proximity to the cooling towers, than beyond. The review team expects the effects of cooling-tower noise on wildlife to be minor.

5.3.1.1.8 Electromagnetic Fields Effects on Flora and Fauna (Plants, Agricultural Crops, Honeybees, Wildlife, Livestock)

The incremental risk of electromagnetic fields (EMFs) would be low because the effects of EMFs on terrestrial biota are considered to be of minor significance because the overall health, productivity, and reproduction of individual species appear to be unaffected (NRC 2013-TN2654). The EMFs produced by operating transmission lines up to 1,100 kV have not been reported to have any biologically significant impact on plants, wildlife, agricultural crops, or livestock. Areas under and in the vicinity of the lines have been studied numerous times. Vegetation, foliar damage resulting from EMF-induced corona at leaf margins, agricultural crop production, wildlife population abundance, livestock production, and potential livestock avoidance of the lines have been investigated. In addition, many laboratory experiments with plants and laboratory animals have been conducted, often using electric fields much stronger than those occurring under transmission lines (NRC 2013-TN2654). The results of these studies are summarized below.

Plants

Studies have shown that minor damage to plant foliage and buds can occur in the vicinity of strong electric fields. Damage typically occurs only to the tips and margins of leaves in the uppermost plant parts that are the closest to the lines. The damage in the form of leaf burn is most prevalent on small pointed leaves and is similar to leaf damage that might occur as a result of drought or other environmental stresses. The damage generally does not interfere with overall plant growth (NRC 2013-TN2654).

Honeybees

As discussed in the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS) (NUREG–1437; NRC 2013-TN2654), several studies have shown that honeybees in hives under transmission lines are affected by EMFs. Adverse effects include increased production of propolis (a reddish resinous cement), reduced growth, greater irritability, and increased mortality. These effects can be greatly reduced by shielding the hives with a grounded metal screen or by moving the hives away from the lines. Thus, these impacts were not caused by direct effects of the electric fields on the bees but by voltage buildup and electric currents within the hives and the resultant shocks to bees. Bees kept in moisture-free nonconductive conditions are not adversely affected (NRC 2013-TN2654). The review team expects that any adverse effects on honeybees from operation of transmission lines would be localized.

Wildlife and Livestock

Chronic exposure to electric fields is experienced by small birds and mammals that primarily inhabit transmission line right-of-way corridors and by birds (i.e., primarily raptors) that nest in transmission line towers. EMF exposures to larger animals and livestock are usually relatively brief because these animals inhabit relatively large areas instead of small areas beneath the lines. Exposures occur as these larger animals pass beneath the lines or as birds fly by the lines. The literature on population studies of small bird and mammal species in transmission line corridors has expressed virtually no concern for possible impacts of EMFs. These species apparently thrive beneath the lines, where their abundance appears to depend on habitat quality rather than on the strength of the electric fields to which they are exposed or the size of the transmission lines. In addition, livestock in both field and laboratory studies have shown no significant impacts when exposed to EMF (NRC 2013-TN2654).

Conclusion

No substantial impacts of EMFs on terrestrial biota have been identified.

5.3.1.2 Offsite Areas

As discussed in EIS Section 3.2.2.3.5, overhead transmission lines within various corridors over the TVA service territory could require upgrades in the form of rebuilds, reconductoring, or uprates to handle power generated by the proposed nuclear plant. As noted in EIS Section 4.3.1.2, work would be confined to existing right-of-ways. TVA would manage these right-of-ways in the same manner as at present after the upgrades are completed. The impacts of continued management of the affected right-of-ways would be minor, as described above in Sections 5.3.1.1.2, Transmission Line Corridor Maintenance, 5.3.1.1.4, Avian Mortality from Transmission Lines, and 5.3.1.1.8, Electromagnetic Fields Effects on Flora and Fauna.

5.3.1.3 Important Terrestrial Species and Habitats

This section describes the potential operation impacts on the important terrestrial species and habitats identified in the correspondence with Federal and State agencies as described in EIS Section 2.4.1.11. A more detailed assessment of operation impacts on Federally listed species and critical habitats is provided in NRC's draft biological assessment (BA) (see Appendix M).

Federally Listed and Other Rare Bat Species

Indiana bats (*Myotis sodalis*) (Federally endangered), northern long-eared bats (NLEB) (*Myotis septentrionalis*) (Federally threatened), tricolored bats (*Perimyotis subflavus*) (petitioned for listing under the ESA, State Status Rare S2S3), little brown bats (*Myotis lucifugus*) (petitioned for listing under the ESA, no State Status), and eastern small-footed myotis (*Myotis leibii*) (State Status Rare S2S3) may roost and forage on the CRN Site and in the BTA. The gray bat (*Myotis grisescens*) (Federally endangered) may forage on the CRN Site and in the BTA (EIS Section 4.3.1.3). All these species may be affected by the following during plant operations: transmission line maintenance, collision with cooling towers, and cooling-tower noise.

As indicated in EIS Section 5.3.1.1, there would be no new transmission line corridor maintenance that would result from the proposedproject, except within the relocated section of the 161-kV transmission line corridor on the CRN Site (Figure 4-3). The risk of potential impacts on tree-roosting bat species (Indiana bat, NLEB, tricolored bat, little brown bat, and eastern small-footed myotis) from danger tree (i.e., any tree on or off the right-of-way that could contact electric supply lines) (that could also be used as a roost tree) removal along such a short new section of transmission line corridor would be minimal. There would be no risk of potential impacts for gray bats (which do not roost in trees) from danger tree removal in the new 161-kV corridor.

As with birds, bats also experience collision mortality with tall natural draft cooling towers (NRC 1996-TN288). As indicated in EIS Section 5.3.1.1 for birds, the low height (maximum of 65 ft) of the proposed mechanical draft cooling towers for the CRN Site makes the risk of bat collisions unlikely. The rarity of the six bat species further decreases the likelihood of collisions. Therefore, the review team concludes that the risk of collisions is minor to negligible.

As indicated in EIS Section 5.3.1.1, cooling-tower noise would be below 70 dBA at 1,000 ft from the source (TVA 2017-TN4921), where little forest habitat would remain following development of the CRN Site (Figure 4-1). Thus, the likelihood of the five tree-roosting bat species roosting in this area after site development is low, as is the risk of avoidance of cooling-tower noise and displacement in this area. Although more forest habitat would remain beyond 1,000 ft after site development (Figure 4-1), the likelihood of disturbance of tree-roosting bat species is also lower due to even lower (further attenuated) sound levels. Cooling-tower noise would be unlikely to disrupt nighttime foraging by tree-roosting bats within 1,000 ft because this area would be cleared and developed and likely provide less suitable and less used foraging habitat than elsewhere on the CRN Site. The gray bat likely forages mostly over the river and associated wetlands, outside the CRBRP footprint, where there likely would be minor risk of disturbance due to cooling-tower noise.

Further discussion of impacts on the Indiana bat, NLEB, gray bat, tricolored bat, and little brown bat is provided in the NRC's draft BA (see EIS Appendix M).

5.3.1.3.1 Sharp-Shinned Hawk (Accipiter striatus) – Rare (S3B)

The sharp-shinned hawk breeds in dense woods and during the nonbreeding season hunts along forest edges (Cornell 2015-TN4433) (see EIS Section 4.3.1.3). It is considered rare during the breeding part of its life cycle. Because it breeds in dense woods, this part of its life cycle would not be affected by new transmission line corridor maintenance and cooling-tower noise. It would be at minimal risk for collisions with the mechanical draft cooling towers due to their low height (maximum 65 ft tall) and because they are located at least 400 m from a forest edge (Figure 5-2).

5.3.1.3.2 Bald Eagle (Haliaeetus leucocephalus) – Rare (S3)

Bald eagles are not currently known to nest or roost on the CRN Site or in the BTA, nor are there known foraging concentrations of eagles at these locations (see EIS Section 4.3.1.3). However, the review team expects that the forested habitats near the Clinch River (including where it abuts the CRN Site) are suitable for use by the bald eagle. If the bald eagle were to use these forested habitats, the review team believes that the eagle would not likely be affected by operating activities at the CRN Site. The review team also believes that the eagle would be at minimal risk for disruption due to cooling-tower noise and possible collisions with the mechanical draft cooling towers due to their height (maximum 65 ft tall) and because the towers are located over 1,200 ft from a forest edge (Figure 5-2).

5.3.1.3.3 Eastern Slender Glass Lizard (Ophisaurus attenuatus longicaudus) – Rare (S3)

The eastern slender glass lizard inhabits dry upland areas including brushy, cut-over woodlands and grassy fields (TDEC 2017-TN5217) and thus could inhabit the new corridor for the relocated 161-kV transmission line once it is established. However, the species was not observed in similar habitat on the CRN Site or in the BTA (LeGrand et al. 2015-TN5188) and the species is not known to frequent the ORR (Giffen et al. 2009-TN5184). Thus, effects on the species from vegetation maintenance in the new transmission line corridor are unlikely.

5.3.1.3.4 Rare Plants

The rare plants described in EIS Section 2.4.1.11 (shining ladies'-tresses [*Spiranthes lucida*] – rare [S1S2], spreading false-foxglove [*Aureolaria patula*] – rare [S3], and American ginseng [*Panax quinquefolius*] – rare [S-CE]) occupy forest habitat (Table 2-12). Thus, they would not inhabit the new 161-kV transmission line corridor once it is established, and would therefore not be affected by vegetation maintenance in the new corridor.

5.3.1.3.5 Important Terrestrial Habitats

As indicated above in Section 5.3.1.1, the effects of salt drift on vegetation would not extend into forest habitat, and there would be no local fogging or icing. Thus, the important terrestrial habitats within 2 mi of the CRN Site or in the BTA (Table 2-13 and Figure 2-28) would not be affected. The new 161-kV transmission line corridor would not be established within or near any of these important habitats; thus, the important habitats would not likely be affected by vegetation maintenance in the new corridor.

5.3.1.4 Monitoring

TVA has not proposed any monitoring during the operational period. However, monitoring measures may be developed in consultation with other applicable Federal, State, and local agencies.

5.3.1.5 Mitigation

The review team does not expect that mitigation would be necessary for the minor impacts described above for operations. However, mitigation measures may be developed in consultation with other applicable Federal, State, and local agencies.

5.3.1.6 Summary

The potential impacts of operating activities at the CRN Site and the associated cooling system (mechanical draft cooling towers) on terrestrial resources would be minor. The potential impacts of transmission line operation, including those from EMFs, and transmission line corridor maintenance on important species and habitats, including wetlands and floodplains, are considered minor, due to their limited spatial extent and assuming related BMPs are implemented.

The review team evaluated the potential terrestrial ecological impacts of operating activities at the CRN Site, including the heat-dissipation system, transmission lines, associated corridor maintenance, and other sources of potential adverse effects. Given the information provided in the ER submitted by TVA (2017-TN4921), responses to information needs, and interactions with State and Federal agencies, and the review team's own independent assessment, the review team concludes the impacts from operation of the proposed new facilities on terrestrial resources would be SMALL, and mitigation would not be warranted.

5.3.2 Aquatic Impacts

This section describes potential impacts on the existing aquatic ecosystems and threatened and endangered species from operating activities at the CRN Site. The review team's analysis of the potential impacts on the aquatic ecosystems, biota, and threatened and endangered species from operation activities at the CRN Site is based on TVA's ER (TVA 2017-TN4921); the review team's observations at the site; discussions and information provided by TVA, the FWS, Oak Ridge National Laboratory, and the State of Tennessee; and peer-reviewed articles or other documents obtained directly by the review team.

The review team considered operational activities that could have a potential to affect aquatic species and habitats, including the operation of the intake, discharge, and the barge facility. Potential effects from intake operation include water withdrawal and consumption, as well as entrainment and impingement of aquatic biota. Potential effects of the discharge operation on the aquatic habitats in the reservoir include thermal discharges, for cold shock, and physical changes resulting from scouring and chemical discharges.

5.3.2.1 Site and Vicinity

5.3.2.1.1 Onsite Streams and Ponds

During operations the review team expects that TVA would continue to manage impacts on onsite streams and ponds in a manner similar to that described in EIS Section 4.3.2 using BMPs for the streamside management zones (SMZs) established along the border of surface waters including intermittent and perennial streams and other perennial waterbodies such as ponds.

5.3.2.1.2 Barging Activities

TVA indicated that the volume of equipment transported to the site by barge during operations would be less than the volume delivered during the building of the facilities, and TVA indicated that most deliveries of modules and components would instead occur via road or rail (TVA 2017-TN4921). Because the barge facilities would have already been built prior to use during operations; and because barge traffic would be lower during operations than while building the facilities, for which the review team expects minimal aquatic impacts; the review team expects that aquatic impacts from barge traffic during operatios would also be minimal.

5.3.2.1.3 Withdrawal and Consumption

Based on an estimated expected average withdrawal rate of 40 cfs for normal plant operation, on average less than 1 percent of the mean annual discharge from Melton Hill Reservoir to the Clinch River would be withdrawn from the intake located near CRM 17.9.

The EPA has developed regulations that address water withdrawals and intake flow restrictions for new facilities that produce electric power (40 CFR Part 125-TN254). These regulations implement Section 316(b) of the CWA. These regulations provide limits on the total design intake flow for all cooling-water intake structures. The limits depend on the type of waterbody in which the intake structure is located. For facilities that withdraw from a freshwater river or stream, the regulations limit the total design intake flow to no more than 5 percent of the mean annual flow. For facilities that withdraw water from lakes or reservoirs, the regulations indicate that the withdrawals "must not disrupt the natural thermal stratification or turnover pattern of the source water," although there is an exception if a Federal or State resource agency indicates that the disruption has a beneficial effect on the management of fisheries (40 CFR Part 125-TN254).

Although TVA's proposed withdrawal rate using the CRN intake meets the limits for a river, the Clinch River arm of the Watts Bar Reservoir is considered a reservoir. Despite being considered a reservoir, the upstream location in the vicinity of the proposed intake exhibits only weak thermal stratification in the water column (TVA 2017-TN 4921), suggesting that the water was well mixed at this location as a result of the inflow from Melton Hill Dam. The reservoir therefore provides aquatic habitat that functions more like river than reservoir habitat). However, the results of measurements of temperature and dissolved oxygen in the area near the proposed location of the discharge indicate the possibility that some stratification may be taking place based on a decrease in temperature with depth during July in the 2011 study of water-quality parameters (TVA 2013-TN5167). The additional 400-cfs minimum release rate from Melton Hill Dam bypass would increase the mixing of the water downstream of the intake, and could be considered beneficial to regionally indigenous aquatic biota that prefers thermally mixed river habitat rather than unnaturally stratified reservoir habitat.

TVA estimated the resulting consumptive use of 12,808 gpm (28.5 cfs) to be about 0.6 percent of the average flow rate (TVA 2017-TN4921). This is the percentage of the water withdrawn from the river that is not returned to the river, but instead is evaporated or lost in the form of water droplets from the cooling towers. Based on this information, the review team does not expect this low rate of water withdrawal or consumptive loss from operation of the units to noticeably affect aquatic biota or habitats.

5.3.2.1.4 Impingement and Entrainment

TVA is considering a shoreline intake. A description of the placement of the intake is provided in Chapter 3 of this EIS. TVA has stated that the intake would be designed such that the maximum intake velocity through the inlet, the trash racks, and the water screens would be less than 0.5 ft/s (TVA 2017-TN4921), as required in the EPA regulations that address water withdrawals and intake flow restrictions for new facilities that produce electric power (40 CFR Part 125-TN254). EPA indicated that this approach velocity is recommended based on a fish swimming speed study. The study suggested that the species and life stages evaluated could endure a 1.0-ft/s velocity (66 FR 65256-TN243). The EPA regulations assume a safety factor of two and derive the 0.5-ft/s threshold (66 FR 65256-TN243). These regulations are specified to limit the effects of entrainment and impingement.

EPA's regulations for cooling-water intake structures for new facilities (Subpart I of 40 CFR Part 125-TN254) define impingement as "the entrapment of all life stages of fish and shellfish on the outer part of an intake structure or against a screening device during periods of intake water withdrawal." Impingement occurs when water withdrawal occurs at such a velocity that it forces an individual organism against trash racks, trash bars, intake screens, or some other physical component of the intake structure such that the individual organism cannot swim, walk, crawl, or otherwise move away from the structure. Impingement typically affects fish and positively buoyant vegetation more than other biota, and some species are more susceptible than others. Factors affecting impingement survivability include fish length, burst speed, and overall health (e.g., disease, previous injury) of the individual organism. Impingement can harm or kill an organism through physical abrasion, starvation, exhaustion, asphyxiation, descaling, drowning, or other physical harm. Through-screen velocity is an important factor affecting impingement rates and impingement survivability of fish and shellfish species.

Entrainment occurs when organisms pass through all components of the intake structure and enter the power plant with the cooling water. Entrained organisms typically are quite small because they pass through intake screens; typical entrained organisms include fish eggs, larvae, and juveniles. Entrainment mortality for facilities employing once-through cooling can vary widely—as noted in EPA's report entitled, *National Pollutant Discharge Elimination System: Regulations Addressing Cooling Water Intake Structures for New Facilities*, published in Volume 66 of the Federal Register, page 65256, on December 18, 2001 (66 FR 65256-TN243)—based on the species entrained, the plant design and operation, time of year, and other factors. The NRC staff, however, generally assumes complete mortality for entrained organisms in the case of closed-cycle cooling.

Compliance with EPA's regulations addressing cooling-water intake structures for new facilities (Subpart I of 40 CFR Part 125 [TN254]) is generally protective of fish and shellfish populations and usually does not result in detectable effects on populations of aquatic organisms from impingement or entrainment.

5.3.2.1.5 Discharge Analysis

Discharge of heated water back into the Clinch River arm of the Watts Bar Reservoir may affect aquatic habitats and species in several ways. Thermal discharges raise the temperature of the water and can cause adverse effects. Chemically treated water is also a stressor of aquatic biota, as is physical alteration of habitat that may occur through scouring or other sediment transportation processes during cooling-water discharges.

<u>Thermal Impacts from Cooling-Water Discharges</u>

Although most of the excess heat in cooling-water transfers to the atmosphere in the cooling tower by evaporation and conductive cooling, some 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 discharge structure is described in Chapter 3 of this EIS. Cooling-tower blowdown would be discharged to the Clinch River at CRM 15.5.

Thermal discharge would be regulated as part of the NPDES permit administered by TDEC (TVA 2017-TN4921). According to TDEC criteria,

> The effect of…waste discharge on the receiving waters shall be considered beyond the mixing zone except as provided in this paragraph. The extent to which this is practicable depends upon local conditions and the proximity and nature of other uses of the waters. Such mixing zones…shall be restricted in area and length and shall not
>
> - Prevent the free passage of fish or cause aquatic life mortality in the receiving waters
> - Contain materials in concentrations that exceed acute criteria beyond the zone immediately surrounding the outfall
> - Result in offensive conditions
> - Produce undesirable aquatic life or result in dominance of a nuisance species
> - Endanger the public health or welfare or adversely affect the reasonable and necessary uses of the area

- Create a condition of chronic toxicity beyond the edge of the mixing zone
- Adversely affect nursery and spawning areas or
- Adversely affect species with special state or federal status (TNSOS 2017-TN5071).

Modeling of the thermal discharge is described in EIS Section 5.2.3.1. The description is based on TVA's evaluation of the thermal discharge effects. TVA's evaluation assumed the maximum values for withdrawal, discharge, and discharge temperature occurring during extreme summer and winter conditions when the plant was operating at full power. TVA's model suggested that the largest mixing zone occurs during the winter and results in local excursions of high-temperature water beyond a 150-ft-diameter mixing zone—the mixing zone that covers about 45 percent of the river width at a depth of 5 ft. This mixing zone was the result of a flow reversal that can occur in the reservoir as a result of the timing of water release from Melton Hill Dam. The flow reversal reduces the extent of downstream dispersion of the thermal plume and causes it to occupy a wider area of the reservoir as it moves upstream from the discharge (TVA 2017-TN4921). However, the models show that there is still room for fish to avoid the thermal plume and pass without any obstruction. Further, no nursery and spawning areas or special State or Federal status species are affected at this location. The other TDEC criteria listed above would be met. And as discussed previously the conditions resulting from the discharges would be temporary (TVA 2017-TN4921).

The review team concludes that based on the TVA simulation results discussed in EIS Section 5.2.3.1 the largest mixing zone during unsteady flow at the discharge location would not noticeably affect biota and would be temporary.

Chemical Impacts from Cooling-Water Discharges

Discharge from the cooling towers would contain anti-scaling compounds, corrosion inhibitors, and biocides to eliminate growth of bacteria and algae. The discharge could also contain concentrated minerals, salts, and organic compounds that enter the makeup water system. TDEC would approve the use and quantities of chemicals for treatment of intake water based on the specifications TVA includes in their future Biocide/Corrosion Treatment Plan. This approval would be requested as part of the NPDES permit application for the facility. This would likely include biocides for zebra mussels. TVA would provide the quantities of these chemicals at the COL application stage (TVA 2017-TN4921).

Physical Impacts from Operation of Discharge and Intake Structures

Physical impacts on water quality could occur from increased water velocity or dredging activity that could result in sediment erosion, suspension, and transport as discussed in EIS Section 5.2.3. The diffuser ports that are part of the system used to discharge cooling water would direct effluent upward into the water column so that no physical alteration or scouring occurs that could affect benthic habitat or species (TVA 2017-TN4921, TVA 2016-TN5008). TVA also stated that no dredging to maintain the intake or discharge structures is anticipated during operation, because sediment accumulation is not anticipated (TVA 2017-TN4921).

5.3.2.2 Offsite Areas

The only potential offsite aquatic impacts during operations would be from maintaining the upgraded overhead transmission lines discussed in EIS Section 4.3.2.2. As discussed in EIS

Section 2.4.2.1, SMZs are established along the border of surface waters including intermittent and perennial streams and other perennial waterbodies such as ponds. TVA guidance for Environmental Protection and BMPs (TVA 2012-TN4911) limit the broadcast application of fertilizers and herbicides within the SMZs, including the spraying of herbicides other than those labeled for aquatic use. TVA guidance indicates that these chemicals should not be applied either directly to perennial streams and waterbodies or intermittent ones and that drift should also not be allowed. In addition, application should not be on land surfaces that are adjacent or where direct washoff into a stream or waterbody could occur. This applies to the surface of drainage canals or streams where direct washoff into a waterbody or stream could occur. Specific herbicides are labeled for use within SMZs but they are only used selectively (TVA 2017-TN4921).

5.3.2.3 Important Aquatic Species and Habitats – Site and Vicinity and Offsite Areas

As discussed in EIS Section 2.4.2.3, the review team considers it unlikely that Federally listed species (specifically the pink mucket (*Lampsilis abrupta*), sheepnose mussel (*Plethobasus cyphyus*), and Spotfin Chub (*Erimonax monachus*) are present in the Clinch River arm of the Watts Bar Reservoir in the area of the CRN Site or in the streams and ponds on the site and in the BTA. The review team has determined that building the facilities at the CRN Site would not likely affect Federally listed species, and would not substantially affect the commercial and recreational species and other important species described in EIS Section 2.4.2.3. Further, operating the proposed project would not likely affect the hellbender (*Cryptobranchus alleganiensis*) because it is also unlikely to be present as far downstream as the CRN Site.

For reasons explained above in Section 5.3.2.2, operation of the CRN facilities including the water intake and discharge facilities situated on the Clinch River arm of Watts Bar Reservoir, would not affect the State-Endangered Lake Sturgeon or the Tennessee Dace.

Federally and State-listed species that occur under the transmission lines would be protected by the BMPs that are discussed in the previous subsection.

5.3.2.4 Summary and Conclusions

The potential impacts of operating activities at the CRN Site and associated facilities would be minor. The potential impacts include temporary and permanent removal of water from the Clinch River, entrainment and impingement of biota during intake operation, thermal and chemical discharges from the discharge, and maintenance on transmission lines. Based on its review of the TVA ER and other relevant information, the review team concludes that the impacts of operations on aquatic resources would be SMALL. The conclusion reflects the expectation that TVA would adhere to EPA regulations on cooling-water intakes and would apply for and follow the requirements of an NPDES permit issued by the State of Tennessee.

5.4 Socioeconomic Impacts

Operation of a new nuclear power plant on the CRN Site could affect individual communities, the surrounding region, and minority and low-income populations. This section assesses the impacts of operations-related activities and the associated workforce on the region. The review team reviewed the TVA ER (TVA 2017-TN4921) and verified the data sources used in TVA's application by examining cited references and independently confirming data in discussions with community members and public officials (NRC 2018-TN5386). To verify data in the ER, the review team requested clarifications and additional information from TVA as needed. Unless otherwise specified in the sections below, the review team has relied upon verified data from TVA (2017-TN4921 and supplemental submissions). Where the review team used different analytical methods or additional information for its own analysis, the EIS includes explanatory discussions and citations for the additional sources.

As discussed in Chapter 2 of this draft EIS, the review team considered the entire region within a 50-mi radius of the CRN Site when assessing socioeconomic impacts. Because of expected commuter patterns, the distribution of residential communities in the area, and the likely socioeconomic impacts, the review team identified a primary economic region composed of the four counties nearest to the site—Anderson, Knox, Loudon, and Roane Counties in Tennessee—as the area with the greatest potential for social and economic impacts.

Section 5.4.1 presents a summary of the physical impacts of the project. Section 5.4.2 provides a description of the demographic impacts. Section 5.4.3 describes the economic impacts, including impacts on the local and State economy and tax revenues. Section 5.4.4 describes the impacts on infrastructure and community services. Section 5.4.5 summarizes the socioeconomic impacts of operations activities at the CRN Site.

5.4.1 Physical Impacts

As characterized in TVA's application, operations at the CRN Site would cause physical impacts on nearby communities, including noise, odors, exhausts, thermal emissions, and visual intrusions. The review team expects some of these impacts would be mitigated by compliance with all applicable Federal, State, and local environmental regulations and site-specific permit conditions. This section addresses potential physical impacts that may affect people, buildings, and roads.

5.4.1.1 Workers and the Local Public

This section discusses potential effects of air emissions and noise on workers, nearby residents, and nearby users of recreational facilities. The CRN Site is located adjacent to the existing ORR—a DOE reservation that is home to several Federal facilities. The site is located on the southern part of a peninsula in the Clinch River, approximately 10 mi south of Oak Ridge, Tennessee; 16 mi west of Knoxville, Tennessee; and 7 mi east of Kingston, Tennessee.

The nearest residences to the CRN Site are located immediately across the Clinch River approximately 1,900 ft to the south of the expected location of the CRN Site cooling towers (TVA 2017-TN4921). The closest recreational areas are the Melton Hill Dam and Reservoir, just upstream from the site and the Gallaher Recreation area, just downstream. Because of distance and intervening foliage, residents and visitors to recreational areas would experience minimal impacts, although boaters on the Clinch River would be able to view the facilities operating on the site.

All activities related to operation at the CRN Site would occur within the site boundary and would be performed in compliance with Occupational Safety and Health Administration (OSHA) standards, BMPs, and other applicable regulatory and permit requirements.

Because of the close proximity of workers to the sources of operations-related physical impacts, on-site workers involved in operational activities at the CRN Site would experience the most direct exposure to physical impacts. Excessive noise is expected inside some buildings, so workers would wear personal protective equipment. Auxiliary boilers, cooling towers, emergency diesel generators, and/or combustion engines would be required to meet workplace and environmental standards before startup. The CRN Site would comply with OSHA standards for on-site exposure to noise, vapors, dusts, and other air contaminants for workers. Operations workers also would receive safety training. Emergency first aid care would be available, and regular health and safety monitoring would be conducted (TVA 2017-TN4921). Based on the foregoing, the review team determined the physical impacts on on-site workers would also be minimal.

The physical impacts on workers and the local public from operations at offsite facilities would be of short duration and would be considered a minor annoyance or nuisance, and no further mitigation beyond that identified by the applicant in its ER would be warranted.

Further discussion of the health impacts on operations workers can be found in Section 5.8.1 of this chapter. Because the review team determined the nonradiological health impacts to operations workers and the public would be minimal, the review team also determined the socioeconomic component of the physical impacts on operations workers and the public would also be minimal and no additional mitigation beyond what TVA has identified in its ER would be warranted.

5.4.1.2 Noise

Common on-site sources of noise from the proposed CRN Site operations include mechanical draft cooling towers, transformers, turbines, and the operation of pumps along with intermittent contributions from loud speakers and auxiliary equipment such as diesel generators. There would also be off-site noise from corona discharge associated with high-voltage transmission lines (TVA 2017-TN4921). These noise sources are discussed in EIS Section 5.8.2. The review team determined that noise sources during operation of the SMR units at the CRN Site would be attenuated to below the NRC threshold for minimal impacts (NUREG–1555). Therefore, the review team expects minimal socioeconomic impacts due to operations-related noise.

5.4.1.3 Air Quality

Discussion of operations-related air quality is provided in EIS Section 5.7. The socioeconomic aspect of air-quality impacts relate to the costs incurred by individuals who experience health-related problems due to increased air pollution (e.g., medical costs and lost work impacts). As discussed in Section 5.7, the review team determined air-quality degradation due to operations activities for the CRN Site would be minimal and, therefore, any associated socioeconomic impact from the degradation of human health would also be minimal. Impacts of cooling-tower salt deposition, fogging, and icing are discussed in EIS Section 5.1.1.

5.4.1.4 Structures

Activities associated with operations at the CRN Site should not affect offsite buildings because of distance and intervening terrain. On-site buildings are designed to withstand any impact from operational activities. Consequently, the review team determines the operations impacts on on-site and off-site buildings would be minimal.

5.4.1.5 Transportation

This EIS assesses the impact of workers commuting to and from the CRN Site from three perspectives: socioeconomic impacts from congestion and reductions in levels of service (LOSs), air-quality impacts resulting from the emissions from vehicles, and the potential health impacts caused by traffic-related accidents. EIS Section 2.5.2.4 describes the local transportation network around the CRN Site, and Figure 2-11 depicts the road and highway system in the economic region. EIS Section 5.4.4.1 discusses the socioeconomic impacts from additional vehicular traffic volumes, road and intersection capacities, and LOS due to operations-related activities. The following discusses the impact of physical changes to local roads and highways due to operations-related increased traffic activities.

5.4.1.5.1 Roads

Use of area roadways by commuting workers could contribute to physical deterioration of roadway surfaces. However, some or all of the mitigation measures incorporated during the building phase would remain in place during operations (see EIS Section 4.4.1.3.1). Given the much smaller volume of traffic on the roads during operations compared to during building, the review team determines that the overall impacts on road quality would be less than the impacts on road quality from building activities. Therefore, the operations-related impacts on road quality would be minimal.

5.4.1.5.2 Water

As discussed in EIS Section 2.5.2.4.4, there is an existing barge facility at the CRN Site. To support delivery of large components and equipment for building, TVA indicated that the existing barge facility at CRN Site would need to be modified. The refurbishment would comply with regulatory requirements. The barge slip and the expected barge deliveries are expected to have a negligible impact on river traffic on the Tennessee and Clinch Rivers.

5.4.1.5.3 Rail

A rail spur would be reconditioned and used during construction. TVA anticipates continuing to use the rail facility during operations, but indicates that its use would be much reduced compared to during construction. Therefore, the review team expects that the impact on the rail system and related systems would be minor during operations.

5.4.1.6 Aesthetics

Similar to the discussion in EIS Section 4.4.1.4, the completed CRN Site would be visible primarily to on-site workers and residents living in close proximity to the site. Aesthetic impacts on off-site areas would occur mainly because of the introduction of large new elements into the visual environment, including SMR facilities, transmission lines, cooling towers, and steam plumes.

A new operating nuclear power plant at the CRN Site would contribute to the industrial character of the existing CRN Site. The principal visual features added by a new plant would be SMR buildings (up to 160 ft tall), mechanical draft cooling towers and their associated plumes, and the switchyard and associated powerlines. Under Federal Aviation Administration regulations, the tallest buildings would be appropriately marked with lighting, making them visible during nighttime hours. Figure 5-3 and Figure 5-4 depict how the plumes from the operating cooling towers would appear from several sensitive locations during daylight. TVA modified these photographs by superimposing simulated average plumes onto existing views (TVA 2017-TN4921).

Figure 5-3 reflects how a new nuclear power plant would appear from the property of the closest residents to the CRN Site (1,900 ft south of the cooling towers, looking north). Figure 5-4 depicts how the new nuclear power plant might appear to river recreationists upstream from the site (from the northwest, looking southeast). The additional structures on the CRN Site would be clearly visible from both of these locations.

The cooling-tower plume would be the dominant visual feature, but the major buildings of the site also would be clearly visible. The height of the plumes would depend on weather conditions and winds. The median plume height for the cooling tower would be 200 m above ground level and would be higher during the winter months (TVA 2017-TN4921). Accordingly, TVA's visual simulations suggest the plume height could extend to 300 m no more often than 3 percent of the time. Because there currently is no such visual intrusion, these impacts would be noticeable and relatively permanent, but not destabilizing.

Figure 5-3. Visual Simulation of the Operating Facilities at the CRN Site Showing the Annual Average Cooling-Tower Plume. View looking south to north. (Source: TVA 2017-TN4921)

Figure 5-4. Visual Simulation of the Operating Facilities at the CRN Site Showing the Annual Average Cooling-Tower Plume. View looking east to west. (Source: TVA 2017-TN4921)

5.4.1.7 Summary of Physical Impacts

Based on the information provided by TVA and the review team's independent evaluation and outreach, the review team concludes that the physical impacts of operations-related activities on workers and the local public, buildings, and transportation would be SMALL, and no mitigation beyond that proposed by TVA would be warranted. However, the addition of new cooling towers, related steam plumes, and new reactor facilities at the CRN Site would noticeably affect the aesthetic qualities from viewpoints in Roane and Anderson Counties. Thus, the review team concludes that operating a new nuclear power plant would have MODERATE physical impacts on aesthetic and recreational resources and that the impacts would not be amenable to mitigation.

5.4.2 Demography

TVA anticipates it would need 500 employees for operations-related activities at the CRN Site. Based on the current residential distribution of DOE-related ORR operations workforces, TVA estimated 50 percent of the operations workforce for a new plant would live in the economic region and the remaining 250 workers would be hired from outside the economic region.

As discussed in EIS Section 4.4.2, the review team assumes all in-migrating workers would bring their families. Assuming the Tennessee average household size of 2.53 (USCB 2016-TN4965), the review team predicts a population increase of 633 people in the economic region. As discussed in Section 4.4.2 for the construction workforce, the review team assumed that the in-migrating workers would settle in the economic region in a pattern similar to the residency pattern of the existing DOE-related ORR workforce. The resulting operations-related increase in population within the economic region is summarized in Table 5-2. The in-migration of operations workers and their families would increase the population of the economic region by about nine-hundredths of 1 percent. The increase would be minimal throughout the economic region. The resulting impacts on other socioeconomic resources also would be minimal, as a result.

Table 5-2. Estimated Population Increase in the Economic Region during Operations, Not Including Outage Workers

County	Workers	Population Increase	Projected 2025 Population[(a)]	Percent Increase
Anderson	67	170	80,713	0.21
Knox	125	316	516,603	0.06
Loudon	15	38	62,151	0.06
Roane	43	109	56,805	0.19
Total	**250**	**633**	**714,968**	**0.09**

(a) Source: EIS Table 2-15.

In addition to the full-time operations workforce at the CRN Site, 1,000 workers would be required every 18–24 months for outages. TVA assumed that all of the outage workers would migrate from outside the economic region for short-term temporary work during the 30–60-day outage period. Because the economic region has a higher concentration of energy industry labor, the review team assumed that half of the needed labor could be acquired from the local economic region, meaning that 500 workers would temporarily relocated to the economic region, rather than 1,000. Because outages last only a month or two, outage workers typically do not bring their families. The maximum size of the in-migrating workforce during operations

(250 operations workers and 500 outage workers) is about two-thirds the in-migrating peak employment construction workforce (1,114). The in-migrating construction workforce constituted less than two-fifths of 1 percent of the baseline population, which the review team determined would have a SMALL impact on the economic region. Because the in-migrating operations workers—including outage workers—would be fewer than the number of in-migrating construction workers, the review team concludes that these levels of increase would not noticeably affect the demographic character of the economic region or any of its counties and, therefore, the impact would be SMALL.

A small number of operations workers and their families would in-migrate to counties outside of the economic region. The current and projected populations of the demographic region are so large and the in-migrating population is so small that the in-migrating workers would represent less than 1 percent of the total population in any of the counties where these employees reside and would not be noticeable. Therefore, the review team concludes that the demographic impacts of operation on the remainder of the 50-mi region also would be SMALL.

5.4.3 Economic Impacts on the Community

This section evaluates the economic and tax impacts on the economic region from operating a new nuclear power plant at the CRN Site. The evaluation assesses the impacts and demands from the workforce for operating a new plant. As indicated in EIS Section 5.4.2, the review team assumes that 250 workers would migrate into the economic region. Assuming a family size of 2.53, the review team assumes approximately 633 people would move into the economic region. This number of people would have only minimal impacts on demands for services in the economic region or any one county.

5.4.3.1 Economy

Operation of a new nuclear power plant at the CRN Site would have a positive impact on the local and regional economy through direct employment of the operations workforce, purchases of materials and supplies for operation, and maintenance of the plant and any capital expenditures that occur within the region.

TVA would employ 500 full-time operations workers and 1,000 temporary (about 30–60 days) outage workers every 18–24 months. Based on occupational employment and salary information published by the U.S. Bureau of Labor Statistics for occupations related to power plant operations, the 2016 median wage for operations workers in the Knoxville metropolitan area was $65,520 (BLS 2017-TN5389). For an annual workforce of 500, $32.8 million would be paid in annual wages to the economic region. A total of $16.4 million would be paid annually to the 250 workers in-migrating into the economic region.

The review team assumed outage workers would be paid similarly to construction workers ($40,920 per year; see EIS Section 4.4.3.1), prorated for the short interval of work expected during an outage. Assuming 1,000 workers are needed for outages for exactly 1 month, TVA would pay $3.41 million every 18–24 months to outage workers. Approximately 50 percent of those outage workers would be from the economic region, so TVA would pay about $1.71 million to local workers every 18–24 months. Annualized, this payment in new (in-migrating worker) wages would be between $0.85 and $1.14 million. These payments reflect wage/salary payments only and do not account for any benefits such as health insurance that also might be paid.

TVA would also purchase materials and supplies for operation and maintenance of the plant, and any capital expenditures that would occur in the region would also have direct and indirect effects on the local and regional economy. At the ESP stage, TVA has not selected a reactor technology, nor provided any estimation of expenditures expected from operating SMR units. The review team will reexamine this information if the NRC receives a COL application for the proposed project. Because the new plant's output would be a maximum of 800 megawatts electric (MW(e)), with an average capacity factor of 95 percent, the review team assumes that the proposed project could generate an annual average of 6.658 TWh. Using the Energy Information Administration's (EIA) cost estimates for operating utility-scale generating plants (DOE/EIA 2013-TN4968), fixed operations and maintenance costs for advanced nuclear power plants average to $93.28 per kW/yr and variable operations and maintenance costs average $2.14 per kWh. Using the PPE-based output estimates, these costs would amount to $88.871 million (2012$) annually if the plant were operating at the PPE output level.

The review team assessment of operations worker location and economic impacts of operation expenditures is based on the two recent studies covering the local area described in EIS Section 4.4.2 and additional review team analysis. The studies suggest the region surrounding the ORR has a larger nuclear-specialized labor and services sector than most areas surrounding nuclear facilities. Therefore, the CRN economic impact region should be more likely to retain a larger proportion of a nuclear energy project's construction and operations expenditures than other regions that host nuclear power plants. The review team assumed that 50 percent of TVA's annual operation expenditures would be made in the economic region, resulting in approximately $44.4 million per year in local expenditures made to local enterprises for labor and services.

The purchases by TVA during operations would support employment in other sectors of the local economy at vendors and shops that provide materials and supplies for operations. TVA obtained operations-related multipliers from the Bureau of Economic Analysis for its economic assessments for the economic region. These multipliers indicate that for every direct operations job imported to the economic region, an additional 1.2149 indirect and induced jobs would be created (TVA 2017-TN4921). This means that the 250 new operations jobs in the economic region would add 304 indirect and induced jobs to the regional economy, for a net impact of 554 jobs. The income generated by the new operations jobs also generates indirect and induced income in the rest of the economy. For operations-related income, each dollar of income generates $0.5423 dollars of indirect and induced income. Thus, the $38.83 million paid annually to operations workers ($36.3 million for operations + $2.53 million for outages) would result in an additional $21.06 million in labor income generated in the economic region through the multiplier effect; for a net impact of $59.89 million in labor income annually.

Given the size of the economies and workforces in the economic region, although the absolute impacts are substantial, the review team estimates the relative impact of operations at the CRN Site would be minor, and positive, in the context of the larger economy of the economic region.

5.4.3.2 Taxes

The tax structure for the economic region and region is discussed in EIS Section 2.5.2.6. Primary tax revenues associated with operating activities at the CRN Site would be from (1) local taxes on worker incomes, (2) State sales taxes on worker expenditures, (3) State sales taxes on the purchases of materials and supplies, (4) payments in lieu of taxes made by TVA.

As discussed in EIS Section 4.4.3.2, the impacts on tax revenues from building the facilities would be relatively minor relative to the other sources of revenue available to the affected jurisdictions. Given that the revenue impacts of construction would be somewhat larger than the economic impacts of operations, the revenue impacts expected from operations would be much smaller by comparison, representing only a negligible impact in the economic region. The review team will need to revisit these impacts if the NRC receives a COL application regarding the proposed project. If the estimated payments were known, the review team expects that the additional payments to the counties of the economic region affected by the proposed project would be minor in relation to the other existing revenue streams currently available.

5.4.3.3 Summary of Economic Impacts on the Community

Based on the information provided by TVA and the review team's independent evaluation and outreach, the review team concludes that the economic impacts would be SMALL and beneficial for the economic region. The review team predicts SMALL and beneficial impacts on sales and excise tax and income tax receipts in the economic region. The review team will revisit impacts from fee-in-lieu-of-taxes payments to the State of Tennessee and the four counties of the economic region at the COL application stage.

5.4.4 Infrastructure and Community Service Impacts

This section provides the estimated impacts on infrastructure and community services, including transportation, recreation, housing, public services, and education.

5.4.4.1 Traffic

Existing transportation routes would be affected by an increase in commuter traffic to and from the CRN Site associated with the operations and outages workforce. The workforce for the new plant would use the same access routes identified for plant construction.

TVA commissioned a traffic impact analysis (TIA) to determine traffic impacts around the CRN Site. The AECOM Technical Services Inc. (AECOM) (2015-TN5000) study analyzed deterioration of LOS on roads and intersections that would be used to access the CRN Site. The study made assumptions about the following: (1) the maximum anticipated construction workforce; (2) build-out year of 2024; (3) selection of key access routes; (4) traffic load being is based upon a combination of peak construction, outage workforce, maximum operations workforce present during building at the CRN Site, and (5) baseline background traffic at once (TVA 2017-TN4921). The AECOM (2015-TN5000) analysis presents two scenarios based on alternative staffing models of the construction workforce. Further discussion of the analysis and its assumptions are in EIS Sections 2.5.2.3 and 4.4.4.1.

The TIA suggests certain mitigation measures to alleviate traffic impacts during building, which are discussed in EIS Section 4.4.4.1. According to Table 4-7, some intersections would have unacceptable LOS values in the future no-build scenario. These intersections generally show improvement with the implementation of suggested mitigation measures, but not in all cases. Because the operations workforce and the outage workforce are significantly smaller than the assumptions used in the TIA (approximately 1,200–1,300 vehicles per day compared to nearly 5,000 as discussed in Table 4-7), the review team expects impacts from traffic in the economic region to be minor. The measures identified in the TIA would be expected to be somewhat more effective in mitigating lower overall traffic volumes. The greatest impacts would be during shift changes when an outage is in process. Therefore, given the review team anticipated a noticeable but not destabilizing impact (mitigated) from building-related activities, the much smaller operations-related traffic impacts would be minor and additional mitigation beyond that implemented for the building phase of the project would not be warranted.

Additional traffic can cause an increase in road accidents. Section 5.8.6 of this draft EIS determines the expected nonradiological socioeconomic impacts from operations-related traffic increases would be negligible. The economic aspect of the nonradiological socioeconomic impacts are a corollary to the nonradiological health impact assessment and include lost time and wages to workers, lost productivity to employers, and increased medical costs and the cost of vehicular damages to the public. The review team estimates the total annualized peak employment traffic-related increase in accidents would be about 78 accidents. Given the much smaller number of operations and outage workers that would be contributing to the traffic impacts during operations, the review team determined the socioeconomic component of the changes in operations-related nonradiological health impacts from traffic would also be minor and mitigation beyond that performed for the building-related portion of the project would not be warranted.

5.4.4.2 Recreation

Recreational resources in the economic region may be affected by operations activities at the CRN Site. Impacts may include (1) increased user demand associated with the projected increase in population as a result of the in-migrating workforce and their families, (2) an impaired recreational experience associated with the views of the site and the expected cooling tower plumes, and (3) accessibility delays associated with increased traffic on local roadways. Increased user demand as a result of the in-migrating population may include increased competition for campsites at campgrounds and at hotels/motels, which could be used for temporary housing for some of the workforce during outages or for recreational purposes by the new operations workforce. Because the number of in-migrating workers would be minimal and distributed across the economic region, these impacts would be minor.

As discussed in EIS Section 5.4.1.6, operations at the CRN Site would add to the already industrial nature of the site, and there would be some aesthetic impacts at recreational areas that have views of the CRN Site. These areas are typically along the Clinch River, where views of the cooling-tower plumes may affect the experience of recreationists (boating, camping, fishing, wildlife viewing, etc.) compared to baseline conditions.

People using recreational facilities in Roane and Anderson Counties may experience minor traffic congestion on the roads during morning and afternoon commutes of the operations and outage workforces. However, because 50 percent of the operations workforce already lives within commuting distance of the CRN Site, the review team does not expect the in-migrating portion of the operations workforce would place other than minor stresses upon the capacity of recreational facilities near the site. The economic region and region's parks and recreational facilities have sufficient capacity to accommodate in-migrating workers and their families and the review team expects minimal impact on recreation near the site (NRC 2018-TN5386) during operations.

The review team expects the impacts on recreational activities in the vicinity to be minimal, except for a noticeable but not destabilizing aesthetic impact from operations at the site that would not be amenable to mitigation.

5.4.4.3 Housing

EIS Section 2.5.2.6 discusses housing information for the economic region. According to Table 2-35, there are 27,397 vacant units in the economic region. As discussed in EIS Section 5.4.2, 250 workers and their families would move into the economic region. The rest of the operations workforce would be expected to come from the region and commute daily to the site, therefore having no impact on the housing stock.

The minimal number of in-migrating workers and families may choose to buy available vacant housing or rent. Operations workers are more likely to take advantage of the permanent housing stock or build new homes. Outage workers are more likely to take advantage of the temporary housing stock because they are expected to be at the CRN Site for a relatively short period of time. In addition to the housing stock for owner-occupied housing and rental units, there is also sufficient stock of temporary housing in the economic region if workers decide to stay in hotels, motels, or campgrounds.

Given the large supply of vacant housing relative to the minimal in-migrating operations workforce during operations and the availability of short-term accommodations for outage workers, the review team expects sufficient housing to be available for workers relocating to the area and minimal impacts on the housing supply or prices in the local area.

Construction of new SMR units and their associated transmission lines could affect property values, if proximity to nuclear reactors or to transmission lines affects the attractiveness of properties to prospective buyers or renters. Various studies have reviewed the recent evidence and found the body of studies to be inconclusive. For example, Bezdek and Wendling (2006-TN2748) found that various studies report no statistical effect of proximity to nuclear plants, while other studies have found positive or negative effects. In the case of transmission lines, studies have often also reached different conclusions. When effects were found they tended to be small, decay with distance, and dissipate over time. Because the current evidence is inconclusive, it is not possible to state whether construction of SMR units at the CRN Site and their associated transmission lines would or would not affect property values.

Based on the information provided by TVA, interviews with local officials, and its own independent review, the review team expects there would be minimal impacts in the economic region and the region on the price and availability of housing from operations at the CRN Site.

5.4.4.4 Public Services

This section discusses the impacts on existing water supply, wastewater treatment, police, fire protection, and healthcare services in the economic region.

5.4.4.4.1 Water Supply and Wastewater Treatment Services

Approximately 50 percent of the project operations workforce would be local workers who currently reside in the region. The majority of these workers would commute from their homes to the project site and would not relocate. Therefore, the majority of workers are currently served by the water supply and wastewater treatment facilities within the communities where they reside.

During operations, the review team expects 250 workers (633 people, including families) to move into the economic region. These relocating workers would increase the demand on the water supply and wastewater treatment services within the communities where they reside. However, this increased demand would be bounded by the increased water demand during building. Therefore, the review team determined that impacts on water supply and wastewater treatment in the economic region would be minimal, and mitigation would not be warranted.

Similarly, TVA indicates that the expected use rate during normal operations would be 50 gpm (72,000 gpd or 0.072 Mgd), with a maximum use rate of 100 gpm (144,000 gpd or 0.144 Mgd) (TVA 2017-TN4921), which is less than the water use rate during building. Therefore, the review team determined that CRN Site operations would have minimal impacts on the City of Oak Ridge water supply and wastewater treatment facilities and no mitigation would be warranted.

5.4.4.4.2 Police, Fire Protection, and Healthcare Services

The operations workforce at the CRN Site would negligibly increase the demand on police, fire protection, and healthcare services within the communities where workers reside and at the CRN Site.

Approximately 50 percent of the project workforce would be local workers who currently reside in the region. The majority of these workers would commute from their homes to the project site and would not relocate. Therefore, the majority of workers are currently served by the police, fire protection, and healthcare services within the communities where they reside.

During operations, the review team expects 250 workers and their families to move into the economic region. This constitutes a total of 633 people moving into the economic region during operations. These relocating workers would increase the demand on the police, fire protection, and healthcare services within the communities where they reside.

No county in the economic region would have a population increase greater than one-half of 1 percent. In discussion with local officials the review team found no need to increase police, fire protection, or healthcare services because of in-migrating operations workers. The review team, after discussion with local officials, found that with the minimal increases in population, there should be only a negligible effect on the performance of police, fire protection, and healthcare services in the economic region.

Locally, Roane County, the City of Oak Ridge, and Anderson County first responders would see any impact caused by the operations workforce. All hospitals in the area are under capacity (NRC 2018-TN5386). Because of their proximity to the site, these three jurisdictions would receive the most impacts from operations and outage worker injuries or accidents on the roads leading to the site and at the site. After discussions with local officials and its own independent analysis, the review team expects a minimal impact on these services from operations at the CRN Site, and no mitigation would be warranted.

5.4.4.5 Education

The operations workforce at the CRN Site would increase the demand for educational services within the communities where workers reside. Approximately 50 percent of the project workforce would be local workers who currently reside in the region. The majority of these workers would commute from their homes to the project site and would not relocate. Therefore, the majority of workers are currently served by the educational services within the communities in which they reside. The minimal number of in-migrating students would be easily absorbed and distributed throughout the economic region.

Based on the review team's independent analysis and discussions with local officials, the review team finds that the impacts on schools in the economic region would be minimal, and no mitigation would be warranted.

5.4.4.6 Summary of Community Service and Infrastructure Impacts

Based on the information provided by TVA and the review team's independent evaluation and outreach, the review team concludes that impacts on all infrastructure and community services would be SMALL for the economic region, with the exception of recreational impacts near the CRN Site. The review team expects MODERATE adverse impacts on local recreational resources because of impacts on viewsheds from the increased industrial character of the CRN Site and the impacts on recreational experiences given the cooling-tower plumes during plant operations.

5.4.5 Summary of Socioeconomic Impacts

The review team has assessed the activities related to operating a new nuclear power plant at the CRN Site and the potential socioeconomic impacts in the region and economic region. Physical impacts on workers and the general public include those on noise levels, air quality, and existing structures. Other physical impacts apply to transportation infrastructure degradation (roads, water, and rail routes), and aesthetics. The review team concludes all physical impacts from operations at the CRN Site would be SMALL, with the exception of a MODERATE impact on aesthetics that could not be reduced through mitigation.

On the basis of information supplied by TVA and the review team interviews conducted with public officials, the review team concludes that impacts from operations at the CRN Site on the demographics of the economic region would be SMALL. Economic impacts throughout the economic region would be SMALL and beneficial. Tax impacts would be SMALL and beneficial throughout the economic region. The review team will need to revisit tax impacts if the NRC receives a COL application regarding the proposed project.

Infrastructure and community services impacts span issues associated with traffic, recreation, housing, public services, and education. Impacts from operations at the CRN Site on traffic, housing, public services, and education would be SMALL. Recreational impacts would be SMALL generally, with MODERATE impacts in close proximity to the proposed site because of impacts on viewsheds from the increased industrial character of the CRN Site, which would not be amenable to mitigation.

5.5 Environmental Justice

The review team evaluated whether minority or low-income populations would experience disproportionately high and adverse human health or environmental effects from the operation of a new nuclear power plant at the CRN Site. To perform this assessment, the review team (1) identified (through U.S. Census Bureau and American Community Survey demographic data, TVA's ER, and on-the-ground assessments) minority and low-income populations of interest; (2) identified all potentially significant pathways for human health, environmental, physical, and socioeconomic effects on those identified populations of interest; and

(3) determined whether or not the characteristics of the pathway or special circumstances of the minority or low-income populations would result in a disproportionately high and adverse impact.

To perform this assessment, the review team followed the methodology described in EIS Section 2.6.1. In the context of operations activities at the CRN Site, the review team considered the questions outlined in Section 2.6.1. For all three health-related questions, the review team determined that the level of environmental emissions projected is well below the protection levels established by NRC and EPA regulations and would not impose a disproportionate and adverse effect on minority or low-income populations.

5.5.1 Health Impacts

Section 5.8 below assesses the nonradiological health effects on operations workers and the local population from fugitive dust, noise, occupational injuries, and transport of materials and personnel. In Section 5.8.2, the review team concludes that nonradiological health impacts on the general public would be SMALL to MODERATE. MODERATE noise impacts would be expected in close proximity to the site. However, no environmental justice populations were identified in close proximity to the site. The review team's investigation and outreach did not identify any unique characteristics or practices among minority or low-income populations that might result in disproportionately high and adverse nonradiological health effects.

Section 5.9 below assesses the radiological doses to the operations workforce and the local population and concludes that the doses would be within NRC and EPA dose standards. Section 5.9 concludes that radiological health impacts on the operations workforce at the CRN Site would be SMALL.

During operations at a new plant, TVA would be required to maintain a radiological environmental monitoring program (REMP). A REMP assesses the impact of the plant on the environment, and samples of environmental media are collected and analyzed for radioactivity. A plant effect would be indicated if the radioactive material detected in a sample was significantly larger than the background level. Per regulatory requirements, the review team expects similar practices for a new plant at the CRN Site. Based on this information, the review team concludes that there would be no disproportionately high and adverse impact on low-income or minority populations. As discussed in EIS Sections 2.6 and 4.5, none of the block groups exceeding low-income thresholds used for environmental justice impact assessment are in close proximity (10 mi) to the CRN Site. Because of the distance between the site and the closest minority or low-income population, the review team did not identify any disproportionately high and adverse impacts from health-related pathways.

5.5.2 Physical and Environmental Impacts

For the physical and environmental considerations described in EIS Section 2.6.1, the review team determined through literature searches and consultations that (1) the impacts on the natural or physical environment would not significantly or adversely affect a particular group; (2) no minority or low-income population would experience an adverse impact that would appreciably exceed or be likely to appreciably exceed those of the general population; and (3) the environmental effects would not occur in groups affected by cumulative or multiple adverse exposure from environmental hazards.

The review team determined that the physical and environmental impacts from operations at the CRN Site would attenuate rapidly with distance, intervening foliage, and terrain. There are four primary exposure media in the environment: soil, water, air, and noise. The following subsections discuss each of these pathways in greater detail.

5.5.2.1 Soil

The review team did not identify any pathway by which operations-related impacts on soils at the CRN Site would impose a disproportionately high and adverse impact on any population of interest. The review team considers the risk of soil salinization from cooling towers to be low. Therefore, the review team determines there is no soil-related pathway by which minority or low-income populations of interest could receive a disproportionately high and adverse impact. Because of the distance between the site and the closest minority or low-income population, the review team did not identify any disproportionately high and adverse impacts from soil-related pathways.

5.5.2.2 Water

Operations at the CRN Site could affect water quality in the Clinch River. Water-quality impacts would result from increased stormwater runoff from the impervious surfaces of the CRN Site and thermal and chemical constituents in the cooling-water discharges. As discussed in EIS Sections 5.2 and 5.3.2, operations at the CRN Site would generate a small thermal plume from cooling-water discharge into the Clinch River. Solutes in the effluent discharged would be diluted by the large water volume of the Clinch River. In addition, discharges would be required to comply with limits imposed by permits. Consequently, the increase in temperature and concentration of these chemicals and the thermal plume impacts in the Clinch River would be negligible. Therefore, the review team determines there is no water-related pathway by which minority or low-income populations of interest could receive a disproportionately high and adverse impact. Furthermore, because of the distance between the site and the closest minority or low-income population, the review team did not identify any disproportionately high and adverse impacts from water-related pathways.

5.5.2.3 Air

Air emissions sources associated with operations at the CRN Site would include standby diesel generators and/or gas turbines, auxiliary boilers, diesel-driven pumps, and other ancillary equipment. These emissions sources would be small, occur infrequently or mostly during the winter months, and be permitted for use by a Clean Air Act (42 U.S.C. § 7401 *et seq*.-TN1141) Permit. Cooling towers would emit small amounts of particulate matter as drift. However, emissions from these sources would be expected to have only a minimal impact on ambient air quality in offsite communities. Therefore, the review team determines there is no air-related pathway by which minority or low-income populations of interest could receive a disproportionately high and adverse impact. Furthermore, because of the distance between the site and the closest minority or low-income population, the review team did not identify any disproportionately high and adverse impacts from air-related pathways.

5.5.2.4 Noise

Primary noise sources associated with operations at the CRN Site would be cooling towers and transformers. As noted in EIS Section 5.8.2, noise from the transformers and cooling towers would be buffered by the distance of the plant from residences such that ambient sound level should not increase appreciably. Noise levels are anticipated to be less than 65 dBA at the nearest noise-sensitive receptor. Therefore, the review team determines there is no noise-related pathway by which minority or low-income populations of interest could receive a disproportionately high and adverse impact. Furthermore, because of the distance between the site and the closest minority or low-income population, the review team did not identify any disproportionately high and adverse impacts from noise-related pathways.

5.5.2.5 Summary of Physical and Environmental Impacts

The review team's investigation and outreach did not identify any unique characteristics or practices among minority or low-income populations that might result in physical or environmental impacts that would be different from those on the general population. Furthermore, because of the distance between the site and the closest minority or low-income population, the review team did not identify any disproportionately high and adverse impacts from environmental pathways.

As shown in Table 2-30, most of the census block groups classified as minority or low-income are located in Anderson and Roane Counties. The closest block groups to the CRN Site are about 8 mi north of the site in the City of Oak Ridge. The census block groups would not be affected by any physical or environmental impacts because of their distance from the site.

Based on information provided by TVA and the review team's independent review, the review team found no pathways from soil, water, air, and noise that would lead to disproportionately high and adverse impacts on minority or low-income populations.

5.5.3 Socioeconomic Impacts

Socioeconomic impacts (discussed in EIS Section 5.4) were reviewed to evaluate whether there would be any operational activities that could have a disproportionately high and adverse impact on minority or low-income populations. Except for adverse effects on aesthetics and recreational resources, all adverse socioeconomic impacts associated with operations at the CRN Site are expected to be SMALL for the general public. The review team finds that there could be adverse MODERATE impacts on recreational resources to the general public; however, these impacts are not expected to disproportionately affect the nearby low-income and minority populations.

5.5.4 Subsistence and Special Conditions

The NRC's environmental justice methodology includes an assessment of populations with unique characteristics, such as minority communities exceptionally dependent on subsistence resources or identifiable in compact locations, such as Native American settlements or high-density concentrations of minority populations.

5.5.4.1 Subsistence

Access to the CRN Site is restricted, so there is limited plant-gathering, hunting, and fishing activities at the site. TVA and the review team independently interviewed community leaders throughout the four-county economic region and found that no such practices were identified in the vicinity of the CRN Site. There is no documented subsistence fishing in the Clinch River, and all hunting, plant-gathering, and fishing near the CRN Site is done for recreational purposes (EIS Section 2.6.3).

From the information provided by TVA, interviews with local officials, and the review team's independent evaluation, the review team concludes that there would be no operations-related disproportionately high and adverse impacts on subsistence activities on minority or low-income populations.

5.5.4.2 High-Density Communities

As discussed in EIS Section 2.6.3, there are no high-density communities in the economic region. From its own independent evaluation and interaction with local officials, the review team does not predict any impacts on the communities in the economic region because of the distance from the site and because no pathways exist for adverse impacts at that distance.

5.5.5 Migrant Labor

As discussed in EIS Section 2.6.4, migrant populations in the economic region are minimal and linked to the agriculture and residential construction industries. Therefore, from the information provided by TVA, interviews with local officials, and the review team's independent evaluation, the review team concludes that there would be no disproportionately high and adverse impacts on migrant laborers.

5.5.6 Summary of Environmental Justice Impacts

The review team evaluated the proposed operations activities at the CRN Site on environmental justice populations. The review team did not identify any potential environmental pathways by which the identified minority or low-income populations within a 50-mi demographic region or in the economic region would likely experience disproportionately high and adverse human health, environmental, physical, or socioeconomic effects as a result of operations activities.

5.6 Historic and Cultural Resources

The National Environmental Policy Act of 1969, as amended (NEPA; 42 U.S.C. § 4321 *et seq*.-TN661), requires Federal agencies to take into account the potential impacts of their proposed actions on the cultural environment, which includes archaeological sites, historic buildings, and traditional cultural places important to a community. The National Historic Preservation Act of 1966, as amended, (NHPA; 54 U.S.C. § 300101 *et seq*.-TN4157) also requires Federal agencies to consider the impacts on those resources if they are eligible for listing in the National Register of Historic Places (NRHP). Such resources are referred to as "historic properties" in NHPA. As outlined in 36 CFR 800.8 (TN513), "Coordination with the National Environmental Policy Act of 1969," the NRC is coordinating compliance with Section 106 of NHPA by fulfilling its responsibilities under NEPA. Because the USACE has no action as part of the ESP, the USACE will defer its consultation on NHPA Section 106 impacts until the COL stage of the application process and will define its permit area at that time.

Operating two or more SMRs at the CRN Site may affect known or previously undiscovered historic and cultural resources located within the onsite and offsite direct- and indirect-effects area of potential effect (APE). In accordance with 36 CFR Part 800 (TN513), the NRC is required to make a reasonable and good faith effort to identify historic properties in the APE and, if such properties are present, determine whether significant impacts are likely to occur. If there are potentially adverse impacts, the NRC shall consult with the State Historic Preservation Office (SHPO), Federally recognized American Indian Tribes, and interested members of the public as necessary, to address mitigation and/or avoidance measures. Even if no historic properties (i.e., places eligible for listing in the NRHP) are present or affected, the NRC is still required to notify the SHPO before proceeding. If it is determined that historic properties are present, the NRC and SHPO are required to assess and resolve any adverse effects of the undertaking.

For a description of historic and cultural resources and historic properties located within the onsite and offsite indirect-effects APE, see EIS Section 2.7.

5.6.1 Onsite Impacts on Historic and Cultural Resources

There is a high potential for TVA to encounter historic and cultural resources during operation- and maintenance-related ground-disturbing activities. This is due to the presence of multiple archaeological resources and the high potential for deeply buried archaeological deposits within the onsite direct-effects APE. Operational impacts on archaeological resources are expected to be avoided or minimized because TVA is responsible for complying with NHPA Section 106 and is committed to following the steps outlined in "36 CFR 800.3–800.14 (TN513) for undertakings that are associated with SMR operation and maintenance, in perpetuity" (TVA 2017-TN4922:E3-6). Accordingly, TVA will avoid, minimize, or mitigate potential operation-related impacts on archaeological resources. TVA is also required to comply with other Federal historic and cultural resource laws such as the Native American Graves Protection and Repatriation Act (NAGPRA) (25 U.S.C. § 3001 *et seq*.-TN1686), Archaeological Resources Protection Act (16 U.S.C. § 470aa *et seq*.-TN1687), Archeological and Historic Preservation Act (54 U.S.C. § 312501 *et seq*.-TN4844), NHPA, American Indian Religious Freedom Act (42 U.S.C. § 1996 *et seq*.-TN5281), Executive Order (EO) 13007 (TN5250), "Indian Sacred Sites", and EO 13175 (TN4846), "Consultation and Coordination with Indian Tribal Governments." TVA also maintains procedures and management plans that take into consideration impacts on historic and cultural resources during operations. In the event that archaeological resources or human remains are encountered during operations, TVA has NHPA Section 106 and NAGPRA inadvertent discovery procedures requiring stop work and consulting party notifications (TVA 2017-TN4922:E3-3, and E3-6-E3-7).

Impacts on the Hensley Cemetery are expected to be negligible because operation and maintenance activities would avoid the cemetery. Indirect visual impacts are expected to be minimized because the cemetery is surrounded by vegetation and trees affording visual screening. TVA also intends to maintain the grounds and continue to provide access (TVA 2017-TN4921) and must comply with the State of Tennessee's Cemetery and Burial Site laws (T.C.A. Title 46-TN5088).

No impacts are expected to occur on traditional cultural properties of significance to American Indian Tribes because none have been identified in the onsite direct- or indirect-effects APE at the time of publishing this draft EIS. See Section 2.7.4 of this EIS for additional information about consultation with American Indian Tribes.

There are no architectural resources located within the onsite direct-effects APE; therefore, there would be no impact on these resources from operation and maintenance activities. In addition, operation and maintenance activities would not visually impact the two extant unevaluated architectural resources (RE1439 and Structure 3) located within the onsite indirect-effects APE due to the presence of vegetative screening.

5.6.2 Offsite Impacts on Historic and Cultural Resources

Operation and maintenance impacts associated with offsite project areas (i.e., Melton Hill Dam and transmission lines) are expected to be minimal because TVA is responsible for complying with NHPA Section 106 and is committed to following the steps outlined in "36 CFR 800.3–800.14 (TN513) for undertakings that are associated with SMR operation and maintenance, in perpetuity" (TVA 2017-TN4922:E3-6). TVA is also required to comply with other Federal historic and cultural resource laws and maintains procedures and management plans that take into consideration impacts on historic and cultural resources during operations. In the event that archaeological resources or human remains are encountered during operations, TVA has NHPA Section 106 and NAGPRA inadvertent discovery procedures requiring stop work and consulting party notifications (TVA 2017-TN4922:E3-3, and E3-6-E3-7). Accordingly, TVA would avoid, minimize, or mitigate any potential operation-related impacts on historic and cultural resources and historic properties located in additional offsite project areas (TVA 2017-TN4922:E3-6).

5.6.3 Summary

For the purposes of the review team's NEPA analysis, the review team concludes onsite and offsite impacts on historic and cultural resources from operation- and maintenance-related activities would be SMALL. This conclusion is based on (1) the NRC's ongoing consultation with 20 American Indian Tribes and Tennessee Historical Commission, (2) TVA's Federal cultural resource compliance responsibilities, and (3) TVA's procedures and management plans that take into consideration impacts on cultural resources during operations.

For the purposes of the NHPA Section 106 analysis, the NRC staff concludes that there would be no adverse effect on historic properties from operational activities. Mitigation is not warranted.

5.7 Meteorology and Air Quality Impacts

The primary impacts of operating a new nuclear power plant at the CRN Site on local meteorology and air quality would be from releases to the environment of heat and moisture from the primary cooling system, operation of auxiliary equipment (e.g., generators and auxiliary boilers), and mobile emissions (e.g., worker vehicles). Section 5.7.1 discusses potential air-quality impacts from nonradioactive effluent releases at the CRN Site. The potential impacts of releases from operating the cooling system are discussed in Section 5.7.2. Section 5.7.3 discusses the potential air-quality impacts associated with transmission lines during plant operation.

5.7.1 Air-Quality Impacts

EIS Section 2.9 describes the meteorological characteristics and air quality of the CRN Site. Based on the CRN Site PPE, sources of air emissions would include stationary combustion sources (auxiliary boilers, emergency diesel generators, and/or standby power gas turbines), mechanical draft cooling towers (TVA 2017-TN4921), and mobile sources (worker vehicles, onsite heavy equipment and support vehicles, and delivery of materials and disposal of wastes). Stationary combustion sources would operate only for limited periods, often for periodic maintenance testing.

5.7.1.1 Criteria Pollutants

The principal air emission sources associated with a new nuclear power plant at the CRN Site would be cooling towers, auxiliary boilers for heating and startup, engine-driven emergency equipment, and emergency power supply system diesel generators and/or gas turbines. Estimates of the annual auxiliary boiler, diesel generator, and gas turbine air emissions, which include nitrogen oxides (NO_x), carbon monoxide (CO), sulfur oxides (SO_x), hydrocarbons in the form of volatile organic compounds, and particulate matter, are provided in Table 5-3. A specific SMR technology and supporting equipment have not been selected, so detailed emission data are not available. Equipment associated with auxiliary systems and the cooling towers, which are defined in the PPE (Appendix I of this EIS), contribute gaseous and particulate emissions to the air. The auxiliary boilers would be used for heating buildings associated with the new plant, primarily during the winter months, and for process steam during site startups. The diesel generators/gas turbines and engine-driven emergency equipment would be used intermittently and for brief durations (TVA 2017-TN4921).

Air emission sources associated with a new nuclear power plant would be managed in accordance with Federal, State, and local air-quality control laws and regulations. A new plant at the CRN Site would comply with all regulatory requirements of the Clean Air Act, as well as the TDEC requirements to minimize impacts on state and regional air quality. When the project design is selected, modeling, as required, will be conducted to demonstrate the project emissions will not result in exceedances of the National Ambient Air Quality Standards. Because the project is located in an attainment area for all National Ambient Air Quality Standard criteria pollutants, the proposed project is not subject to a Nonattainment New Source Review (TVA 2017-TN4921).

Table 5-3. Annual Estimated Emissions from Cooling Towers, Auxiliary Boilers, Diesel Generators, and Gas Turbines at the CRN Site

Emission Effluent	Cooling Towers (lb/yr)[(a)]	Auxiliary Boilers (lb/yr)[(b)]	Diesel Generators (lb/yr)[(c)]	Gas Turbines (lb/yr)[(d)]	Total Emissions	
					(lb/yr)	(ton/yr)
Nitrogen Oxides	NA[(e)]	33,900	39,000	2,300	75,200	37.6
Carbon Monoxide	NA	5,900	3,100	600	9,600	4.8
Sulfur Oxides	NA	41,600	NA	25	41,625	20.8
Volatile Organic Compounds[(f)]	NA	500	700	15	1,215	0.6
Particulate Matter (PM_{10})	6,700	7,700	300	NA	14,400	7.2

(a) Based on 8,760 hours of operation at 0.76 lb/hr, using Reisman and Frisbie 2002-TN5258
(b) Based on 36 days of operation, one auxiliary boiler.
(c) Based on 4 hours of operation per month.
(d) Based on 4 hours of operation per month.
(e) NA = not applicable.
(f) As total hydrocarbon.

Source: TVA 2017-TN4921.

Additional operations-related traffic would also result in vehicular air emissions. Nominal localized increases in emissions would occur due to the increased numbers of cars, trucks, and delivery vehicles that would travel to and from the CRN Site. Most of the increased traffic would be associated with employees driving to and from work. Once the workers are at the site, the volume of traffic and its associated emissions are expected to decrease. Mitigation measures that will be considered when the facility is operating include staggering work shifts, requiring delivery vehicles to shut down engines while off-loading, restricting idling times of onsite vehicles, use of electric and hybrid vehicles, and supporting and promoting van/carpooling and other commuter programs (TVA 2017-TN4921). The review team concludes that impacts on local and regional air quality from operations-related traffic would be minimal, regardless of the implementation of the mitigation measures discussed above.

The closest mandatory Class I Federal area where visibility is an important value is the Great Smoky Mountains National Park near Gatlinburg, Tennessee (40 CFR 81.428-TN5047), approximately 31 mi east-southeast of the CRN Site. Another Class I Federal area, the Joyce-Kilmer Slickrock Wilderness Area, in Graham County, North Carolina (40 CFR 81.428-TN5047), is approximately 36 mi to the southeast. These Class I areas are cross-wind to the prevailing southwesterly and northeasterly wind directions, so direct transport from the CRN Site to these Class I areas is unlikely. Given the minor air emissions from the CRN Site, there is little likelihood that activities at the CRN Site could adversely affect air quality and air-quality-related values (e.g., visibility or acid deposition) in these Class I areas.

Based on the information provided by TVA, the review team's independent evaluation, and applicant compliance with applicable Federal, State, and local regulations, the review team concludes that the air-quality impacts of criteria pollutants would not be noticeable, and additional mitigation would not be warranted.

5.7.1.2 Greenhouse Gases

Operating a nuclear power plant involves the emission of some greenhouse gases (GHGs), primarily carbon dioxide (CO_2), along with methane (CH_4) and nitrous oxide (N_2O). The review team has estimated that the total GHG footprint for operating a new nuclear power plant at the CRN Site for 40 years is on the order of 317,000 metric tons (MT) of CO_2 equivalent (CO_2e, an emission rate of about 7,925 MT CO_2e annually, averaged over the period of operation). This amounts to about 0.008 percent of the total projected GHG emissions estimate in Tennessee of 100,000,000 MT of gross CO_2e in 2015 (EPA 2015-TN4925). This also equates to about 0.0001 percent of the total United States annual emission rate of 6.6 billion MT CO_2e in 2015 (EPA 2017-TN4924). The value of 317,000 MT CO_2e includes the emissions from a nuclear power plant operating (181,000 MT CO_2e) and the associated emissions from the operations workforce (136,000 MT CO_2e). These estimates are based on GHG footprint estimates in Appendix K of this EIS for a 1,000-MW(e) nuclear power reactor with an 80 percent capacity factor, which is expected to be comparable to the proposed 800-MW(e) SMR project, which assumes a 90 to 98 percent capacity factor.

GHG emissions are also subject to Prevention of Significant Deterioration review as of January 2, 2011. A new major stationary source for GHG emissions must be a major source for another pollutant and have the potential to emit more than 100,000 tons per year of CO_2e. Based on the review team's estimate of 7,925 MT CO_2e emitted annually from operation of a new nuclear power plant at the CRN Site, this would not be classified as a major source. Applicable regulations under 40 CFR 52.21(b)(49)(iv)(a) (TN4498) will be addressed by the applicant during air permitting as required.

Based on its assessment of the GHG footprint of plant operations as compared to the annual GHG emissions for Tennessee and the United States, the review team concludes that the atmospheric impacts of GHGs from plant operations would not be noticeable, and additional mitigation would not be warranted.

5.7.2 Cooling-System Impacts

The proposed cooling system for the CRN Site is expected to consist of one or more mechanical draft cooling towers (TVA 2017-TN4921). The PPE lists the mechanical draft tower height as 65 ft. The towers are located 2,950 ft from the northern boundary of the CRN Site, 1,400 ft from the western boundary, 635 ft from the southern boundary, and 2,300 ft from the eastern boundary. The proposed cooling towers would remove excess heat by evaporating water. Upon exiting the tower, water vapor would mix with the surrounding air, and this process would generally lead to condensation and formation of a visible plume, which would have aesthetic impacts. Other meteorological and atmospheric impacts include ground-level fogging/icing, plume shadowing, drift deposition from dissolved salts and chemicals found in the cooling water, and ground-level temperature and humidity increases. In addition, plumes from the cooling towers could interact cumulatively with emissions from other sources.

TVA used the Electric Power Research Institute's SACTI prediction computer code to estimate potential seasonal and annual impacts associated with operating the proposed cooling towers (EPRI 1987-TN3335). Site-specific, tower-specific, and circulating-water-specific engineering data were used as input to the SACTI model. The final SMR cooling-tower design is not yet determined; a representative set of cooling-tower parameters were developed based on the heat-rejection requirements. These parameters were consistent with Case Study 1 of the SACTI User's Manual, because this heat rejection is similar to that of this proposed project. Two years (April 21, 2011–July 9, 2013) of onsite meteorological data, and ceiling height and mixing height data from the Lovell Field Airport in Chattanooga, Tennessee, were used (TVA 2017-TN4921). The source of cooling water for the towers is the Clinch River. The TDS value of 0.068 g/g is assumed for the analysis. As cooling water continues to evaporate from the towers or be lost via drift, the concentration of minerals in the water increases, which can lead to scaling and corrosive conditions. To control TDS levels, a portion of the circulating water would be blown down. Four cycles of concentration, defined as the ratio of TDS concentration in the circulating water compared to the raw makeup water, are assumed. Although the final SMR has not been selected, the mechanical draft design would be equipped with efficient drift eliminators to reduce particulate matter (PM) emissions and, thereby, salt deposition around the site. Detailed model input data to SACTI for linear mechanical draft cooling towers are presented in ER Table 5.3-2 (TVA 2017-TN4921, TVA 2016-TN5284). The SACTI modeling results for visible plumes, ground-level fogging/icing, plume shadowing, and salt deposition are presented by the applicant in the ER and have been confirmed by the staff's independent review.

Both ground-level air temperature and humidity would increase in the vicinity of the warm and humid cooling-tower plumes. However, any increases in ground-level air temperature and humidity would be localized and short-lived because the plume, reaching a considerable height, disperses and mixes with the far larger volume of surrounding air. Therefore, ground-level air temperature and humidity increases are not considered further.

5.7.2.1 Visible Plumes

Results from the SACTI analysis, as reported by TVA (2017-TN4921), indicate that the largest frequency of visible plume occurrence is on the site. On an annual basis, SACTI predicts that the plume lengths from the cooling towers would be more than 984.3 ft (300 m) for about 3 percent of the time for any wind direction. By season, the most frequent occurrence is predicted during the winter. The visible plume length in winter extends to 5,577.4 ft (1,700 m) for east-northeast, east, east-southeast, and southeast directions. For other directions, the visible plume length is 984.3 ft (300 m). Winter plume centerlines tend to be higher than the annual centerline. The 50-percent centerline height in winter is 656.2 ft (200 m), whereas the annual plume centerline height is 492.1 ft (150 m) (TVA 2017-TN4921).

The visible plume predictions include nighttime hours when plumes may not be perceived. TVA presented photos of plume rendering from several key observation points to illustrate the visual intrusion of the cooling-tower plumes (TVA 2017-TN4921). Based on the surrounding natural landscape, and the infrequent nature of plume occurrences at offsite distances, the visual intrusion of the visible plume would not be noticeable under typical atmospheric conditions, and does not warrant mitigation.

5.7.2.2 Ground Fogging and Icing

Ground-level fogging occurs when a visible plume from a cooling tower contacts the ground. In general, fogging is predicted to occur more frequently in non-summer months. Due to the relatively small size of these cooling towers compared with cooling towers that would service a larger power plant, as well as the air temperature in this area, the SACTI code predicts no fogging or icing hours at any distance from the towers (TVA 2017-TN4921).

5.7.2.3 Plume Shadowing

Plume shadowing from cooling-tower plumes is predicted by the SACTI model by calculating the average number of hours the visible plume would shadow the ground. The maximum hours of plume shadowing occur at 656.2 ft (200 m) to the northeast of the towers for 634 hr/yr. Plume shadowing frequency decreases rapidly with increasing distances. Plume shadowing frequency decreases to a maximum of 283 hr/yr, or 3 percent of the year, at 1,312.3 ft (400 m) to the west-southwest, and 237 hr/yr, or 2.7 percent of the year, at 1,968.5 ft (600 m) to the west-southwest.

Plume shadowing varies seasonally, such that at 1,968.5 ft (600 m) from the tower, plume shadowing occurs 3.9, 3.7, 5.8, and 2.7 percent of the time in winter, spring, summer, and fall seasons, respectively (TVA 2017-TN4921). The impacts of plume shadowing are expected to be minor and would not require mitigation.

5.7.2.4 Salt Deposition

The proposed cooling-tower design includes efficient drift eliminators to minimize the loss of cooling water from the tower via drift, but some droplets still would escape from the tower along with the moving airstream and would be deposited on the ground. The drift from the cooling tower would have the same concentration of salts and other dissolved solids as the water circulating in the towers. The sodium (Na) and chloride (Cl) concentrations in the cooling-tower circulating water were used to estimate a concentration of 0.010086 g salt/g solution for the SACTI input. NUREG–1555 (NRC 2000-TN614) notes that deposition rates of 100 to 200 $kg/km^2/mo$ are generally not damaging to plants. However, rates of 1,000 to 2,000 $kg/km^2/mo$ cause leaf damage in many species. The SACTI model predicted maximum deposition rates of 6276 $kg/km^2/mo$ annually at 328.1 ft (100 m) west of the towers. The maximum salt deposition rate for all directions occurred at 328.1 ft (100 m) from the towers; the average salt deposition at that distance is 2,983 $kg/km^2/mo$. At 656.2 ft (200 m) from the tower, the predicted annual average salt deposition rates are below 1,000 $kg/km^2/mo$ at all but the west and west-northwest directions. At distances of 984.3 ft (300 m) and greater, annual average salt deposition rates are all below 1,000 $kg/km^2/mo$. Finally, at distances of 1,968.5 ft (600 m) and greater, the annual average deposition rate is below 100 $kg/km^2/mo$ (TVA 2017-TN4921).

The maximum seasonal impact would occur during the summer, with a maximum salt deposition of 11,270 kg/km^2/mo at 100 m west of the towers, and average salt deposition of 4,574 kg/km^2/mo at 100 m from the towers, while the minimum seasonal impact would occur during the winter, with 1,527 kg/km^2/mo average at 328.1 ft (100 m) from the towers. These impacts are above the levels considered acceptable in NUREG–1555 (NRC 2000-TN614). The predicted rates are above the levels for which deposition could cause leaf damage in many species (i.e., exceeding 1,000 kg/km^2/mo in any month during the growing season). Distances of 328.1 ft (100 m) from the towers are within the developed area immediately surrounding the cooling towers on the CRN Site; as a result, vegetation on the slopes established adjacent to the cooling towers may be adversely affected by salt deposition. At 984.3 ft (300 m) and beyond, the salt deposition is below 1,000 kg/km^2/mo. As a result, salt deposition that may affect vegetation remains primarily on the CRN Site. Vegetation impact is a function of the sensitivity of the plants to salt and the duration between rain events, when precipitation washes salt deposits from foliage (TVA 2017-TN4921).

5.7.2.5 Interaction with Other Pollutant Sources

Combustion sources that would be associated with a new nuclear power plant at the CRN Site would operate for only limited periods. With the exception of particulates, these combustion sources emit criteria air pollutants (such as NO_x, sulfur dioxide [SO_2], and CO) that are different from those produced by the cooling towers (i.e., small amounts of PM as drift). Interaction among pollutants emitted from these sources and the cooling-tower plumes would be for only limited periods and would not have a significant impact on air quality. The nearest large pollution-emitting facility to the CRN Site is Hittman Transportation, located approximately 1.24 mi north of the proposed CRN cooling towers. SACTI model results indicate that water and salt deposition from the cooling towers decline significantly at these distances, and visible plume frequency for this distance and direction is about 15 hr/yr (TVA 2017-TN4921). Based on the above considerations and the assumption that cooling towers associated with the CRN Site would be similar to existing cooling towers used at other nuclear sites, the review team concludes that the cooling-tower impacts on air quality would be minimal, and additional mitigation of air-quality impacts would not be warranted.

As discussed above, the SACTI model predicts that potential impacts of plumes from the proposed cooling towers at the CRN Site would be limited primarily to the immediate onsite area and just beyond the site boundary. The cooling towers proposed for the CRN Site would be equipped with high-efficiency drift eliminators, which are intended to significantly reduce PM emissions (especially larger PM) and salt deposition. The area around the CRN Site is relatively sparsely populated and less sensitive to the potential impacts from cooling-tower operations (e.g., plume shadowing or salt deposition). On the basis of the analysis presented by the applicant in its ER and the staff's independent evaluation of that analysis, the staff concludes that atmospheric impacts of cooling-tower operation at the CRN Site would not be noticeable and that no further mitigation would be warranted.

5.7.3 Transmission Line Impacts

Impacts of existing transmission lines on air quality are addressed in the GEIS (NRC 2013-TN2654). Small amounts of ozone and even smaller amounts of NO_x are produced by transmission lines. The production of these gases was found to be insignificant for 745-kV transmission lines (the largest lines in operation) and for a prototype 1,200-kV transmission line. In addition, it was determined that potential mitigation measures, such as burying transmission lines, would be very costly and would not be warranted.

A new 500-kV switchyard is planned for the CRN Site. The Watts Bar NP-Bull Run FP 500-kV line will be looped in with approximately 0.7 mi of double-circuit transmission line. An additional 161-kV switchyard may be constructed and looped into the Kingston FP-Fort Loudoun HP#1 line with approximately 0.2 mi of double-circuit transmission line. A portion of the Kingston FP-Fort Loudoun HP#1 161-kV line will be relocated within the CRN Site. Additional transmission line upgrades may be necessary to support the added generation capacity. These existing transmission line sizes and additions are well within the range of transmission lines evaluated in the GEIS (NRC 2013-TN2654). The review team therefore concludes that air-quality impacts from the transmission lines would not be noticeable and mitigation would not be warranted.

5.7.4 Summary

The review team evaluated potential impacts on air quality associated with criteria pollutants and GHG emissions from operating a new nuclear power plant at the CRN Site. The review team also evaluated potential impacts of cooling-system emissions. In each case, the review team determined that the impacts would be minimal. On this basis, the review team concludes that the impacts of operating a new nuclear power plant on air quality from criteria pollutant emissions, GHG emissions, the cooling system, and transmission lines would be SMALL and that no further mitigation would be warranted.

5.8 Nonradiological Health Impacts

This section addresses the health impacts of operating proposed SMR units at the CRN Site. Nonradiological health impacts on the public from operation of the cooling system, noise generated by unit operations, EMFs, and transporting operations and outage workers are discussed. Nonradiological health impacts are also evaluated for workers at the proposed CRN Site. Health impacts from radiological sources during operations are discussed in EIS Section 5.9.

5.8.1 Etiological (Disease-Causing) Agents

Operation of new SMR units at the CRN Site would result in a thermal discharge to the Clinch River arm of the Watts Bar Reservoir (TVA 2017-TN4921). Cooling water would be withdrawn from the river at CRM 17.9, and heated water would be discharged from a structure located near CRM 15.5 (TVA 2017-TN4921). Such discharges of warmer water have the potential to increase the growth of thermophilic microorganisms (microorganisms that favor warmer water), including etiological agents, both in the CWS and the Clinch River. Thermophilic microorganisms include enteric (intestinal) pathogens such as *Salmonella* spp., *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.

As stated in EIS Section 2.10.1.3, available data assembled by the U.S. Centers for Disease Control and Prevention for the years 2006 to 2012 (CDC 2017-TN4902) report only 3 occurrences (a total of 24 cases) of waterborne outbreaks of disease from non-treated recreational water (not pools or spas) in the State of Tennessee and outbreaks of Legionellosis, Salmonellosis, or Shigellosis were below the range of national trends (CDC 2017-TN4902). Although *Naegleria fowleri* is common in freshwater ponds, lakes, and reservoirs throughout the southern states, no cases have been reported in Tennessee in the last 10 years (CDC 2017-TN4902). While it is possible that the thermal discharge from new SMR units at the CRN Site could have an impact on the abundance of etiological agents present in the receiving waters (the Clinch River), the thermal plume would be small under normal operating conditions at most times of the year (TVA 2017-TN4921). Based on the historically low risk of diseases from etiological agents in Tennessee, the limited extent of thermal impacts in the Clinch River, and the limited opportunities for public exposure, the review team concludes that the impacts on human health would be minimal, and mitigation would not be warranted.

5.8.2 Noise Impacts

In NUREG–1437 (NRC 1996-TN288), the staff discusses the environmental impacts of noise at existing nuclear power plants. Common sources of noise from plant operation include cooling towers, transformers, turbines, and the operation of pumps along with intermittent contributions from loud speakers and auxiliary equipment such as diesel generators. There would also be noise from corona discharge associated with high-voltage transmission lines (TVA 2017-TN4921).

The primary sources of background noise at the proposed CRN Site are vehicle traffic, environmental noise (i.e., birds, wind through the trees etc.), industrial/construction equipment, and boating/water craft (AECOM 2014-TN5004; TVA 2017-TN4921). The primary sources of noise expected once the proposed CRN Site is operational would likely be from the cooling tower.

The proposed SMR units at the CRN Site would use mechanical draft cooling towers (TVA 2017-TN4921). Noise levels from the mechanical draft cooling towers are expected to be 70 dBA at a distance of 1,000 ft from the source (TVA 2017-TN4921). The nearest offsite residence to the cooling towers on the CRN Site is approximately 1,900 ft south of the proposed site for the cooling-tower block directly across the Clinch River in the middle of a field. Noise energy attenuates over distance as the noise wave is absorbed and dispersed as it interacts with the physical environment (e.g., foliage and terrain). Land clearing during the building phase would remove the vegetation between the cooling-tower site and river bank, thereby inhibiting the dampening effect of attenuation. Therefore, the land clearing activities during building could result in sound levels actually greater than those AECOM observed during its ambient noise measurements taken in 2014. In addition, noise does not attenuate as much over water as over the same distance of open land, and the closest residence is situated across the Clinch River surrounded by open land (see Figure 5-4 in EIS Section 5.4.1.6). Because TVA did not conduct a noise-modeling study to estimate noise levels at the closest sensitive receptors during operations (TVA 2017-TN4921), the review team calculated the noise level from the cooling tower at the closest residence to be about 64 dBA without additional attenuation (https://www.easycalculation.com/physics/classical-physics/decibels-distance.php).

Based upon the review team's independent assessment of the loudest operational source of noise and the assessment of ambient noise levels by TVA, the review team expects the noise level of operations activities would be minimal, and mitigation (as identified by TVA in its ER) could further reduce noise levels at the critical receptor (1,900 ft from the cooling towers).

5.8.3 Acute Effects of Electromagnetic Fields

Electric shock resulting from direct access to energized conductors or from induced charges in metallic structures are examples of acute effect from EMFs associated with transmission lines (NRC 1999-TN289). Such acute effects are controlled and minimized by conformance with National Electrical Safety Code (NESC) criteria and adherence to the standards for transmission systems. In its ER, TVA states that new transmission lines would be required for the SMRs to service new power generation at the CRN Site, along with new switchyards, and that all new structures would be designed and constructed to comply with all NESC provisions, which limit the induced current due to electrostatic effects to 5 mA (TVA 2017-TN4921). Transmission system upgrades are described in EIS Section 3.2.2.3.5.

With TVA's commitment to designing new transmission lines to conform to the present NESC criteria, the staff concludes that the impact on the public from acute effects of EMFs would be negligible, and further mitigation would not be warranted.

5.8.4 Chronic Effects of Electromagnetic Fields

Operating power transmission lines in the United States produce EMFsof nonionizing radiation at 60 Hz, which is considered to be an extremely low frequency (ELF) EMF. 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-TN288). At that time, research results were not conclusive. The National Institute of Environmental Health Sciences (NIEHS) directs related research through the DOE. An NIEHS report (NIEHS 1999-TN78) 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 review team reviewed available scientific literature published since the NIEHS report about the chronic effects on human health from exposure to ELF-EMF and found that several other organizations reached the same conclusions (AGNIR 2006-TN3906; WHO 2007-TN1272). Additional work under the auspices of the World Health Organization updated the assessments of a number of scientific groups that had previously assessed the potential for transmission line EMF to cause adverse health impacts in humans. The World Health Organization (WHO) review (WHO 2007-TN1272) summarized the potential for ELF-EMF exposureto cause disease such as cancers in children and adults, depression, suicide, reproductive dysfunction, developmental disorders, immunological modifications, and neurological disease. The results of the WHO review found that the extent of scientific evidence linking these diseases to EMF exposure is not conclusive.

The review team reviewed available scientific literature on chronic effects of EMF on human health and found that the scientific evidence regarding the chronic effects of ELF-EMF exposureon human health does not conclusively link ELF-EMF exposureto adverse health impacts.

5.8.5 Occupational Health

In general, occupational health risks for new units are expected to be dominated by occupational injuries (e.g., falls, electric shock, asphyxiation) to workers engaged in activities such as maintenance, testing, and plant modifications (BLS 2016-TN4904). The estimated workforce for operation of the CRN units is 500 workers (TVA 2017-TN4921). In 2015, the annual incidence rate (the number of injuries and illnesses per 100 full-time workers) for nuclear power generation in the United States was 0.2 injury/illnesses per 100 full-time equivalent employees (FTEs). The State of Tennessee does not report to that level of detail; instead, it reports "utility operation" and the incidence rate for 2015 was 2.5 injury/illnesses per 100 FTEs (BLS 2017-TN4906). Historically, injury and fatality rates at nuclear reactor facilities have been lower than the average U.S. industrial rates (BLS 2017-TN4906). Based on the incidence rate in Tennessee for general utilities, a total of 12.5 injuries/illnesses could occur per year (BLS 2017-TN4906). If the more specific nuclear industry data are used (national rate of 0.2 injury/illnesses per 100 FTEs), the total injury and illnesses expected would be 1 per year (BLS 2017-TN4906).

Occupational injury and fatality risks are reduced by strict adherence to NRC and and Occupational Safety and Health Administration (OSHA) safety standards (29 CFR Part 1910-TN654), practices, and procedures. Appropriate State and local statutes must also be considered when assessing the occupational hazards and health risks related to new nuclear unit operation. The staff expects TVA would adhere to NRC, OSHA, State of Tennessee safety standards, and TVA's own practices and procedures during operation of the new units (reference from info need response).

TVA (2017-TN4921) reports that it maintains a safety program (discussed in EIS Section 4.8) to protect workers from industrial safety risks at the existing Watts Bar Nuclear Power Plant and would implement the program for the proposed new SMR units at the CRN Site. Health impacts on workers would be monitored and controlled in accordance with the applicable OSHA regulations. While Tennessee's incidence rates are higher than the national average, the review team determined the nonradiological impacts of operations on worker health would be minor. Application of mitigation measures identified in Table 10-2 of this EIS (and discussed in this subsection), could further reduce incidence rates. Mitigation beyond that described would not be warranted.

5.8.6 Transportation Impacts

This EIS assesses the impact of transporting workers to and from the CRN Site from the perspective of three areas of impact: (1) the socioeconomic impacts, (2) the air-quality impacts of fugitive dust and particulate matter emitted by vehicle traffic, and (3) the potential health impacts related to additional traffic-related accidents. Human health impacts are addressed in this section, while the socioeconomic impacts are addressed in EIS Section 5.4.1.3, and air-quality impacts are addressed in EIS Section 5.7.1.

The general approach used to calculate the nonradiological impacts of fuel and waste shipments is the same as that used to calculate the impacts of transporting operations and outage personnel to and from the proposed CRN Site (see EIS Section 4.8.3). However, preliminary estimates are the only data available to estimate the impacts of fuel and waste shipments. The impacts evaluated in this section for SMR units at the CRN Site are appropriate to characterize the alternative sites discussed in Section 9.3 of this draft EIS. Alternative sites evaluated in this EIS include ORR Site 2 and ORR Site 8 in Roane County in close proximity to the proposed CRN Site, and the Redstone Arsenal Site 12 in Madison County, Alabama (approximately 200 mi from the proposed CRN Site). There is no meaningful differentiation among the proposed and alternative sites regarding the nonradiological environmental impacts of transporting operations and outage personnel to the CRN Site and alternative sites, and these issues are not discussed further in Chapter 9 of this EIS.

The assumptions made by the review team to provide reasonable estimates of the parameters needed to calculate nonradiological impacts are listed below.

- The total number of workers estimated for operation of the proposed CRN Site was estimated to be 500 for the SMR units (TVA 2017-TN4921). An additional 1,000 temporary workers are estimated to be needed for refueling outages (TVA 2017-TN4921), which would occur at 18- or 24-month intervals for each unit. The staff assumed that outages for multiple units would not occur simultaneously.
- The average one way commuting distance for operations and outage workers was conservatively assumed by the review team to be 50 mi one way (TVA 2017-TN4921).
- To develop representative commuter traffic impacts, data from the Tennessee Department of Transportation provides Tennessee-specific accident, injury, and fatality rates for the years 2010 to 2014 (TVA 2017-TN4921).

The estimated impacts of transporting operations and outage workers to and from the proposed CRN Site and alternative sites are listed in Table 5-4. The total annual traffic fatalities during operations, including both operations and outage personnel, represent about a 2 percent increase above the average 10 traffic fatalities per year that occurred in Roane County, Tennessee, from 2010 to 2014 (TDOSHS 2017-TN5351). The impacts of transporting operations and outage workers to and from the ORR 2 and ORR 8 alternatives sites were the same as for the proposed CRN Site. The impacts of transporting operations and outage workers to and from the Redstone Arsenal Site 12 represent about a 2 percent increase for the site in Madison County, Alabama. These percentages represent negligible increases relative to the current traffic fatality risks in the areas surrounding the proposed CRN Site and alternative sites.

Based on the information provided by TVA, the review team's independent evaluation, and considering this increase would be negligible relative to the current traffic fatalities (i.e., before the proposed units are constructed) in the affected counties, the review team concludes that the nonradiological impacts of transporting operations and outage workers to the proposed CRN Site and alternative sites would be minimal, and mitigation would not be warranted.

Table 5-4. Nonradiological Impacts of Transporting Workers to and from the Proposed CRN Site for SMRs

	Accidents Per Year	Injuries Per Year	Fatalities Per Year
Permanent workers	2.7×10^{1}	7.4	1.5×10^{-1}
Outage workers	4.5	1.2	2.4×10^{-2}

5.8.7 Summary of Nonradiological Health Impacts

The review team evaluated health impacts on the public and workers from the proposed cooling system, noise generated by plant operations, acute and chronic impacts of EMFs, and transporting operations and outage workers to and from the proposed CRN Site. Health risks to workers are expected to be dominated by occupational injuries at rates higher than the average U.S. industrial rates (by an order of magnitude). However, the review team determined that the higher occupational injury rate would not result in a noticeable impact. Health impacts on the public from noise generated by plant operations would be minor. Health impacts on the public and workers from etiological agents and acute impacts of EMF would be minimal. The review team reviewed available scientific literature about the chronic effects of EMF on human health and found that the scientific evidence regarding the chronic effects of ELF-EMF exposure on human health does not conclusively link ELF-EMF exposure to adverse health impacts. Based on information provided by TVA and the review team's independent evaluation, the review team concludes that the nonradiological health impacts of operations associated with the CRN Site would be SMALL for all categories and mitigation would not be warranted.

5.9 Radiological Impacts of Normal Operations

This section addresses the radiological impacts of normal operations of proposed SMRs on the CRN Site, including a discussion of the estimated radiation dose to a member of the public and to the nonhuman biota inhabiting the area around the CRN Site. Estimated doses to workers are also discussed. The determination of radiological impacts was based on the PPE approach, where bounding direct radiation and liquid and gaseous radiological effluents were used in the evaluation.

5.9.1 Exposure Pathways

The public and nonhuman biota would be exposed to potential increased ambient background radiation from normal operations of new SMRs at the CRN Site via liquid effluent, gaseous effluent, and direct radiation pathways. TVA estimated the potential exposures to the public and nonhuman biota by evaluating exposure pathways typical of those surrounding the proposed SMRs at the CRN Site. TVA considered pathways that could cause the highest calculated radiological dose based on the use of the environment by the residents located around the site (TVA 2017-TN4921). For example, factors such as the location of homes, consumption of milk from dairy cows, consumption of meat, and consumption of vegetables grown in area gardens were considered.

For the liquid effluent release pathway, TVA considered the following exposure pathways when evaluating the dose to the maximally exposed individual (MEI): (1) ingestion of aquatic organisms as food (i.e., fish and invertebrates) and ingestion of water from downstream sources; (2) ingestion of locally grown meats, fruits, vegetables, and milk that is irrigated by water drawn from the Clinch River and associated reservoirs; and (3) radiation exposure from swimming and boating activities on the Clinch River arm of the Watts Bar Reservoir. A description of the MEI for the liquid effluent release pathway is provided In EIS Appendix G, Section G.1.1. Liquid effluents were assumed to be released through a permitted site outfall into the Clinch River. The analysis for population dose considered the same exposure pathways as those used for the individual dose assessment.

For the gaseous release pathway, TVA considered the following exposure pathways in evaluating the dose to the MEI and to the population: (1) immersion in airborne activity in the plume; (2) direct radiation exposure from deposited activity on the ground; (3) inhalation of airborne activity in the plume; (4) ingestion of meat and milk; and (5) ingestion of garden fruit and vegetables (see Figure 5-5). A description of the MEI for the gaseous release pathway is provided in EIS Appendix G, Section G.1.2.

For population doses from the gaseous effluents, TVA used the same exposure pathways as those used for the individual dose assessment, including the assumed milk ingestion pathway. All agricultural products grown within 50 mi of the CRN Site were assumed to be consumed by the population within 50 mi of the site (Figure 5-5).

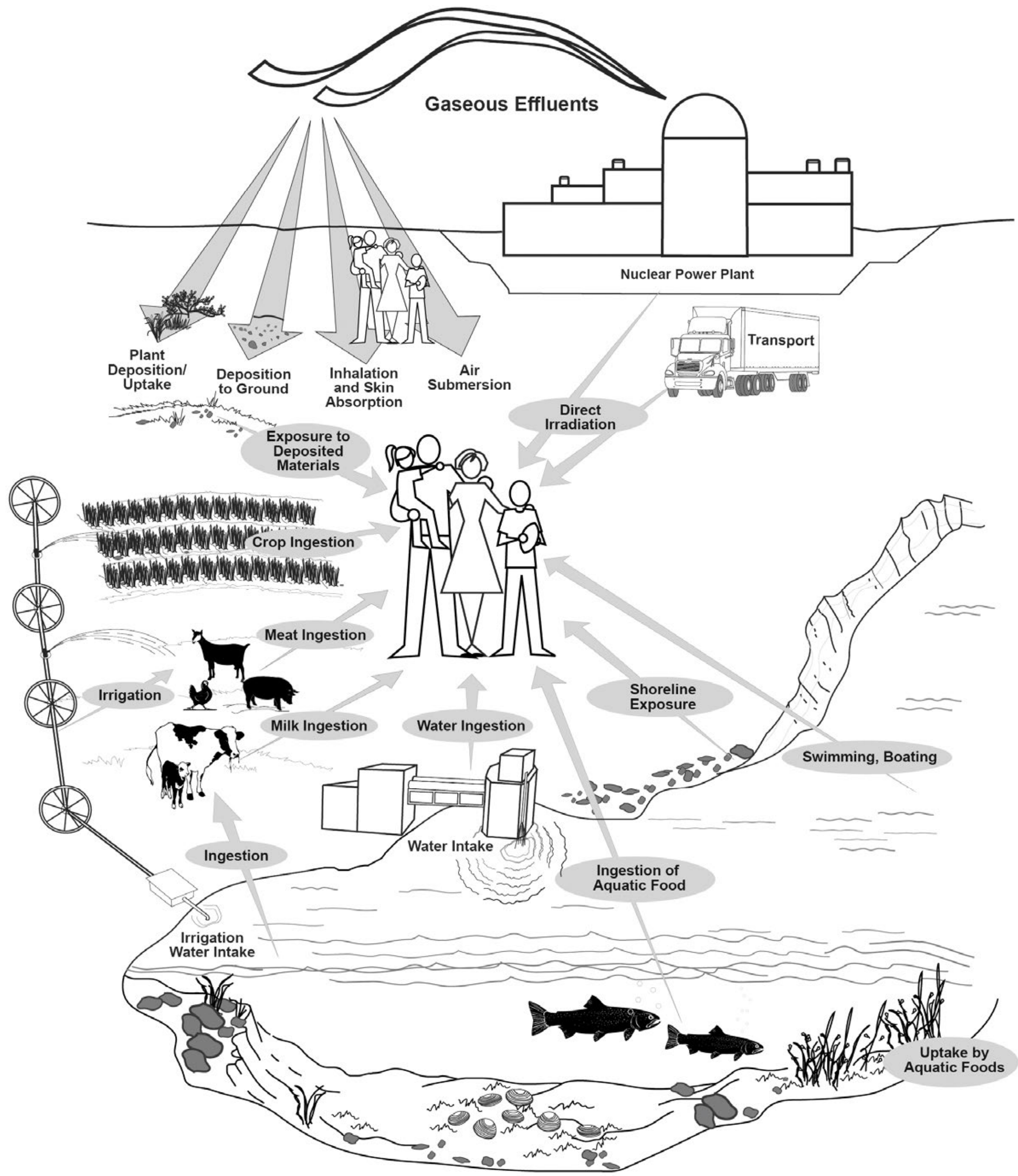

Figure 5-5. Example Exposure Pathways to Humans (Source: Modified from Soldat et al. 1974-TN710)

TVA indicates that, based on an NRC evaluation of operating nuclear plants in the GEIS, the external dose from operating SMRs would be negligible at the site boundary (NRC 2013-TN2654). That is, NUREG–1437 states that direct radiation from sources within a light water reactor (LWR) is due primarily to nitrogen-16, a radionuclide produced in the reactor core by neutron activation of oxygen-16 from water. Because the primary coolant of an LWR is contained in a heavily shielded area, dose rates in the vicinity of LWRs are generally undetectable and less than 1 mrem/yr at the site boundary. TVA further indicates that because the LWRs evaluated in NUREG–1437 are larger than SMRs, the direct dose rate would even be less for SMRs. As discussed in Section 2.11 of this draft EIS, the COL applicant is required to establish a REMP at least two years prior to operation. The staff relies on findings from NUREG–1437 to assess certain environmental impacts of new reactors. The SMR designs considered by TVA in developing the PPE use the same type of fuel (i.e., form of the fuel, enrichment, burnup, and fuel cladding) as that considered in the NRC staff's evaluation in NUREG–1437 and therefore are relevant to light water SMRs.

Exposure pathways considered by TVA in the ER when evaluating dose to nonhuman biota are shown in Figure 5-6 and include the following:

- 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, and
- surface exposure from deposition of iodine and particulates from gaseous effluents.

The NRC staff reviewed the exposure pathways that TVA evaluated for the public and nonhuman biota and found the pathways to be accurately described and therefore appropriate, based on documentation review and interviews with TVA staff during the environmental site audit in May 2017 (NRC 2018-TN5386).

5.9.2 Radiation Doses to Members of the Public

TVA calculated the dose to the MEI and the population living within a 50-mi radius of the CRN Site from both the liquid and gaseous effluent release pathways (TVA 2017-TN4921). As discussed in the previous section, direct radiation exposure to the MEI from sources of radiation at the proposed SMRs would be bounded by that from a large LWR.

5.9.2.1 Liquid Effluent Pathway

Liquid pathway doses to the MEI were calculated using the LADTAP II computer program (Strenge et al. 1986-TN82). The following activities were considered in the dose calculations: (1) consumption of water from downstream sources; (2) consumption of fish, shellfish, or other aquatic organisms from water sources affected by liquid effluents; (3) direct radiation from swimming in, boating on, and shoreline use of waterbodies affected by liquid effluents; and (4) consumption of food impacted by irrigation water drawn from the Clinch River arm of the Watts Bar Reservoir (e.g., locally grown fruit and vegetable crops, meat from pasture-fed cattle, milk from pasture-fed milk cows).

The liquid effluent releases per unit and per site used in the estimates of dose are found in Tables 3.5-1 and 3.5-2 of the ER (TVA 2017-TN4921). Other parameters used as inputs to the LADTAP II program—including the effluent discharge rate, dilution factor for discharge, transit time to receptor, and liquid pathway consumption and usage factors (e.g., shoreline usage and fish consumption)—are found in ER Tables 5.4-1, 5.4-2, and 5.4-3 (TVA 2017-TN4921). TVA calculated per unit and per site liquid pathway doses to the MEI; these dose estimates are shown in ER Tables 5.4-8 and 5.4-9 (TVA 2017-TN4921). The results show that the MEI is an adult for whom the majority of the dose comes from fish and invertebrate ingestion, and the maximally exposed organ is the gastrointestinal lining of the lower intestine (see EIS Table 5-5). ER Table 5.4-12 provides the annual whole body and thyroid doses to the population per unit for the various liquid pathways calculated by TVA (TVA 2017-TN4921).

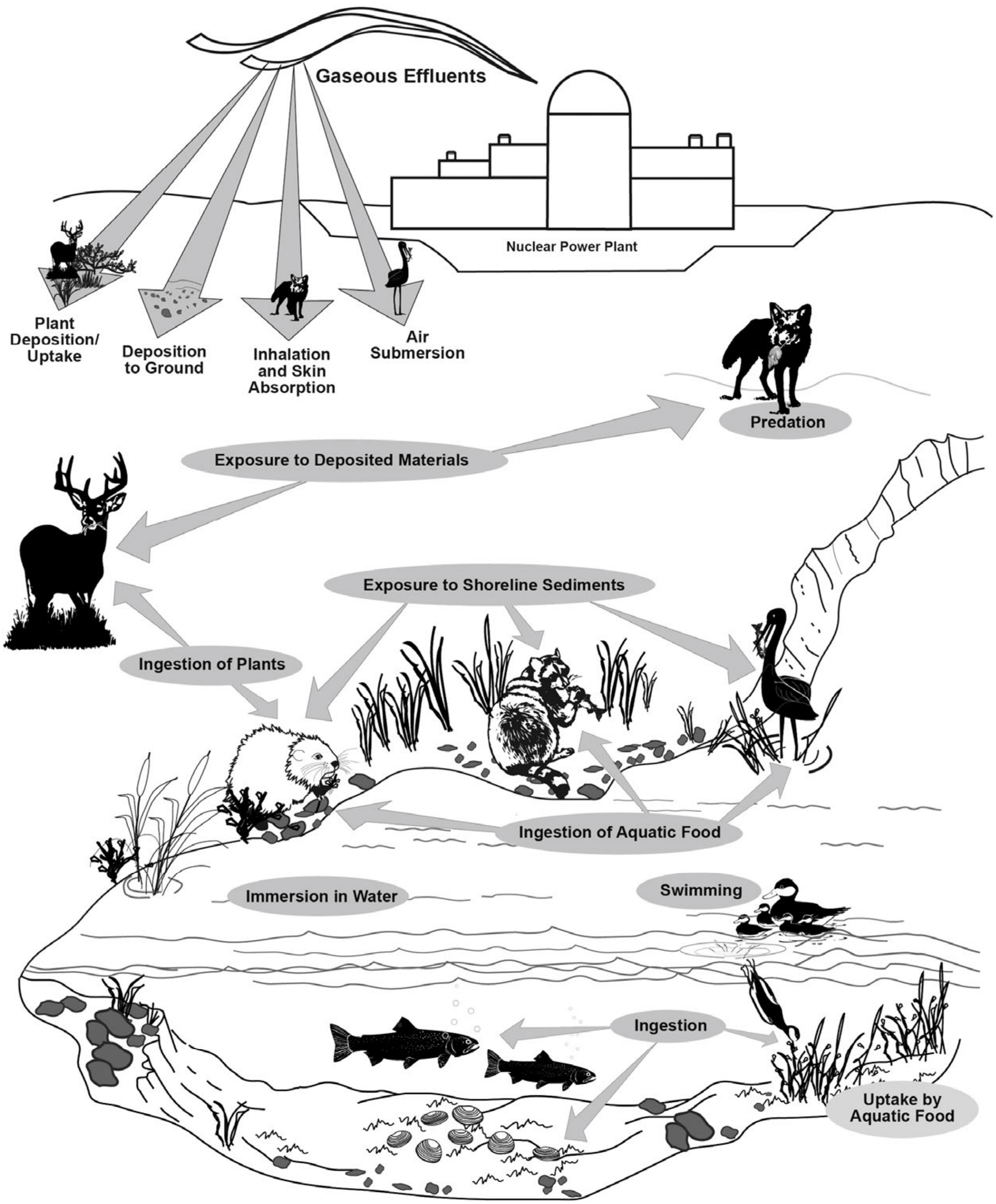

Figure 5-6. Example Exposure Pathways to Biota Other than Humans (Source: Soldat et al. 1974-TN710)

Table 5-5. Doses to the MEI for Liquid Effluent Releases from the CRN Site

Pathway	Age Group	Total Body (mrem/yr)	Maximum Organ (GI-LLI)[(a)] (mrem/yr)	Thyroid (mrem/yr)
Drinking Water	Adult	1.3×10^{-2}	1.7×10^{-2}	8.9×10^{-2}
	Teen	8.9×10^{-3}	1.2×10^{-2}	7.5×10^{-2}
	Child	1.7×10^{-2}	1.8×10^{-2}	1.8×10^{-1}
	Infant	1.6×10^{-2}	1.7×10^{-2}	2.8×10^{-1}
Fish and Invertebrate	Adult	1.1×10^{-1}	2.8×10^{-1}	3.8×10^{-2}
	Teen	7.4×10^{-2}	1.9×10^{-1}	3.6×10^{-2}
	Child	4.3×10^{-2}	6.7×10^{-2}	4.0×10^{-2}
Direct Radiation	All	6.8×10^{-4}	6.8×10^{-4}	6.8×10^{-4}

(a) GI-LLI = gastrointestinal lining of lower intestine.

Sources: Table 5.4-9 in TVA 2017-TN4921 and TVA 2016-TN5002.

The NRC staff recognizes the LADTAP II computer program as an appropriate method for calculating the dose to the MEI for liquid effluent releases. The NRC staff performed an independent evaluation of liquid pathway doses by using input parameters from the ER, and results were similar to those in the ER. The NRC staff determined that all the input parameters used in TVA's calculations are appropriate. Results of NRC staff's independent evaluation are presented in Appendix G of the EIS.

5.9.2.2 Gaseous Effluent Pathway

TVA calculated the gaseous pathway doses to the MEI using the GASPAR II computer program (Strenge et al. 1987-TN83) at the following locations: nearest meat animal, nearest residence, nearest vegetable garden, and nearest site boundary. The GASPAR II computer program was also used to calculate annual population doses. The following activities were considered in the dose calculations: (1) direct radiation from submersion in the gaseous effluent cloud and exposure to particulates deposited on the ground; (2) inhalation of gases and particulates; (3) ingestion of milk and meat from animals eating grass affected by gases and particulates deposited on the ground; and (4) ingestion of foods (e.g., vegetables) affected by gases and particulates deposited on the ground.

The gaseous effluent release source term used in the estimate of dose to the MEI and population are found in ER Tables 3.5-3 and 3.5-4 (TVA 2017-TN4921). Other parameters used as inputs to the GASPAR II program, including population data, milk production rates, vegetable production rates, meat production rates, atmospheric dispersion factors, ground deposition factors, receptor locations, and consumption factors, are found in ER Tables 5.4-5 and 5.4-7 (TVA 2017-TN4921).

Gaseous pathway doses to the MEI calculated by TVA are found in ER Tables 5.4-10 and 5.4-11, per unit and per site, respectively (TVA 2017-TN4921). ER Tables 5.4-13 and 5.4-17 (per unit and per site, respectively) show the annual total body and thyroid doses to the population from various gaseous pathways calculated by TVA (2017-TN4921).

The NRC staff recognizes the GASPAR II computer program as an appropriate tool for calculating dose to the MEI and population from gaseous effluent releases. The NRC staff performed an independent evaluation of gaseous pathway doses by running the GASPAR II computer program using input parameters from the ER, and found consistent results (see EIS Table 5-6). The NRC staff determined that the input parameters used in TVA's calculations were not unreasonable. Results of the NRC staff's independent evaluation are found in Appendix G of this EIS.

Table 5-6. Doses to the MEI from the Gaseous Effluent Pathway for the CRN Site[(a)]

Location	Age Group	Total Body Dose (mrem/yr)	Max Organ (Thyroid) (mrem/yr)	Skin Dose[(b)] (mrem/yr)
Plume (0.66 mi WNW)	All	$5.0 \times 10^{+0}$	$5.0 \times 10^{+0}$	$1.1 \times 10^{+1}$
Ground (0.66 mi WNW)	All	4.3×10^{-1}	4.3×10^{-1}	5.1×10^{-1}
Inhalation nearest residence (0.66 mi WNW)	Adult	6.0×10^{-1}	$5.1 \times 10^{+0}$	$0.0 \times 10^{+0}$
	Teen	6.1×10^{-1}	$6.4 \times 10^{+0}$	$0.0 \times 10^{+0}$
	Child	5.4×10^{-1}	$7.6 \times 10^{+0}$	$0.0 \times 10^{+0}$
	Infant	3.1×10^{-1}	$6.8 \times 10^{+0}$	$0.0 \times 10^{+0}$
Vegetable (1.15 mi WNW)	Adult	$1.1 \times 10^{+0}$	$4.0 \times 10^{+0}$	$0.0 \times 10^{+0}$
	Teen	$1.5 \times 10^{+0}$	$5.2 \times 10^{+0}$	$0.0 \times 10^{+0}$
	Child	$3.1 \times 10^{+0}$	$1.0 \times 10^{+1}$	$0.0 \times 10^{+0}$
Meat animals (0.70 mi WNW)	Adult	7.0×10^{-1}	9.0×10^{-1}	1.3×10^{-2}
	Teen	5.5×10^{-1}	7.0×10^{-1}	1.3×10^{-2}
	Child	$9.6 \times 10^{+0}$	$1.2 \times 10^{+0}$	1.3×10^{-2}
Milk animals (N/A)	Adult	–	–	–
	Teen	–	–	–
	Child	–	–	–
	Infant	–	–	–

(a) Ground-level releases were assumed. Doses are based on 2 years of meteorological data (see EIS Section 2.9.3).
(b) No infant doses were calculated for the vegetable and meat pathway because the doses that infants receive by consumption are only from milk, drinking water, and inhalation (NRC 1977-TN90).

Source: Table 5.4-11 in the TVA ER (TVA 2017-TN4921).

5.9.3 Impacts on Members of the Public

This section describes the NRC staff's evaluation of the estimated impacts from radiological releases and direct radiation from SMRs operating at the CRN Site. The evaluation addresses dose from operations to the MEI located near the CRN Site and the population dose (collective dose to the population within 50 mi) around the site.

5.9.3.1 Maximally Exposed Individual

TVA states that the total body and organ dose estimates to the MEI from liquid and gaseous effluents for one SMR unit at the CRN Site would be within the design objectives of Appendix I (10 CFR Part 50, Appendix I [TN249]). The total body and maximum organ annual doses at the nearest location from liquid effluents were well within the respective 3 mrem and 10 mrem Appendix I design objectives. Annual doses at the exclusion area boundary from gaseous effluents were well within the Appendix I design objectives of 10 mrad air dose from gamma radiation, 20 mrad air dose from beta radiation, 5 mrem to the total body, and 15 mrem to the skin. In addition, the dose to the thyroid was within the 15 mrem Appendix I design objective. A comparison of dose estimates to MEI for SMRs at the CRN Site to the Appendix I design objectives is found in EIS Table 5-7. The NRC staff completed an independent evaluation of compliance with Appendix I dose design objectives and found similar results, as shown in Appendix G of this EIS. Gaseous and liquid effluents from the CRN Site would be below the Appendix I dose design objectives (TVA 2017-TN4921).

Table 5-7. Comparison of MEI Dose Estimates from Liquid and Gaseous Effluents of the CRN Site (per Unit) to 10 CFR Part 50 Appendix I, Design Objectives

Radionuclide Releases/Dose	Applicant Assessment	Appendix I Design Objectives
Gaseous effluents (noble gases only)		
Beta air dose (mrad/yr)	$1.2 \times 10^{+1}$	20
Gamma air dose (mrad/yr)	$9.5 \times 10^{+0}$	10
Total body dose (mrem/yr)	9.0×10^{-1}	5
Skin dose (mrem/yr)	$1.9 \times 10^{+0}$	15
Gaseous effluents (radioiodines and particulates)		
Organ dose − Thyroid (mrem/yr)	$4.5 \times 10^{+0}$	15
Liquid effluents		
Total body dose (mrem/yr)	2.0×10^{-2}	3
Maximum organ dose − GI-LLI[(a)] (mrem/yr)	9.7×10^{-2}	10

(a) GI-LLI = gastrointestinal lining of lower intestine.

Sources: Table 5.4-15 in the TVA ER (TVA 2017-TN4921); 10 CFR Part 50-TN249

TVA compared the combined dose estimates from SMRs at the CRN Site against 40 CFR Part 190 (TN739). Table 5-8 of this EIS shows that TVA's assessment of the total doses to the MEI (per site) would be well below the standards of 40 CFR Part 190 (TN739). The NRC staff completed an independent evaluation of compliance with the standards of 40 CFR Part 190 (TN739) and found similar results, as shown in Appendix G of this EIS.

Table 5-8. Comparison of MEI Doses from All Units for the CRN Site to 40 CFR Part 190

Type of Dose	Liquid	Gaseous	Direct[(a)]	Total	Limit
Whole Body (mrem/yr)	1.7×10^{-1} [(b)]	$1.0 \times 10^{+1}$ [(c)]	$1.0\times 10^{+0}$	$1.1 \times 10^{+1}$	25
Thyroid (mrem/yr)	6.6×10^{-1} [(d)]	$2.4 \times 10^{+1}$ [(e)]	$0.0\times 10^{+0}$	$2.5 \times 10^{+1}$	75
Other Organ (bone) (mrem/yr)	5.4×10^{-1} [(d)]	$2.3 \times 10^{+1}$ [(f)]	$0.0\times 10^{+0}$	$2.4 \times 10^{+1}$	25

(a) The direct dose rate is assumed to be 1 mrem/yr (TVA 2017-TN4921).
(b) Liquid MEI for total body dose is an adult.
(c) Gaseous MEI for total body is a child. The value is the sum of child total body dose from meat, milk, vegetable, and inhalation exposure plus the ground and plume exposure (TVA 2017-TN4921).
(d) Liquid MEI for both thyroid and bone doses is a child.
(e) Gaseous MEI for thyroid dose is a child. The value is the sum of child thyroid dose from milk and inhalation exposure plus the ground and plume exposure (TVA 2017-TN4921).
(f) Gaseous MEI for bone dose is a child. The value is the sum of child bone dose from meat, milk, vegetable, and inhalation exposure plus the ground and plume exposure (TVA 2017-TN4921).

Sources: Table 5.4-16 in the TVA ER (TVA 2017-TN4921; 40 CFR Part 190 (TN739).

5.9.3.2 Population Dose

TVA estimated the annual collective total body dose within a 50-mi radius of the CRN Site to be 68 person-rem/yr by multiplying the doses per unit by 4 to approximate the doses from all units.

TVA's per unit liquid and gaseous pathway collective doses are provided in Table 5-9 of this EIS (TVA 2017-TN4921). Collective dose was estimated using a combination of the GASPAR II and LADTAP II computer codes, accounting for gaseous and liquid effluent pathways, respectively. The estimated collective dose to the same population from natural background radiation is estimated to be about 8.3×10^5 person-rem/yr. The dose from natural background radiation was calculated by multiplying the 50-mi radius population estimate (2,658,157) for the year 2067 by the annual background dose rate (311 mrem/yr) (NCRP 2009-TN420). The year 2067 represents a 10-year period for licensing and construction and a 40-year period for operation from issuance of a COL. An additional description for use of the year 2067 is included in EIS Appendix G, Section G.1.1.4. The NRC staff's independent estimate of the collective dose (45 person-rem/yr) is also discussed in Appendix G of this EIS.

Table 5-9. Calculated Doses to the Population within 50 Mi of the CRN Site from Gaseous and Liquid Pathways

Pathway	Applicant Assessment (person-rem/yr)
Gaseous effluents	
Plume	8.0×10^{-1}
Ground	5.7×10^{-1}
Inhalation	$1.4 \times 10^{+0}$
Vegetable	$7.7 \times 10^{+0}$
Milk	$1.8 \times 10^{+0}$
Meat	$2.6 \times 10^{+0}$
Liquid effluents	
Ingestion (aquatic foods, water, and terrestrial irrigated foods)	$2.4 \times 10^{+0}$
External exposure (shoreline, swimming, and boating)	4.0×10^{-2}

Sources: Tables 5.4-12 and 5.4-13 in the TVA ER (TVA 2017-TN4921).

The NRC staff performed a comparison of the TVA population dose estimates taken from Tables 2.5.1-2, 2.5.1-3, 2.5.1-5, and 2.5.1-10 of the ER (TVA 2017-TN4921) with the staff estimates. The staff's independent calculation for population dose yielded results that were comparable to the TVA SAR estimates for a new SMR plant. For calculating the population dose from gaseous effluents, the population distribution used by TVA and the NRC staff was for year 2067. The NRC staff estimates were slightly different than the estimates by TVA (TVA 2017-TN4921) and are presented in Appendix G of this EIS.

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 greater for higher radiation exposures. Therefore, a linear, no-threshold dose response model is used to describe the relationship between radiation dose and detriments such as cancer induction. Simply stated, any increase in dose, no matter how small, results in an incremental increase in health risk. A recent report by the National Research Council (2006-TN296), the Biological Effects of Ionizing Radiation (BEIR) VII report, uses the linear, no-threshold dose response model as a basis for estimating the risks from low doses. This approach is accepted by the NRC staff as a conservative model for estimating health risk from radiation exposure, recognizing the model probably overestimates those risks. Based on this method, the NRC staff estimated the risk to the public from radiation exposure using the nominal probability coefficient for total detriment. In a publication of the International Commission on Radiological Protection (ICRP) (ICRP 2007-

TN422), a health detriment of 570 effects per 1,000,000 person-rem (or 0.00057 effects per person-rem) was associated with fatal cancers, nonfatal cancers, and severe hereditary effects.

Both the 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-rem), the assessment should find that the most likely number of excess health effects is zero (NCRP 1995-TN728; ICRP 2007-TN422). As noted above, the estimated annual collective total body dose to the population living within 50 mi of the CRN Site is 45 person-rem, which is less than the 1,754 person-rem value that both ICRP and NCRP suggest would most likely result in zero excess health effects (NCRP 1995-TN728; ICRP 2007-TN422).

In addition, at the request of the U.S. Congress, the National Cancer Institute conducted a study and published a report in 1990 titled *Cancer in Populations Living Near Nuclear Facilities* (Jablon et al. 1991-TN77). The National Cancer Institute report included an evaluation of health statistics around all nuclear power plants, as well as several other nuclear fuel cycle facilities, in operation in the United States in 1981; it found “no evidence that an excess occurrence of cancer has resulted from living near nuclear facilities” (Jablon et al. 1991-TN77).

5.9.3.3 Summary of Radiological Impacts on Members of the Public

The NRC staff evaluated the health impacts from routine gaseous and liquid radiological effluent releases from a new nuclear plant at the CRN Site. Based on the information provided by TVA and the NRC staff’s own independent evaluation, the NRC staff concludes there would be no observable health impacts on the public from normal operation of a new nuclear power plant, the health impacts would be SMALL, and additional mitigation would not be warranted.

5.9.4 Occupational Doses to Workers

TVA estimates that the projected radiation dose to a construction worker from licensed operations would be less than 100 mrem annually as specified in 10 CFR 20.1301 (TN283). TVA would need to maintain individual doses to operational workers within 5 rem annually as specified in 10 CFR 20.1201 (TN283) and incorporate as low as is reasonably achievable (ALARA) provisions to maintain doses below this limit. The NRC staff concludes that the health impacts from radiation exposure to the operations workforces would be SMALL based on individual doses for workers being maintained within 10 CFR 20.1201 limits.

5.9.5 Impacts on Biota Other than Humans

TVA estimated doses to nonhuman biota in the site environs using surrogate species. Surrogate species used in the ER are well defined and provide an acceptable method for evaluating doses to nonhuman biota (TVA 2017-TN4921). Surrogate species analysis was performed for aquatic species such as fish, invertebrates, and algae, and for terrestrial species such as muskrats, raccoons, and birds, such as herons and ducks. Exposure pathways considered in evaluating doses to biota other than humans were discussed in EIS Section 5.9.1 and are shown in Figure 5-5. The NRC staff has reviewed TVA’s analysis and completed an independent evaluation that found similar results, as shown in Appendix G.

5.9.5.1 Liquid Effluent Pathway

TVA used the LADTAP II computer code (Strenge et al. 1986-TN82) to calculate doses to nonhuman biota from the liquid effluent pathway. In estimating the concentration of radioactive effluents in the Clinch River arm of the Watts Bar Reservoir, TVA included no credit for dilution or transit time from the outflow. Liquid pathway doses were higher for nonhuman biota than for humans because of considerations for bioaccumulation of radionuclides, ingestion of aquatic plants, ingestion of invertebrates, increased time spent in water and on the shoreline compared to humans, and the assumption of no dilution beyond the outflow. The liquid effluent release parameters used in estimating nonhuman biota dose are found in ER Table 5.4-3 (TVA 2017-TN4921). The doses to nonhuman biota from liquid effluent doses (from all units) are provided in ER Table 5.4-18 (TVA 2017-TN4921).

5.9.5.2 Gaseous Effluent Pathway

Gaseous effluents would contribute to the total body dose of the terrestrial surrogate species (i.e., muskrat, raccoon, heron, and duck). The exposure pathways include inhalation of airborne radionuclides, external exposure due to immersion in gaseous effluent plumes, and surface exposure from deposition of iodine and particulates from gaseous effluents. TVA used the calculations methods of MEI from gaseous effluent releases described in EIS Section 5.9.2 to calculate dose to terrestrial surrogate species, with a modification increasing the ground deposition factors by a factor of two to account for the closer proximity of terrestrial animals to the ground compared to the MEI. The effluent parameters used in estimating dose are found in ER Table 5.4-4, and the gaseous doses are presented in ER Table 5.4-13 (TVA 2017-TN4921). Total body dose estimates to the surrogate species from the gaseous pathway are shown in Table 5-10 (TVA 2017-TN4921).

Table 5-10. Nonhuman Biota Dose Rates from All SMR Units at the CRN Site

Biota	Liquid Pathway (mrad/yr)	Gaseous Pathway (mrad/yr)	Total Body Biota Dose All Pathways (mrad/yr)
Fish	$1.6 \times 10^{+0}$	0	$1.6 \times 10^{+0}$
Invertebrate	$7.6 \times 10^{+0}$	0	$7.6 \times 10^{+0}$
Algae	$2.5 \times 10^{+0}$	0	$2.5 \times 10^{+0}$
Muskrat	$3.4 \times 10^{+0}$	$8.4 \times 10^{+1}$	$8.7 \times 10^{+1}$
Raccoon	$1.3 \times 10^{+0}$	$8.4 \times 10^{+1}$	$8.5 \times 10^{+1}$
Heron	$8.9 \times 10^{+0}$	$8.4 \times 10^{+1}$	$9.3 \times 10^{+1}$
Duck	$3.2 \times 10^{+0}$	$8.4 \times 10^{+1}$	$8.7 \times 10^{+1}$

Source: Tables 5.4-18 and 5.4-20 in the TVA ER (TVA 2017-TN4921).

5.9.5.3 Impact of Estimated Nonhuman Biota Doses

The International Atomic Energy Agency (IAEA) and NCRP reported a chronic absorbed dose rate of no greater than 1,000 mrad/d would ensure protection of aquatic organism populations (IAEA 1992-TN712; NCRP 1991-TN729). IAEA also concluded that a chronic absorbed dose rate of 100 mrad/d or less does not appear to cause observable changes in terrestrial animal populations (IAEA 1992-TN712).

Table 5-11 compares estimated absorbed dose rates to surrogate biota species produced by releases from the CRN Site (TVA 2017-TN4921) to the IAEA/NCRP biota dose guidelines (IAEA 1992-TN712; NCRP 1991-TN729). The absorbed dose rates from all surrogate species were much lower than the guidelines. The absorbed dose rate estimated for the CRN Site is conservative because no consideration was given to dilution or decay of liquid effluents during transit. Actual absorbed dose rates to biota are likely to be much lower than the IAEA/NCRP biota dose guidelines.

Table 5-11. Comparison of Nonhuman Biota Dose Rates from All SMR Units at the CRN Site to Relevant Guidelines for Nonhuman Biota Protection

Biota	Total Body Dose Rate for CRN Site[(a),(b)] (mrad/d)	IAEA/NCRP Guidelines for Protection of Nonhuman Biota Populations[(b),(c)] (mrad/d)
Fish	4.5×10^{-3}	1,000
Invertebrate	2.1×10^{-2}	1,000
Algae	6.7×10^{-3}	1,000
Muskrat	2.4×10^{-1}	100
Raccoon	2.3×10^{-1}	100
Heron	2.5×10^{-1}	100
Duck	$2.4 \times 10^{+1}$	100

(a) Estimate of the total absorbed dose rate based on the annual dose to nonhuman biota from liquid and gaseous effluents as given in ER Table 5.4-20 (TVA 2017-TN4921).
(b) Divide mrad/d by 100 to obtain mGy/d.
(c) IAEA and NCRP guidelines for protection of nonhuman biota populations (IAEA 1992-TN712; NCRP 1991-TN729).

On the basis of the information provided by TVA and the NRC staff's independent evaluation, the NRC staff concludes that the radiological impact on nonhuman biota from a new nuclear power plant at the CRN Site would be SMALL, and additional mitigation is not warranted.

5.9.6 Radiological Monitoring

A REMP would be put into place for the CRN Site per the requirements of NRC Regulatory Guide (RG) 4.1, *Radiological Environmental Monitoring for Nuclear Power Plants* (NRC 2009-TN3802; TVA 2017-TN4921). The REMP would include monitoring of the airborne exposure pathway, direct exposure pathway, water exposure pathway, aquatic exposure pathway from the Clinch River arm of the Watts Bar Reservoir, and ingestion exposure pathway in a 5-mi radius of the station, with indicator locations near the site perimeter and control locations at distances greater than 10 mi. An annual survey would be conducted of the area surrounding the site to verify the accuracy of land-use assumptions used in the analyses, including the occurrence of milk production. The preoperational REMP would sample various media in the environment to determine a baseline from which to observe the magnitude and fluctuation of radioactivity in the environment once the new power plant began operation.

The preoperational program would include collection and analysis of air particulates, precipitation, food products, ground water, drinking water, surface water, fish, sediment, iodine in milk (if milk cattle are determined to be within 5 mi of the site) as well as measurement of direct ambient gamma radiation. After operation, the monitoring program would assess the radiological impacts on workers, the public, and the environment. Radiological releases would be summarized in Annual Radiological Environmental Operating Reports and annual radioactive effluent release reports. The limits for all radiological releases would be specified in respective Offsite Dose Calculation Manuals. Administrative controls and physical barriers would be in place or would be implemented to monitor and minimize dose to construction workers from SMR units that are operational.

TVA provided potential REMP sampling station locations in ER Table 6.2-2 (TVA 2017-TN4921). The NRC staff will review the finalized monitoring locations and other monitoring requirements provided with the COL application. During the COL application phase, the NRC staff will determine whether the operational REMP will be adequate for the evaluation of impacts on the environment related to operating a new nuclear power plant at the CRN Site.

5.10 Nonradioactive Waste Impacts

This section describes the potential impacts on the environment that could result from the generation, handling, and disposal of nonradioactive waste and mixed waste during operations at the proposed CRN Site. EIS Section 3.4.4 describes the nonradioactive waste systems. Types of nonradioactive waste that would be generated, handled, and disposed of during operational activities include solid wastes, liquid effluents, and air emissions. Solid wastes include municipal waste, 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. Air emissions would primarily be generated by vehicles and diesel generators. In addition, small quantities of hazardous waste, and mixed waste, which is waste that has both hazardous and radioactive characteristics, may be generated during plant operations. The assessment of potential impacts resulting from these types of wastes is presented in the following sections.

5.10.1 Impacts on Land

Management practices regarding solid-waste handling at the proposed CRN Site would be similar to those used at the Watts Bar Nuclear Power Plant (TVA 2017-TN4921). Operational solid wastes such as office waste, cardboard, wood, or metal would be recycled or reused to the extent possible (TVA 2017-TN4921). Estimates of nonhazardous solid-waste streams were not provided in the applicant's ER, but TVA provided the review team with an upper bound value of 290 tons of trash per month (TVA 2017-TN4922). This number was based on a 3-year average (2014 through 2016) of solid nonhazardous waste that was produced at Watts Bar Nuclear Units 1 and 2 (TVA 2017-TN4922). The estimated 290 tons of trash per month that is produced by Watts Bar is significantly greater than what is expected from the CRN Site reactors in the PPE. This makes the 290 tons per month a conservative upper bound (TVA 2017-TN4922). TVA plans to dispose of municipal solid waste such as resins and debris from trash racks and screens collected from the water-intake structure in offsite, licensed commercial disposal facilities (TVA 2017-TN4921). TVA would follow all applicable Federal, State, and local requirements and standards for handling, transporting, and disposing of solid waste (TVA 2017-TN4921).

Based on the plans to manage solid and liquid wastes in a manner similar to the existing Watts Bar Nuclear Power Plant in accordance with all applicable Federal, State, and local requirements and standards, and the effective practices for reusing, recycling, and minimizing waste, the review team expects that impacts on land from nonradioactive wastes generated during the operation of CRN units would be minimal, and no further mitigation would be warranted.

5.10.2 Impacts on Water

Water withdrawn from the Clinch River for cooling and other operational purposes for the proposed units would be discharged to the Clinch River. These discharges would contain both chemicals and biocides and would be controlled by a NPDES wastewater permit. Other potential nonradioactive liquid effluents from the proposed units operations are stormwater runoff and sanitary wastewater discharges (TVA 2017-TN4921). Stormwater at the proposed CRN Site would be routed through swales and infiltration beds located throughout the property to minimize runoff (TVA 2017-TN4921). The NPDES permit would limit the volume and constituent concentrations.

Sanitary wastewater would be discharged to the City of Oak Ridge wastewater treatment system (TVA 2017-TN4921). Sanitary waste flow rates are likely to be similar to those at the Watts Bar nuclear facility and would range from a normal daily rate of 50 gallons per minute (gpm) to a maximum effluent flow rate of 100 gpm (TVA 2017-TN4922). The main plant has a capacity of 30.0 million gallons per day (Mgd), and the Rarity Ridge plant has a capacity of 0.6 Mgd. The plants treat a combined flow of 5.6 Mgd (TVA 2017-TN4921). Both plants operate under current TDEC NPDES permits. The expected effluent flow from the potable/sanitary water system is an average daily flow of 72,000 gpd, and a maximum daily flow of 144,000 gpd (TVA 2017-TN4921). Sections 5.2.3.1 and 5.2.3.2 of this chapter discuss impacts on surface and groundwater quality from operation of CRN units.

Based on the regulated practices for managing liquid waste that would be implemented at the CRN Site, and the capacity for the local waste treatment plants to receive the volumes of sanitary wastes that would be generated by the proposed plant, the review team expects that impacts on water from nonradioactive effluents during the operation of CRN units would be minimal, and no further mitigation would be warranted.

5.10.3 Impacts on Air

Operation of proposed CRN units would result in gaseous emission from operation of diesel generators. Impacts on air quality are discussed in Section 5.7.2 of this chapter. In addition, vehicular traffic associated with personnel necessary to operate units would increase vehicle emissions in the area. Increases in air emissions from the operation of units would require compliance with the Federal and State air-quality control laws and regulations (TVA 2017-TN4921).

Based on the regulated practices for managing air emissions from stationary sources, the review team expects that impacts on air from nonradioactive emissions during the operation of CRN units would be minimal, and no further mitigation would be warranted.

5.10.4 Mixed-Waste Impacts

Mixed waste contains both low-level radioactive waste and hazardous waste. The generation, storage, treatment, or disposal of mixed waste is regulated by the Atomic Energy Act of 1954, as amended (42 U.S.C. § 2011 *et seq*.-TN663), the Solid Waste Disposal Act of 1965 (42

U.S.C. § 82 *et seq*.-TN1032), as amended by the Resource Conservation and Recovery Act (RCRA) in 1976 (42 U.S.C. § 6901 *et seq*.-TN1281), the Hazardous and Solid Waste Amendments (which amended RCRA in 1984 [42 U.S.C. § 6921 *et seq*.-TN1033]), and by Tennessee regulations overseen by TDEC.

The types of mixed waste that would be generated at the CRN Site may include the following (TVA 2017-TN4921):

- waste oil from pumps and other equipment
- chlorinated fluorocarbons resulting from cleaning, refrigeration, degreasing, and decontamination activities
- organic solvents, reagents, compounds, and associated materials such as rags and wipes
- metals such as lead from shielding applications and chromium from solutions and acids
- metal-contaminated organic sludge and other chemicals
- aqueous corrosives consisting of organic and inorganic acid.

As discussed in Section 3.6.3.3 of the ER, operation of the CRN units is expected to produce waste in quantities that would allow classification as a Small Quantity Generator of Hazardous Wastes that would be disposed of by a licensed hazardous-waste management facility (TVA 2017-TN4921). In addition, TVA would implement a waste minimization plan to reduce the amount of mixed waste produced onsite (TVA 2017-TN4921). Elements of the waste minimization plan include the following BMPs:

- inventory identification and control that uses a tracking system to manage waste generation data and waste minimization opportunities
- work planning to reduce mixed-waste generation (An example of work planning is pre-task planning to determine what materials and equipment are needed to perform the anticipated work.)
- mixed-waste reduction, recycling, and reuse methods that maximize opportunities for reclamation and reuse of waste materials whenever feasible
- training and education of employees on the principles and benefits of the waste minimization.

TVA stated that although the treatment, storage, and disposal methods for mixed wastes generated by the proposed units have not been established for the CRN Site, industry standard controls would be applied during all phases of storage (TVA 2017-TN4921).

Based on the practices for minimizing waste currently in place for Watts Bar Nuclear Power Plant (TVA 2017-TN4922) and the plans to manage mixed wastes in a similar manner in accordance with all applicable Federal, State, and local requirements and standards, the review team expects that impacts from the generation of mixed waste at the CRN Site would be minimal, and no further mitigation would be warranted.

5.10.5 Summary of Nonradioactive Waste Impacts

Solid, liquid, gaseous, and mixed wastes generated during operation of CRN units would be handled according to county, State, and Federal regulations. County and State permits and regulations for handling and disposal of solid waste would be obtained and implemented.

Discharges to the Clinch River of liquid effluents used for operations, including wastewater and stormwater, would be controlled and limited via an NPDES permit. Air emissions from units operations would be compliant with local, State, and Federal air-quality standards and regulations. The impacts of mixed-waste generation, storage, and disposal during operation of proposed units would be compliant with requirements and standards.

Based on the information provided by TVA, the effective practices for recycling, minimizing, managing, and waste disposal planned to be used at the CRN Site, the expectation that regulatory approvals would be obtained to regulate the additional waste that would be generated from proposed units, and the independent evaluations as discussed in the referenced sections of this EIS, the review team concludes that the potential impacts from nonradioactive waste resulting from the operation of the proposed units at the CRN Site would be SMALL, and no further mitigation would be warranted.

Cumulative impacts on water and air from nonradiological effluents and emissions are discussed in EIS Sections 7.2 and 7.6, respectively. For the purposes of EIS Chapter 9, the review team expects that there would be no substantive differences between the impacts of nonradiological waste for the proposed units and the alternative sites and no substantive cumulative impacts that warrant further discussion beyond those discussed for the alternative sites in EIS Section 9.3.

5.11 Environmental Impacts of Postulated Accidents

The NRC staff considered the radiological consequences on the environment of potential accidents at a new nuclear power plant at the CRN Site. Consequence estimates are based on the PPE that was developed considering four potential SMR technologies: the BWXT mPower™ SMR (NRC 2013-TN5231), Holtec SMR-160 (SMR 2017-TN5232), NuScale SMR (NuScale 2016-TN5233), and the Westinghouse SMR (Westinghouse 2013-TN5234).

The term "accident," as used in this section, refers to any off-normal event not addressed above in Section 5.9 that results in release of radioactive materials into the environment. The focus of this review is on events that could lead to releases substantially in excess of permissible limits for normal operations. Normal release limits are specified in 10 CFR Part 20, Appendix B, Table 2 (TN283).

Many safety features combine to reduce the risk associated with accidents at nuclear power plants. Safety features in the design, construction, and operation of nuclear units at the sites, which compose the first line of defense, are intended to prevent the release of radioactive materials from the site. A range of active and passive safety feature systems are included in the SMR designs being considered. The passive safety features rely almost exclusively on natural forces, such as natural circulation of cooling water for safe shutdown, that require minimal reliance on offsite utilities or operator actions. The design objectives and the measures for keeping levels of radioactive materials in effluents to unrestricted areas ALARA are specified in 10 CFR Part 50, Appendix I (TN249). Additional measures are designed to mitigate the consequences of failures in the first line of defense. These include NRC reactor site criteria in 10 CFR Part 100 (TN282), which require the site to have certain characteristics that reduce the risk to the public and the potential impacts of an accident, and emergency preparedness plans and protective action measures for the site and environs, as set forth in 10 CFR 50.47 (TN249), 10 CFR Part 50, Appendix E (TN249), and NUREG–0654/FEMA-REP-1 (NRC 1980-TN512). All of these safety features, measures, and plans make up the defense-in-depth philosophy to protect the health and safety of the public and the environment.

On March 11, 2011, and for an extended period thereafter, several nuclear power plants in Japan experienced the loss of important equipment necessary to maintain reactor cooling after the combined effects of severe natural phenomena (i.e., an earthquake followed by a tsunami it caused). In response to these events, the Commission established the Near-Term Task Force (NTTF) to review the current regulatory framework in place in the United States and to make recommendations for improvements. The task force reported the results of its review (NRC 2011-TN684) and presented its recommendations to the Commission on July 12 and July 19, 2011, respectively. As part of the short-term review, the task force concluded that while improvements are expected to result from the lessons learned, the continued operation of nuclear power plants and licensing activities for new plants did not pose an imminent risk to public health and safety. A number of areas were recommended to the Commission for long-term consideration. Collectively, these recommendations are intended to clarify and strengthen the regulatory framework for protection against severe natural phenomena, mitigation of the effects of such events, coping with emergencies, and improving the effectiveness of NRC programs.

On March 12, 2012, the Commission issued three Orders and a Request for Information to holders of U.S. commercial nuclear reactor licenses and construction permits to enhance safety at U.S. reactors based on specific lessons learned from the event at Japan's Fukushima Dai-ichi Nuclear Power Plant as identified in the task force report.

The first Order (EA-12-049) and third Order (EA-12-051) apply to every U.S. commercial nuclear power plant, including recently licensed new reactors (77 FR 16091-TN2476; 77 FR 16082-TN1424). The first Order requires a three-phase approach for mitigating beyond-design basis external events. Licensees are required to use installed equipment and resources to maintain or restore cooling of the core, containment, and spent fuel during the initial phase (possibly 72 hours or longer, dependent on the reactor design). During the transition phase (the next 4 days), licensees are required to provide portable, onsite equipment and consumables sufficient to maintain or restore these functions until they can be accomplished with resources brought from offsite. During the final phase (after 7 days), licensees are required to obtain sufficient offsite resources to sustain those functions indefinitely (77 FR 16091-TN2476). The second Order (EA-12-050) requires reliable hardened vent systems at boiling water reactor facilities with "Mark I" and "Mark II" containment structures (77 FR 16098-TN2477). The third Order requires reliable spent fuel pool level instrumentation (77 FR 16082-TN1424). The Request for Information addressed five topics: (1) seismic reevaluations, (2) flooding reevaluations, (3) seismic hazard walkdowns, (4) flooding hazard walkdowns, and (5) a request for licensees to assess their current communications system and equipment under conditions of onsite and offsite damage and prolonged station blackout, and perform a staffing study to determine the number and qualifications of staff required to fill all necessary positions in response to a multi-unit event (NRC 2012-TN3236; 77 FR 16082-TN1424; 77 FR 16091-TN2476; NRC 2012-TN3237). The Request for Information asked reactor licensees to reevaluate seismic and flooding hazards using methods to determine if their plants' design should be changed.

Each new reactor application evaluates the natural phenomena against the site for the proposed reactor design by applying present-day regulatory guidance and methodologies. This includes the determination of the characteristics of the flood and seismic hazards. With respect to flooding, TVA in Site Safety Analysis Report (SSAR) Section 2.4, Hydrologic Engineering, provided the necessary flood hazard analysis (TVA 2017-TN5387). The NRC staff will review and evaluate the information submitted by the applicant concerning the potential for flooding at the site due to a variety of causes, for example, including probable maximum precipitation, probable maximum flooding on rivers and streams, and potential dam failures. Based on a review and evaluation of the applicant's information, the NRC staff must determine whether the applicant appropriately considered flood-causing phenomena and their combinations that are relevant for the CRN Site. The detailed results of the NRC staff's safety review for flooding will be available for public inspection in Section 2.4, Hydrologic Engineering, of the safety evaluation report (SER) at a future date.

With respect to the consideration of severe accidents initiated by seismic events, TVA submitted in SSAR Section 2.5, Geology, Seismology, and Geotechnical Engineering, the CRN Site seismic hazard analysis (TVA 2017-TN5387). In this analysis, the applicant evaluates the impacts of the Central and Eastern United States Seismic Source Characterization model, as documented in NUREG–2115 (NRC 2012-TN3810), on the CRN Site-specific seismic hazard calculation. This model considers up-to-date seismic source information for the Central and Eastern United States. The NRC staff will review and evaluate the applicant's Section 2.5 of the SSAR and will determine whether the applicant's analyses of vibratory ground motion adequately characterizes the CRN Site. An applicant for a COL or CP referencing the CRN Site ESP, is expected to use these analyses in its accident analyses and design margin determination. The detailed results of the NRC staff's safety review for seismic events will be available for public inspection in Section 2.5, Geology, Seismology, and Geotechnical Engineering, of the SER at a future date.

In addition to the above seismic and flooding considerations, the staff expects the safety features of the SMR designs could further address the environmental risks of severe accidents considered in this CR ESP EIS analysis. The expected SMR designs could have additional capabilities, such as below-grade containment and passive containment cooling for the ultimate heat sink, to avoid severe accidents as well as implementing mitigation strategies to withstand severe accidents. Additionally, in accordance with Nuclear Electric Institute (NEI) and staff guidance on implementing EA-12-049 (NEI 2015-TN5062; NRC 2017-TN5063), future COL applicants would be responsible for describing their proposed overall implementation of these mitigation strategies, such as the industry's "FLEX" and station blackout mitigating strategies, or they must provide design or engineered alternatives. As such, at the time of a COL application, TVA would need to document how the selected reactor design and proposed mitigation strategies meet the requirements of the orders.

In sum, none of the information the NRC staff has identified about the Fukushima accident or about the steps taken by the NRC to date to implement the NTTF recommendations suggests that the seismic and flooding hazards assumed in this EIS would not affect the severe accident analysis. In addition, the available mitigation capability (i.e., passive safety systems) were not taken into account in the severe accident analysis to lessen the assumed risk of a severe accident. For these reasons, the NRC's analysis of the environmental impacts of design basis and severe accidents presented herein remains valid.

This section discusses (1) the types of radioactive materials; (2) the paths to the environment; (3) the relationship between radiation dose and health effects; and (4) the environmental impacts of reactor accidents, including both design basis accidents (DBAs) and severe accidents. The environmental impacts of accidents during transportation of spent fuel are discussed in Chapter 6 of this EIS.

The potential for dispersion of radioactive materials in the environment depends on the mechanical forces that physically transport the materials and on the physical and chemical forms of the material. Radioactive material exists in a variety of physical and chemical forms.

The majority of the radioactive material in the fuel is in the form of nonvolatile solids. However, there is a significant amount of radioactive material in the form of volatile solids or gases. The gaseous radioactive materials include the chemically inert noble gases (e.g., krypton and xenon), which have a high potential for release. Radioactive forms of iodine, which are created in substantial quantities in the fuel by fission, are volatile. Other radioactive materials formed during the operation of a nuclear power plant have lower volatilities and, therefore, have lower tendencies to escape from the fuel than the noble gases and iodines.

Radiation dose to individuals is determined by their proximity to radioactive material, the duration of their exposure, and the extent to which they are shielded from the radiation. Pathways that lead to radiation exposure include (1) external radiation from radioactive material in the air, on the ground, and in the water; (2) inhalation of radioactive material; and (3) ingestion of food or water containing material initially deposited on the ground and in water.

Radiation protection experts assume that any amount of radiation exposure may pose some risk of causing cancer or a severe hereditary effect and that the risk is higher for higher radiation exposures. Therefore, a linear, no-threshold response relationship is used to describe the relationship between radiation dose and detriments such as cancer induction. A report by the National Research Council, the BEIR VII report, uses the linear, no-threshold dose response model as a basis for estimating the risks from low doses (National Research Council 2006-TN296). This approach is accepted by the NRC as a conservative model for estimating health risks from radiation exposure, recognizing that the model may overestimate those risks.

Physiological effects are clinically detectable if individuals receive radiation exposure resulting in a dose greater than about 25 rad over a short period of time (hours). Doses of about 250 to 500 rad received over a relatively short period (hours to a few days) can be expected to cause some fatalities.

5.11.1 Design Basis Accidents

TVA evaluated the potential consequences of postulated accidents to demonstrate that an SMR represented by a surrogate SMR based on a PPE could be constructed and operated at the CRN Site without undue risk to the health and safety of the public (TVA 2017-TN4921). This evaluation uses a representative DBA for the CRN Site based on site-specific meteorology. It examines the accident with the highest offsite consequences (Loss-of-Coolant Accident [LOCA]) for the surrogate SMR being considered for the CRN Site.

SSAR Section 1.11 (TVA 2017-TN5387), as modified by supplemental information to the ER that TVA provided (TVA 2016-TN5019), along with ER Section 3.2 (TVA 2017-TN4921) discusses the four conceptual light water-cooled SMR designs considered by TVA. These four designs were used to create a “surrogate SMR” based on NEI 10-01, “Industry Guideline for Developing a Plant Parameter Envelope in Support of Early Site Permit” (NEI 2012-TN5237). The PPE data pertinent to the DBA analysis are found in ER Table 3.1-2 under PPE Sections 9.1 and 16.1 (TVA 2017-TN4921).

All four designs are considered passively safe, where for safe shutdown, they require minimal (or no) reliance on offsite power, offsite water, or operator actions (TVA 2017-TN4920). These unique design features preclude various conventional reactor design basis events. For the SMR designs, the primary coolant system and most of its components (i.e., pressurizer, steam generators, and reactor coolant pumps, where applicable) are integrated into an enclosed single vessel rather than being segregated as individual components as occurs in the current-generation reactors.

Reactor accident analyses model time-dependent transport of radionuclides out of the reactor core through several pathways, where each pathway has different time-dependent radionuclide removal mechanisms. Because each of the four reactor designs considered would have different release pathways, and each pathway would pose different release rates and radionuclide removal mechanisms, the vendor design that generated the largest post-accident dose from the LOCA was selected for use in the CRN Site-specific accident analysis.

As discussed in ER Section 7.1 (TVA 2017-TN4921), past pressurized water reactor DBA analyses have shown that offsite doses due to a postulated LOCA are expected to more closely approach 10 CFR 52.17 (TN251) limits than other DBAs that may have a higher probability of occurrence but with resultant lower consequences. Therefore, TVA evaluated one DBA involving consequences from a LOCA resulting from the single largest break size for the design with the largest power level per SMR unit of the four SMR designs being considered. The potential consequences of accidental releases from a DBA depend on the specific radionuclides released, the amount of each radionuclide released, and the meteorological conditions.

As indicated in the ER (TVA 2017-TN4921) and supplemental information (TVA 2016-TN5019), TVA followed guidance in NEI 10-01 to derive the PPE source term for accidental airborne radioactive releases. TVA indicates that the source term for the surrogate SMR is based on the vendor design that was the most limiting because it was considered bounding for all four SMR designs. Some of the baseline assumptions used to derive the source term include:

- Core melt is based on NRC RG 1.183 methodology and assumed design containment leakage with reduction after 24 hours (NRC 2000-TN517).
- Passive containment fission product removal processes.

TVA based the source term on a standard LWR fuel enriched to less than 5 percent, which is representative of the SMR designs under consideration, a maximum single unit power level of 800 megawatt thermal (MW(t)), and an average burnup of 51 gigawatt days per metric tons of uranium (GWD/MTU) for the maximum assembly, while the maximum average burnup for the remaining SMR designs is less than 41 GWD/MTU (TVA 2017-TN4921). Although core power and burnup do not necessarily directly correlate, larger core powers and burnup generate higher activity releases (TVA 2016-TN5019). For the environmental analysis, the LOCA PPE source term is the same as that used to evaluate the DBA dose analysis for siting in SSAR Chapter 15 (TVA 2017-TN5387).

For environmental reviews, consequences are evaluated assuming realistic meteorological conditions. Meteorological conditions are represented in these consequence analyses by an atmospheric dispersion factor, which is also referred to as χ/Q. Acceptable methods of calculating χ/Q for DBAs from meteorological data are set forth in NRC RG 1.145 (NRC 1983-TN279). Consistent with NUREG–1555 (NRC 2000-TN614), the 50th percentile χ/Q values are used, which reflect probable meteorological conditions at the site.

Table 5-12 lists χ/Q values pertinent to the environmental review of the DBA for the CRN Site (TVA 2017-TN4921). The first column lists the time periods and boundaries for which χ/Q and dose estimates are needed. For the exclusion area boundary, the postulated DBA dose and its atmospheric dispersion factor are calculated for a short term, i.e., 2 hours; for the low-population zone, they are calculated for the course of the accident, i.e., 30 days composed of four time periods. The second column lists the χ/Q values presented in Table 7.1-2 of the TVA ER

(TVA 2017-TN4921). TVA calculated the χ/Q values listed in those tables using onsite meteorology described in SSAR Section 2.3 (TVA 2017-TN5387).

The specific CRN Site layout and building configuration has yet to be determined because a design has not yet been chosen. This results in uncertainties surrounding any modeling of near-field atmospheric dispersion around buildings (such as is needed to determine main control room doses). Thus, the COL applicant will need to verify that the χ/Q values presented in the ESP are still bounding during the COL application stage when a technology is selected and the specific plant layout will be known.

The NRC staff reviewed SSAR Section 2.3 and ER Section 2.7 for the meteorological data used by TVA and the related site-specific atmospheric dispersion factors (TVA 2017-TN5387). Based on these reviews and as discussed in EIS Section 2.9.3.1, the NRC staff concludes the atmospheric dispersion factors for the CRN Site are acceptable for use in evaluating potential environmental consequences of postulated DBAs.

Table 5-12. Atmospheric Dispersion Factors for CRN Site Design Basis Accident Calculations

Time Period and Boundary	χ/Q (s/m^3)
0 to 2 hr, or worst 2-hr period, EAB	5.58×10^{-4}
0 to 8 hr, LPZ	4.27×10^{-5}
8 to 24 hr, LPZ	3.80×10^{-5}
24 to 96 hr (1 to 4 d), LPZ	2.94×10^{-5}
96 to 720 hr (4 to 30 d), LPZ	2.04×10^{-5}

EAB = exclusion area boundary; LPZ = low-population zone.

Source: TVA 2017-TN4921.

Table 5-13 summarizes the dose consequences from the LOCA DBA considered by TVA for the surrogate SMR in terms of total effective dose equivalent (TEDE). TEDE is estimated by the sum of the committed effective dose equivalent from inhalation and the deep dose equivalent from external exposure.

Table 5-13. Doses for the Surrogate Plant LOCA

Time Period and Boundary	TEDE in rem[a]
0 to 2 hr, or worst 2-hr period, EAB	2.4
0 to 8 hr, LPZ	0.38
8 to 24 hr, LPZ	0.025
24 to 96 hr (1 to 4 d), LPZ	0.0098
96 to 720 hr (4 to 30 d), LPZ	0.015
LPZ TOTAL	0.43

EAB = exclusion area boundary; LPZ = low-population zone.
(a) To convert rem to Sv, divide by 100.

Source: Table 7.1-2 of TVA 2017-TN4921.

Dose conversion factors from Federal Guidance Report 13 (Eckerman et al. 1999-TN5020) were used to calculate the committed effective dose equivalent. Similarly, dose conversion factors from Federal Guidance Report 12 (Eckerman and Ryman 1993-TN3955) were used to calculate the deep dose equivalent.

The NRC staff reviewed the TVA selection of a DBA. Because design certifications of the SMR core designs have not been completed, the DBA selection is based on a surrogate SMR. The NRC staff considers this approach appropriate given that selection of DBAs will be revisited once the COL applicant has selected a specific design and submitted a COL application for approval, and this DBA is expected to bound consequences from a finalized design. In addition, the NRC staff reviewed the calculation of the site-specific consequences of the DBA and found the results of the calculations to be acceptable for the given DBA PPE source term.

There are no environmental criteria related to the potential consequences of DBAs. The calculated DBA doses shown in Table 5-13 are considerably smaller than the radiation dose limits of 10 CFR 50.67 (TN5414). Therefore, the NRC staff concludes the potential environmental impacts of the DBA for the surrogate SMR at the CRN Site would be small.

The NRC staff reviewed the TVA DBA analysis and site-specific data (TVA 2017-TN4921) for the surrogate SMR and found them to be not unreasonable, appropriate, and acceptable. The site-specific analysis results demonstrate that the surrogate SMR DBA doses meet the site acceptance criteria of 10 CFR 50.34 (TN249). On this basis, the NRC staff concludes that the environmental consequences from DBAs at the CRN Site would be of SMALL significance for any of the SMR reactor technologies being considered.

5.11.2 Severe Accidents

In its ER (TVA 2017-TN4921), TVA considers the potential consequences of severe accidents for four different SMR technologies at the CRN Site: BWXT mPower SMR (NRC 2013-TN5231), Holtec SMR-160 (SMR 2017-TN5232), NuScale SMR (NuScale 2016-TN5233), and Westinghouse SMR (Westinghouse 2013-TN5234). Three pathways are considered: (1) the atmospheric pathway, in which radioactive material is released to the air; (2) the surface-water pathway, in which airborne radioactive material falls out on open bodies of water; and (3) the groundwater pathway, in which groundwater is contaminated by a basemat melt-through with subsequent contamination of surface water by the groundwater.

Subpart B of 10 CFR Part 52 (TN251) requires applications for standard design certification to include information from the probabilistic risk assessment (PRA) of the design. Final design and PRA information were not available for the SMR technologies being considered at the time of the ESP application. TVA requested the necessary information from the four SMR vendors to enable an assessment of potential severe accident consequences. As discussed in ER Section 7.2, TVA selected design information that leads to bounding severe accident consequences based on the largest SMR considered for the CRN Site.

TVA bases its evaluation of the potential environmental consequences for the atmospheric and surface-water ingestion pathways on the results of the MELCOR Accident Consequence Code System (MACCS) computer code version 3.10.0 with the WinMACCS graphical user interface (Chanin and Young 1998-TN66). TVA estimated the severe accident source terms based on the largest SMR design being considered for the CRN Site (i.e., a maximum single unit power level of 800 MW(t)) (TVA 2017-TN4921). TVA considers this severe accident source term to be representative of what would be encountered as a result of severe accidents for the SMR designs that are within the PPE. In the evaluation, TVA used site-specific meteorological, population, and land-use data.

In conducting confirmatory calculations, the NRC staff evaluated impacts for three different plume exposure pathway emergency planning zone (EPZ) assumptions: 1) site boundary EPZ (at 0.21 mi.) considered in Part 5A of the TVA ESP application (TVA 2017-TN5443); 2) the 2-mi

EPZ considered in Part 5B of the TVA ESP application (TVA 2017-TN5442); and 3) a 10-mi EPZ, which is consistent with those assumed for large LWRs. The three evaluation assumptions were performed pending a final determination of the EPZ exemption request in Part 6 of the TVA ESP application (TVA 2017-TN5444).

TVA assumed that 99.5 percent of the population within the 2-mi EPZ of the CRN Site would be evacuated following notification of a general emergency. In conducting confirmatory calculations, the NRC staff made the same assumption for both the 2-mi EPZ and 10-mi EPZ offsite risk analyses. However, in the offsite risk analysis for the CRN site boundary EPZ analysis, the NRC staff assumed no evacuation occurs. This is because evacuation notifications are given to the population that resides within an EPZ, and there will be no residences within the CR Site boundary.

The MACCS computer code (Chanin et al. 1990-TN2056; Jow et al. 1990-TN526) was developed to evaluate the potential offsite consequences of severe accidents for the sites addressed in NUREG–1150 (NRC 1990-TN525). Version 3.10.0 of MACCS is the version employed in these calculations (Chanin and Young 1998-TN66). The MACCS code evaluates the consequences of atmospheric releases of material following a severe accident. The pathways modeled include exposure to the passing plume, exposure to material deposited on the ground and skin, inhalation of material in the passing plume and resuspended from the ground, and ingestion of contaminated food and surface water. Additionally, MACCS has (1) a flexible emergency-response model, (2) a library of radionuclides based on the Federal Guidance Report series documents, and (3) a semidynamic food-chain model (Chanin and Young 1998-TN66). To support the staff's review, TVA provided the NRC with copies of the input and output files for the MACCS computer runs (TVA 2017-TN5093). The NRC staff reviewed the input and output files and ran independent confirmatory calculations with the MACCS code with the results further discussed later in this section.

Environmental consequences of some potential surface-water pathways (e.g., swimming and aquatic food consumption) are not evaluated by MACCS. Similarly, the MACCS code does not address the potential environmental consequences of the groundwater pathway. TVA relied on generic environmental analyses in the GEIS (NRC 2013-TN2654) for these pathways.

Three types of severe accident consequences were assessed: (1) human health, (2) economic costs, and (3) land area affected by contamination. Human health effects are expressed in terms of the number of cancers that might be expected if a severe accident were to occur. These effects are directly related to the cumulative radiation dose received by the general population. MACCS estimates both early fatalities and latent cancer fatalities. Early fatalities are related to high doses or dose rates and can be expected to occur within a year of exposure (Jow et al. 1990-TN526). Latent cancer fatalities are related to exposure of a large number of people to low doses and dose rates and can be expected to occur after a latent period of several (2 to 15) years.

Population health-risk estimates are based on the population distribution within a 50-mi radius of the site. Economic costs of a severe accident include costs associated with short-term relocation of people; decontamination of property and equipment; interdiction of food supplies, land and equipment use; and condemnation of property. The affected land area is a measure of the areal extent of the residual contamination following a severe accident. Farmland decontamination is an estimate of the area that has an average whole body dose rate for the 4-year period following the release that would be greater than 0.005 Sv/yr (0.5 rem/yr) if not reduced by decontamination and that would have a dose rate following decontamination of less than 0.005 Sv/yr (0.5 rem/yr). Decontaminated land is not necessarily suitable for farming.

Risk is the product of the frequency or probability, and consequences of an accident. For example, the probability of a severe accident (also called core damage frequency [CDF]) without loss of containment for the surrogate SMR is estimated to be 4.27×10^{-8} per reactor-year (Ryr). TVA calculated the cumulative population dose associated with a severe accident without loss of containment assuming a 2-mi EPZ to be $1.12 \times 10^{+1}$ person-Sv ($1.12 \times 10^{+3}$ person-rem) (TVA 2017-TN4921). Therefore, the population dose risk for this release class is the product of 4.27×10^{-8} Ryr^{-1} and $1.12 \times 10^{+1}$ person-Sv and equals 4.79×10^{-7} person-Sv Ryr^{-1} (4.79×10^{-5} person-rem Ryr^{-1}).

The CDFs listed in this EIS are those estimated for the maximum thermal power rating for an SMR considered for the CRN Site based on the vendor information provided to TVA. TVA used the following six severe accident sequences (release categories) (TVA 2017-TN4921):

1. Intact Containment (IC): Containment integrity is maintained throughout the accident. The release of radioactivity to the environment is due to nominal design leakage.
2. Containment Bypass (BP): Radioactivity is released from the reactor coolant system to the environment via the secondary system or other interfacing system bypass. Containment failure occurs prior to the onset of core damage. This accident class contributes to the large, early release frequency.
3. Containment Isolation Failure (CI): Radioactivity is released through a failure of the valves that close the penetrations between containment and the environment. Containment failure occurs prior to the onset of core damage. This accident class contributes to the large, early release frequency.
4. Early Containment Failure (CFE): Radioactivity is released through a containment failure caused by some dynamic severe accident phenomenon after the onset of core damage but prior to core relocation. Such phenomena could include hydrogen detonation, hydrogen diffusion flame, steam explosions, or vessel failures. This accident class contributes to the large, early release frequency.
5. Intermediate Containment Failure (CFI): Radioactivity is released through a containment failure caused by some dynamic severe accident phenomenon after core relocation but before 24 hours have passed since initiation of the accident. Such phenomena could include hydrogen detonation and hydrogen deflagration. This accident class contributes to large releases but does not occur early in the accident life cycle.
6. Late Containment Failure (CFL): Radioactivity is released through a containment failure caused by some dynamic severe accident phenomenon more than 24 hours after initiation of the accident. Such phenomena could include the failure of containment heat removal. This accident class contributes to large releases but does not occur early in the accident life cycle.

5.11.2.1 Air Pathway

The MACCS code directly estimates consequences associated with releases to the air pathway. The results of the MACCS runs for the selected SMR design are presented in Table 5-14 to Table 5-16.

Table 5-14. Environmental Risks from a Severe Accident at the CRN Site Assuming a Site Boundary EPZ

		Environmental Risk[a]						
Release Category (Accident Class)	Description	Core Damage Frequency (Ryr^{-1})[b]	Population Dose Risk (person-rem/Ryr)[c]	Fatalities (Ryr^{-1}) Early[d]	Fatalities (Ryr^{-1}) Latent Cancer[e]	Cost[f] ($/Ryr)	Farm Land Decontamination[g] (ha/Ryr)	Population Dose from Water Ingestion (person-rem/Ryr)[c]
BP	Containment Bypass	2.03×10^{-9}	4.83×10^{-3}	2.96×10^{-9}	2.09×10^{-6}	1.69×10^{1}	3.92×10^{-5}	6.23×10^{-4}
CFE	Early Containment Failure	1.45×10^{-9}	1.15×10^{-3}	0.00	5.44×10^{-7}	2.18	4.93×10^{-6}	9.38×10^{-5}
CI	Containment Isolation Failure	2.56×10^{-10}	1.53×10^{-4}	2.97×10^{-12}	8.09×10^{-8}	4.38×10^{-1}	9.47×10^{-7}	1.09×10^{-5}
IC	Intact Containment	4.27×10^{-8}	3.47×10^{-5}	0.00	1.67×10^{-8}	8.71×10^{-4}	0.00	9.82×10^{-7}
CFI	Intermediate Containment Failure	3.72×10^{-11}	2.36×10^{-5}	0.00	1.20×10^{-8}	2.96×10^{-2}	9.23×10^{-8}	9.00×10^{-7}
CFL	Late Containment Failure	4.65×10^{-16}	3.46×10^{-10}	0.00	1.84×10^{-13}	4.88×10^{-6}	1.19×10^{-11}	1.26×10^{-12}
	Total	4.65×10^{-8}	6.19×10^{-3}	2.97×10^{-9}	2.74×10^{-6}	$1.95 \times 10^{+1}$	4.51×10^{-5}	7.30×10^{-4}

(a) NRC staff estimates.
(b) Core damage frequencies are based on data supplied by TVA (TVA 2017-TN4921).
(c) To convert person-rem to person-Sv, divide by 100.
(d) Early fatalities are fatalities related to high doses or dose rates that generally can be expected to occur within a year of the exposure (Jow et al. 1990-TN526).
(e) Latent cancer fatalities are fatalities related to low doses or dose rates that can be expected to occur after a latent period of several (2–15) years.
(f) Cost risk includes costs associated with short-term relocation of people, decontamination, interdiction, and condemnation. It does not include costs associated with health effects (Jow et al. 1990-TN526).
(g) Farm Land Decontamination area refers to land with contamination levels that could cause the average whole body dose rate for the 4-year period following the accident to exceed 0.005 Sv/yr if decontamination does not occur, but where this dose rate can be reduced to less than 0.005 Sv/yr by decontamination.

Table 5-15. Environmental Risks from a Severe Accident at the CRN Site Assuming a 2-Mi EPZ.

Release Category (Accident Class)	Description	Environmental Risk: Core Damage Frequency (Ryr^{-1})[a]	Population Dose Risk (person-rem/Ryr)[b]	Fatalities (Ryr^{-1}): Early[c]	Fatalities (Ryr^{-1}): Latent Cancer[d]	Cost[e] ($/Ryr)	Farm Land Decontamination[f] (ha/Ryr)	Population Dose from Water Ingestion (person-rem/Ryr)[b]
BP	Containment Bypass[g]	2.03×10^{-9}	6.12×10^{-3}	1.77×10^{-11}	3.19×10^{-6}	2.42×10^{1}	1.35×10^{-4}	1.01×10^{-4}
	Containment Bypass[h]	2.03×10^{-9}	4.71×10^{-3}	1.48×10^{-11}	2.03×10^{-6}	1.67×10^{1}	3.92×10^{-5}	6.23×10^{-4}
CFE	Early Containment Failure[g]	1.45×10^{-9}	1.26×10^{-3}	0.00	6.57×10^{-7}	4.50	3.08×10^{-5}	1.55×10^{-5}
	Early Containment Failure[h]	1.45×10^{-9}	1.12×10^{-3}	0.00	5.18×10^{-7}	2.15	4.93×10^{-6}	9.38×10^{-5}
CI	Containment Isolation Failure[g]	2.56×10^{-10}	2.54×10^{-4}	2.28×10^{-12}	1.97×10^{-7}	5.73×10^{-1}	3.86×10^{-6}	2.18×10^{-6}
	Containment Isolation Failure[h]	2.56×10^{-10}	1.46×10^{-4}	1.49×10^{-14}	7.42×10^{-8}	4.28×10^{-1}	9.47×10^{-7}	1.09×10^{-5}
IC	Intact Containment[g]	4.27×10^{-8}	4.79×10^{-5}	0.00	2.21×10^{-8}	2.53×10^{-2}	3.40×10^{-10}	1.94×10^{-7}
	Intact Containment[h]	4.27×10^{-8}	3.30×10^{-5}	0.00	1.58×10^{-8}	3.29×10^{-2}	0.00	9.82×10^{-7}
CFI	Intermediate Containment Failure[g]	3.72×10^{-11}	3.84×10^{-5}	4.06×10^{-15}	2.18×10^{-8}	4.09×10^{-2}	4.06×10^{-15}	2.07×10^{-7}
	Intermediate Containment Failure[h]	3.72×10^{-11}	2.25×10^{-5}	0.00	1.11×10^{-8}	2.88×10^{-2}	9.23×10^{-8}	9.00×10^{-7}
CFL	Late Containment Failure[g]	4.65×10^{-16}	1.52×10^{-7}	0.00	8.25×10^{-11}	6.05×10^{-4}	0.00	4.50×10^{-11}
	Late Containment Failure[h]	4.65×10^{-16}	3.48×10^{-10}	0.00	1.87×10^{-13}	4.84×10^{-6}	1.19×10^{-11}	1.26×10^{-12}
	Total[g]	4.65×10^{-8}	7.71×10^{-3}	2.00×10^{-11}	4.09×10^{-6}	2.93×10^{1}	1.69×10^{-4}	1.19×10^{-4}
	Total[h]	4.65×10^{-8}	6.03×10^{-3}	1.48×10^{-11}	2.65×10^{-6}	1.94×10^{1}	4.51×10^{-5}	7.30×10^{-4}

(a) Core damage frequencies are based on data supplied by TVA 2017-TN4921.
(b) To convert person-rem to person-Sv, divide by 100.
(c) Early fatalities are fatalities related to high doses or dose rates that generally can be expected to occur within a year of the exposure (Jow et al. 1990-TN526).
(d) Latent cancer fatalities are fatalities related to low doses or dose rates that can be expected to occur after a latent period of several (2–15) years.
(e) Cost risk includes costs associated with short-term relocation of people, decontamination, interdiction, and condemnation. It does not include costs associated with health effects (Jow et al. 1990-TN526).
(f) Farm Land Decontamination area refers to land with contamination levels that could cause the average whole body dose rate for the 4-year period following the accident to exceed 0.005 Sv/yr if decontamination does not occur, but where this dose rate can be reduced to less than 0.005 Sv/yr by decontamination.
(g) TVA estimates (TVA 2017-TN4921).
(h) NRC staff estimates.

Table 5-16. Environmental Risks from a Severe Accident at the CRN Site Assuming a 10-Mi EPZ

Release Category (Accident Class)	Description	Environmental Risk[a]						
		Core Damage Frequency (Ryr^{-1})[b]	Population Dose Risk (person-rem/Ryr)[c]	Fatalities (Ryr^{-1}): Early[d]	Fatalities (Ryr^{-1}): Latent Cancer[e]	Cost[f] ($/Ryr)	Farm Land Decontamination[g] (ha/Ryr)	Population Dose from Water Ingestion (person-rem/Ryr)[c]
BP	Containment Bypass	2.03×10^{-9}	4.67×10^{-3}	1.48×10^{-11}	2.00×10^{-6}	1.68×10^{1}	3.92×10^{-5}	6.23×10^{-4}
CFE	Early Containment Failure	1.45×10^{-9}	1.10×10^{-3}	0.00	5.10×10^{-7}	2.25	4.93×10^{-6}	9.38×10^{-5}
CI	Containment Isolation Failure	2.56×10^{-10}	1.44×10^{-4}	1.49×10^{-14}	7.19×10^{-8}	4.45×10^{-1}	9.47×10^{-7}	1.09×10^{-5}
IC	Intact Containment	4.27×10^{-8}	3.25×10^{-5}	0.00	1.55×10^{-8}	3.48	0.00	9.82×10^{-7}
CFI	Intermediate Containment Failure	3.72×10^{-11}	2.21×10^{-5}	0.00	1.08×10^{-8}	3.14×10^{-2}	9.23×10^{-8}	9.00×10^{-7}
CFL	Late Containment Failure	4.65×10^{-16}	3.46×10^{-10}	0.00	1.86×10^{-13}	4.84×10^{-6}	1.19×10^{-11}	1.26×10^{-12}
	Total	4.65×10^{-8}	5.97×10^{-3}	1.48×10^{-11}	2.61×10^{-6}	2.30×10^{1}	4.51×10^{-5}	7.30×10^{-4}

(a) NRC staff estimates.
(b) Core damage frequencies are based on data supplied by TVA (TVA 2017-TN4921).
(c) To convert person-rem to person-Sv, divide by 100.
(d) Early fatalities are fatalities related to high doses or dose rates that generally can be expected to occur within a year of the exposure (Jow et al. 1990-TN526).
(e) Latent cancer fatalities are fatalities related to low doses or dose rates that can be expected to occur after a latent period of several (2–15) years.
(f) Cost risk includes costs associated with short-term relocation of people, decontamination, interdiction, and condemnation. It does not include costs associated with health effects (Jow et al. 1990-TN526).
(g) Farm Land Decontamination area refers to land with contamination levels that could cause the average whole body dose rate for the 4-year period following the accident to exceed 0.005 Sv/yr if decontamination does not occur, but where this dose rate can be reduced to less than 0.005 Sv/yr by decontamination.

The CDFs given in Table 5-14 to Table 5-16 are for internally initiated accident sequences. Internally initiated accident sequences include sequences that are initiated by human error, equipment failures, loss of offsite power, etc. It should be noted that the CDFs cited by TVA are based on the largest SMR considered for the CRN Site. None of the SMR designs under consideration had submitted applications for certification to the NRC at the time of ESP submittal. Consequently, CDFs will be reevaluated at the COL stage once a specific SMR technology is selected for the CRN Site. The CDFs in Table 5-14 to Table 5-16 are the values available at the time the TVA ER was prepared.

Table 5-14 to Table 5-16 show that the probability-weighted consequences (i.e., risks) of severe accidents are small for all risk categories for the largest SMR design considered for the CRN Site for all of the EPZs considered. For perspective, Table 5-17 compares the health risks from severe accidents for the largest SMR design considered for the CRN Site with the risks for current-generation reactors at various sites.

In Table 5-17, the health risks estimated for the largest SMR considered for the CRN Site are compared with health-risk estimates for the five reactors considered in NUREG–1150 (NRC 1990-TN525) and also for Sequoyah Nuclear Power Plants, Units 1 and 2 in NUREG–1437 Supplement 53 (NRC 1990-TN525) and Watts Bar Nuclear Power Plant, Unit 2 in NUREG–0498 (NRC 1990-TN525). Although risks associated with both internally and externally initiated events were considered for the Peach Bottom and Surry reactors in NUREG–1150 (NRC 1990-TN525), only risks associated with internally initiated events are presented from NUREG–1150 in Table 5-17. The resulting health risks for the SMR designs considered at the CRN Site are lower than the risks associated with current-generation reactors presented in NUREG–1150 (NRC 1990-TN525).

The last two columns of Table 5-17 provide average individual fatality risk estimates. To put these estimates into context for the environmental analysis, the staff compares these estimates to the safety goals. The Commission has set safety goals for average individual early fatality and latent cancer fatality risks from reactor accidents in the Safety Goal Policy Statement (51 FR 30028 -TN594). These goals are presented here solely to provide a point of reference for the environmental analysis and do not serve the purpose of a safety analysis. The Policy Statement expressed the Commission’s policy regarding the acceptance level of radiological risk from nuclear power plant operation as follows:

- Individual members of the public should be provided a level of protection from the consequences of nuclear power plant operation such that individuals bear no significant additional risk to life and health.
- Societal risks to life and health from nuclear power plant operation should be comparable to or less than the risks of generating electricity by viable competing technologies and should not be a significant addition to other societal risks.

The following quantitative health objectives are used in determining achievement of the safety goals:

- The risk to an average individual in the vicinity of a nuclear power plant of prompt fatalities that might result from reactor accidents should not exceed one-tenth of 1 percent (0.1 percent) of the sum of prompt fatality risks resulting from other accidents to which members of the U.S. population are generally exposed.

- The risk to the population in the area near a nuclear power plant of cancer fatalities that might result from nuclear power plant operation should not exceed one-tenth of 1 percent (0.1 percent) of the sum of cancer fatality risks resulting from all other causes.

Table 5-17. Comparison of Environmental Risks for a Small Modular Reactor at the CRN Site with Risks for Current-Generation Reactors

	Core Damage Frequency (Ryr^{-1})	50-Mi Population Dose Risk (person-rem/Ryr)[(a)]	Fatalities Ryr^{-1}		Average Individual Fatality Risk Ryr^{-1}	
			Early	Latent Cancer	Early	Latent Cancer
Grand Gulf[(b)]	4.0×10^{-6}	$5 \times 10^{+1}$	8×10^{-9}	9×10^{-4}	3×10^{-11}	3×10^{-10}
Peach Bottom[(b)]	4.5×10^{-6}	$7 \times 10^{+2}$	2×10^{-8}	5×10^{-3}	5×10^{-11}	4×10^{-10}
Sequoyah[(b)]	5.7×10^{-5}	$1 \times 10^{+3}$	3×10^{-5}	1×10^{-2}	1×10^{-8}	1×10^{-8}
Surry[(b)]	4.0×10^{-5}	$5 \times 10^{+2}$	2×10^{-6}	5×10^{-3}	2×10^{-8}	2×10^{-9}
Zion[(b)]	3.4×10^{-4}	$5 \times 10^{+3}$	4×10^{-5}	2×10^{-2}	9×10^{-9}	1×10^{-8}
Sequoyah License Renewal Unit 1[(c)]	3.0×10^{-5}	$4.5 \times 10^{+1}$	--	--	--	--
Sequoyah License Renewal Unit 2[(c)]	3.5×10^{-5}	$4.4 \times 10^{+1}$	--	--	--	--
Watts Bar Unit 2[(d)]	1.8×10^{-5}	$2.0 \times 10^{+1}$	--	1.2×10^{-2}	--	--
Surrogate SMR[(e)] at CRN Site for Site Boundary EPZ	4.7×10^{-8}	6.2×10^{-3}	3.0×10^{-9}	2.7×10^{-6}	6.7×10^{-12}	3.5×10^{-12}
Surrogate SMR[(f)] at CRN Site for 2mi. EPZ	4.7×10^{-8}	7.7×10^{-3}	2.0×10^{-11}	4.1×10^{-6}	1.3×10^{-13}	9.1×10^{-12}
Surrogate SMR[(e)] at CRN Site for 2-mi EPZ	4.7×10^{-8}	6.0×10^{-3}	1.5×10^{-11}	2.7×10^{-6}	3.4×10^{-14}	2.7×10^{-12}
Surrogate SMR[(e)] at CRN Site for 10-mi EPZ	4.7×10^{-8}	6.0×10^{-3}	1.5×10^{-11}	2.6×10^{-6}	3.4×10^{-14}	2.3×10^{-12}

(a) To convert person-rem to person-Sv, divide by 100.
(b) Calculated based on MACCS and presented in NUREG–1150 (NRC 1990-TN525).
(c) Calculated based on MACCS and presented in NUREG–1437 Supplement 53 (NRC 2013-TN2654).
(d) Calculated based on MACCS and presented in NUREG–0498 (NRC 1990-TN525).
(e) Calculated by the NRC staff using MACCS (see Appendix G).
(f) Calculated by TVA using MACCS (TVA 2017-TN4921).

Table 5-18. Comparison of Environmental Risks from Severe Accidents for a Small Modular Reactor at the CRN Site with Risks for Current Plants from Operating License Renewal Reviews

	Core Damage Frequency (yr–1)	50-Mi Population Dose Risk (person-rem Ryr^{-1})[(a)]
Current Reactor Maximum[(b)]	2.4×10^{-4}	$6.9 \times 10^{+1}$
Current Reactor Mean[(b)]	3.1×10^{-5}	$1.5 \times 10^{+1}$
Current Reactor Median[(b)]	2.5×10^{-5}	$1.3 \times 10^{+1}$
Current Reactor Minimum[(b)]	1.9×10^{-6}	5.5×10^{-1}
Sequoyah License Renewal, Unit 1	3.0×10^{-5}	$4.5 \times 10^{+1}$
Sequoyah License Renewal, Unit 2	$3.5 \times 1\ 0^{-5}$	$4.4 \times 10^{+1}$
Watts Bar Unit 2	1.8×10^{-5}	$2.0 \times 10^{+1}$
Surrogate SMR[(c)] at CRN Site for Site Boundary EPZ	4.7×10^{-8}	6.2×10^{-3}
Surrogate SMR[(c)] at CRN Site for 2-mi. EPZ	4.7×10^{-8}	6.0×10^{-3}
Surrogate SMR[(d)] at CRN Site for 2-mi. EPZ	4.7×10^{-8}	7.7×10^{-3}
Surrogate SMR[(c)] at CRN Site for 10-mi. EPZ	4.7×10^{-8}	6.0×10^{-3}

(a) To convert person-rem to person-Sv, divide by 100.
(b) Based on MACCS and MACCS calculations for over 70 current plants at over 40 sites.
(c) Calculated by the NRC staff using MACCS (see Appendix G).
(d) Calculated by TVA using MACCS (TVA 2017-TN4921).

These quantitative health objectives are translated into two numerical objectives:

- The individual risk of a prompt fatality from all "other accidents to which members of the U.S. population are generally exposed," is about 4.0×10^{-4} per year, including a 1.3×10^{-4} per year risk associated with transportation accidents (NSC 2010-TN3240); one-tenth of 1 percent of these figures imply that the individual risk of prompt fatality from a reactor accident should be less than 4×10^{-7} per Ryr.
- "The sum of cancer fatality risks resulting from all other causes" for an individual is taken to be the cancer fatality rate in the United States, which is about 1 in 500 or 2×10^{-3} per year (Reed 2007-TN523); one-tenth of 1 percent of this implies that the risk of cancer to the population in the area near a nuclear power plant because of its operation should be limited to 2×10^{-6} per Ryr.

MACCS calculates average individual early fatality and latent cancer fatality risks. The average individual early fatality risk is calculated using the population distribution within 1 mi of the site boundary. The average individual latent cancer fatality risk is calculated using the population distribution within 10 mi of the site. For sites considered in NUREG–1150 (NRC 1990-TN525), these risks were well below the Commission's safety goals (51 FR 30028 -TN594). The risks calculated for the selected SMR at the CRN Site are lower than the risks associated with the current-generation reactors considered in NUREG–1150. All risk values are also well below the Commission's safety goals.

The NRC staff compared the CDF and population dose risk estimate for the largest SMR design considered at the CRN Site with statistics summarizing the results of contemporary severe accident analyses performed for over 70 reactors at over 40 sites. The results of these analyses are included in the final site-specific Supplements 1 through 57 of NUREG–1437 (NRC 2016-TN5385) and in ERs included with license renewal applications for sites for which supplements have not been published. All of the analyses were completed after publication of NUREG–1150 (NRC 1990-TN525); the analyses for most of the reactors used MACCS2, which was released in 1997.

Table 5-18 shows that the CDF estimated for the largest SMR considered at the CRN Site is significantly lower than those of current-generation reactors. Similarly, the population doses estimated for it are well below the mean and median values for current-generation reactors that have undergone or are undergoing license renewal and are lower than the current reactor minimum. Population projections for the year 2067 have been considered for the CRN Site (TVA 2017-TN4921). The year 2067 has been selected considering the 40-year operating life following the projected commencement of operation date for the last unit (i.e., 2027). The population projection for the year 2067 is the most conservative estimate because it corresponds to the highest population value at the end of the site operation, assuming the population always increases with time.

Finally, the population dose risk from a severe accident for the SMR considered at the CRN Site (as large as 8×10^{-3} person-rem/Ryr) may be compared with the dose risk for normal operation of a this SMR at the CRN Site. The population dose risk from normal operation of the largest SMR considered is 68 person-rem/yr (TVA 2017-TN4921). Thus, the population dose risk associated with a severe accident is less than the dose risk associated with normal operations.

5.11.2.2 Surface-Water Pathways

Surface-water pathways are an extension of the air pathway. These pathways cover the effects of radioactive material deposited on open bodies of water. The surface-water pathways of interest include exposure to external radiation from submersion in water and activities near the water, ingestion of water, and ingestion of fish and other aquatic creatures. Of these pathways, the MACCS code evaluates only the ingestion of contaminated water. The risks associated with this surface-water pathway calculated for the CRN Site are included in the last column of Table 5-14 to Table 5-16. For each accident class, the population dose risk from ingestion of water is a small fraction of the dose risk from the air pathway.

Surface-water pathways involving swimming, fishing, and boating are not modeled by MACCS. Typical population exposure risk for the aquatic food pathway for sites located on small rivers was considered in NUREG–1437 (NRC 2013-TN2654). For these sites, the population dose from the food pathway was below the population dose from the air pathway. For analysis of water-related exposure pathways at the Fermi reactor, NUREG–0769 (NRC 1981-TN675) suggests population exposures from swimming are significantly lower than exposures from the aquatic ingestion pathway. If a severe accident occurred at the CRN Site, it is likely that Federal, State, and local officials would restrict access to the river/bay near the site and in contaminated areas around the site. These actions would further reduce surface-water pathway exposures.

Surface waterbodies within the 50-mi radius of the CRN Site include the Tennessee River. Surface waterbodies near the CRN Site include the upper Clinch River, Norris Lake, other smaller bodies of water, and the reservoirs listed in Table 2.3.3-1 of the TVA ER (TVA 2017-TN4921). The NRC evaluated doses from the aquatic food pathway (fishing) for the current nuclear fleet discharging to various bodies of water in the GEIS (NUREG–1437; NRC 2013-TN2654). The NRC evaluation concluded that with interdiction, the risk associated with the aquatic food pathway is small relative to the atmospheric pathway for most sites and essentially the same as the atmospheric pathway for the few sites that have large annual aquatic food harvests. The new site atmospheric pathway doses are lower than those of the current U.S. nuclear fleet; therefore, the doses from surface-water sources are consistently lower for a new reactor at the CRN Site as well.

5.11.2.3 Groundwater Pathway

The groundwater pathway involves a reactor core melt, reactor vessel failure, and penetration of the floor (basemat) below the reactor vessel. Ultimately, core debris reaches the groundwater where soluble radionuclides are transported with the groundwater. MACCS does not evaluate the environmental risks associated with severe accident releases of radioactive material to groundwater. However, this pathway has been addressed by NUREG–1437 in the context of renewal of licenses for current-generation reactors (NRC 2013-TN2654). In NUREG–1437, the staff assumes a 1×10^{-4} Ryr^{-1} probability of occurrence of a severe accident with a basemat melt-through leading to potential groundwater contamination. The staff concluded for the current-generation reactors that groundwater contribution to risk is generally a small fraction of the risk attributable to the atmospheric pathway.

The NRC staff has reevaluated its assumption of a 1×10^{-4} Ryr^{-1} probability of a basemat melt-through. The NRC staff considers the 1×10^{-4} probability to be too large for new sites. The probability of core melt with basemat melt-through should be no larger than the total CDF estimate for the reactor. Table 5-18 gives a total CDF estimate of 4.7×10^{-8} Ryr^{1} for the largest SMR of the four reactor technologies considered. NUREG–1150 (NRC 1990-TN525) indicates that the conditional probability of a basemat melt-through ranges from 0.05 to 0.25 for current-generation reactors. Due to the enhanced safety features of SMRs as shown by the smaller total CDF, the staff believes the risk of basemat melt-through should be even more unlikely to occur for the SMR design considered by TVA.

The groundwater pathway is also more tortuous and affords more time for implementing protective and remedial actions and, therefore, results in a lower risk to the public. The same consideration applies to the other SMR technologies considered at the CRN Site. As a result, the staff concludes the risks associated with releases to groundwater are sufficiently small that they would not have a significant effect on the overall risk of a severe accident for a new SMR at the CRN Site.

5.11.2.4 Externally Initiated Events

The analyses described above are specifically for internally initiated events. TVA's ER and SSAR do not address potential probability-weighted consequences (i.e., risk) of externally initiated events. The consideration of externally initiated events is not necessary for the NRC staff to reach a finding concerning the risks of the reactor designs considered by TVA as being related to the risks for SMR designs from severe accidents. However, externally initiated events can have notable contributions to the total averted costs dependent on the reactor design. As outlined by 10 CFR 52.79(a)(46) (TN251), NRC RG 1.206 (NRC 2007-TN3035), and Section 19.0 Revision 2 of NUREG–0800 (NRC 2007-TN613), these events are required to be included in Level 1 and Level 2 of the PRA and, as such, would be considered in the offsite consequences analysis and the severe accident mitigation alternatives assessment. Therefore, the NRC staff expects a COL applicant would include externally initiated events in a severe accident mitigation alternatives assessment for a COL application.

5.11.2.5 Spent Fuel Pool Accidents

Recent EISs for 10 CFR Part 52 approvals considered environmental impacts of spent fuel pool accidents where the NRC staff relied on the findings in both the 1996 and 2013 versions of NUREG–1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (NRC 1996-TN288 and NRC 2013-TN2654, respectively). The NRC staff relies on findings from these Generic EISs to assess certain environmental impacts of new reactors. The SMR designs considered by TVA in developing the PPE use the same type of fuel (i.e., form of the fuel, enrichment, burnup, and fuel cladding) as that considered in the NRC staff's evaluation in NUREG–1437. To address the scoping comments received in this area, the NRC staff reviewed various analyses of spent fuel pool fires in NUREG–1437 and confirmed that reliance on the findings is appropriate.

The 1996 version of NUREG–1437 stated that the likelihood of a spent fuel-cladding fire is highly remote (NRC 1996-TN288). The 2013 version of NUREG–1437 (NRC 2013-TN2654) reevaluated the impacts of accidents at spent fuel pools in the following sections: (1) in Section 1.9, Public Comments on the Draft GEIS, and beginning on page 1-28; (2) in Section 4.9.1.2, Environmental Consequences of Postulated Accidents, on pages 4-159 and 4-161; and (3) in Section E.3.7, Impact from Accidents at Spent Fuel Pools, with citations to other studies concerning spent fuel pool fires. The 2013 version of NUREG–1437 (NRC 2013-TN2654) concluded that even under the worst probable accident, a loss of spent fuel pool coolant based on a severe seismic-generated accident causing a catastrophic failure of the pool, the environmental impacts from spent fuel pool accidents stated in the 1996 GEIS (NRC 1996-TN288) remain valid.

Spent fuel pool fires are also examined in Appendix F of NUREG–2157, *Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel* (NRC 2014-TN4117). This appendix provides a thorough summary of the studies conducted by NRC since as early as 1975. The NRC used NUREG–1738, *Technical Study of Spent Nuclear Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants* (NRC 2001-TN5235), as the basis for the generic analysis for spent fuel pool fires in NUREG–2157 (NRC 2014-TN4117). After NUREG–1738 was published in 2001, the NRC implemented regulations and issued orders that continued to reduce the likelihood of a spent fuel pool fire. Both the consequences of a spent fuel pool fire and the probability of a spent fuel pool fire are provided in Table F-1 of Appendix F of NUREG–2157. Table F-2 provides a comparison of the frequency-weighted consequences from reactor accidents and spent fuel pool fires. The conclusion in Appendix F of NUREG–2157 (NRC 2014-TN4117) is that the results provided in NUREG–1738 (NRC 2001-TN5235) are comparable to those in NUREG–1437 (NRC 1996-TN288). In addition, mitigation measures implemented by licensees based on NRC orders and regulations have lowered the probability and risk of a spent fuel pool fire.

The impacts from onsite spent fuel storage for a new reactor have been discussed in Section 6.1.6, Radiological Wastes, in recent EISs. In this discussion, the NRC staff cites the 2013 version of NUREG–1437 (NRC 2013-TN2654) and to NUREG–2157 (NRC 2014-TN4117) for all onsite spent fuel storage impacts, which would include accidents as discussed in the two Generic EISs. For Section 6.1.6 in this draft EIS, the NRC staff also applies these two NUREGs for assessing the environmental impacts from onsite spent fuel storage at the CRN Site.

Since March 2012, NRC reactor licensees and new reactor applicants have addressed the mitigation of beyond DBAs based on the Commission's Orders EA-12-049 (77 FR 16091-TN2476), EA-12-050 (77 FR 16098-TN2477), and EA-12-051 (77 FR 16082-TN1424).

Specifically, EA-12-051 requires plant modifications to address spent fuel pool accident mitigation by the use of reliable spent fuel pool level instrumentation and EA-12-050 requires a three-phase approach for mitigating beyond-design-bases external events such as the industry FLEX initiative, which would also address maintaining enough water in spent fuel pools to prevent reaching the conditions for a spent fuel pool fire. The Commission's Orders would be implemented by an applicant at the CP/COL stage for the proposed SMR design.

In ER Table 3.1-2 under PPE Section 18, Miscellaneous Items (see Appendix I of this EIS), TVA provides information regarding the nuclear fuel parameters that were considered for the ESP application. Several of these parameters are related to the information necessary to assess the potential environmental impacts from a severe accident involving the spent fuel pool. The parameters related to the nuclear fuel are as follows (TVA 2017-TN4921):

- PPE Items 18.0.1: UO_2 is the form of the reactor fuel.
- PPE Item 18.1: Maximum fuel enrichment of less than 5 percent U-235 enrichment.
- PPE Item 18.2: The maximum average assembly burnup of 51 GWD/MTU.
- PPE Item 18.3: The peak fuel rod exposure at end of life of 62 GWD/MTU.
- PPE Item 18.7: The nuclear fuel rod clad material is Zircaloy.

The above nuclear fuel characteristics bound or are the same as those applied in the prior spent fuel pool accidents studies previously described in this section for NUREG–1437 and related NRC studies.

Under PPE Item 18.0.4, TVA sets a refueling frequency of 2 years for each SMR (see Section 5.8.2.1.1 of the ER [TVA 2017-TN4921]), 96 assemblies removed per refueling along with the spent fuel pool capacity and the cooling time for the spent nuclear fuel at 6 years. Thus, a dedicated spent fuel pool would hold approximately 288 fuel assemblies, a smaller amount of spent fuel than considered in the large LWR spent fuel pool accident analyses discussed earlier. For example, NUREG–1738, *Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants*, assumed the spent fuel pool inventory was 3.5 core loads (likely in the range of approximately 1,000 to 4,000 spent fuel assemblies) with an average burnup of 60 GWD/MTU (NRC 2001-TN5235). Another study of the consequences of a spent fuel pool accident, NUREG–2161, *Consequence Study of a Beyond-Design-Basis Earthquake Affecting the Spent Fuel Pool for a U.S. Mark 1 Boiling Water Reactor*, provides the assumption in Appendix D of approximately 3,055 spent fuel assemblies in the pool for the subsequent accident analysis (NRC 2014-TN5236).

The SMR pool capacity, based on the 6-year time for storing spent fuel in the pool, is significantly less than the expected number of spent fuel assemblies to manage over a 60-year operating lifetime of the CRN facility. Thus, this limit requires that TVA have a designated area of the site for an independent spent fuel storage installation (ISFSI), which would be operational within 6 years of the start of operation. The ISFSI location is shown in Figure 3.1-2, CRN Site Cleared Areas (TVA 2017-TN4921). Therefore, at the COL stage, the COL applicant would determine if the design-specific vendor information about the management of spent nuclear fuel for the selected SMR design fits within the PPE values and, if not, would appropriately address these environmental impacts in the COL application.

While TVA has yet to select a specific SMR design, each of the SMR vendors listed in the ER has indicated the location of their spent fuel pools would be at or below grade level and either within the reactor building (NRC 2013-TN5231; NuScale 2016-TN5233; Westinghouse 2013-TN5234) or the containment (SMR 2017-TN5232). The significance of this is that every one of the SMR spent fuel pools contemplated in the ER would have the highest seismic safety qualification and would meet the NRC regulatory requirement to withstand aircraft impacts in 10 CFR 50.150 (TN249). These assertions are documented in Appendix J of this EIS (Clinch River Representations and Assumptions). As described above in Section 5.11, an SMR design built at the CRN Site shall meet NRC Order EA-12-051 for reliable spent fuel pool level instrumentation (77 FR 16082-TN1424) and a CP/COL applicant must comply with NRC Order EA-12-049 for mitigating beyond-design basis external events (77 FR 16091-TN2476).

As described above, the staff has reviewed the past NRC studies concerning spent fuel pool accidents, TVA's PPE values regarding spent fuel pool inventory and spent fuel pool characteristics, and the Fukushima actions in regard to spent fuel pool level instrumentation and mitigation. Based on this information, the staff expects the risks from spent fuel pool accidents for a design bounded by the PPE would be lower than the risks of a spent fuel pool severe accident for a large LWR. The already remote risk of spent fuel pool fires for large LWRs, as described in the 1996 version of NUREG–1437 (NRC 1996-TN288) and confirmed in the 2013 version (NRC 2013-TN2654), would be more remote for the SMRs considered in developing the PPE based on the best available information about those SMR designs because (1) the spent fuel pools are assumed to be located underground, (2) the fuel transfer would be expedited because the pool would be significantly smaller than that of a large LWR and therefore the number of spent fuel assemblies in the pool would be much lower; and (3) implementation of the NRC orders improves the safety of the spent fuel pools and provides mitigating strategies for preventing spent fuel pool fire. Therefore, because the impact from spent fuel pool fires is considered SMALL for large LWRs, it is also SMALL for the SMRs considered for the CRN Site.

5.11.2.6 Summary of Severe Accident Impacts

The NRC staff has reviewed the analysis in the TVA ER (TVA 2017-TN4921) and conducted its own confirmatory analysis using the MACCS code. The results of the TVA analysis and the NRC analysis indicate that the environmental risks associated with severe accidents for an SMR located at the CRN Site would be small compared to risks associated with operation of the current-generation reactors. These risks are well below NRC safety goals. On this basis, the staff concludes the probability-weighted consequences of severe accidents at the CRN Site would be SMALL.

It is worth noting that a significant effort has been made to re-quantify realistic severe accident source terms under the State-of-the-Art Reactor Consequence Analysis (SOARCA) project (NRC 2012-TN3092). The results of the SOARCA project indicate that source term timing progresses more slowly, and releases much smaller amounts of radioactive material than calculated in earlier studies. As a result, public health consequences from severe nuclear power plant accidents modeled in SOARCA are smaller than previously calculated.

At the COL stage, the NRC staff would need to verify that the environmental impacts of severe accidents from the selected reactor technology at the CRN Site remain bounded by the environmental impacts from the designs considered in this EIS. For the COL submission, NRC anticipates that applicant analyses will be comprehensive in scope and will address all applicable internal and external events and all plant operating modes.

5.11.3 Severe Accident Mitigation Alternatives

This section is not required for an ESP permit.

5.11.4 Summary of Postulated Accident Impacts

The NRC staff evaluated the environmental impacts from both DBAs and internally initiated severe accidents for SMR technologies being considered at the CRN Site. Based on the information provided by TVA and the NRC staff's independent review, the NRC staff concludes the potential environmental impacts from the operation of the surrogate SMR evaluated in this EIS at the CRN Site would be SMALL. However, the environmental impacts of severe accident mitigation alternatives or involving other reactor designs cannot be resolved in this ESP review but they will be addressed at the COL stage.

5.12 Measures and Controls to Limit Adverse Impacts during Operation

In its evaluation of environmental impacts during operation of a new nuclear power plant at the CRN Site, the review team considered TVA's stated intent to comply 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, discharge prevention and response, and hazardous material management);
- compliance with applicable requirements of permits or licenses required for construction of a new nuclear power plant at the CRN Site (e.g., Department of the Army Section 404 Permit, NPDES permit);
- compliance with existing TVA processes and/or procedures applicable for environmental compliance activities during construction and preconstruction at the CRN Site (e.g., solid-waste management, hazardous-waste management, and discharge prevention and response); and
- management and minimization of solid, radiological, chemical, and hazardous wastes.

Examples of TVA measures to minimize impacts and protect the environment include the following:

- implementing plans to manage stormwater and to prevent and appropriately address accidental spills, and
- adhering to Federal, State, and local permitting requirements.

The review team considered these measures and controls in its evaluation of the potential environmental impacts of plant operation. Table 5-19 summarizes the measures and controls to limit adverse impacts during operation of a new nuclear power plant at the CRN Site based on information provided in the TVA ER (TVA 2017-TN4921) and other information provided by the applicant. Some measures apply to more than one impact category.

Table 5-19. Measures and Controls to Limit Adverse Impacts during Operation of a New Nuclear Power Plant at the CRN Site

Resource Area	Specific Measures and Controls
Land-Use Impacts	• Land already committed for plant operations. • Limit disturbance of vegetation to the area within the site designated for CRN Site construction. Minimize potential impacts through best management practices (BMPs) and TVA procedures. • To extent feasible, avoid any additional disturbances of land in right-of-ways. • Inspect vegetation within and adjacent to right-of-ways on a regular basis to assist in planning corrective and routine maintenance in accordance with TVA's *A Guide for Environmental Protection and Best Management Practices for TVA Transmission Construction and Maintenance Activities*. • Limit continued vegetation removal to the minimal amount needed to support the transmission line right-of-way.
Water-Related Impacts	
Water-Use	• Design cooling towers to limit drift and evaporative water loss. • Follow procedures of the TVA Drought Management Plan during drought conditions.
Water Quality	• Manage stormwater in accordance with a site-specific stormwater pollution prevention plan. • Design diffuser to meet the objectives of maximizing thermal and chemical mixing while minimizing scour and hydrologic modifications. • Limit wastewater discharges and comply with Tennessee Department of Environment and Conservation (TDEC) National Pollutant Discharge Elimination System (NPDES) permit. • Follow the TDEC-approved Biocide/Corrosion Treatment Plan. • Comply with State water-quality standards and TVA procedures associated with thermal discharges. • Minimize the potential of hazardous materials/waste spills or releases through training and rigorous compliance with the Resource Conservation and Recovery Act of 1976, as amended (RCRA) and applicable regulations and TVA procedures, and implementation of a site-specific Integrated Pollution Prevention Plan.
Cooling-System Impacts	
Intake System	
Hydrodynamic Descriptions and Physical Impacts	• To the extent practical, design pumps, machinery, and screens to reduce hydrodynamic impacts. • Design cooling-water system to minimize water losses and reduce intake flows.
Aquatic Ecosystems	• Minimize impingement and entrainment of organisms through compliance with Section 316(b) of the Clean Water Act (CWA) (implemented by the NPDES permit).
Discharge System	
Thermal Discharges and Other Physical Impacts	• Compliance with State water-quality standards and TVA procedures associated with thermal discharges • Minimize the thermal discharge to the Clinch River arm of the Watts Bar Reservoir with a closed-loop cooling system.

Table 5-19. (contd)

Resource Area	Specific Measures and Controls
Aquatic Ecosystems	• Monitor chemical concentrations to comply with the Biocide/Corrosion Treatment Plan submitted as part of the application for a TDEC NPDES permit.
Cooling Towers	
Heat Dissipation to the Atmosphere	• To the extent practical, design cooling towers using Best Available Technology to reduce evaporative losses and noise.
Impacts on Members of the Public	• To the extent practical, use pumps and machinery that reduce noise levels. • Treat cooling water to reduce salt and mineral impurities. • Design cooling towers to reduce evaporative and drift water losses. • If necessary, initiate a water conservation program. • Periodically monitor and test water for etiologic agents (thermophilic microorganisms) according to programs such as the Centers for Disease Control's Surveillance for Waterborne-Disease Outbreaks-United States.
Ecological Impacts	
Terrestrial Ecosystems	• Minimize potential impacts through compliance with permitting requirements, BMPs, and TVA procedures. • As appropriate, train employees on how to perform work in a manner that reduces adverse environmental impacts; to the extent feasible, avoid any additional disturbances to sensitive terrestrial or wetland habitats/species. • Identify sensitive areas requiring restrictions on types of vegetation maintenance. • As practical, reseed cleared areas to limit erosion using noninvasive species/native plants, per TVA procedures. • Use licensed operators to apply herbicides. • Comply with the TDEC General Permit for Pesticide Discharges (includes herbicides). • As practicable, use noise suppression/mufflers on vehicles/machinery and other engineering controls such as earthen berms and placing foliage between noise sources and receptors.
Aquatic Ecosystems	• Minimize potential impacts through compliance with permitting requirements, BMPs, and TVA procedures. • Identify streamside management zones and place restrictions on the type of vegetation management activities performed there. • To the extent feasible, avoid any additional disturbances to sensitive aquatic habitats/species.
Socioeconomic Impacts	
Physical Impacts of a New Nuclear Power Plant	• As appropriate, train and appropriately protect workers to reduce the risk of potential exposure to noise. • Operate air emissions sources and monitor release of air emissions in accordance with State and Federal regulations, air permit requirements, and TVA procedures. • Include efficient drift eliminators to minimize drift emissions from cooling towers. • Manage thermal discharge from cooling-water system in accordance with requirements of TDEC NPDES permit and TVA procedures.

Table 5-19. (contd)

Resource Area	Specific Measures and Controls
Socioeconomic Impacts of a New Nuclear Power Plant	• Use roadway improvements from construction to offset impacts expected during operations.
Environmental Justice	None
Historic and Cultural Resources	• TVA would conduct operation and maintenance activities in compliance with National Historic Preservation Act (NHPA) Section 106 and would avoid, minimize, or mitigate potential operation-related impacts on historic and cultural resources. TVA would also comply with the Native American Graves Protection and Repatriation Act (NAGPRA), Archaeological Resources Protection Act (ARPA), Archeological and Historic Preservation Act (AHPA), NHPA, American Indian Religious Freedom Act (AIRFA), Executive Orders 13007 (Indian Sacred Sites) and 13175 (Consultation and Coordination with Indian Tribal Governments). TVA also maintains procedures and management plans that take into consideration impacts on historic and cultural resources during operations. In the event that archaeological resources or human remains are encountered during operations, TVA has NHPA Section 106 and NAGPRA inadvertent discovery procedures requiring stop work and consulting party notifications.
Air Quality	• Comply with permit limits and regulations for installing and operating air emission sources.
Nonradiological Health Impacts	• Minimize potential impacts through compliance with permitting requirements; BMPs; State, local, and Federal requirements; and TVA procedures. • Minimize night and weekend maintenance operations to reduce noise impacts. • Use mitigation measures to decrease the electromagnetic fields related to the underground transmission line. • Maintain vertical clearance from the ground for overhead transmission lines and safety procedures to prevent direct contact with the underground transmission line.
Radiological Impacts of Normal Operation	
Radiation Doses to Members of the Public Occupational Radiation Doses	• Doses from planned releases of radiation are less than the limits prescribed under Title 10 of the *Code of Federal Regulations* (10 CFR) 20.1301 (TN283) and 40 CFR Part 190 (TN739). • Implement a radiological environmental monitoring program to monitor specified exposure pathways. • Minimize effluent discharges in accordance with applicable regulations.
Impacts on Biota Other than Humans	• Calculated doses for biota other than humans within National Council on Radiation Protection and Measurements (NCRP) and International Atomic Energy Agency (IAEA) guidelines. • Implement an annual offsite radiological environmental monitoring program to evaluate potential exposures and doses to biota other than humans and the environment. • Use of exposure guidelines, such as 40 CFR Part 190 (TN739), that apply to members of the public in unrestricted areas, is considered very conservative when evaluating calculated doses to biota other than humans. The International Commission on Radiological Protection (ICRP) states that "… if man is adequately protected, then

Table 5-19. (contd)

Resource Area	Specific Measures and Controls
	other living things are also likely to be sufficiently protected," and uses human protection to infer environmental protection from the effects of ionizing radiation.
Radioactive Waste Impacts	
Radioactive Waste System Impacts	• Manage and dispose of radioactive constituents according to applicable regulations and TVA procedures. • As appropriate, train employees to follow applicable waste management procedures and regulations and TVA procedures.
Mixed-Waste System Impacts	• Manage and release hazardous air constituents in accordance with the Clean Air Act regulations (40 CFR Parts 50-99-TN5264) and TVA procedures. • Manage and release hazardous water effluents in accordance with the Clean Water Act and TVA procedures. • Manage, treat, and dispose of hazardous waste according to RCRA regulations and TVA procedures. • As appropriate, train employees to follow applicable waste management procedures and regulations and TVA procedures. • Carefully monitor mixed waste. • Perform inspections for compliance with applicable waste management laws and regulations and TVA procedures. • Limit mixed-waste generation through source reduction, recycling, and treatment options. • Develop and follow a waste management plan. • Develop and follow a waste minimization plan to reduce the amount of waste that is generated. • Adopt an as low as is reasonably achievable program and train employees on implementation of this program, as appropriate.
Accidents	
Design Basis Accidents	• The calculated dose consequences of design basis accidents for the PPE at the CRN Site were found to be within regulatory limits.
Severe Accidents	• The calculated probability-weighted consequences (i.e., risks) of severe accidents for the largest SMR considered at the CRN Site were found to be lower than the probability-weighted consequences for current operating reactors and the Commission's safety goals.
Nonradioactive Waste Impacts	
Nonradioactive Waste System Impacts	• Develop and follow a waste minimization plan to reduce the amount of waste that is generated. • Release hazardous air emissions according to limits imposed by the Clean Air Act Amendments of 1977, as amended (42 U.S.C. § 7401 *et seq*.-TN4540), the Clean Air Act regulations (40 CFR Parts 50-99-TN5264), and TVA procedures. • Release hazardous water effluents according to limits imposed by the Clean Water Act/Federal Water Pollution Control Act and NPDES program and permit requirements, and TVA procedures. • Manage, treat, and dispose of hazardous waste according to RCRA regulations and TVA procedures. • Generate and dispose of nonhazardous nonradioactive waste according to applicable local, State, and Federal regulations, including the Solid Waste Disposal Act, as amended, (42 U.S.C. § 82 *et seq*.-

Table 5-19. (contd)

Resource Area	Specific Measures and Controls
Pollution Prevention and Waste Minimization	TN1032), and 40 CFR Part 261 (TN5092), "Identification and Listing of Hazardous Waste," and TVA procedures. • Perform inspections for compliance with applicable waste management laws and regulations and TVA procedures. • As appropriate, train employees to follow applicable procedures and waste regulations. • Comply with current Waste Minimization Plan developed for existing TVA reactors to address hazardous-waste management, treatment (decay in storage), work planning, waste tracking, and awareness training.

Source: TVA 2017-TN4921.

5.13 Summary of Operational Impacts

The review team's evaluation of the environmental impacts of operations at a new nuclear power plant at the CRN Site is summarized in Table 5-20. Impact category levels are denoted in the table as SMALL, MODERATE, or LARGE as a measure of their expected adverse impacts. Some impacts, such as the addition of tax revenue for the local economies, are likely to be beneficial and are noted as such in the Impact Level column.

Table 5-20. Summary of Operational Impacts for a New SMR at the CRN Site

Resource Area	Comments	Impact Category Level
Land-Use Impacts	Land-use impacts of salt deposition from cooling-tower operations would be minor and confined to the CRN Site. Operating a new nuclear power plant would be consistent with existing land uses at the CRN Site, local zoning, and land-use planning. Operations would not affect prime farmlands or farmlands of unique or statewide importance. Land-use impacts of transmission line right-of-way maintenance would be minor and confined to the right-of-way. Use of the right-of-ways would not affect adjacent land uses or prime farmlands or farmlands of unique or statewide importance.	SMALL
Water-Related Impacts		
Water Use		
Surface Water	Water loss occurs primarily as a result of evaporation and drift from cooling towers. Cooling water would be obtained directly from the Clinch River arm of the Watts Bar Reservoir. A small amount of water for potable and sanitary uses would be supplied by the City of Oak Ridge public water supply system, which is sourced from the Melton Hill Reservoir.	SMALL
Groundwater	No groundwater would be used for operations.	SMALL
Water Quality		
Surface Water	Potential impacts on surface water from stormwater pollution and inadvertent spills associated with operations activities. Localized increase in temperature and concentrations of contaminants from plant discharge to the Clinch River arm of the Watts Bar Reservoir.	SMALL
Groundwater	Potential impacts from inadvertent spills of contaminants such as gasoline, diesel fuel, lubricants, and other liquids.	SMALL
Ecological Impacts		
Terrestrial Resources and Wetlands	Localized, minor salt drift impacts from cooling towers. Minor effect on wildlife near the cooling towers from operating noise. Impact on terrestrial ecology from continued maintenance of right-of-way vegetation. Application of herbicides. Operation of noisy equipment.	SMALL

Table 5-20. (contd)

Resource Area	Comments	Impact Category Level
Aquatic Resources	Some fish killed by impingement and entrainment.	SMALL
	Minor aquatic impacts resulting from loss of habitat based on consumption of water from the Clinch River arm of the Watts Bar Reservoir	
	Small localized increase in water temperature from thermal plume resulting from water discharged to the Clinch River arm of the Watts Bar Reservoir and resulting minor impact on aquatic organisms.	
	Minor localized impact on benthic or other aquatic organisms from the thermal plume.	
	Localized impact on aquatic organisms from small turbidity effect near the discharge structure.	
	Discharges of chemicals in blowdown water.	
	Potential Impact on aquatic biota from continued maintenance involving clearing of vegetation along [transmission] right-of-ways near waterbodies.	
	Potential for some erosion and subsequent runoff of sediment into waterbodies.	
	Potential migration of herbicides into waterbodies.	
	Potential discharge or spills of herbicides that pollute the aquatic ecosystem.	
Socioeconomic Impacts		
Physical Impacts	The physical impacts of operations-related activities on workers and the local public, buildings, and transportation would be SMALL. However, the addition of new cooling towers and new reactor facilities at the CRN Site, and related operations causing cooling-tower steam plumes, would noticeably affect the aesthetic qualities from viewpoints in Anderson and Roane Counties and would, therefore, have a MODERATE physical impact on aesthetic resources.	SMALL to MODERATE (aesthetics)
Demography	The current and projected populations of the region are so large and the in-migrating population is so small that the in-migrating workers would represent less than 1 percent of the total population in any of the counties where these employees reside. Therefore, there would be no demographic impacts of operation on the remainder of the economic region.	SMALL
Social and Economic Impacts on the Community		
Economy	Economic impacts throughout the economic region and economic region would be SMALL and beneficial.	SMALL (beneficial to the region)
Taxes	Tax impacts would be SMALL and beneficial throughout the economic region.	SMALL (beneficial for the region

Table 5-20. (contd)

Resource Area	Comments	Impact Category Level
Infrastructure and Community Services		
Transportation	The impacts from traffic in the economic region would be minimal and localized for operations, including during outages when operations-related traffic would be greatest.	SMALL
Recreation	The impacts on recreational activities in the vicinity would be minimal, except for a noticeable, but not destabilizing, reduction in recreational enjoyment due to the aesthetic impact from structures on the site and the visual intrusion of the cooling-tower plumes.	MODERATE
Housing	There would be minimal impacts in the economic region and the region on the price and availability of housing from operations at the CRN Site.	SMALL
Public Services	There would be minimal impacts on the local water supply and on wastewater treatment facilities, as well as on police, fire protection, and healthcare services.	SMALL
Education	The impacts on schools in the economic region would be minimal.	SMALL
Environmental Justice	No potential environmental pathways were identified by which the minority or low-income populations in the economic region would likely experience disproportionately high and adverse human health, environmental, physical, or socioeconomic effects as a result of operations activities.	None[(a)]
Historic and Cultural Resources	Impacts are possible during the life of the operating license if inadvertent discoveries result in adverse effects on places with human remains or on historic properties.	SMALL
Air Quality	Diesel generators and other fossil fuel combustion equipment would contribute to air emissions. Cooling towers would emit plumes.	SMALL
Nonradiological Health Impacts	Comply with Occupational Safety and Health Administration standards and other Federal, State, and local safety regulations. Use standard sound attenuation measures for mechanical draft cooling towers.	SMALL to MODERATE
Radiological Impacts		
Members of the Public	The staff evaluated the health impacts on members of the public from routine gaseous and liquid radiological effluent releases from two or more SMRs at the CRN Site. Doses to members of the public would be below NRC and EPA standards, and there would be no observable health impacts (10 CFR Part 20-TN283; 10 CFR Part 50-TN249; 40 CFR Part 190-TN739).	SMALL
Plant Workers	Occupational doses to plant workers at the site would be below NRC standards and program to maintain doses ALARA would be implemented.	SMALL
Biota Other than Humans	Doses to biota other than humans would be well below National Council on Radiation Protection and Measurements and International Atomic Energy Agency guidelines.[(b)]	SMALL

Table 5-20. (contd)

Resource Area	Comments	Impact Category Level
Nonradioactive Waste	Current TVA practices and procedures would help minimize waste generation at a new nuclear power plant at the site. Solid, liquid, gaseous, and mixed wastes generated during the operation of a new nuclear power plant would be handled according to county, State, and Federal regulations.	SMALL
Postulated Accidents		
Design Basis Accidents	Staff reviewed the CRN DBA analysis and CRN Site-specific data for the PPE under consideration and found them to be appropriate and acceptable. The site-specific analysis results demonstrate that accident dose associated with the PPE meet the site acceptance criteria of 10 CFR 50.34 (TN249). The accident dose also meets the site acceptance criteria of 10 CFR Part 100 (TN282).	SMALL
Severe Accidents	The environmental consequences of severe accidents at the CRN Site would be of minor significance.	SMALL

(a) The entry “None” for Environmental Justice does not mean there are no adverse impacts on minority or low-income populations from the proposed action. Rather, “None” means that, while adverse impacts may exist, they do not affect minority or low-income populations in any disproportionate manner, relative to the general population.

(b) The ICRP states that if humans are adequately protected, then other living things are also likely to be sufficiently protected (ICRP 1977-TN713; ICRP 1990-TN74).

6.0 FUEL CYCLE, TRANSPORTATION, AND DECOMMISSIONING

This chapter addresses environmental impacts from the (1) uranium fuel cycle and solid-waste management (Section 6.1), (2) transportation of radioactive material (Section 6.2), and (3) decommissioning (Section 6.3) of two or more small modular reactors (SMRs) with a combined maximum net electrical output of 800 MW(e) at the Clinch River Nuclear (CRN) Site in Roane County, Tennessee. In its application for an early site permit (ESP) for the CRN Site, the Tennessee Valley Authority (TVA) proposes to use the site for SMRs for which designs are not yet finalized. TVA used information from four vendors that are designing SMRs to develop a plant parameter envelope (PPE) as a surrogate for a specific plant design (TVA 2015-TN5085). The PPE provides bounding values for key plant characteristics that allow assessment of environmental impacts. TVA's table of PPE values is provided in Appendix I of this draft environmental impact statement (EIS).

The assessment of fuel-cycle impacts is based on values in Table S–3 in Title 10 of the *Code of Federal Regulations* (CFR) Section 51.51(b) (10 CFR Part 51-TN250), which in turn assumes an 80 percent annual capacity factor referenced to a 1,000-megawatt electric (MW(e)) light water reactor (LWR), resulting in 800 MW of electrical output. For its bounding analysis in this part of the environmental review, TVA assumed a 98 percent capacity factor for two or more SMR(s) with a combined maximum net electrical power output of 800 MW(e), resulting in an effective net power output of 784 MW(e). TVA used the ratio of net output for SMRs at the CRN Site to the 800 MW(e) net output of the reference reactor to scale the impact values from Table S–3 by a factor of 0.98 (TVA 2017-TN4921). Although TVA scaled the Table S-3 reference values by a factor of 0.98 to account for the slightly reduced impact from SMRs (TVA 2017-TN4921), the NRC staff rounded up to 1 and used the Table S-3 reference values in its analyses.

6.1 <u>Fuel-Cycle Impacts and Solid-Waste Management</u>

This section discusses the environmental impacts from the uranium fuel cycle and solid-waste management for the proposed SMRs at the CRN Site. The environmental impacts from the PPE for the four SMR designs are evaluated against specific criteria for LWR designs in 10 CFR 51.51 (TN250).

The regulations in 10 CFR 51.51(a) (TN250) state that

> Under §51.50, every environmental report prepared for the construction permit stage or early site permit stage or combined license stage of a light-water-cooled nuclear power reactor, and submitted on or after September 4, 1979, shall take Table S–3, Table of Uranium Fuel Cycle Environmental Data, as the basis for evaluating the contribution of the environmental effects of 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 to the environmental costs of licensing the nuclear power reactor. Table S–3 shall be included in the environmental report and may be supplemented by a discussion of the environmental significance of the data set forth in the table as weighed in the analysis for the proposed facility.

The new nuclear power plant evaluated for the CRN Site is an SMR design based on light-water-cooled reactor technology that uses uranium dioxide fuel; therefore, Table S–3 (10 CFR 51.51(b) [TN250]) can be used to assess the environmental impacts of the uranium fuel cycle. Table S–3 values are normalized for a reference 1,000-MW(e) LWR at an 80 percent capacity factor. The 10 CFR 51.51(b) (TN250) Table S–3 values are reproduced in EIS Table 6-1.

Specific categories of environmental considerations are included in Table S–3 (see Table 6-1). These categories relate to land use, water consumption and thermal effluents, radioactive releases, burial of transuranic high-level waste (HLW) and low-level waste (LLW), and radiation doses resulting from both transportation and occupational exposures. In developing Table S–3 (49 FR 9351 -TN5279; 49 FR 10922 -TN5280; 67 FR 77651 -TN5278; 72 FR 49351 -TN4796), the staff considered two fuel-cycle options that differed in their treatments of irradiated (spent) fuel removed from a reactor. The no-recycle option treats all spent fuel as waste to be disposed at a Federal waste repository, whereas the uranium-only recycle option involves reprocessing spent fuel to recover unused uranium and to return it for use in new fuel. Neither cycle involves the recovery of plutonium. The environmental impacts resulting from reprocessing, waste management, and transportation of wastes were evaluated for each of the two fuel cycles (i.e., uranium-only and no-recycle). As described in NUREG-1437 (NRC 1996-TN288), the environmental impacts specified in Table S–3 represent the worst-case bounding estimates for potential releases resulting from the uranium fuel cycles evaluated (i.e., uranium-only and no-recycle). The staff relies on findings from NUREG-1437 to assess certain environmental impacts of new reactors. The SMR designs considered by TVA in developing the PPE use the same type of fuel (i.e., the same form of the fuel, enrichment, burnup, and fuel cladding) as that considered in the NRC staff's evaluation in NUREG-1437 and therefore are relevant to light water SMRs. The uranium fuel cycle is defined as the total of the operations and processes associated with provision, use, and ultimate disposition of fuel for nuclear power reactors.

Table 6-1. Uranium Fuel-Cycle Environmental Data as Provided in Table S–3 of 10 CFR 51.51(b) (TN250)[(a)]

Environmental Considerations	Total	Maximum Effect per Annual Fuel Requirement or Reference Reactor Year of Model 1,000-MW(e) LWR
Natural Resource Use		
Land (acres):		
Temporarily committed[(b)]	100	
Undisturbed area	79	
Disturbed area	22	Equivalent to a 110-MW(e) coal-fired power plant
Permanently committed	13	
Overburden moved (millions of metric tons [MT])	2.8	Equivalent to a 95-MW(e) coal-fired power plant
Water (millions of gallons):		
Discharged to air	160	<2 percent of model 1,000-MW(e) LWR with cooling tower
Discharged to waterbodies	11,090	

Table 6-1. (contd)

Environmental Considerations	Total	Maximum Effect per Annual Fuel Requirement or Reference Reactor Year of Model 1,000-MW(e) LWR
Discharged to ground	127	
Total	11,377	<4 percent of model 1,000 MW(e) with once-through cooling
Fossil fuel:		
Electrical energy (thousands of MW-hr)	323	<5 percent of model 1,000-MW(e) LWR output
Equivalent coal (thousands of MT)	118	Equivalent to the consumption of a 45-MW(e) coal-fired power plant
Natural gas (millions of standard cubic feet)	135	<0.4 percent of model 1,000-MW(e) LWR output
Effluents – Chemical (MT)		
Gases (including entrainment):[c]		
SO_x	4,400	
NO_x[d]	1,190	Equivalent to emissions from 45-MW(e) coal-fired plant for a year
Hydrocarbons	14	
CO	29.6	
Particulates	1,154	
Other gases:		
F	0.67	Principally from UF_6 production, enrichment, and reprocessing. The concentration is within the range of state standards, below the level that has effects on human health.
HCl	0.014	
Liquids:		
SO_4^-	9.9	From enrichment, fuel-fabrication, and reprocessing steps. Components that constitute a potential for adverse environmental effect are present in dilute concentrations and receive additional dilution by receiving bodies of water to levels below permissible standards. The constituents that require dilution and the flow of dilution water are NH_3 – 600 cfs, NO_3 – 20 cfs, fluoride – 70 cfs.
NO_3^-	25.8	
Fluoride	12.9	
Ca^{++}	5.4	
Cl^-	8.5	
Na^+	12.1	
NH_3	10.0	
Fe	0.4	
Tailings solutions (thousands of MT)	240	From mills only—no significant effluents to the environment
Solids	91,000	Principally from mills—no significant effluents to the environment
Effluents – Radiological (curies)		
Gases (including entrainment):		
Rn-222	-	Presently under reconsideration by the Commission
Ra-226	0.02	
Th-230	0.02	

Table 6-1. (contd)

Environmental Considerations	Total	Maximum Effect per Annual Fuel Requirement or Reference Reactor Year of Model 1,000-MW(e) LWR
Uranium	0.034	
Tritium (thousands)	18.1	
C-14	24	
Kr-85 (thousands)	400	
Ru-106	0.14	
I-129	1.3	Principally from fuel reprocessing plants
I-131	0.83	
Tc-99	-	Presently under consideration by the Commission
Fission products and transuranics	0.203	
Liquids:		
Uranium and daughters	2.1	Principally from milling—included tailings liquor and returned to ground, no effluents; therefore, no effect on the environment
Ra-226	0.0034	From UF_6 production
Th-230	0.0015	
Th-234	0.01	From fuel-fabrication plants—concentration 10 percent of 10 CFR Part 20 (TN283) for total processing 26 annual fuel requirements for model LWR
Fission and activation products	5.9×10^{-6}	
Solids (buried on the site):		
Other than high level (shallow)	11,300	9,100 Ci come from low-level reactor wastes and 1,500 Ci come from reactor decontamination and decommissioning—buried at land burial facilities. 600 Ci comes from mills—included in tailings returned to ground. Approximately 60 Ci come from conversion and spent fuel storage. No significant effluent to the environment.
TRU and HLW (deep)	1.1×10^{7}	Buried at Federal Repository
Effluents – thermal (billions of British thermal units)	4,063	<5 percent of model 1,000-MW(e) LWR
Transportation (person-rem):		
Exposure of workers and general public	2.5	
Occupational exposure (person-rem)	22.6	From reprocessing and waste management

Table 6-1. (contd)

Environmental Considerations	Total	Maximum Effect per Annual Fuel Requirement or Reference Reactor Year of Model 1,000-MW(e) LWR

(a) In some cases where no entry appears, it is clear from the background documents that the matter was addressed and that, in effect, the table should be read as if a specific zero entry had been made. However, other areas are not addressed at all in the table. Table S–3 does not include health effects from the effluents described in the table, or estimates of releases of radon-222 from the uranium fuel cycle, or estimates of technetium-99 released from waste-management or reprocessing activities. These issues may be the subject of litigation in the individual licensing proceedings.

Data supporting this table are given in the *Environmental Survey of the Uranium Fuel Cycle*, WASH-1248 (AEC 1974-TN23); the *Environmental Survey of the Reprocessing and Waste Management Portion of the LWR Fuel Cycle*, NUREG–0116 (Supp. 1 to WASH-1248) (NRC 1976-TN292); the *Public Comments and Task Force Responses Regarding the Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle*, NUREG–0216 (Supp. 2 to WASH-1248) (NRC 1977-TN1255); and in the record of the final rulemaking pertaining to Uranium Fuel Cycle Impacts from Spent Fuel Reprocessing and Radioactive Waste Management, Docket RM-50-3. The contributions from reprocessing, waste management, and transportation of wastes are maximized for either of the two fuel cycles (i.e., uranium-only and no-recycle). The contribution from transportation excludes transportation of cold fuel to a reactor and of irradiated fuel and radioactive wastes from a reactor, which are considered in Table S–4 of 10 CFR 51.20(g) (TN250). The contributions from the other steps of the fuel cycle are given in columns A–E of Table S–3A of WASH-1248.

(b) The contributions to temporarily committed land from reprocessing are not prorated over 30 years, because the complete temporary impact accrues regardless of whether the plant services 1 reactor for 1 year or 57 reactors for 30 years.

(c) Estimated effluents based upon combustion of equivalent coal for power generation.

(d) 1.2 percent from natural-gas use and process.

Source: Adapted from Table S–3 in 10 CFR 51.51(b) (TN250). Some minor changes have been made to formatting and wording, but not to the data as they appears in Table S–3.

The Nuclear Nonproliferation Act of 1978 (22 U.S.C. § 3201 *et seq*.-TN737) significantly affected the disposition of spent nuclear fuel by deferring indefinitely the commercial reprocessing and recycling of spent fuel produced in the U.S. commercial nuclear power program. The ban on the reprocessing of spent fuel was lifted in October 1981 by the Reagan administration, but industry has not resumed reprocessing. During the 109th Congress, the Energy Policy Act of 2005 (42 U.S.C. § 15801 *et seq*.-TN738) was enacted. It authorized the U.S. Department of Energy (DOE) to conduct an advanced fuel-recycling technology research and development program to evaluate proliferation-resistant fuel-recycling and transmutation technologies that minimize environmental or public health and safety impacts. Consequently, while Federal policy does not prohibit reprocessing, additional government and commercial efforts would be necessary before commercial reprocessing and recycling of spent fuel produced in the U.S. commercial nuclear power plants could commence.

The no-recycle option is presented schematically in Figure 6-1. Natural uranium is mined in either open-pit or underground mines, or by an in situ leach-solution mining process. In situ leach mining, presently the primary form of uranium mining in the United States, involves injecting a lixiviant solution into the uranium ore body to dissolve uranium and then pumping the solution to the surface for further processing. The ore or in situ leach solution is transferred to mills where it is processed to produce "yellowcake" (U_3O_8). A conversion facility prepares the U_3O_8 by converting it to uranium hexafluoride (UF_6), which is then processed by an enrichment facility to increase the percentage of the more fissile uranium-235 isotope and decrease the percentage of the nonfissile uranium-238 isotope. At a fuel-fabrication facility, the enriched uranium, which is approximately 5 percent uranium-235, is then converted to uranium dioxide (UO_2). The UO_2 is pelletized, sintered, and inserted into tubes to form fuel assemblies, which are placed in a reactor to produce power. When the content of the uranium-235 reaches a point at which the nuclear reactor has become inefficient with respect to neutron economy, the fuel assemblies are withdrawn from the reactor as spent fuel. After onsite storage for sufficient time to allow for short-lived fission-product decay and to reduce the heat-generation rate, the fuel assemblies are transferred to a waste repository for internment. Disposal of spent fuel elements in a waste repository constitutes the final step in the no-recycle option.

The following assessment of the environmental impacts of the fuel cycle as related to the operation of SMRs at the proposed CRN Site is based on the values given in Table S–3 (Table 6-1) and the staff's analysis of the radiological impact from radon-222 and technetium-99. In NUREG–1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS) (NRC 1996-TN288, NRC 1999-TN289, NRC 2013-TN2654),[(1)] the staff provides a detailed analysis of the environmental impacts from the uranium fuel cycle. Although NUREG–1437 is specific to the impacts related to license renewal, the information is relevant to this review because the surrogate SMR design considered here uses the same type of fuel as that considered in the staff's evaluation in NUREG–1437. The staff's analyses in NUREG–1437 (NRC 2013-TN2654) are summarized and set forth here.

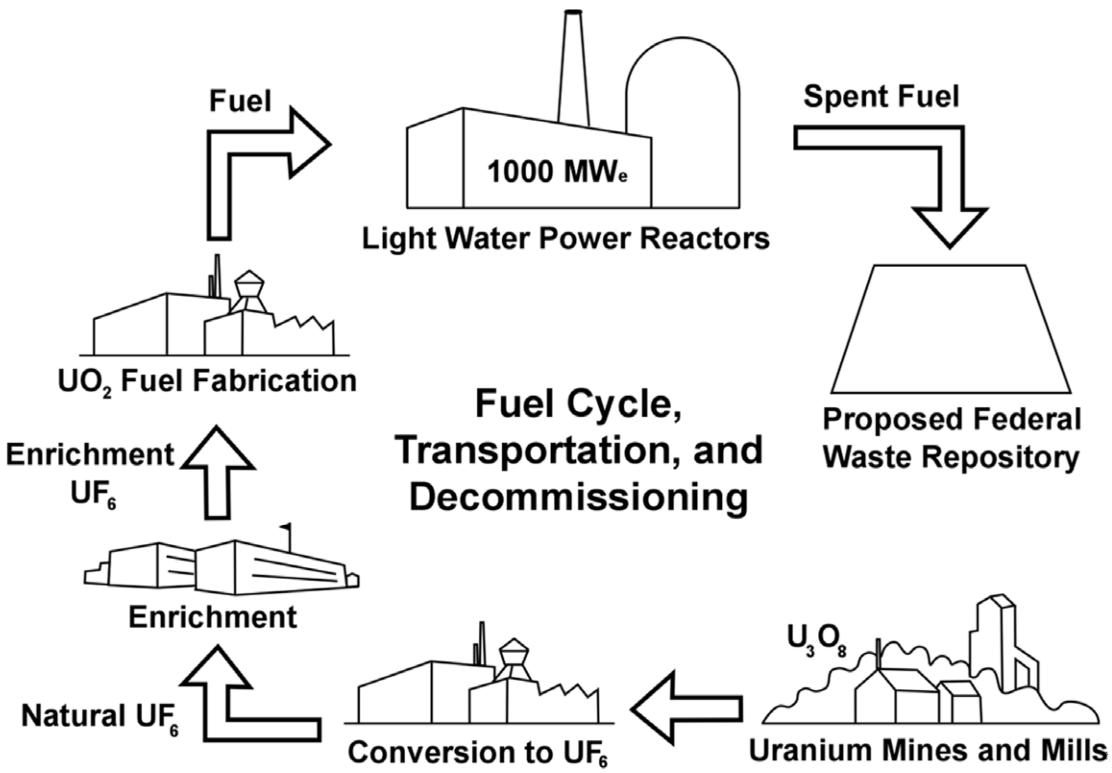

Figure 6-1. The Uranium Fuel Cycle: No-Recycle Option (Source: Derived from NRC 1999-TN289)

(1) NUREG–1437 was originally issued in 1996 (NRC 1996-TN288). Addendum 1 to NUREG–1437 was issued in 1999 (NRC 1999-TN289). NUREG–1437, Revision 1, was issued in June 2013 (NRC 2013-TN2654). The version of NUREG–1437 cited, whether 1996 or 2013, is the one in which the technical information is discussed. In some cases, the technical information is discussed in both documents. For those instances, NUREG–1437, Revision 1, is cited.

Because an SMR technology has not yet been selected, the staff's analyses rely on the PPE described in Section 3.2.1 and Appendix I of this draft EIS. The bounding power rating of a single unit is assumed to be 800 MW(t) and for the site it is assumed to be 2,420 MW(t), as described in EIS Section 3.2.1. For this analysis, the net electric power output for the site is assumed to be 800 MW(e).

The fuel-cycle impacts in Table S–3 are based on a reference 1,000-MW(e) LWR operating at an annual capacity factor of 80 percent for a net electric output of 800 MW(e). The NRC staff assumed for its review and evaluation of the environmental impacts at the CRN Site a net electric output of 800 MW(e), which is equivalent to the Table S–3 value for net electric output; therefore, the impacts at the CRN Site are assumed to be equivalent to the impacts described in Table S–3. Throughout this chapter, use of the term *1,000-MW(e) LWR-scaled model* refers to the impacts at the CRN Site (i.e., the Table S–3 values scaled by 1.0).

Recent changes in the uranium fuel cycle may have some bearing on environmental impacts, but, as discussed below, the staff is confident that the contemporary normalized uranium fuel-cycle impacts are less than those identified in Table S–3. This assertion is true in light of the following recent uranium fuel-cycle trends in the United States:

- increasing use of in situ leach uranium mining, which does not produce mine tailings and would lower the release of radon gas. A detailed discussion of this subject is provided in Section 6.1.5 of this chapter.
- transitioning of U.S. uranium enrichment technology from gaseous diffusion to gas centrifugation. The latter process uses only a small fraction of the electrical energy per separation unit compared to gaseous diffusion. (U.S. gaseous-diffusion plants relied on electricity derived mainly from the burning of coal.)
- current LWRs using nuclear fuel more efficiently due to higher fuel burnup. Less uranium fuel per year of reactor operation is required than in the past to generate the same amount of electricity.
- discharging fewer spent fuel assemblies per reactor-year, so the waste storage/repository impact is lessened.

The values in Table S–3 were calculated from industry averages for the performance of each type of facility or operation within the fuel cycle. Recognizing that this approach meant that there would be a range of reasonable values for each estimate, the staff chose the assumptions or factors to be applied so that the calculated values would not be underestimated. This approach was intended to make sure that the actual environmental impacts would be less than the quantities shown in Table S–3 for all LWR nuclear power plants within the widest range of operating conditions. The staff recognizes that many of the fuel-cycle parameters and interactions vary in small ways from the estimates in Table S–3, and concludes that these variations would have no impacts on the Table S–3 calculations. For example, to determine the quantity of fuel required for a year's operation of a nuclear power plant in Table S–3, the staff defined the reference reactor as a 1,000-MW(e) LWR operating at 80 percent capacity with a 12-month fuel-reloading cycle and an average fuel burnup of 33,000 megawatt-day(s) per metric ton of uranium (MWd/MTU). This is a "reference reactor-year" (NRC 2013-TN2654).

If approved, a combined license (COL) for a new nuclear power plant at the CRN Site would allow 40 years of operation. In NUREG–1437, the sum of the initial fuel loading plus all of the reloads for the lifetime of the reactor was divided by a 60-year lifetime (40-year initial license term and 20-year license renewal term) to obtain an average annual fuel requirement. This approach was followed in NUREG–1437 (NRC 1996-TN288, NRC 1999-TN289) and carried forward into NUREG–1437, Revision 1 (NRC 2013-TN2654), for both boiling water reactors and pressurized water reactors. The higher annual requirement, 35 metric tons (MT) of uranium made into fuel for a boiling water reactor, was chosen in NUREG–1437, Revision 1, as the basis for the reference reactor-year (NRC 2013-TN2654). The average annual fuel requirement presented in NUREG–1437, Revision 1, would only be increased by 2 percent if a 40-year lifetime was evaluated. However, a number of fuel-management improvements have been adopted by nuclear power plants to achieve higher performance and to reduce fuel and separative-work (enrichment) requirements. Since the time when Table S–3 was promulgated, these improvements have reduced the annual fuel requirement, which means the Table S–3 assumptions remain bounding as applied to the SMRs at the proposed CRN Site.

Another change supporting the bounding nature of the Table S–3 assumptions with respect to the impacts of a new nuclear power plant at the CRN Site is the elimination of the U.S. restrictions on the importation of foreign uranium. Until recently, the economic conditions of the uranium market favored use of foreign uranium at the expense of the domestic uranium industry. In the 1980s, the economic conditions of the uranium market resulted in the closing of most U.S. uranium mines and mills, thereby substantially reducing the environmental impacts in the United States from uranium-mining activities. More recently, there is renewed interest in uranium recovery in the United States. Factoring in changes to the fuel cycle suggests that the environmental impacts of mining and tail millings could drop to levels below those given in Table S–3, but Table S–3 estimates remain bounding as applied to the SMRs at the proposed CRN Site.

In summary, these reasons highlight why Table S–3 is likely to overestimate impacts from a new nuclear power plant at the CRN Site; therefore, the information in Table S–3 remains adequate for use in the bounding approach used in this analysis. Section 4.12.1.1 of NUREG–1437, Revision 1 (NRC 2013-TN2654), and Section 6.2 of NUREG–1437 (NRC 1996-TN288) discuss in greater detail the sensitivity to changes in the uranium fuel cycle since issuance of Table S–3 on the environmental impacts.

6.1.1 Land Use

The total annual land requirement for the fuel cycle supporting the 1,000-MW(e) LWR-scaled model is about 113 ac. Approximately 13 ac are permanently committed land, and 100 ac are temporarily committed. A “temporary” land commitment is a commitment for the life of the specific fuel-cycle plant (e.g., a mill, enrichment plant, or succeeding plants). After the decommissioning of the nuclear units, such land can be released for unrestricted use. “Permanent” commitments represent land that may not be released for use after plant shutdown and decommissioning because decommissioning activities do not result in the removal of sufficient radioactive material to meet the limits in 10 CFR Part 20 (TN283), Subpart E, for release of that area for unrestricted use. Of the 100 ac of temporarily committed land, 22 ac are assumed to be disturbed (NRC 1996-TN288). In comparison, a coal-fired power plant using the same megawatt electric output as the LWR-scaled model and using strip-mined coal requires the disturbance of about 160 ac/yr for fuel alone. The staff concludes that the impacts on land use to support the 1,000-MW(e) LWR-scaled model would be SMALL.

6.1.2 Water Use

The principal water use for the fuel cycle supporting a 1,000-MW(e) LWR-scaled model is that required to remove waste heat from the power stations supplying electrical energy to the enrichment step of this cycle. From Table S–3, of the total annual water use of about 1.14×10^{10} gal, about 1.11×10^{10} gal are required for the removal of waste heat, assuming that the power stations use once-through cooling. Also, scaling from Table S–3, other water uses involve the discharge to air (e.g., evaporation losses in process cooling) of about 1.60×10^{8} gal/yr and discharge to the ground (e.g., mine drainage) of about 1.27×10^{8} gal/yr.

On a thermal-effluent basis, annual discharges from the nuclear fuel cycle are less than 4 percent of the 1,000-MW(e) LWR-scaled model using once-through cooling. The consumptive-water use of 1.60×10^{8} gal/yr is about 2 percent of the 1,000-MW(e) LWR-scaled model using cooling towers. The maximum consumptive-water use (assuming that all plants supplying electrical energy to the nuclear fuel cycle use cooling towers) would be less than 6 percent of the 1,000-MW(e) LWR-scaled model using cooling towers. Under this condition, thermal effluents would be negligible. The staff concludes that the impacts on water use for these combinations of thermal loadings and water consumption would be SMALL.

6.1.3 Fossil Fuel Impacts

As indicated in Appendix K, the largest source of greenhouse gas (GHG) emissions associated with nuclear power is from the fuel cycle, not operation of the plant. The largest source of GHGs in the fuel cycle is production of electric energy and process heat from combustion of fossil fuel in conventional power plants. This energy is used to power components of the fuel cycle such as enrichment.

Table S–3 in 10 CFR 51.51 (TN250) presents data for evaluating the environmental effects of a reference 1,000-MW(e) light water-cooled nuclear power reactor resulting from the uranium fuel cycle. Table S–3 does not provide an estimate of GHG emissions associated with the uranium fuel cycle but does state that 323,000 MWh is the assumed annual electric energy use associated with the uranium fuel cycle for the reference 1,000-MW(e) nuclear power plant, and this 323,000 MWh of annual electric energy is assumed to be generated by a 45-MW(e) coal-fired power plant burning 118,000 MT of coal. Table S–3 also assumes approximately 135,000,000 standard cubic feet (scf) of natural gas is also required per year to generate process heat for certain portions of the uranium fuel cycle.

In Appendix K of this EIS, the NRC staff used the fossil fuel usage assumptions presented in Table S–3 to estimate that the GHG footprint of the fuel cycle to support a reference 1,000-MW(e) LWR with an 80 percent capacity factor for a 40-year operational period is on the order of 10,100,000 MT of carbon dioxide (CO_2) equivalent (CO_2e). This rate of GHG production equals about 250,000 MT of CO_2e per year, less than 0.004 percent of the total U.S. annual GHG emission rate of 6.6 billion MT of CO_2e in 2015 (EPA 2017-TN4924).

The largest use of electricity in the fuel cycle comes from the enrichment process. The development of Table S–3 assumed that the gaseous-diffusion process is used to enrich uranium. The gaseous-diffusion technology is no longer used for uranium enrichment. The last gaseous-diffusion enrichment facility in the U.S. ceased enrichment operations in 2013 (USEC 2013-TN2765). Current enrichment facilities use gas-centrifuge technologies, and recent applications for new uranium enrichment facilities are based on gas-centrifuge and laser-separation technologies. The same amount of enrichment from gas-centrifuge and laser-separation facilities uses less electricity and therefore results in lower amounts of air emissions (e.g., CO_2) than a gaseous-diffusion facility. In addition, U.S. electric utilities have begun to switch from coal to cheaper, cleaner-burning natural gas (DOE/EIA 1995-TN2996); the Table S–3 assumption that a 45-MW(e) coal-fired plant is used to generate the 323,000 MWh of annual electric energy for the uranium fuel cycle also results in conservative air emission estimates. Therefore, the NRC staff concludes that the values for electricity use and air emissions in Table S–3 continue to be appropriately bounding values.

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 would be SMALL.

6.1.4 Chemical Effluents

The quantities of gaseous and particulate chemical effluents produced in fuel-cycle processes are given in Table S–3 for the reference 1,000-MW(e) LWR. According to WASH-1248 (AEC 1974-TN23), the quantities result from the generation of electricity for fuel-cycle operations. The principal effluents are sulfur oxides, nitrogen oxides, and particulates. Table S-3 states that the fuel cycle for the reference 1,000-MW(e) LWR requires 323,000 MWh of electricity. The fuel cycle for the 1,000-MW(e) LWR-scaled model therefore also requires 323,000 MWh of electricity, or less than 0.008 percent of the 4.08 billion MWh of electricity generated in the United States in 2016 (DOE/EIA 2017-TN5086). Therefore, the gaseous and particulate chemical effluents from fuel-cycle processes to support the operation of the 1,000-MW(e) LWR-scaled model would add less than 0.008 percent to the national gaseous and particulate chemical effluents for electricity generation.

Liquid chemical effluents produced in fuel-cycle processes are related to fuel enrichment and fabrication and may be released to receiving waters. These effluents are usually present in dilute concentrations such that only small amounts of dilution water are required to reach levels of concentration that are within established standards. Table S–3 specifies the amount of dilution water required for specific constituents. In addition, all liquid discharges into the navigable waters of the United States from facilities associated with the fuel-cycle operations would be subject to requirements and limitations set by appropriate Federal, State, Tribal, and local agencies.

Tailings solutions and solids are generated during the milling process, but as Table S–3 indicates, effluents are not released in quantities sufficient to have a significant impact on the environment.

Based on the above analysis, the NRC staff concludes that the impacts of these chemical effluents (i.e., gaseous, particulate, and liquid) would be SMALL.

6.1.5 Radiological Effluents

Radioactive effluents estimated to be released to the environment from waste-management activities and certain other phases of the fuel-cycle process are listed in Table S–3. NUREG–1437, Revision 1 (NRC 2013-TN2654) provides the 100-year environmental dose commitment to the U.S. population from fuel-cycle activities for 1 year of operation of the reference 1,000-MW(e) LWR using the radioactive effluents in Table S–3. Excluding reactor releases and dose commitments because of exposure to radon-222 and technetium-99, the total overall whole body gaseous dose commitment and whole body liquid dose commitment from the fuel cycle were calculated to be approximately 400 person-rem and 200 person-rem, respectively. The 1,000-MW(e) LWR-scaled model results in whole body dose commitment estimates of 400 person-rem for gaseous releases and 200 person-rem for liquid releases. Therefore, for both pathways, the estimated 100-year environmental dose commitment to the U.S. population would be approximately 600-person-rem for the 1,000-MW(e) LWR-scaled model.

Currently, the radiological impacts associated with radon-222 and technetium-99 releases are not addressed in Table S–3. Principal radon releases occur during mining and milling operations and as emissions from mill tailings, whereas principal technetium-99 releases occur from gaseous-diffusion enrichment facilities. TVA provided an assessment of radon-222 and technetium-99 in its Environmental Report (ER) (TVA 2017-TN4921). TVA's evaluation relied on the information discussed in NUREG–1437 (NRC 1996-TN288).

In Section 6.2 of NUREG–1437 (NRC 1996-TN288), the NRC staff estimated the radon-222 releases from mining and milling operations and from mill tailings for each year of operation of the reference 1,000-MW(e) LWR. The estimated release of radon-222 for the 1,000-MW(e) LWR-scaled model is approximately 5,200 Ci. Of this total, about 78 percent would be from mining, 15 percent from milling operations, and 7 percent from inactive tailings before stabilization. For radon releases from stabilized tailings, the staff assumed that the LWR-scaled model would result in an emission of 1 Ci/reactor-year (i.e., the same as the NUREG–1437 [NRC 1996-TN288] estimate for the reference reactor-year). The major risks from radon-222 are from exposure to the bone and the lung, although there is a small risk from exposure to the whole body. The organ-specific dose-weighting factors from 10 CFR Part 20 (TN283) were applied to the bone and lung doses to estimate the 100-year dose commitment from radon-222 to the whole body. The estimated 100-year environmental dose commitment from mining, milling, and tailings before stabilization for each site year (assuming the 1,000-MW(e) LWR-scaled model) would be approximately 930 person-rem to the whole body. From stabilized tailings piles, the estimated 100-year environmental dose commitment would be approximately 18 person-rem to the whole body. Additional insights regarding Federal policy/resource perspectives concerning institutional controls comparisons with routine radon-222 exposure and risk and long-term releases from stabilized tailing piles are discussed in NUREG–1437 (NRC 1996-TN288).

The staff also considered the potential health effects associated with releases of technetium-99 (NRC 2013-TN2654). The estimated releases of technetium-99 for the reference reactor-year for the 1,000-MW(e) LWR-scaled model are 0.007 Ci from chemical processing of recycled UF_6 before it enters the isotope-enrichment cascade and 0.005 Ci into the groundwater from an HLW repository. The major risks from technetium-99 are from exposure of the gastrointestinal tract and kidney, although there is a small risk from exposure to the whole body. The organ-specific dose-weighting factors from 10 CFR Part 20 (TN283) were applied to the gastrointestinal tract and kidney doses, and the total-body 100-year dose commitment from technetium-99 to the whole body was estimated to be 100 person-rem for the 1,000-MW(e) LWR-scaled model.

Radiation protection experts assume that any amount of radiation may pose some risk of causing cancer or a severe hereditary effect and that the risk is higher for higher radiation exposures. Therefore, a linear, no-threshold dose response relationship is used to describe the relationship between radiation dose and detriments such as cancer induction. *Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR* [Biological Effects of Ionizing Radiation] V*II—Phase 2*, a recent report by the National Research Council (2006-TN296), uses the linear, no-threshold dose response model as a basis for estimating the risks from low doses. This approach is accepted by the NRC as a conservative method for estimating health risks from radiation exposure, recognizing that the model may overestimate those risks. Based on this method, the 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 1,000,000 person-rem (10,000 person-Sv), equal to 0.00057 effect per person-rem. The coefficient is taken from Publication 103 of the International Commission on Radiological Protection (ICRP 2007-TN422).

The nominal probability coefficient was multiplied by the sum of the estimated whole body population doses from gaseous effluents, liquid effluents, radon-222, and technetium-99 discussed above (approximately 1,650 person-rem/year) to calculate that the U.S. population would incur a total of approximately 0.9 fatal cancers, nonfatal cancers, and severe hereditary effects annually.

Radon-222 releases from tailings are indistinguishable from background radiation levels at a few kilometers from the tailings pile (at less than 0.6 mi in some cases) (NRC 1996-TN288, NRC 1999-TN289). The public dose limit in the U.S. Environmental Protection Agency (EPA) regulation, 40 CFR Part 190 (TN739), is 25 mrem/yr to the whole body from the entire fuel cycle, but most NRC licensees have airborne effluents resulting in doses of less than 1 mrem/yr (61 FR 65120 -TN294).

In addition, at the request of the U.S. Congress, the National Cancer Institute conducted a study and published *Cancer in Populations Living Near Nuclear Facilities* in 1990 (Jablon et al. 1990-TN1257). The report included an evaluation of health statistics around all nuclear power plants as well as several other nuclear fuel-cycle facilities in operation in the United States in 1981 and found "no evidence that an excess occurrence of cancer has resulted from living near nuclear facilities" (Jablon et al. 1990-TN1257). The contribution to the annual average dose received by an individual from fuel-cycle-related radiation and other sources as reported in a publication of the National Council on Radiation Protection and Measurements (NCRP 2009-TN420) is listed in Table 6-2. The contribution from the nuclear fuel cycle to an individual's annual average radiation dose is extremely small (about 0.1 mrem/yr) compared to the annual average background radiation dose (about 311 mrem/yr).

Based on the analyses presented above, the staff concludes that the environmental impacts of radioactive effluents from the fuel cycle, including gaseous and liquid releases, are SMALL.

6.1.6 Radiological Wastes

The estimated quantities of buried radioactive waste material (LLW, HLW, and transuranic wastes) generated by the reference 1,000-MW(e) LWR are specified in Table S–3. For LLW disposal at land burial facilities, the Commission notes in Table S–3 that there would be no significant radioactive releases to the environment. The CRN Site is in the State of Tennessee, which is part of the Southeast Interstate Low-Level Radioactive Waste Management Compact. The DOE Manifest Information Management System was used to prepare a summary (Table 6-3) of LLW disposal from 2006–2015 of wastes generated in the State of Tennessee (DOE 2017-TN5087). During the period from 2012–2015, most of the LLW generated in Tennessee was either shipped to the EnergySolutions disposal facility near Clive, Utah, or to the Waste Control Specialists disposal facility in Andrews County, Texas.

It is anticipated that TVA would enter into an agreement with a licensed facility that would accept LLW from the new nuclear power plant at the CRN Site. Alternatively, TVA could

- Implement measures to reduce the generation of Class B and C wastes, extending the capacity of the onsite solid-waste storage system.
- Construct additional temporary storage facilities on the site.
- Enter into an agreement with a third-party contractor to process, store, own, and ultimately dispose of LLW from the new nuclear capacity at the CRN Site.

Table 6-2. Comparison of Annual Average Dose Received by an Individual from All Sources

	Source	Dose (mrem/yr)[(a)]	Percent of Total
Ubiquitous background	Radon & Thoron	228	37
	Space	33	5
	Terrestrial	21	3
	Internal (body)	29	5
	Total background sources	**311**	**50**
Medical	Computed tomography	147	24
	Medical x-ray	76	12
	Nuclear medicine	77	12
	Total medical sources	**300**	**48**
Consumer	Construction materials, smoking, air travel, mining, agriculture, fossil fuel combustion	13	2
Other	Occupational	0.5[(b)]	0.1
	Nuclear fuel cycle	0.05[(c)]	0.01
Total		**624**	**100**

(a) NCRP Report 160 expressed doses in mSv/yr (1 mSv/yr equals 100 mrem/yr).
(b) Occupational dose is regulated separately from public dose and is provided here for informational purposes.
(c) Estimated using 153 person-Sv/yr from Table 6.1 of NCRP 160 and a 2006 U.S. population of 300 million.

Source: NCRP 2009-TN420.

Table 6-3. 2006–2015 Summary of Disposal of LLW Generated in the State of Tennessee

Years	Disposal Facility	Volume (ft^3)	Activity (Ci)	Class
2006–2008	Barnwell	2,918	1,865	A, B, C
NA	Beatty	NA	NA	NA
2006-2015	Energy Solutions	1,861,525	4,333,802	A
2007, 2009–2011, 2013	Richland	54	0.29	C
2012–2015	Waste Control Specialists	10,897	33,410	A, B, C

Source: DOE 2017-TN5087.

The Waste Control Specialists, LLC, site in Andrews County, Texas, is licensed to accept Class A, B, and C LLW from the Texas Compact (Texas and Vermont). Waste Control Specialists, LLC, may accept Class A, B, and C LLW from outside the Texas Compact for disposal subject to established criteria, conditions, and approval processes (Tex. Admin Code 31-675.23 -TN731). Because TVA would likely have to choose one or a combination of these options, the staff considered the environmental impacts of each of these options.

Table S–3 addresses the environmental impacts of TVA entering into an agreement with a licensed facility for disposal of LLW, and Table S–4 addresses the environmental impacts from transportation of LLW, as discussed in Section 6.2 of this chapter. The use of third-party contractors was not explicitly addressed in Tables S–3 and S–4, but such third-party contractors are already licensed by the NRC or Agreement States and the resulting environmental impacts are not significant compared to the impacts described in Tables S–3 and S–4.

Measures to reduce the generation of Class B and C wastes, such as reducing the service run length of resin beds, could increase the volume of LLW but would not increase the total activity (in curies) of radioactive material in the waste. The volume of waste would still be bounded by or very similar to the estimates in Table S–3, and the environmental impacts would not be significantly different.

In most circumstances, the NRC's regulations (10 CFR Part 50 -TN249) allow licensees operating nuclear power plants to construct and operate additional onsite LLW storage facilities without seeking approval from the NRC. Licensees are required to evaluate the safety and environmental impacts before constructing the facility and to make those evaluations available to NRC inspectors. A number of nuclear power plant licensees have constructed and operate such facilities in the United States. Typically, these additional facilities are constructed near the power block inside the security fence on land that has already been disturbed during initial plant construction. Therefore, the impacts on environmental resources (e.g., land use and aquatic and terrestrial biota) would be minimal. All of the NRC (10 CFR Part 20 -TN283) and EPA (40 CFR Part 190 -TN739) dose limitations would apply for both public and occupational radiation exposure. The radiological environmental monitoring programs around nuclear power plants that operate such facilities show that the increase in radiation dose at the site boundary is not significant; the radiation doses continue to be below 25 mrem/yr, the dose limit of 40 CFR Part 190 (TN739). The NRC staff concludes that doses to members of the public within the NRC and EPA regulations are a minimal impact. Therefore, the impacts from construction and operation of additional onsite LLW storage facilities would be minor.

In addition, the NRC staff assessed the impacts of onsite LLW storage at currently operating nuclear power plants and concluded that the radiation doses to offsite individuals from interim LLW storage are insignificant (NRC 2013-TN2654). The types and amounts of LLW generated by the CRN Site would be very similar to those generated by currently operating nuclear power plants, and the construction and operation of these interim LLW storage facilities would be very similar to the construction and operation of the currently operating facilities. Additionally, in NUREG–1437 (NRC 2013-TN2654), the NRC staff concluded that there should be no significant issues or environmental impacts associated with interim storage of LLW generated by nuclear power plants. Interim storage facilities would be used until these wastes could be safely shipped to licensed disposal facilities.

As part of the Table S–3 rulemaking, the NRC staff evaluated, along with more conservative assumptions, the zero-release assumption associated with waste burial in a repository, and the NRC reached an overall generic determination that fuel-cycle impacts would not be significant. In 1983, the Supreme Court affirmed the NRC's position that the zero-release assumption was reasonable in the context of the Table S–3 rulemaking to address generically the impacts of the uranium fuel cycle in individual reactor-licensing proceedings (Baltimore Gas and Electric Co. *v*. Natural Resources Defense Council, Inc. 1983-TN1054).

Environmental impacts from onsite spent fuel storage, either in a spent fuel pool or independent spent fuel storage installation (ISFSI), during the licensed life of the plant have been studied extensively and are well understood. SMR designs considered by TVA would likely include an ISFSI for onsite spent fuel storage. In the context of operating license (OL) renewal, the staff provides descriptions of the storage of spent fuel during the licensed lifetime of reactor operations (NRC 2013-TN2654). Radiological impacts are well within regulatory limits; thus, the radiological impacts of onsite storage during operations would be minimal. Nonradiological environmental impacts have been shown to be not significant (NRC 1989-TN3714). Thus, the NRC staff has determined that disturbance to resource areas (e.g., terrestrial and aquatic ecology, historic and cultural resources, and land-use resources) that may be associated with potential additional onsite operational storage would not alter the conclusions presented in

Chapters 5 and 7 of this EIS. However, the U.S. Army Corps of Engineers may require additional mitigation measures for any disturbance of wetland resources. The overall conclusion for onsite storage of spent fuel during the licensed lifetime of reactor operations is that the environmental impacts would be minor.

On August 26, 2014, the Commission issued a revised rule at 10 CFR 51.23 (TN250) and associated *Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel*, NUREG–2157 (NRC 2014-TN4117). The revised rule adopts the generic impact determinations made in NUREG–2157 and codifies the NRC's generic determinations regarding the environmental impacts of continued storage of spent nuclear fuel beyond a reactor's OL (i.e., those impacts that could occur as a result of the storage of spent nuclear fuel at at-reactor or away-from-reactor sites after a reactor's licensed life for operation and until a permanent repository becomes available).

In CLI-14-08 (NRC 2014-TN4303), the Commission held that the revised 10 CFR 51.23 (TN250) and associated NUREG–2157 (NRC 2014-TN4117) cure the deficiencies identified by the court in *New York v. NRC* (2012-TN2397), 681 F.3d 471 (D.C. Cir. 2012) and stated that the rule satisfies the NRC's National Environmental Policy Act (NEPA; 42 U.S.C. § 4321 *et seq*. -TN661) obligations with respect to continued storage for an ESP, among other actions, thereby including the TVA ESP application. As directed by 10 CFR 51.23(b) (TN250), the impacts assessed in NUREG–2157 (NRC 2014-TN4117) are deemed incorporated into this EIS.

The staff's evaluation of the potential environmental impacts of continued storage of spent fuel presented in NUREG–2157 (NRC 2014-TN4117) identifies an impact level, or a range of impacts, for each resource area for a range of site conditions and time frames. The time frames analyzed in NUREG–2157 include the short-term time frame (i.e., 60 years beyond the licensed life of a reactor), the long-term time frame (i.e., an additional 100 years after the short-term time frame), and an indefinite time frame (see Section 1.8.2 of NUREG–2157 [NRC 2014-TN4117]).

The analysis in Section 4.20 of NUREG–2157 (NRC 2014-TN4117) concludes that the potential impacts of spent fuel storage at the reactor site in both a spent fuel pool and in an at-reactor ISFSI would be SMALL during the short-term time frame. However, for the longer time frames for at-reactor storage, and for all time frames for away-from-reactor storage, Sections 4.20 and 5.20 of NUREG–2157 provide a range of potential impacts in some resource areas. These ranges reflect uncertainties that are inherent to analyzing environmental impacts on some resource areas over long time frames. Those uncertainties exist, however, regardless of whether the impacts are analyzed generically or site-specifically.

Appendix B of NUREG–2157 (NRC 2014-TN4117) provides an assessment of the technical feasibility of a deep geologic repository and continued safe storage of spent fuel. That assessment concluded that a deep geologic repository is technically feasible and that a reasonable time frame for its development is about 25 to 35 years. The assessment in NUREG–2157 noted that DOE's goal is to have sited, constructed, and commenced operations of a repository by 2048 (NRC 2014-TN4117). If the current proposed action and any future licensing actions are approved and no renewals are granted in the future, the short-term time frame will end 60 years after the end of the licensed period. The licensed period plus the short-term time frame is more than twice as long as the time estimated to develop a deep geologic repository.

The most likely impacts of the continued storage of spent fuel are those considered for at-reactor storage in the short-term time frame. In the unlikely event that fuel remains on the site into the long-term and indefinite time frames, the ranges in NUREG–2157 reflect factors that lead to uncertainties regarding the potential impacts over these very long periods of time (NRC 2014-TN4117). Based on the analysis and impact determination in NUREG–2157 (NRC 2014-TN4117), and taking into account the impacts that the NRC can predict with certainty, which are SMALL; the uncertainty reflected by the ranges in the long-term and indefinite time frames; and the relative likelihood of the time frames, the staff finds that the impacts for at-reactor storage at a new nuclear power plant at the CRN Site are likely to be minor.

Spent fuel could also be moved to an away-from-reactor storage facility. However, there is uncertainty regarding whether an away-from-reactor storage facility would be constructed, where it might be located, and what the impacts in short-term, long-term, and indefinite time frames might be. As a result, these impacts provide limited insights for the decision maker in the overall picture of the environmental impacts of the proposed action and do not change the staff's overall conclusion regarding the environmental impacts of radiological wastes from the fuel cycle, which includes the impacts associated with spent fuel storage.

The NRC staff concludes, based on Table S–3 and the above conclusions regarding storage and disposal of LLW and spent fuel, that the environmental impacts from radioactive waste storage and disposal associated with the operation of a new nuclear power plant at the CRN Site would be SMALL.

6.1.7 Occupational Dose

The annual occupational dose attributable to all phases of the fuel cycle for the 1,000-MW(e) LWR-scaled model is about 600 person-rem. This is based on the NUREG–1437 occupational dose estimate of 600 person-rem attributable to all phases of the fuel cycle for the model 1,000-MW(e) LWR (NRC 1996-TN288, NRC 1999-TN289). The NRC staff concludes that the environmental impact from this occupational dose would be SMALL because the dose to any individual worker would be maintained within the limits of 10 CFR Part 20 (TN283), which is 5 rem/yr.

6.1.8 Transportation

The transportation dose to workers and the public related to the uranium fuel cycle totals approximately 2.5 person-rem annually for the reference 1,000-MW(e) LWR, according to Table S–3 and, equivalently, the 1,000-MW(e) LWR-scaled model at the CRN Site. For purposes of comparison, the estimated collective dose from natural background radiation to the projected population of 1,658,157 within 50 mi of the CRN Site in 2067 is about 826,700 person-rem/year (TVA 2017-TN4921). Based on this comparison, the NRC staff concludes that environmental impacts of transportation would be SMALL.

6.1.9 Summary

The staff evaluated the environmental impacts of the uranium fuel cycle, as given in Table S–3 of 10 CFR 51.51(b) (TN250), considered the effects of radon-222 and technetium-99, and appropriately scaled the impacts for the 1,000-MW(e) LWR-scaled model. The NRC staff also evaluated the environmental impacts of GHG emissions from the uranium fuel cycle and appropriately scaled the impacts for the 1,000-MW(e) LWR-scaled model. Based on this evaluation, the staff concludes that the impacts of the uranium fuel cycle would be SMALL.

6.2 Transportation Impacts

This section addresses both the radiological and nonradiological environmental impacts from normal operating and accident conditions resulting from (1) shipment of unirradiated fuel to the CRN Site and alternative sites (Section 6.2.1), (2) shipment of spent fuel to an interim storage facility or a permanent geologic repository (Section 6.2.2), and (3) shipment of LLW and mixed waste to offsite disposal facilities (Section 6.2.3). For the purposes of these analyses, the NRC staff considered the proposed Yucca Mountain, Nevada, repository site as a surrogate destination for a monitored retrievable storage facility or permanent repository. The impacts evaluated in this section for a new nuclear power plant at the CRN Site are appropriate for characterizing the alternative sites discussed in Section 9.3 of this draft EIS. In addition to the proposed CRN Site, which is located on the Oak Ridge Reservation, the alternative sites evaluated in this EIS include two additional sites located on the Oak Ridge Reservation, and one site located at the Redstone Arsenal in Alabama. There is no meaningful differentiation among the proposed and the alternative sites regarding the radiological and nonradiological environmental impacts from normal operating and accident conditions; therefore, these conditions are not discussed further in Chapter 9.

The NRC performed a generic analysis of the environmental effects of the transportation of fuel and waste to and from LWRs in the *Environmental Survey of Transportation of Radioactive Materials To and From Nuclear Power Plants*, WASH-1238 (AEC 1972-TN22) and in a supplement to WASH-1238, NUREG–75/038 (NRC 1975-TN216), and found the impact to be small. These documents provided the basis for Table S–4 in 10 CFR 51.52 (TN250) that summarizes the environmental impacts of transportation of fuel and waste to and from one LWR of 3,000 to 5,000 MW(t) (1,000 to 1,500 MW(e)). Impacts are provided for normal conditions of transport and accidents in transport for a reference 1,100-MW(e) LWR.[(2)] Dose to transportation workers during normal transportation operations was estimated to result in a collective dose of 4 person-rem per reference reactor-year. The combined dose to the public along the route and the dose to onlookers were estimated to result in a collective dose of 3 person-rem per reference reactor-year.

Environmental risks of radiological effects during accident conditions, as stated in Table S–4, are small. Nonradiological impacts from postulated accidents were estimated as one fatal injury in 100 reference reactor-years and one nonfatal injury in 10 reference reactor-years. Subsequent reviews of transportation impacts in NUREG–0170 (NRC 1977-TN417) and NUREG/CR–6672 (Sprung et al. 2000-TN222) concluded that impacts were bounded by Table S–4 in 10 CFR 51.52 (TN250). In accordance with 10 CFR 51.52(a) (TN250), a full description and a detailed analysis of transportation impacts are not required when licensing an LWR (i.e., impacts are assumed to be bounded by Table S–4) if the reactor meets the following criteria:

- The reactor has a core thermal power level that does not exceed 3,800 MW(t).

(2) The transportation impacts associated with the CRN Site were normalized for a reference 1,100-MW(e) LWR at an 80 percent capacity factor for comparison to Table S–4. Note that the basis for Table S–4 is a 1,100 MW(e) LWR at an 80 percent capacity factor (AEC 1972-TN22; NRC 1975-TN216). The basis for Table S–3 in 10 CFR 51.51(b) (TN250) that was discussed in Section 6.1 of this EIS is a 1,000-MW(e) LWR with an 80 percent capacity factor (NRC 1976-TN292). However, because fuel cycle and transportation impacts are evaluated separately, this difference does not affect the results and conclusions in this EIS.

- Fuel is in the form of sintered uranium oxide pellets that have a uranium-235 enrichment not exceeding 4 percent by weight, and the pellets are encapsulated in Zircaloy-clad fuel rods.(3)
- The average level of irradiation of the fuel from the reactor does not exceed 33,000 MWd/MTU, and no irradiated fuel assembly is shipped until at least 90 days after it is discharged from the reactor.
- With the exception of irradiated fuel, all radioactive waste shipped from the reactor is packaged and in solid form.
- Unirradiated fuel is shipped to the reactor by truck; irradiated (spent) fuel is shipped from the reactor by truck, railcar, or barge; and radioactive waste, other than irradiated fuel, is shipped from the reactor by truck or railcar.

The environmental impacts of the transportation of fuel and radioactive wastes to and from nuclear power facilities are resolved generically in 10 CFR 51.52 (TN250), provided that the specific conditions in the rule (see above) are met. The NRC may consider requests for licensed plants to operate at conditions above those in the facility's licensing basis; for example, higher burnups (above 33,000 MWd/MTU), enrichments (above 4 weight percent uranium-235), or thermal power levels (above 3,800 MW(t)). Departures from the conditions itemized in 10 CFR 51.52(a) (TN250) are to be supported by a full description and detailed analysis of the environmental effects, as specified in 10 CFR 51.52(b) (TN250). Departures found to be acceptable for licensed facilities cannot serve as the basis for initial licensing of new reactors.

In its ESP application, TVA did not identify a specific reactor design. Rather, the ESP application used a surrogate SMR by applying bounding parameters from four SMR designs. As previously discussed in this EIS, the SMR designs considered are LWRs and include the BWXT mPower™ SMR, the Holtec SMR-160, the NuScale SMR, and the Westinghouse SMR. Overall, the generating output of the surrogate SMR at the CRN Site or alternative sites is 800 MW(e) and the station capacity factor is 90 percent (TVA 2017-TN4921, TVA 2017-TN4922). Additional PPE values are provided in Appendix I of this EIS

None of the proposed nuclear fuel characteristics provided in the PPE meet all of the conditions in 10 CFR 51.52(a) (TN250). This conclusion is based on the following:

- The maximum fuel enrichment PPE for the four small modular reactor designs requires fuel that exceeds the U-235 enrichment of 4 percent.
- The maximum average assembly burnup PPE for the four small modular reactor designs are expected to exceed the average irradiation level of 33,000 MWd/MTU.

Therefore, a full description and detailed analysis of the environmental effects of transportation of fuel and waste to and from the surrogate SMR is required to be provided in the ER, including values for the environmental impact under normal conditions of transport and for the environmental risk from accidents during transport. In its ER and in supplemental information, TVA provided a full description and detailed analyses of transportation impacts for the proposed CRN Site (TVA 2017-TN4921, TVA 2017-TN4922). In these analyses, the radiological impacts of transporting fuel and waste to and from the proposed CRN Site were calculated using the

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(3) 10 CFR 51.52(a)(2) (TN250) specifies the use of Zircaloy as the fuel rod cladding material. The NRC has also specified in 10 CFR 50.46 (TN249) that ZIRLO is an acceptable fuel rod cladding material, and that with regard to the potential environmental impacts associated with the transportation of M5 clad fuel assemblies, the M5 cladding had no impact on previous assessments determined in accordance with 10 CFR 51.52 (65 FR 794 -TN2657).

RADTRAN 6.5 computer code. For this EIS, the NRC staff estimated the radiological impacts of transporting fuel and waste to and from the proposed CRN Site and alternative sites using the RADTRAN 6 (Weiner et al. 2013-TN3390, Weiner et al. 2014-TN3389) computer code.

Public comments on previous new reactor EISs also were considered when developing the scope of this EIS. Based on the previous public comments, this EIS includes an explicit analysis of the nonradiological impacts of transporting unirradiated fuel, spent fuel, and radioactive waste to and from the CRN Site and alternative sites. Nonradiological impacts of transporting construction workers and materials and operations workers are addressed in EIS Sections 4.8.3 and 5.8.6, respectively. Publicly available information about traffic accident, injury, and fatality rates was used to estimate nonradiological impacts. In addition, the radiological impacts on maximally exposed individuals (MEIs) are evaluated.

6.2.1 Transportation of Unirradiated Fuel

The NRC staff performed an independent evaluation of the environmental impacts of transporting unirradiated (i.e., fresh) fuel to the CRN Site and alternative sites. Radiological impacts of normal conditions and transportation accidents as well as nonradiological impacts are discussed in this section. Radiological impacts on populations and MEIs are presented. TVA assumed in its ER (TVA 2017-TN4921, TVA 2017-TN4922) that the unirradiated fuel would be shipped from Richland, Washington. The NRC staff's analysis evaluated a generic route from a fuel-fabrication facility to the CRN Site based on WASH-1238 (AEC 1972-TN22) and also evaluated representative routes from the fuel-fabrication facility to the CRN Site and alternative sites. Consistent with the ER, the representative routes were determined using the Transportation Routing Analysis Geographical Information System (TRAGIS) routing code (Liu et al. 2016-TN4885). There are no substantive differences between the impacts calculated, for the purposes of Chapter 9, for the CRN Site and the three alternative sites. The site-specific differences are minor because the differences in dose estimates as a result of differences in shipping distances among the potential fuel-fabrication plant to the CRN Site and alternative sites are small.

6.2.1.1 Normal Conditions

Normal conditions, sometimes referred to as "incident-free" transportation, are transportation activities during which shipments reach their destination without releasing any radioactive material to the environment (i.e., not being involved in a vehicular accident). Impacts from these shipments would be from the low levels of radiation that penetrate the shielding provided by unirradiated fuel shipping containers. Radiation exposures at some level would occur to the following individuals: (1) persons residing along the transportation corridors between the fuel-fabrication facility and the CRN Site or alternative sites; (2) persons in vehicles traveling on the same route as an unirradiated fuel shipment; (3) persons at vehicle stops for refueling, rest, and vehicle inspections; and (4) transportation crew workers.

6.2.1.1.1 Truck Shipments

Table 6-4 provides a PPE estimate of the number of truck shipments of unirradiated fuel for the surrogate SMR compared to those of the reference 1,100-MW(e) reactor specified in WASH-1238 (AEC 1972-TN22) operating at 80 percent capacity (880 MW(e)). The results are consistent with the estimates provided in TVA's ER and supplemental information (TVA 2017-TN4921, TVA 2017-TN4922).

Table 6-4. Number of Truck Shipments of Unirradiated Fuel for the Reference LWR and the Surrogate SMR at the CRN Site, Normalized to the Reference LWR (880 MW(e) net)

Reactor Type	Number of Shipments per Site			Unit Electric Generation (MW(e))[(b)]	Capacity Factor[(b)]	Normalized Shipments per 880 MW(e) (net)[(c,d)]	Normalized Average Annual Shipments
	Initial Core	Total Reload	Total[(a)]				
Reference LWR (WASH-1238)	18	234	252	1,100	0.8	252	6.3
Surrogate SMR	36	456	492	800	0.9	601	15

(a) Total shipments of unirradiated fuel over a 40-year plant lifetime including the initial core load.
(b) Unit capacities and capacity factors were taken from WASH-1238 (AEC 1972-TN22) for the reference LWR.
(c) Shipments for the surrogate SMR were taken from TVA 2017-TN4921 and TVA 2017-TN4922.
(d) Normalized to net electric output for WASH-1238 reference LWR (i.e., 1,100-MW(e) plant at 80 percent or net electrical output of 880 MW(e)).

6.2.1.1.2 Shipping Mode and Weight Limits

In 10 CFR 51.52 (TN250), a condition is identified that states all unirradiated fuel is shipped to the reactor by truck. TVA specifies that unirradiated fuel would be shipped to the proposed reactor site by truck. 10 CFR 51.52 (TN250) Table S–4 includes a condition that the truck shipments not exceed 73,000 lb as governed by Federal or State gross vehicle weight restrictions. TVA states in its ER that the unirradiated fuel shipments to the CRN Site and alternative sites would comply with applicable weight restrictions (TVA 2017-TN4921, TVA 2017-TN4922).

6.2.1.1.3 Radiological Doses to Transport Workers and the Public

10 CFR 51.52 (TN250), Table S–4, includes conditions related to radiological dose to transport workers and members of the public along transport routes. These doses are a function of many variables, including the radiation dose rate emitted from the unirradiated fuel shipments, the number of exposed individuals and their locations relative to the shipment, the time in transit (including travel and stop times), and the number of shipments to which the individuals are exposed. For this EIS, the radiological dose impacts of the transportation of unirradiated fuel were independently calculated by the NRC staff for the worker and the public using the RADTRAN 6 computer code (Weiner et al. 2013-TN3390, Weiner et al. 2014-TN3389).

One of the key assumptions in WASH-1238 (AEC 1972-TN22) for the reference LWR unirradiated fuel shipments is that the radiation dose rate at 3.3 ft from the transport vehicle is about 0.1 mrem/hr. This assumption also was used in the NRC staff's analysis of the unirradiated fuel shipments for the surrogate SMR. This assumption is reasonable because the reactor fuel materials would be low-dose-rate uranium radionuclides and would be packaged similarly to those described in WASH-1238 (i.e., inside a metal container that provides little radiation shielding). The numbers of shipments per year were obtained by dividing the normalized shipments in Table 6-4 by 40 years of reactor operation. Other key input parameters used in the radiation dose analysis for unirradiated fuel are provided in Table 6-5.

Table 6-5. RADTRAN 6 Input Parameters for Reference LWR Fresh Fuel Shipments

Parameter	RADTRAN 6 Input Value	Source
Shipping distance, km	3,200	AEC 1972 (TN22)[(a)]
Travel fraction – Rural	0.90	Rural, suburban, and urban travel fractions are taken from NRC 1977 (TN417).
Travel fraction – Suburban	0.05	
Travel fraction – Urban	0.05	
Population density – Rural, persons/km^2	10	Rural, suburban, and urban population densities are taken from DOE 2002 (TN418).
Population density – Suburban, persons/km^2	349	
Population density – Urban, persons/km^2	2,260	
Vehicle speed – km/hr	88.5	Conservative in-transit speed of 55 mph assumed; predominantly interstate highways used.
Traffic count – Rural, vehicles/hr	530	Rural, suburban, and urban traffic counts are taken from DOE 2002 (TN418).
Traffic count – Suburban, vehicles/hr	760	
Traffic count – Urban, vehicles/hr	2,400	
Dose rate at 1 m from vehicle, mrem/hr	0.1	AEC 1972 (TN22)
Packaging length, m	5.5	TVA 2017 (TN4922)
Number of truck crew	2	AEC 1972 (TN22); NRC 1977 (TN417); DOE 2002 (TN418).
Stop time, hr/trip	4	Based on one 30-minute stop per 4-hour driving time.
Population density at stops, persons/km^2	[(b)]	

(a) AEC 1972-TN22 provides a range of shipping distances between 40 km (25 mi) and 4,800 km (3,000 mi) for unirradiated fuel shipments. A 3,200-km (2,000-mi) “representative” shipping distance was assumed here.
(b) See Table 6-9 for truck stop parameters.

The RADTRAN 6 results for this generic unirradiated fuel shipment based on WASH-1238 (AEC 1972-TN22) are as follows:

- worker dose: 1.3×10^{-3} person-rem/shipment
- general public dose (onlookers/persons at stops and sharing the highway): 2.2×10^{-3} person-rem/shipment
- general public dose (along route/persons living near a highway or truck stop): 3.2×10^{-5} person-rem/shipment.

To estimate the annual doses to the public and workers from the average annual shipments of unirradiated fuel for the surrogate SMR, TVA assumed in its ER (TVA 2017-TN4921, TVA 2017-TN4922) that the unirradiated fuel would be shipped from Richland, Washington. Table 6-6 presents the annual radiological impacts on workers, public onlookers (persons at stops and sharing the road), and members of the public along the route (i.e., residents within 0.5 mi of the highway) for transporting unirradiated fuel from Richland, Washington, to the CRN Site and alternative sites.

The cumulative annual dose estimates in Table 6-6 were normalized to 1,100 MW(e) (880 MW(e) net electrical output). The NRC staff performed an independent review and determined that all dose estimates are bounded by the Table S–4 conditions of 4 person-rem/year to transportation workers, 3 person-rem/year to onlookers, and 3 person-rem/year to members of the public along the route.

Table 6-6. Radiological Impacts under Normal Conditions of Transporting Unirradiated Fuel to the CRN Site or Alternative Sites, Normalized to Reference LWR (880 MW(e) net)

Site and Reactor Type	Normalized Average Annual Shipments	Cumulative Annual Dose (person-rem/yr per 880 MW(e) [net])[(a,b)]		
		Workers	Public – Onlookers	Public – Along Route
Reference LWR (WASH-1238)	6.3	8.4×10^{-3}	1.4×10^{-2}	2.0×10^{-4}
CRN Site	15	7.8×10^{-3}	4.4×10^{-2}	1.2×10^{-3}
ORR Site #2	15	7.8×10^{-3}	4.4×10^{-2}	1.2×10^{-3}
ORR Site #8	15	7.8×10^{-3}	4.4×10^{-2}	1.2×10^{-3}
Redstone Arsenal Site	15	7.8×10^{-3}	4.4×10^{-2}	1.2×10^{-3}
10 CFR 51.52 (TN250), Table S–4 Condition	<1 per day	4.0×10^{0}	3.0×10^{0}	3.0×10^{0}

(a) Divide person-rem/year by 100 to obtain doses in person-Sv/year.
(b) Normalized average annual shipments were taken from TVA 2017-TN4921, TVA 2017-TN4922.

Radiation protection experts assume that any amount of radiation may pose some risk of causing cancer or a severe hereditary effect and that the risk is higher for higher radiation exposures. Therefore, a linear, no-threshold dose response relationship is used to describe the relationship between radiation dose and detriments such as cancer induction. A recent report by the National Research Council (2006-TN296), the BEIR VII report, uses the linear, no-threshold dose response model as a basis for estimating the risks from low doses. This approach is accepted by the NRC as a conservative method for estimating health risks from radiation exposure, recognizing that the model may overestimate those risks. 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 1,000,000 person-rem (10,000 person-Sv), equal to 0.00057 effects per person-rem. The coefficient is taken from ICRP Publication 103 (ICRP 2007-TN422).

Both the NCRP and ICRP suggest that when the collective effective dose is smaller than the reciprocal of the relevant risk detriment (in other words, less than 1/0.00057, which is less than 1,754 person-rem), the risk assessment should note that the most likely number of excess health effects is zero (NCRP 1995-TN728; ICRP 2007-TN422). The largest annual collective dose estimate for transporting unirradiated fuel to the CRN Site and alternative sites was less than 5×10^{-2} person-rem, which is less than the 1,754 person-rem value that ICRP and NCRP suggest would most likely result in zero excess health effects.

To place these impacts in perspective, the average U.S. resident receives about a 311 mrem/yr effective dose equivalent from natural background radiation (i.e., exposures from cosmic radiation; naturally occurring radioactive materials, such as radon; and global fallout from testing of nuclear explosive devices) (NCRP 2009-TN420). Using this average effective dose, the collective population dose from natural background radiation to the population along the representative route would be about 240,000 person-rem. Therefore, the radiation doses from transporting unirradiated fuel to the CRN Site and alternative sites are minimal compared to the collective population dose to the same population from exposure to natural sources of radiation.

6.2.1.1.4 Maximally Exposed Individuals under Normal Transport Conditions

A scenario-based analysis was conducted by the NRC staff to develop estimates of incident-free radiation doses to MEIs for fuel and waste shipments to and from the CRN Site and alternative sites. An MEI is a person who may receive the highest radiation dose from a shipment to and/or from the CRN Site and alternative sites. The following discussion applies to unirradiated fuel shipments to, and spent fuel and radioactive waste shipments from, the CRN Site and any of the alternative sites. The analysis is based on information in DOE's *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE 2002-TN1236) and incorporates data about exposure times, dose rates, and the number of times an individual may be exposed to an offsite shipment. Adjustments were made where necessary to reflect the normalized fuel and waste shipments addressed in this EIS. In all cases, the NRC staff assumed that the dose rate emitted from the shipping containers is 10 mrem/hr at 2 m (6.6 ft) from the side of the transport vehicle. This assumption is conservative because the assumed dose rate is the maximum dose rate allowed by U.S. Department of Transportation (DOT) regulations in 49 CFR 173.441 (TN298). Most unirradiated fuel and radioactive waste shipments would have much lower dose rates than the regulations allow (AEC 1972-TN22; DOE 2002-TN418). The analysis of MEIs is described below.

<u>Truck Crew Member</u>

Truck crew members would receive the highest radiation doses during incident-free transport because of their proximity to the loaded shipping container for an extended period. The analysis assumed that crew member doses are limited to 2 rem/yr, which is the DOE administrative control level presented in DOE-STD-1098-99, *DOE Standard, Radiological Control*, Chapter 2, Article 211 (DOE 2005-TN1235). This limit is anticipated to apply to spent nuclear fuel shipments to a disposal facility because DOE would take title to the spent fuel at the reactor site and be responsible for performing the spent nuclear fuel shipments. There would be more shipments of spent nuclear fuel from the CRN Site (or alternative sites) than there would be shipments of unirradiated fuel to, and radioactive waste other than spent fuel from, these sites. This is because the capacities of spent fuel shipping casks are limited due to their substantial radiation shielding and accident-resistance requirements. Spent fuel shipments also have significantly higher radiation dose rates than unirradiated fuel and radioactive waste (DOE 2002-TN418). As a result, crew doses from unirradiated fuel and radioactive waste shipments would be lower than the doses from spent nuclear fuel shipments. The DOE administrative limit of 2 rem/yr (DOE 2005-TN1235) is less than the NRC limit for occupational exposures of 5 rem/yr (10 CFR Part 20 -TN283).

The DOT does not regulate annual occupational exposures. It does recognize that air crews are exposed to elevated cosmic radiation levels and recommends dose limits to air crew members from cosmic radiation (Friedberg and Copeland 2003-TN419). Air passengers are less of a concern because they do not fly as frequently as air crew members. The recommended limits are a 5-year effective dose of 2 rem/yr with no more than 5 rem in a single year (Friedberg and Copeland 2003-TN419). As a result of this recommendation, a 2-rem/yr MEI dose to truck crews is a reasonable estimate to apply to shipments of fuel and waste from the CRN Site and alternative sites.

Inspectors

Radioactive shipments are inspected by Federal or State vehicle inspectors, for example, at state ports of entry. DOE (2002-TN1236) assumed that inspectors would be exposed for 1 hour at a distance of 1 m (3.3 ft) from the shipping containers. Assuming conservatively that the external dose rate at 2 m (6.6 ft) is at the maximum allowed by DOT regulations (10 mrem/hr) in 49 CFR 173.441 (TN298), the dose rate at 1 m (3.3 ft) is about 14 mrem/hr (Weiner et al. 2013-TN3390, Weiner et al. 2014-TN3389). Therefore, the dose per shipment is about 14 mrem. This is independent of the location of the reactor site. Based on this conservative external dose rate and the assumption that the same person inspects all shipments of fuel and waste to and from the CRN Site and alternative sites, the annual doses to vehicle inspectors were calculated to be about 3.2 rem/yr, based on a combined total of 227 shipments of unirradiated fuel, spent fuel, and radioactive waste per year. This value exceeds the 2-rem/yr DOE administrative control level for individual doses (DOE 2005-TN1235) and is about 60 percent of the 5-rem/yr NRC occupational dose limit (see 10 CFR Part 20 -TN283).

Residents

The analysis assumed that a resident lives adjacent to a highway where a shipment would pass and would be exposed to all shipments along a particular route. Exposures to residents on a per-shipment basis were obtained from the NRC staff's RADTRAN 6 output files. These dose estimates are based on an individual located 100 ft from the shipments that are traveling 15 mph. The potential radiation dose to the maximally exposed resident is about 0.13 mrem/yr for shipments of fuel and waste to and from the CRN Site and alternative sites.

Individuals Stuck in Traffic

This scenario addresses potential traffic interruptions that could lead to a person being exposed to a loaded shipment for 1 hour at a distance of 4 ft. The NRC staff's analysis assumed this exposure scenario would occur only one time to any individual, and the dose rate was at the regulatory limit of 10 mrem/hr at 2 m (6.6 ft) from the shipment. The dose to the MEI was calculated in DOE (2002-TN1236) to be 16 mrem.

Persons at a Truck Service Station

This scenario estimates doses to an employee at a service station where all truck shipments to and from the CRN Site and alternative sites are assumed to stop. DOE (2002-TN1236) assumed this person is exposed for 49 minutes at a distance of 52 ft from the loaded shipping container. The exposure time and distance were based on the observations discussed by Griego et al. (1996-TN69). This results in a dose of about 0.34 mrem/shipment and an annual dose of about 77 mrem/yr for the CRN Site and alternative sites, assuming that a single individual services all unirradiated fuel, spent fuel, and radioactive waste shipments to and from the CRN Site and alternative sites.

6.2.1.2 Radiological Impacts of Transportation Accidents

Accident risks are a combination of accident frequency and consequence. Accident frequencies for transportation of unirradiated fuel to the CRN Site and alternative sites are expected to be lower than those used in the analysis in WASH-1238 (AEC 1972-TN22), which forms the basis for Table S–4 of 10 CFR 51.52 (TN250). This is based on the NRC staff review of the trends in improvements in highway safety and security, and an overall reduction in traffic accident, injury, and fatality rates since WASH-1238 was published. There is no significant difference in the consequences of transportation accidents severe enough to result in a release of unirradiated fuel particles to the environment between the surrogate SMR and current-generation LWRs because the fuel form, cladding, and packaging are similar to those analyzed in WASH-1238 (AEC 1972-TN22). Consequently, consistent with the conclusions of WASH-1238, the impacts of accidents during transport of unirradiated fuel to a surrogate SMR at the CRN Site and alternative sites are expected to be smaller than those listed in Table S–4 for current-generation LWRs.

6.2.1.3 Nonradiological Impacts of Transportation Accidents

Nonradiological impacts are the human health impacts projected to result from traffic accidents involving shipments of unirradiated fuel to the CRN Site and alternative sites (i.e., the analysis does not consider the radiological or hazardous characteristics of the cargo). Nonradiological impacts include the projected number of traffic accidents, injuries, and fatalities that could result from shipments of unirradiated fuel to the site and return shipments of empty containers from the site.

Nonradiological impacts are calculated using accident, injury, and fatality rates from published sources. The rates (i.e., impacts per vehicle-km traveled) are then multiplied by estimated travel distances for workers and materials. The general formula for calculating nonradiological impacts is as follows:

Impacts = (unit rate) × (round-trip shipping distance) × (annual number of shipments).

In this formula, impacts are presented in units of the number of accidents, number of injuries, and number of fatalities per year. Corresponding unit rates (i.e., impacts per vehicle-km traveled) are used in the calculations.

Accident, injury, and fatality rates were taken from Table 4 in *State-Level Accident Rates for Surface Freight Transportation: A Reexamination* (ANL/ESD/TM-150) (Saricks and Tompkins 1999-TN81). Nationwide median rates were used for shipments of unirradiated fuel to the site. The data are representative of traffic accident, injury, and fatality rates for truck shipments similar to those to be used to transport unirradiated fuel to the CRN Site and alternative sites. In addition, the DOT Federal Motor Carrier Safety Administration evaluated the data underlying the Saricks and Tompkins (1999-TN81) rates, which were taken from the Motor Carrier Management Information System, and determined that the rates were underreported. To account for the underreporting, the NRC staff adjusted the accident, injury, and fatality rates in Saricks and Tompkins (1999-TN81) by using factors derived from data provided by the University of Michigan Transportation Research Institute (UMTRI) (Blower and Matteson 2003-TN410). The UMTRI data indicate that accident rates for 1994 to 1996, the same data used by Saricks and Tompkins (1999-TN81), were underreported by about 39 percent. Injury and fatality rates were underreported by 16 percent and 36 percent, respectively. As a result, the NRC staff increased the accident, injury, and fatality rates by factors of 1.64, 1.20, and 1.57, respectively, to account for the underreporting.

The nonradiological accident impacts for transporting unirradiated fuel to (and empty shipping containers from) the CRN Site and alternative sites are shown in Table 6-7. The nonradiological impacts associated with the WASH-1238 reference LWR are also shown for comparison purposes. Note that there are only small differences between the impacts calculated for the surrogate SMR at the CRN Site and alternative sites and the reference LWR in WASH-1238 (AEC 1972-TN22), due entirely to the estimated annual number of shipments. Overall, the impacts are minimal, and there are no substantive differences among the CRN Site and alternative sites. In addition, the NRC staff verified TVA's analysis in the ER (TVA 2017-TN4921, TVA 2017-TN4922) by performing independent impact calculations. No significant differences were identified.

Table 6-7. Nonradiological Impacts of Transporting Unirradiated Fuel to the CRN Site and Alternative Sites, Normalized to Reference LWR (880 MW(e) net)

Plant Type	Normalized Annual Shipments	One-Way Shipping Distance (km)	Annual Round-Trip Distance (km)	Annual Impacts[(a)]		
				Accidents per Year	Injuries per Year	Fatalities per Year
Reference LWR (WASH-1238)	6.3	3,200	4.0×10^{4}	1.9×10^{-2}	9.3×10^{-3}	5.8×10^{-4}
CRN Site	15	3944.3	7888.7	6.9×10^{-2}	3.5×10^{-2}	1.8×10^{-3}
ORR #2 Site	15	3942.7	7885.4	6.9×10^{-2}	3.5×10^{-2}	1.8×10^{-3}
ORR #8	15	3947.4	7894.8	6.9×10^{-2}	3.5×10^{-2}	1.8×10^{-3}
Redstone Arsenal Site	15	3902.8	7805.6	6.9×10^{-2}	3.5×10^{-2}	1.8×10^{-3}

(a) Normalized average annual shipments were taken from TVA 2017-TN4921 and TVA 2017-TN4922.

6.2.2 Transportation of Spent Fuel

The NRC staff performed an independent analysis of the environmental impacts of transporting spent fuel from the CRN Site and alternative sites to a spent fuel disposal repository. For the purposes of these analyses, the NRC staff considered the proposed Yucca Mountain site in Nevada as a surrogate destination. Currently, the NRC has not made a decision about the DOE application for the proposed geologic repository at Yucca Mountain. However, the NRC staff considers an estimate of the impacts of the transportation of spent fuel to a possible repository in Nevada to be a reasonable bounding estimate of the transportation impacts on a spent fuel interim storage or disposal facility because of the distances involved and the representativeness of the distribution of members of the public in urban, suburban, and rural areas (i.e., population distributions) along the shipping routes. Radiological and nonradiological environmental impacts of normal operating conditions and transportation accidents, as well as nonradiological impacts, are discussed in this section. The NRC Yucca Mountain adjudicatory proceeding is currently suspended, and Yucca Mountain-related matters are pending in Federal Court. Regardless of the outcome of these proceedings, the NRC staff concludes that impacts from the transportation of spent fuel are roughly proportional to the distance from the reactor site to the repository site, in this case, Tennessee to Nevada.

This NRC staff's analysis is based on shipment of spent fuel by legal-weight trucks in shipping casks that have characteristics similar to currently available casks (i.e., massive, heavily shielded, cylindrical metal pressure vessels). Due to the large size and weight of spent fuel shipping casks, each shipment is assumed to consist of a single shipping cask loaded on a modified trailer. These assumptions are consistent with those made in the evaluation of the environmental impacts of transportation of spent fuel in Addendum 1 to NUREG–1437 (NRC 1999-TN289). Because the alternative transportation methods involve rail or heavy-haul truck transportation of larger transportation casks, which would reduce the overall number of spent fuel shipments by truck (NRC 1999-TN289), thereby reducing impacts, these assumptions are conservative. Also, the use of current shipping cask designs for this analysis results in conservative impact estimates because the current designs are based on transporting short-cooled spent fuel (approximately 120 days out of reactor). Future shipping casks would be designed to transport longer-cooled fuel (more than 5 years out of reactor) and would require less shielding to meet external dose limitations. Therefore, future shipping casks are expected to have higher cargo capacities, thus reducing the numbers of shipments and associated impacts.

Radiological impacts of transportation of spent fuel were calculated by the NRC staff using the RADTRAN 6 computer code (Weiner et al. 2013-TN3390, Weiner et al. 2014-TN3389). Routing and population data used in RADTRAN 6 for truck shipments were obtained from the TRAGIS routing code (Liu et al. 2016-TN4885). The population data in the TRAGIS code are based on the 2010 census. Nonradiological impacts were calculated using published traffic accident, injury, and fatality data (Saricks and Tompkins 1999-TN81) in addition to route information from TRAGIS (Liu et al. 2016-TN4885). Traffic accident rates input to RADTRAN 6 and nonradiological impact calculations were adjusted to account for underreporting, as discussed above in Section 6.2.1.3.

6.2.2.1 Normal Conditions

Normal conditions, sometimes referred to as “incident-free” transportation, are transportation activities in which shipments reach their destination without an accident occurring en route. Impacts from these shipments would be from the low levels of radiation that penetrate the heavily shielded spent fuel shipping cask. Radiation exposures would occur to the following populations: (1) persons residing along the transportation corridors between the CRN Site and alternative sites and the proposed repository location; (2) persons in vehicles traveling on the same route as a spent fuel shipment; (3) persons at vehicle stops for refueling, rest, and vehicle inspections; and (4) transportation crew workers (drivers). For purposes of this analysis, it was assumed that the destination for the spent fuel shipments is the proposed Yucca Mountain disposal facility in Nevada. This assumption is conservative because it tends to maximize the shipping distance from the CRN Site and alternative sites. Dose estimates to the MEI from transport of spent fuel under normal conditions are presented above in Section 6.2.1.1.

Shipping casks have not been designed for the spent fuel from SMR designs such as the BWXT mPower SMR, Holtec SMR-160, NuScale SMR, or Westinghouse SMR. Information in the *Early Site Permit Environmental Report Sections and Supporting Documentation* (INEEL 2003-TN71) indicated that advanced LWR fuel designs would not be significantly different from existing LWR designs; therefore, current shipping cask designs were used for the analysis of reactor spent fuel shipments. The NRC staff assumed that the capacity of a truck shipment of reactor spent fuel was 0.5 MTU/shipment, the same capacity as that used in WASH-1238 (AEC 1972-TN22). In its ER (TVA 2017-TN4921, TVA 2017-TN4922), TVA assumed a shipping cask capacity of 0.5 MTU/shipment.

Input to RADTRAN 6 includes the total shipping distance between the origin and destination sites and the population distributions along the routes. This information was obtained by running the TRAGIS computer code (Liu et al. 2016-TN4885) for highway routes from the CRN Site and alternative sites to the proposed Yucca Mountain facility. The resulting route characteristics information is presented in Table 6-8. For truck shipments, all of the spent fuel is assumed to be shipped to the proposed Yucca Mountain facility over designated highway-route controlled-quantity routes. In addition, TRAGIS data were used in RADTRAN 6 on a state-by-state basis. This increases precision and allows the results to be presented for each state along the route between the CRN Site and alternative sites and the proposed geologic repository at Yucca Mountain, if desired.

Radiation doses are a function of many parameters, including vehicle speed, traffic count, dose rate, packaging dimensions, number in the truck crew, stop time, and population density at stops. A list of the values for these and other parameters and the sources of the information is provided in Table 6-9.

For the purposes of this analysis, the transportation crew for spent fuel shipments delivered by truck is assumed to consist of two drivers. Escort vehicles and drivers were considered, but they were not included because their distance from the shipping cask would reduce the dose rates to levels well below the dose rates experienced by the drivers and would be negligible (DOE 2002-TN1236). Stop times for refueling and rest were assumed to occur at the rate of 30 minutes per 4 hours of driving time. TRAGIS outputs were used to determine the number of stops. Doses to the public at truck stops have been significant contributors to the doses calculated in previous RADTRAN 6 analyses. For this analysis, doses to the public at refueling and rest stops ("stop doses") are the sum of the doses to individuals located in two annular rings centered at the stopped vehicle, as illustrated in Figure 6-2. The inner ring represents persons who may be at the truck stop at the same time as a spent fuel shipment and extends 1 to 10 m from the edge of the vehicle. The outer ring represents persons who reside near a truck stop and it extends from 10 to 800 m from the vehicle. This scheme is similar to that used by Sprung et al. (2000-TN222). Population densities and shielding factors were also taken from Sprung et al. (2000-TN222), which were based on the observations of Griego et al. (1996-TN69).

The results of these normal (incident-free) exposure calculations are shown in Table 6-10 for the CRN Site and alternative sites. Population dose estimates are given for workers (i.e., truck crew members), onlookers (doses to persons at stops and persons on highways exposed to the spent fuel shipment), and persons along the route (persons living near the highway).

Table 6-8. Transportation Route Information for Shipments from the CRN Site and Alternative Sites to the Yucca Mountain Spent Fuel Disposal Facility[(a)]

	One-Way Shipping Distance (km)				Population Density (persons/km^2)			Stop Time per Trip (hr)
Reactor Site	**Total**	**Rural**	**Suburban**	**Urban**	**Rural**	**Suburban**	**Urban**	
CRN Site	3689.0	3033.7	561.6	93.7	10.1	370.4	1841.9	4.5
ORR Site 2	3687.4	3032.1	561.6	93.7	10.1	370.4	1841.9	4.5
ORR Site 8	3692.1	3039.2	559.1	93.7	10.1	377.8	1841.9	4.5
Redstone Arsenal Site 12	3635.2	3015.0	526.9	93.3	9.4	354.8	1877.9	4.5

(a) This table presents aggregated route characteristics from the TRAGIS computer code (Liu et al. 2016-TN4885). Input to the RADTRAN 6 computer code was disaggregated to a state-by-state level.

Table 6-9. RADTRAN 6 Normal (Incident-Free) Exposure Parameters

Parameter	RADTRAN 6 Input Value	Source
Vehicle speed, km/hr	Route-Specific	Table 2 in Weiner et al. 2013 (TN3390)
Traffic count – Rural, vehicles/hr Traffic count – Suburban, vehicles/hr Traffic count – Urban, vehicles/hr	Route-Specific	Tables D-2, D-3, and D-5 in Weiner et al. 2013 (TN3390)
Vehicle occupancy, persons/vehicle	1.5	DOE 2002 (TN418)

Table 6-9. (contd)

Parameter	RADTRAN 6 Input Value	Source
Dose rate at 1 m from vehicle, mrem/hr	14	DOE 2002 (TN418); DOE 2002 (TN1236)—approximate dose rate at 1 m that is equivalent to the maximum dose rate allowed by Federal regulations (i.e., 10 mrem/hr at 2 m from the side of a transport vehicle)
Packaging dimensions, m	Length – 5.9 Diameter – 2.3	Table B-1 in NRC 2012 (NRC 2012-TN2658)
Number of truck crew	2	AEC 1972 (TN22); NRC 1977 (TN417); DOE 2002 (TN418)
Stop time, hr/trip	Route-Specific	See Table 6-6
Population density at stops, persons/km^2	30,000	Sprung et al. 2000 (TN222). Nine persons within 10 m of vehicle. See Figure 6-2.
Min/max radii of annular area around vehicle at stops, m	1 to 10	Sprung et al. 2000 (TN222)
Shielding factor applied to annular area surrounding vehicle at stops, dimensionless	1 (no shielding)	Sprung et al. 2000 (TN222)
Population density surrounding truck stops, persons/km^2	340	Sprung et al. 2000 (TN222)
Min/max radius of annular area surrounding truck stop, m	10 to 800	Sprung et al. 2000 (TN222)
Shielding factor applied to annular area surrounding truck stop, dimensionless	0.2	Sprung et al. 2000 (TN222)

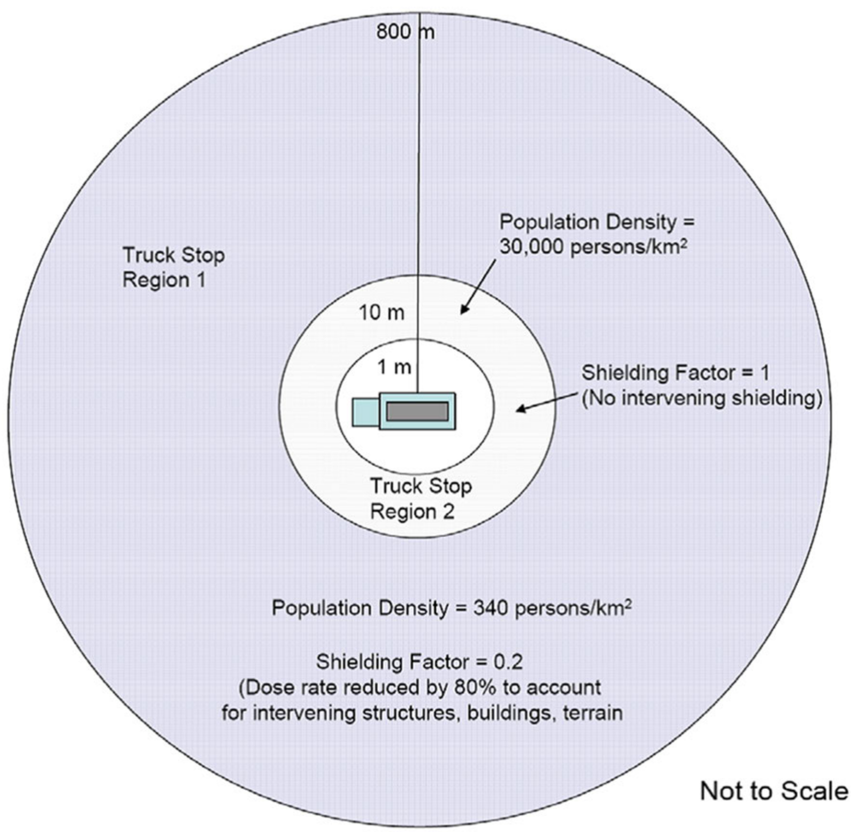

Figure 6-2. Illustration of the Truck Stop Model

Table 6-10. Normal (Incident-Free) Radiation Doses to Transport Workers and the Public from Shipping Spent Fuel from the CRN Site and Alternative Sites to the Proposed HLW Repository at Yucca Mountain, Normalized to Reference LWR (880 MW(e) net)

Site and Reactor Type	Normalized Average Annual Shipments	Normalized Impacts (person-rem/yr)[(a,b)]		
		Workers	Public – Onlookers	Public – Along Route
Reference LWR (WASH-1238)	60	1.2	2.2×10^{1}	4.2×10^{-1}
CRN Site	137	2.8	5.0×10^{1}	9.7×10^{-1}
ORR 2 Site	137	2.8	5.0×10^{1}	9.7×10^{-1}
ORR 8 Site	137	2.8	5.0×10^{1}	9.8×10^{-1}
Redstone Arsenal Site	137	2.7	5.0×10^{1}	8.9×10^{-1}
Table S–4 Condition	–	4×10^{0}	3×10^{0}	3×10^{0}

(a) To convert person-rem to person-Sv, divide by 100.
(b) Normalized average annual shipments were taken from TVA 2017-TN4921, TVA 2017-TN4922.

Shipping schedules for spent fuel generated by the proposed new nuclear power plant have not been determined. The NRC staff determined that it is reasonable to calculate annual doses assuming the annual number of spent fuel shipments is equivalent to the annual refueling requirements as provided in the PPE (TVA 2017-TN4921, TVA 2017-TN4922). Population doses were normalized to the reference LWR in WASH-1238 (880 MW(e) net) (AEC 1972-TN22). This corresponds to a 1,100-MW(e) LWR operating at 80 percent capacity.

The small differences in transportation impacts among the CRN Site and three alternative sites evaluated are not substantive, and the differences among sites are relatively minor and are less than the uncertainty in the analytical results.

The bounding cumulative doses to the exposed population given in Table S–4 are as follows:

- 4 person-rem/reactor-year to transport workers and
- 3 person-rem/reactor-year to general public (onlookers) and members of the public along the route.

The calculated population doses to the crew and onlookers for the reference LWR and the CRN Site and alternative site shipments exceed Table S–4 values. A key reason for the higher population doses relative to Table S–4 is the longer shipping distances assumed for this ESP analysis (i.e., to a proposed repository in Nevada) than the distances used in WASH-1238 (AEC 1972-TN22). WASH-1238 assumed that each spent fuel shipment would travel a distance of 1,000 mi, whereas the shipping distances used in this EIS were about 2,300 mi. If the shorter distance of 1,000 mi were used to calculate the impacts for the CRN and alternative sites spent fuel shipments, the doses would be reduced by about 60 percent. Other important differences are the stop model described above and the additional precision that results from incorporating state-specific route characteristics.

Where necessary, the NRC staff made conservative assumptions to calculate impacts associated with the transportation of spent fuel. Some of the key conservative assumptions are as follows:

- Use of the regulatory maximum dose rate (10 mrem/hr at 2 m) in the RADTRAN 6 calculations. The shipping casks assumed in the EIS prepared by DOE in support of the application for a geologic repository at the proposed Yucca Mountain repository (DOE 2002-TN1236) would transport spent fuel that has cooled for a minimum of 5 years (see 10 CFR Part 961 [TN300], Subpart B). Most spent fuel would have cooled for much longer than 5 years before it is shipped to a possible geologic repository. Based on this, shipments from the CRN Site and alternative sites also are expected to be cooled for longer than 5 years. Consequently, the estimated population doses in Table 6-10 could be further reduced if more realistic dose rate projections are used.

- Use of the shipping cask capacity used in WASH-1238. The WASH-1238 (AEC 1972-TN22) analyses that form the basis for Table S–4 assumed that spent fuel would be shipped at least 90 days after discharge from a current LWR. The spent fuel shipping casks described in WASH-1238 were designed to transport 90-day-cooled fuel, so their shielding and containment designs must accommodate this highly radioactive cargo. Shipping cask capacities assumed in WASH-1238 were approximately 0.5 MTU per truck cask. DOE (2008-TN1237) assumed a 10-year cooling period for spent fuel to be shipped to the repository. This allowed DOE to increase the assumed shipping cask capacity to about 1.8 MTU per truck shipment of uncanistered spent fuel. The NRC staff believes this is a reasonable projection for future spent fuel truck shipping cask capacities. If this assumption were to be used in this EIS, the number of shipments of spent fuel would be reduced by about one-third with a similar reduction in incident-free radiological impacts.

- Use of 30 minutes as the average time at a truck stop in the calculations. Many stops made for actual spent fuel shipments are of short duration (i.e., 10 minutes) for brief visual inspections of the cargo (e.g., checking the cask tie-downs). These stops typically occur in minimally populated areas, such as an overpass or freeway ramp in an unpopulated area. Furthermore, empirical data provided by Griego et al. (1996-TN69) indicate that a 30-minute duration is toward the high end of the stop time distribution. Average stop times observed by Griego et al. (1996-TN69) are about 18 minutes. More realistic stop times would further reduce the population doses in Table 6-10.

A sensitivity study was performed by the NRC staff to demonstrate the effects of using more realistic dose rates, shipping cask capacities, and stop times on the incident-free population dose calculations. For this sensitivity study, the dose rate was reduced to 5 mrem/hr, which is the approximate 50 percent confidence interval of the dose rate distribution estimated by Sprung et al. (2000-TN222) for future spent fuel shipments; the shipping cask capacity was increased to 1.8 MTU; and the stop time was reduced to 18 minutes per stop. All other RADTRAN 6 input values were unchanged. The result is that the annual crew doses were reduced by about 89 percent of the annual doses shown in Table 6-10. Further, the annual doses to onlookers were reduced by about 93 percent and the annual doses to persons along the route were reduced by about 90 percent of the annual doses provided in Table 6-10. Incorporating the difference in distances mentioned above into the sensitivity analysis would further reduce the annual doses, and yield total reductions of 95 percent, 97 percent, and 96 percent for the annual crew doses, the annual doses to onlookers, and the annual doses to persons along the route, respectively.

Using the linear no-threshold dose response relationship discussed above in Section 6.2.1.1, the annual public dose impacts for transporting spent fuel from the CRN Site or alternative sites to Yucca Mountain are about 51 person-rem, which is less than the 1,754 person-rem value that ICRP (2007-TN422) and NCRP (1995-TN728) suggest would most likely result in no excess health effects. This dose is very small compared to the estimated 250,000 person-rem that the same population along the route from the CRN Site to Yucca Mountain would incur annually from exposure to natural sources of radiation. The estimated population dose from natural background radiation along the CRN-to-Yucca Mountain route is different from the natural background dose calculated by the NRC staff for unirradiated fuel shipments in Section 6.2.1.1 because the route characteristics are different for the spent fuel versus unirradiated fuel shipments. A generic route based on WASH-1238 (AEC 1972-TN22) and representative highway routes were used in Section 6.2.1.1 for unirradiated fuel shipments, and representative highway routes were used in this section for spent fuel shipments. The representative routes were determined using the TRAGIS routing code (Liu et al. 2016-TN4885).

6.2.2.2 Radiological Impacts of Accidents

As discussed previously, the NRC staff used the RADTRAN 6 computer code to estimate the impacts of transportation accidents involving spent fuel shipments. RADTRAN 6 considers a spectrum of postulated transportation accidents, ranging from those with high frequencies and low consequences (e.g., “fender benders”) to those with low frequencies and high consequences (i.e., accidents in which the shipping container is exposed to severe mechanical and thermal conditions).

Radionuclide inventories are important parameters in the calculation of accident risks. The radionuclide inventories used in this analysis were from the TVA ER (TVA 2017-TN4921, TVA 2017-TN4922). The spent fuel inventories used in the NRC staff analysis are listed in Table 6-11.

Robust shipping casks are used to transport spent fuel because of the radiation shielding and accident resistance required by 10 CFR Part 71 (TN301). Spent fuel shipping casks must be certified Type B packaging systems, meaning they must withstand a series of severe postulated accident conditions with essentially no loss of containment or shielding capability. These casks also are designed with fissile material controls to ensure that the spent fuel remains subcritical under normal and accident conditions. According to Sprung et al. (2000-TN222), the probability of encountering accident conditions that would lead to shipping cask failure is less than 0.01 percent (i.e., more than 99.99 percent of all accidents would result in no release of radioactive material from the shipping cask). The NRC staff assumed that shipping casks approved for transportation of the surrogate SMR spent fuel would provide equivalent mechanical and thermal protection of the spent fuel cargo as previously analyzed by Sprung et al. (2000-TN222).

Accident frequencies are calculated in RADTRAN 6 using user-specified accident rates and conditional shipping cask failure probabilities. State-specific accident rates were taken from Saricks and Tompkins (1999-TN81) and used in the RADTRAN 6 calculations. The state-specific accident rates were then adjusted to account for underreporting, as described above in Section 6.2.1.3. Conditional shipping cask failure probabilities (i.e., the probability of cask failure as a function of the mechanical and thermal conditions applied in an accident) were taken from Sprung et al. (2000-TN222).

The RADTRAN 6 accident risk calculations were performed using the radionuclide inventories (curie per metric ton uranium, or Ci/MTU) in Table 6-11 multiplied by the shipping cask capacity (0.5 MTU). The resulting risk estimates were then multiplied by assumed annual spent fuel shipments (shipments/year) to derive estimates of the annual accident risks associated with spent fuel shipments from the CRN Site and alternative sites to the proposed geologic repository at Yucca Mountain in Nevada. As they did for routine exposures, the NRC staff assumed that the numbers of shipments of spent fuel per year are equivalent to the annual discharge quantities.

Table 6-11. PPE Radionuclide Inventory Used in Transportation Accident Risk Calculations for the Surrogate SMR[(a)]

Radionuclide	Surrogate SMR Inventory (Ci/MTU)
Am-241	7.3×10^{2}
Am-242m	1.3×10^{1}
Am-243	3.3×10^{1}
Ce-144	8.9×10^{3}
Cm-242	2.8×10^{1}
Cm-243	3.1×10^{1}
Cm-244	7.8×10^{3}
Cm-245	1.2
Co-60	4.1[(b)]
Cs-134	4.8×10^{4}
Cs-137	9.3×10^{4}
Eu-154	9.1×10^{3}
Eu-155	4.6×10^{3}
I-129	4.7×10^{-2}
Kr-85	8.9×10^{3}
Pm-147	1.8×10^{4}
Pu-238	6.1×10^{3}
Pu-239	2.6×10^{2}
Pu-240	5.4×10^{2}
Pu-241	7.0×10^{4}
Pu-242	1.8
Ru-106	1.6×10^{4}
Sb-125	3.8×10^{3}
Sr-90	6.2×10^{4}
Y-90	6.2×10^{4}
Total	4.2×10^{5}

(a) Multiply curie per metric ton uranium (Ci/MTU) by 3.7×10^{10} to obtain becquerels per metric ton uranium (Bq/MTU).
(b) Cobalt-60 is the key radionuclide constituent of fuel assembly crud.
(c) Activation product.

Sources: TVA 2017-TN4921, TVA 2017-TN4922.

For this assessment, release fractions for current-generation LWR fuel designs (Sprung et al. 2000-TN222) were used to approximate the impacts from the surrogate SMR spent fuel shipments. This assumes that the fuel materials and containment systems (i.e., cladding and fuel coatings) behave similarly to current LWR fuel under applied mechanical and thermal conditions.

The NRC staff used RADTRAN 6 to calculate the population dose from the released radioactive material from four of five possible exposure pathways.(4) These pathways are as follows:

- External dose from exposure to the passing cloud of radioactive material (cloudshine).
- External dose from the radionuclides deposited on the ground by the passing plume (groundshine). The NRC staff's analysis included the radiation exposure from this pathway even though the area surrounding a potential accidental release would be evacuated and decontaminated, thereby preventing long-term exposures from this pathway.
- Internal dose from inhalation of airborne radioactive contaminants (inhalation).
- Internal dose from resuspension of radioactive materials that were deposited on the ground (resuspension). The NRC staff's analysis included the radiation exposures from this pathway even though evacuation and decontamination of the area surrounding a potential accidental release would prevent long-term exposures.

Table 6-12 presents the environmental consequences of transportation accidents when shipping spent fuel from the CRN Site and alternative sites to the proposed Yucca Mountain repository. The shipping distances and population distribution information for the routes were the same as those used for the normal "incident-free" conditions (see Section 6.2.2.1 above). The results are normalized to the WASH-1238 (AEC 1972-TN22) reference reactor (880-MW(e)) net electrical generation, 1,100-MW(e) reactor operating at 80 percent capacity) to provide a common basis for comparison to the impacts listed in Table S–4. Note that the impacts for all site alternatives are less than the reference LWR impacts. Although there are slight differences in impacts among alternative sites, none of the alternative sites would be clearly favored over the CRN Site. The transportation accident impact analysis conducted by TVA (2017-TN4921, TVA 2017-TN4922) used methods and data that are similar to those used in this EIS. Differences are insignificant in terms of the overall results.

Table 6-12. Annual Spent Fuel Transportation Accident Impacts for Transporting Spent Fuel from the CRN Site and Alternative Sites, Normalized to Reference LWR Reactor (880 MW(e) net)

Site, Reactor Type	Normalized Population Impacts (person-rem/yr)[a,b]
Reference LWR (WASH-1238 [AEC 1972-TN22])[c]	3.3×10^{-6}
CRN Site	7.5×10^{-6}
ORR 2 Site	7.5×10^{-6}
ORR 8 Site	7.6×10^{-6}
Redstone Arsenal Site	7.5×10^{-6}

(a) Divide person-rem/year by 100 to obtain person-Sv/year.
(b) Normalized average annual shipments were taken from TVA 2017-TN4921, TVA 2017-TN4922.
(c) Based on 60 shipments per year.

Using the linear no-threshold dose response relationship discussed above in Section 6.2.1.1, the annual collective public dose estimate for transporting spent fuel from the CRN Site and alternative sites to Yucca Mountain is less than 8×10^{-6} person-rem, which is less than the

(4) Internal dose from ingestion of contaminated food was not considered because the NRC staff assumed evacuation and subsequent interdiction of foodstuffs following a postulated transportation accident.

1,754 person-rem value that the ICRP (2007-TN422) and NCRP (1995-TN728) suggest would most likely result in zero excess health effects. The collective population dose from natural background radiation to the population along the representative routes from the CRN Site and alternative sites to Yucca Mountain would be about 250,000 person-rem. Therefore, the radiation doses from transporting spent fuel to Yucca Mountain would be minimal compared to the collective population dose to the same population from exposure to natural sources of radiation.

6.2.2.3 Nonradiological Impact of Spent Fuel Shipments

The general approach used to calculate the nonradiological impacts of spent fuel shipments is the same as that used for unirradiated fuel shipments. State-by-state shipping distances were obtained from the TRAGIS output file and combined with the annual number of shipments and accident, injury, and fatality rates by state from Saricks and Tompkins (1999-TN81) to calculate nonradiological impacts. In addition, the accident, injury, and fatality rates from Saricks and Tompkins (1999-TN81) were adjusted to account for underreporting (see Section 6.2.1.3 above). The results are shown in Table 6-13 for the CRN Site and alternative sites. Overall, the impacts are minimal and there are no substantive differences among the alternative sites. In addition, the NRC staff verified TVA's analysis in the ER (TVA 2017-TN4921, TVA 2017-TN4922) by performing independent impact calculations. No significant differences were identified.

Table 6-13. Nonradiological Impacts of Transporting Spent Fuel from the CRN Site and Alternative Sites to Yucca Mountain, Normalized to Reference LWR (880 MW(e) net)

Site	One-Way Shipping Distance (km)	Normalized Nonradiological Impacts per Year[(a)]		
		Accidents	Injuries	Fatalities
Reference LWR (WASH-1238 [AEC 1972-TN22])[(b)]	4,470	3.1×10^{-1}	1.5×10^{-1}	8.8×10^{-3}
CRN Site	3689.0	3.2×10^{-1}	2.1×10^{-1}	1.6×10^{-2}
ORR #2 Site	3687.4	3.2×10^{-1}	2.1×10^{-1}	1.6×10^{-2}
ORR #8 Site	3692.1	3.2×10^{-1}	2.1×10^{-1}	1.6×10^{-2}
Redstone Arsenal Site	3635.2	3.2×10^{-1}	2.1×10^{-1}	1.5×10^{-2}

(a) Normalized average annual shipments were taken from TVA 2017-TN4921 and TVA 2017-TN4922.
(b) Based on 60 shipments per year.

6.2.3 Transportation of Radioactive Waste

This section discusses the environmental effects of transporting radioactive waste other than spent fuel from the CRN Site and alternative sites. The environmental conditions listed in 10 CFR 51.52 (TN250) that apply to shipments of radioactive waste are as follows:

- Radioactive waste (except spent fuel) would be packaged and in solid form.
- Radioactive waste (except spent fuel) would be shipped from the reactor by truck or railcar.
- The weight limitation of 33,100 kg (73,000 lb) per truck and 90.7 MT (100 T) per cask per railcar would be met.
- Traffic density would be less than the condition of one truck shipment per day or three railcars per month.

Radioactive waste other than spent fuel from the surrogate SMR is expected to be capable of being shipped in compliance with Federal or State weight restrictions. Table 6-14 presents the estimate of annual waste volumes and annual number of waste shipments for the surrogate SMR at the CRN Site as presented in the PPE normalized to the reference 1,100-MW(e) LWR defined in WASH-1238 (AEC 1972-TN22). The expected annual waste volumes and waste shipments for the surrogate SMR were less than the 1,100-MW(e) reference reactor that was the basis for Table S–4.

Table 6-14. Summary of Radioactive Waste Shipments from the CRN Site and Alternative Sites, Normalized to Reference LWR (880 MW(e) net)

Reactor Type	Waste-Generation Information (ft^3/yr per unit)	Annual Waste Volume (m^3/yr)	Electrical Output (MW(e))	Normalized Rate, m^3/1,100 MW(e) Unit (880 MW(e) net)[(a)]	Shipments/ 1,100 MW(e) (880 MW(e) net) Electrical Output[(b)]
Reference LWR (WASH-1238 [AEC 1972-TN22])	3,800	108	1,100	108	46
Surrogate SMR	5,000	142	800	173	75

Conversions: 1 m^3 = 35.31 ft^3.

(a) Capacity factors used to normalize the waste-generation rates to an equivalent electrical generation output are 80 percent for the reference LWR (AEC 1972-TN22), and 90 percent for the surrogate SMR (TVA 2017-TN4921, TVA 2017-TN4922). Waste generation for the surrogate SMR is normalized to the 880 MW(e) net electrical output (1,100-MW(e) unit with an 80 percent capacity factor).

(b) The number of shipments per 1,100 MW(e) was calculated assuming the WASH-1238 (AEC 1972-TN22) average waste shipment capacity of 2.34 m^3 (82.6 ft^3 per shipment [108 m^3/yr divided by 46 shipments/year]) for spent resin, evaporator concentrates, filters, sludges, dry active waste, etc. (TVA 2017-TN4921, TVA 2017-TN4922).

The sum of the daily shipments of unirradiated fuel, spent fuel, and radioactive waste is well below the one-truck-shipment-per-day condition given in Table S-4 of 10 CFR 51.52 (TN250) for the surrogate SMR located at the CRN Site and alternative sites. Doubling the shipment estimates to account for empty return shipments of fuel and waste is included in the results.

Dose estimates to the MEI from transport of radioactive waste under normal conditions are presented above in Section 6.2.1.1.

The nonradiological impacts of radioactive waste shipments (see Table 6-15) were calculated using the same general approach used for unirradiated and spent fuel shipments. For this EIS, the shipping distance was assumed to be 500 mi one way for the reference LWR (AEC 1972-TN22). Radioactive waste was assumed to be shipped to and disposed of at the Andrews, Texas disposal site, but shipments to the disposal facility in Clive, Utah, could also be possible and would entail an approximately 60 percent greater shipping distance (see EIS Section 6.1.6, TVA 2017-TN4921, and TVA 2017-TN4922). Distances from the CRN Site and alternative sites to the Andrews, Texas waste disposal site are also listed in Table 6-15. These distances were determined using the TRAGIS routing code (Liu et al. 2016-TN4885). Accident, injury, and fatality rates were used in the calculations (Saricks and Tompkins 1999-TN81). These rates were adjusted to account for underreporting, as described above in Section 6.2.1.3. The results are presented in Table 6-15. As shown, the calculated nonradiological impacts for transportation of radioactive waste other than spent fuel from the CRN Site and alternative sites to the Andrews, Texas waste disposal facility are greater than the impacts calculated for the reference LWR in WASH-1238 (AEC 1972-TN22), principally because of the greater distances to the Andrews, Texas LLW disposal facility and the number of shipments for the surrogate SMR. However, the waste-generation rates and number of shipments for the proposed TVA surrogate SMR are anticipated to be lower than values shown in Table 6-14, and impacts would also be less than the reference LWR (AEC 1972-TN22). For example, in WASH-1238 the capacity of a truck carrying radioactive waste was assumed to be 2.34 m^3 per shipment; however, based on a transporting waste in a 20-ft shipping container, the capacity of a current radioactive waste shipment would be 28.32 m^3 per truck shipment. With this increase in shipping capacity, the NRC staff expects the impacts provided in Table 6-12 would be reduced by a factor of approximately 12.

The NRC staff verified TVA's analysis in the ER (TVA 2017-TN4921, TVA 2017-TN4922) by performing independent impact calculations. Slight differences were identified, but the differences in the estimates of the nonradiological impacts were not significant.

Table 6-15. Nonradiological Impacts of Radioactive Waste Shipments from the CRN Site and Alternative Sites, Normalized to the Reference LWR (880 MW(e) net)[(a)]

	Normalized Shipments per Year	One-Way Distance (km)	Normalized Nonradiological Impacts per Year		
			Accidents	Injuries	Fatalities
Reference LWR (WASH-1238 [AEC 1972-TN22])	46	800	3.4×10^{-2}	1.7×10^{-2}	1.1×10^{-3}
CRN Site	75	1954.3	1.7×10^{-1}	1.1×10^{-1}	4.9×10^{-3}
ORR 2 Site	75	1952.7	1.7×10^{-1}	1.1×10^{-1}	4.9×10^{-3}
ORR 8 Site	75	1957.4	1.7×10^{-1}	1.1×10^{-1}	4.9×10^{-3}
Redstone Arsenal Site	75	1813.1	1.8×10^{-1}	1.1×10^{-1}	4.3×10^{-3}

(a) Normalized shipments were taken from TVA 2017-TN4921 and TVA 2017-TN4922.

6.2.4 Conclusions for Transportation

The NRC staff performed an independent confirmatory analysis of the impacts under normal operating and accident conditions of transporting fuel and wastes to and from a surrogate SMR to be located at the CRN Site. Three alternative sites also were evaluated, including two additional sites located on the Oak Ridge Reservation, and one site located at the Redstone Arsenal in Alabama. To make comparisons to Table S–4, the environmental impacts were adjusted (i.e., normalized) to the environmental impacts associated with the reference LWR in WASH-1238 (AEC 1972-TN22) by multiplying the surrogate SMR impact estimates by the ratio of the total electric output for the reference reactor to the electric output of the proposed surrogate SMR.

Because of the conservative approaches and data used to calculate impacts, the NRC staff does not expect the actual environmental effects to exceed those calculated in this EIS. Thus, the NRC staff concludes that the environmental impacts of the transportation of fuel and radioactive wastes to and from the CRN Site and alternative sites would be SMALL, and would be consistent with the environmental impacts associated with the transportation of fuel and radioactive wastes to and from current-generation reactors presented in Table S–4 of 10 CFR 51.52 (TN250).

The NRC staff concludes that transportation impacts are roughly proportional to the distance from the reactor site to the repository site, in this case Tennessee to Nevada. The distance from the CRN Site or any of the alternative sites to any new planned repository in the contiguous United States would be no more than double the distance from the CRN Site or alternative sites to Yucca Mountain. Doubling the environmental impact estimates from the transportation of spent reactor fuel, as presented in this section, would provide a reasonable bounding estimate of the impacts to meet the needs of NEPA (42 U.S.C. § 4321 *et seq*. -

TN661). The NRC staff concludes that the environmental impacts of these doubled estimates would not be significant and, therefore, would still be SMALL.

6.3 Decommissioning Impacts

At the end of the operating life of a power reactor, NRC regulations require that the facility undergo decommissioning. The NRC defines decommissioning as the safe removal of a facility from service and the reduction of residual radioactivity to a level that permits termination of the NRC license. The regulations governing decommissioning of power reactors are found in 10 CFR 50.75 (TN249), 10 CFR 50.82 (TN249), and 10 CFR 52.110 (TN251). The radiological criteria for termination of the NRC license are in 10 CFR Part 20 (TN283), Subpart E. Minimization of contamination and generation of radioactive waste requirements for facility design and procedures for operation are addressed in 10 CFR 20.1406 (TN283).

In NUREG-0586, Supplement 1, "Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities Regarding the Decommissioning of Nuclear Power Reactors" (Decommissioning GEIS) (NRC 2002-TN665), the NRC staff evaluated the environmental impacts during the decommissioning of nuclear power reactors as residual radioactivity at the site is reduced to levels that allow for termination of the NRC license. If an applicant for a construction permit or COL referencing the ESP for the CRN Site applies for a license to construct a new nuclear power plant at the CRN Site, there is a requirement to provide a report containing a certification that financial assurance for radiological decommissioning would be provided. At the time an application is submitted, the requirements in 10 CFR 50.33 (TN249), 10 CFR 50.75 (TN249), and 10 CFR 52.77 (TN251) (and any other applicable requirements) would have to be met.

At the ESP stage, applicants are not required to submit information regarding the process of decommissioning, such as the method chosen for decommissioning, the schedule, or any other aspect of planning for decommissioning. However, TVA provided information in ER Section 5.9 concerning the environmental impacts of decommissioning based on NUREG–0586, Supplement 1 (NRC 2002-TN665) and concluded that the environmental impacts of decommissioning discussed in NUREG–0586, Supplement 1 would bound those for the SMR reactor designs included in the TVA ER (TVA 2017-TN4921). The NRC staff's evaluation of the environmental impacts of decommissioning presented in NUREG–0586, Supplement 1 identifies a range of impacts for most environmental issues for a range of different reactor designs, although for some issues the staff concluded that the impacts would be site-specific and would have to be addressed by the licensee at the time of decommissioning. The staff has no reason to believe that these impacts, discussed in NUREG–0586, Supplement 1 are not bounding for reactors deployed after 2002, when NUREG–0586, Supplement 1 was published, including the SMR designs included in TVA's PPE. Additionaly, 10 CFR 50.82 or 10 CFR 52.110, as applicable, provide that a licensee shall not perform any decommissioning activities that result in significant environmental impacts not bounded by previously issued environmental review documents, such as NUREG-0586.

NUREG–0586, Supplement 1 does not specifically address the GHG 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 Safe Storage (also called the SAFSTOR decommissioning option), in which decontamination and dismantlement are delayed for a number of years. Given this information, the NRC staff estimated the GHG footprint of decommissioning to be on the order of 27,000 MT CO_2e during a 10-year period without SAFSTOR. The contributions to this footprint are about one-third from decommissioning workforce transportation and two-thirds from equipment usage. The details of the NRC staff's estimate are presented in Appendix K of this EIS. A 40-year SAFSTOR period would increase the GHG footprint of decommissioning by about 40 percent. These GHG footprints are roughly three orders of magnitude lower than the GHG footprint presented above in Section 6.1.3 for the uranium fuel cycle. Therefore, the staff relies upon 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 considered in GEIS-DECOM is used.
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. The 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 will minimize the amount of radioactive material in spills and leakage that would have to be addressed at decommissioning.
6. The ecological impacts of decommissioning are expected to be negligible.
7. The socioeconomic impacts would be short-term and could be offset by decreases in population and economic diversification.

For the proposed SMRs at the CRN Site or at any of the three alternative sites, the impacts from decommissioning are expected to be within the bounds described in NUREG–0586, Supplement 1 (NRC 2002-TN665). Based on the NUREG–0586, Supplement 1 and the evaluation of air-quality impacts from GHG emissions above, the NRC staff concludes that, as long as the regulatory requirements on decommissioning activities to limit the impacts of decommissioning are met, the decommissioning activities would result in a SMALL impact.

7.0 CUMULATIVE IMPACTS

The U.S. Nuclear Regulatory Commission (NRC) regulations in Title 10 of the *Code of Federal Regulations* (CFR) Part 51 implementing the National Environmental Policy Act of 1969, as amended (NEPA) 42 U.S.C. § 4321 *et seq*. -TN661), require the NRC to consider the cumulative impacts of proposals under its review (10 CFR 51.71(d) [TN250]). Cumulative impacts may result when the environmental effects associated with the proposed action are overlaid or added to temporary or permanent effects associated with past, present, and reasonably foreseeable future projects. Cumulative impacts can result from individually minor, but collectively significant, actions taking place over a period of time.

The Tennessee Valley Authority (TVA), submitted an application for an early site permit (ESP), which was accompanied by an Environmental Report (ER) (TVA 2016-TN4637) that included consideration of two or more small modular reactors (SMRs) that might be constructed and operated at the Clinch River Nuclear (CRN) Site. On December 15, 2017, TVA submitted Revision 1 of its application, including the ER (TVA 2017-TN4921) to the NRC. When evaluating the potential impacts of building and operating two or more new SMRs at the CRN Site, the review team considered potential cumulative impacts on resources that could be affected by the construction, preconstruction, operation, and decommissioning of two or more new SMRs at the CRN Site.

Cumulative impacts result when the effects of an action are added to or interact with other past, present, and reasonably foreseeable future effects on the same resources. For purposes of this analysis, past actions are those prior to the acceptance of the ESP application. Present actions are those related to resources from the time of acceptance of the ESP application until issuance of the final environmental impact statement (EIS). Future actions are those that occur following issuance of the final EIS and include those that are reasonably foreseeable through the duration of building activities for two or more SMRs, as would occur under a subsequent NRC-authorized construction permit or combined construction permit and operating license (combined license or COL), operation of a new plant, and its decommissioning. The effect of climate change on the evaluation of environmental impacts is addressed in more detail in Appendix L of this EIS. The geographic area over which past, present, and reasonably foreseeable future actions could contribute to cumulative impacts is dependent on the type of resource considered and is described below for each resource area.

The impacts of the proposed action, as described in Chapters 4 and 5, are combined with other past, present, and reasonably foreseeable future actions in the general area surrounding the CRN Site that would affect the same resources that are affected by two or more new SMRs, regardless of what agency (Federal or non-Federal) or person undertakes such actions. These combined impacts are defined as “cumulative” in 40 CFR 1508.7 (TN428) and include individually minor but collectively potentially significant actions taking place over a period of 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 resource decline.

The description of the affected environment in Chapter 2 serves as the baseline for the cumulative impacts analysis, including the effects of past actions. The incremental impacts related to the building activities (construction activities as defined in 10 CFR 51.4 [TN250] and preconstruction activities) are described and characterized in Chapter 4 and those related to operations are described in Chapter 5. These impacts are summarized for each resource area in the sections that follow. The level of detail is commensurate with the significance of the impact for each resource area.

This chapter includes an overall cumulative-impact assessment for each resource area. The NRC staff performed the cumulative-impact analysis according to guidance provided in COL/ESP-ISG-026, *Interim Staff Guidance on Environmental Issues Associated with New Reactors* (NRC 2014-TN3767) and COL/ESP-ISG-027, *Interim Staff Guidance on Specific Environmental Guidance for Light Water Small Modular Reactor Reviews* (NRC 2014-TN3774). The specific resources and components that could be affected by the incremental effects of the proposed action and other actions in the same geographic area were assessed. This assessment includes the impacts of construction and operation of two or more new SMRs as described in EIS Chapters 4 and 5; impacts of preconstruction activities as described in Chapter 4; impacts of fuel cycle, transportation, and decommissioning as described in Chapter 6; and impacts of past, present, and reasonably foreseeable future Federal, non-Federal, and private actions that could affect the same resources affected by the proposed actions.

The review team visited the CRN Site in October 2014, March 2015, and May 2017 and visited the alternative sites in July 2015 and May 2017 to gather information and to become familiar with the sites and their environs. In addition, a regulatory audit was conducted from May 15 to August 11, 2017, during which time the review team met with TVA staff, Federal, State, and local officials, and local organizations (NRC 2018-TN5386). The team used the information provided in the ER (TVA 2017-TN4921), information from other Federal and State agencies, and information gathered during the CRN Site audit to evaluate the cumulative impacts of building and operating two or more new SMRs at the CRN Site. To inform the cumulative impacts analysis, the staff conducted a search to identify other relevant projects in the vicinity of the CRN Site. The search included information available through regional economic development agencies in Tennessee; U.S. Environmental Protection Agency (EPA) databases—for relevant EISs within the state; the USACE Nashville District website for recent permit applications; state and regional news outlets; township and county planning websites; and the Tennessee Department of Transportation website. The review team developed Table 7-1, which shows the major projects near the CRN Site that were considered relevant in the analysis of cumulative impacts. The review team used this information, the environmental setting in Chapter 2, and impacts described in Chapters 4 and 5 to perform an independent evaluation of cumulative impacts of the proposed action at the CRN Site.

Table 7-1. Projects and Other Actions Considered in the Cumulative Impacts Analysis for the CRN Site

Project Name	Summary of Project	Location	Status
Federal Facilities			
Oak Ridge Reservation	Federally owned 13,547 ha (33,476-ac) site, comprising government and contractor-operated facilities. Includes laboratories, support facilities, environmental cleanup sites, training facilities, and research entities.	Adjacent	Operational (DOE 2016-TN4634; EPA 2016-TN4635)

Table 7-1. (contd)

Project Name	Summary of Project	Location	Status
Oak Ridge National Laboratory	Science and energy U.S. Department of Energy (DOE) laboratory; supercomputers, neutron science and nuclear energy research; Transuranic Waste Processing Center	Adjacent	Operational (DOE 2016-TN5031; TDEC 2016-TN4633)
Y-12 National Security Complex (Y-12 Complex)	Produces and stores U.S. enriched uranium for nuclear weapons and the Navy	Adjacent	Operational (DOE 2016-TN5031; TDEC 2012-TN4636)
East Tennessee Technology Park	Originally part of the K-25 site (produced enriched uranium during the Manhattan Project); covers 2,200 ac. Restoration of the area, including environmental cleanup, facility deactivation and decommissioning, waste disposition, and reindustrialization is ongoing	Adjacent	Operational (DOE 2016-TN5031)
Environmental Management Waste Management Facility	An engineered landfill consisting of six disposal cells; accepts low-level, mixed low-level, and hazardous wastes from Oak Ridge Reservation sites	Adjacent	Operational (DOE 2016-TN5031)
Uranium Processing Facility	Will produce enriched uranium at the Y-12 Complex at Oak Ridge	Adjacent	Under construction (Bechtel 2016-TN4919)
Bear Creek Valley Low-Level Waste Landfill	Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) disposal facility on the Oak Ridge Reservation with a potential capacity of 2.2 to 2.8 million cubic yards	Adjacent	Proposed (DOE 2017-TN5064)
Energy Projects			
Nuclear			
Watts Bar Nuclear Generating Station Units 1 and 2	Two operating pressurized water reactors rated at 3,459 MW(t) each	31 mi SW	Unit 1 operational since 1996 and licensed through 2035, Unit 2 operational since 2016 and licensed through 2055 (TVA 2016-TN4642; NRC 2016-TN4643, NRC 2016-TN4644; TVA 2016-TN4895)

Table 7-1. (contd)

Project Name	Summary of Project	Location	Status
Sequoyah Nuclear Generating Station Units 1 and 2	Two operating pressurized water reactors rated at 3,455 MW(t) each	60 mi SW	Unit 1 operational since 1981 and licensed through 2040; Unit 2 operational since 1982 and licensed through 2041 (NRC 2016-TN4641, NRC 2016-TN4640; TVA 2016-TN4639)
Coal-Fired			
Kingston Fossil Plant	1,400-MW net-capacity coal-fired plan	8 mi W	Operational since 1955 (TVA 2016-TN4647; TDEC 2016-TN4646)
Bull Run Fossil Plant	881-MW net-capacity coal-fired plant	15 mi NE	Operational since 1967 (TVA 2016-TN4649; TDEC 2015-TN4648). Petition granted to object to Title V operating permit in November 2016 (81 FR 85950-TN4900). Storage options for long-term disposal of dry coal combustible residuals was evaluated (TVA 2017-TN5076) and the preferred alternative to construct a landfill adjacent to the plant was adopted (82 FR 19430-TN5077)
Natural Gas-Fired			
University of Tennessee Steam Plant	3.7-MW net-capacity combustion turbine	25 mi ENE	Operational (EIA 2015-TN4650)
Tate and Lyle Loudon Facility Co-Generation Plant	Two 33-MW gas turbines and two generators for heat and power	11 mi SE	Operational (EBR 2017-TN4909)
Landfill Methane Gas			
Alcoa/ Maryville/ Blount County Landfill	1-MW capacity, reciprocating engine	16 mi SE	Operational since 2011 (EPA 2016-TN4653)
Chestnut Ridge Landfill	4.8-MW capacity, reciprocating engine	22 mi NE	Operational since 1992 (TDEC 2016-TN4652)
Meadow Branch Landfill Methane Recovery Project	Landfill gas-collection system; delivered 1,400 MMBtu/day in 2011; 4,000 scfm processing capability	33 mi SW	Operational since 2011 (Renewco 2017-TN5044; EPA 2016-TN4653)

Table 7-1. (contd)

Project Name	Summary of Project	Location	Status
Volunteer Regional Landfill	Landfill gas-collection system; 0.76 Mscf/day collected in 2012	45 mi N	Candidate site (EPA 2016-TN4653)
Solar			
Oak Ridge Solar Park	Installed capacity 49.8 kWp DC, 42 kW AC; annual yield 94,000 kWh	11 mi NE	Operational (Vissolis 2016-TN4654)
Wind			
Buffalo Mountain Energy Center	Wind turbines with a 27-MW capacity	15 mi N	Operational since 2004 (EIA 2016-TN4657)
Hydropower			
Melton Hill Hydroelectric Facility	Two generating units at the Melton Hill Dam with a net capacity of 79 MW upstream on the Clinch River	4.5 mi E	Operational since 1963 (TVA 2016-TN4658)
Fort Loudoun Dam	Four generating units with a net capacity of 162 MW on the Tennessee River	10 mi SE	Operational since 1943 (TVA 2016-TN4659)
Norris Dam	Two generating units with a net capacity of 110 MW upstream on the Clinch River	28 mi NE	Operational since 1936 (TVA 2016-TN4660)
Smoky Mountain Hydro	Four hydro dams – Chilhowee (three generating units with a total capacity of 52.2 MW), Calderwood (three generating units with a total capacity of 140.4 MW), Cheoah (five generating units with a total capacity of 140 MW), and Santeetlah (two generating units with a total capacity of 40.4 MW) on the Little Tennessee River	22 to 45 mi SE	Operational (LIHI 2017-TN5269; Brookfield 2017-TN5227, Brookfield 2017-TN5228, Brookfield 2017-TN5229, Brookfield 2017-TN5230)
Watts Bar Dam	Five generating units with a net capacity of 182 MW on the Tennessee River downstream of Clinch River	30 mi SW	Operational since 1942 (TVA 2016-TN4664)
Fontana Dam	Three generating units with a net capacity of 304 MW on the Little Tennessee River	44 mi SW	Operational since 1944 (TVA 2016-TN4665)
Douglas Dam	Four generating units with a net capacity of 111 MW on the French Broad River	47 mi E	Operational since 1943 (TVA 2016-TN4666)

Table 7-1. (contd)

Project Name	Summary of Project	Location	Status
Transmission Lines/Substations			
Rugby-Sunbright Transmission System	Construction of a new Rugby Substation plus 7.25 mi of power line consisting of steel pole structures on 100-ft right-of-way	30 to 37 mi NW	Construction scheduled to begin in 2017 (TVA 2015-TN4894); TVA issued an Environmental Assessment and Finding of No Signifcant Impact (TVA 2017-TN5045)
Plateau 500-kV Substation	Clearing and grading of the site began in 2015; site completion and linkage to the Wilson-Roane and West Cookeville-Rockwood transmission lines scheduled for 2018	44 mi NW	Under construction (SERTP 2016-TN4896)
Roane-Pineville 500-kV Transmission Line	70-mi-long transmission line		Proposed with in-service date of 2018 (SERTP 2017-TN5046, SERTP 2016-TN4896)
Mining Projects			
Coal Mining	Miscellaneous surface and deep mining projects	Throughout the region	Operational (TDEC 2016-TN4668)
Endsley Quarry	Marble quarry	17 mi SE	Operational (TDEC 2016-TN4669)
Lhoist North America	Crushed and broken limestone	27 mi W	Operational (EPA 2016-TN4670)
Apac Atlantic Inc. Harrison Division Sand Mine 1	Sand and gravel	30 mi W	Operational (EPA 2016-TN4671)
Vulcan Construction Materials	Concrete, asphalt, aggregates, crushed rock, and lime manufacturing	Throughout the region	Operational (EPA 2016-TN4672)
Aggregates USA	Crushed and broken limestone	Throughout the region	Operational (EPA 2016-TN4673)
Various gas and oil projects	Gas and oil wells	Throughout the region	Operational (TDEC 2016-TN4674)
Parks and Recreation Activities			
Federal			
Manhattan Project National Historical Park (Three Sites)	Includes the X-10 Graphite Reactor Historic Landmark, Buildings 9731 and 9204-3 at the Y-12 Complex, and the site of the K-25 building at the Oak Ridge Reservation	3–9 mi N and NE	Operational (NPS 2016-TN4675)

Table 7-1. (contd)

Project Name	Summary of Project	Location	Status
Big South Fork National River and Recreation Area	Consists of 125,000 ac of the Cumberland Plateau, the area offers, hiking, biking, whitewater paddling, horseback riding, rock climbing, camping, and other recreation	43 mi SE	Operational (NPS 2016-TN4676)
Great Smoky Mountains National Park	Includes over 522,400 ac in Tennessee and North Carolina; the park offers camping, hiking, picnicking, fishing, and other recreation	30 mi SE	Operational (NPS 2016-TN4677)
Daniel Boone National Forest	Offers hiking, biking, fishing, rock climbing, boating, target shooting, camping, and picnicking	50 mi N	Operational (USDA 2016-TN4678)
State			
Frozen Head State Park	Consists of over 24,000 ac of wilderness, included backpacking and day hiking trails	17 mi NNW	Operational (TSP 2016-TN4679)
Fort Loudoun State Historic Park	A 1,200-ac National Historic Landmark and site of an early British fortification built in 1756	23 mi SE	Operational (TSP 2016-TN4680)
Norris Dam State Park	Located on the shores of Norris Lake; offers recreational boating, skiing, fishing, hiking, camping, and a museum; consists of more than 4,000 ac	29 mi NE	Operational (TSP 2016-TN4681)
Cove Lake State Park	A 717-ac park that offers scenic nature trails for walking and biking, fishing, and camping	31 mi NE	Operational (TSP 2016-TN4682)
Big Ridge State Park	A 3,687-ac park that offers hiking trails, camping, swimming, and recreation	35 mi NE	Operational (TSP 2016-TN4683)
Cumberland Mountain State Park	A 1,720-ac park offering hiking, swimming, camping, and interpretive programs	36 mi W	Operational (TSP 2016-TN4684)
Seven Islands State Birding Park	Consisting of 416 ac along the French Broad River, the park is a wildlife refuge and research and educational facility for schools	39 mi E	Operational (TSP 2016-TN4685)

Table 7-1. (contd)

Project Name	Summary of Project	Location	Status
Hiwassee/Ocoee Scenic River State Park	Consisting of 23 river miles of the Hiwassee and Ocoee Rivers, the park offers rafting, fishing, and camping	46 mi SSW	Operational (TSP 2016-TN4686)
Non-Hydroelectric Dams			
Tellico Dam	Flood control and recreation on the Little Tennessee River; the reservoir offers 357 mi of shoreline and 15,560 ac of water surface for recreation	10 mi SE	Completed in 1979 (TVA 2016-TN5010)
Transportation Projects			
Airports	Several airports including Knoxville Downtown Island, Raby Airpark, Skyranch, Oliver Springs, and McGhee Tyson airports	Throughout the region	Operational
Oak Ridge Airport	General aviation airport	3 mi N	Proposed by Metropolitan Knoxville Airport Authority (MKAA 2017-TN4948)
Chickamauga Lock	Construction of a lock to replace the current transportation lock at Chickamauga Dam	72 mi SW; but will affect barge traffic throughout the region	Under construction (USACE 2016-TN5079)
Miscellaneous transportation projects	Road and traffic projects; bridge replacements	Throughout the region	Ongoing (TDOT 2016-TN4687)
Other Actions/Projects			
Tellico West Industrial Park	5 to 260 ac sites for industrial development	21 mi SE	Available for development (TRDA 2017-TN4918)
Rockwood Iron and Metal	Former ironworks and metals operations; non-National Priorities List Superfund (Brownfields) site	18 mi W	Subject to State-led cleanup (EPA 2016-TN4688)
Smoky Mountain Smelters	Former fertilizer and smelting operations; Superfund National Priorities List	25 mi E	Undergoing a remedial investigation and feasibility study (EPA 2016-TN4689)
Air emissions sources			
EnergySolutions, LLC Bear Creek Facility	Low-level radioactive waste processing facility	2 mi N	Operational (TDEC 2016-TN4690)
Diversified Scientific Services, Inc.	Hazardous waste treatment, storage and disposal facility	3 mi W	Operational (TDEC 2016-TN4691)

Table 7-1. (contd)

Project Name	Summary of Project	Location	Status
Materials and Energy Corporation	Mixed-waste processing facility	3 mi NNW	Operational (TDEC 2016-TN4692)
Carlisle Tire	Tire manufacturer	20 mi NE	Operational (TDEC 2016-TN4693)
Toho Tenax America, Inc.	Manufacturer of carbon fibers	16 mi W	Operational (TDEC 2016-TN4694)
Various hospitals and industries that use radioactive materials	Medical and other industrial isotopes	Throughout the region	Operational
Various wastewater-treatment plant facilities	Sewage treatment	Throughout the region	Operational
Future Urbanization	Construction of housing units and associated commercial buildings, roads, bridges and rail; and water-treatment and distribution facilities and associated pipelines as described in local planning documents	Throughout the region	Construction would occur in the future, as described in State and local land-use documents
Manufacturing			
Proton Power	Manufacturer of a renewable energy system that produces hydrogen using biomass and waste	2 mi NE	Operational (TDEC 2016-TN4695)
LeMond Composites	Manufacturer of carbon fiber composites	4 mi NNE	Proposed (JEC Group 2016-TN4917)
Nuclear Lead Co, Inc.	Manufacturer of lead shielding for the nuclear industry	10 mi NE	Operational (TDEC 2016-TN4696)
Manufacturing Sciences Corporation	Manufacturer and processor of technology metals	11 mi NE	Operational (TDEC 2015-TN4697)
Canberra	Producer of germanium crystals	11 mi NE	Operational (TDEC 2016-TN4698)
Advanced Measurement Technology	Manufacturer of scientific instruments and electronic parts for various radiation detector components	11 mi NE	Operational (TDEC 2016-TN4699)
Tate and Lyle Loudon Facility	Manufacturer of corn syrup and fuel alcohol	11 mi SE	Operational (DTN 2016-TN4700)
ArcelorMittal LaPlace, LLC	Manufacturer of steel shapes	13 mi W	Operational (TDEC 2016-TN4701)
Kimberly-Clark Corporation	Manufacturer of paper towels and bath tissue	13 mi E	Operational (TDEC 2016-TN4702)

Table 7-1. (contd)

Project Name	Summary of Project	Location	Status
Kimble Chase Life Science and Research Products	Manufacturer of reusable, disposable, and specialty glassware	15 mi W	Operational (Kimble Chase 2016-TN4703)
American Nuclear Corporation	Producer of radioactive sources and detectors, active from 1962 to 1970. License revoked in 1970, after discovery of contamination leaking to the Clinch River.	15 mi SW	Closed. Plant cleaned up and fenced; radioactive materials are being allowed to decay in place (TVA 2017-TN4921)
Horsehead Corporation	Secondary smelting and refining of nonferrous metals	18 mi W	Operational (TDEC 2016-TN4704)
Clinton Pallet	Manufacturer of pallets	19 mi NE	Operational (TDEC 2016-TN4705)
Shawmut Advanced Material Solutions	Manufacturer of laminate	20 mi NE	Operational (TDEC 2010-TN4706)
3M Company	Manufacturer	21 mi NE	Operational (TDEC 2015-TN4707)
MHF Packaging Solutions, LLC	Manufacturer of metal containers	21 mi NE	Operational (TDEC 2016-TN4708)
PolyOne Corporation	Manufacturer of plastic pellets for use in molding in the automotive, medical, and appliance industries	21 mi NE	Operational (TDEC 2016-TN4709)
Doral Steel	Manufacturer of steel	22 mi NE	Operational (TDEC 2015-TN4710)
Aisin Automotive Casting Tennessee, Inc.	Manufacturer of aluminum automotive engine parts	25 mi NE	Operational (TDEC 2016-TN4711)
Keurig Green Mountain	Production facility	31 mi E	Operational (Keurig 2016-TN4712)
Various Iron Works	Manufacturers of iron, including Capps Crabtree, Pip’s, Towe, Volunteer, and Miller	Throughout the region	Operational
Other industrial and manufacturing facilities	Manufacturing and industrial plants	Throughout the region	Operational

7.1 Land Use

The description of the affected environment in Section 2.2 of this EIS serves as the baseline for the cumulative-impact assessment for land use. As described in EIS Section 4.1, the NRC staff concludes the impacts of NRC-authorized construction on land use would be MODERATE because of the conversion of substantial areas of undeveloped naturally vegetated land to a developed condition, and because of the long-term dedication of a 935-ac tract of Federally owned land in an industrial setting that would have otherwise been available for other industrial uses. As described in EIS Section 5.1, the review team concludes the impacts of operations on land use would be SMALL.

As described in Section 4.1 of this EIS, the combined impacts from construction and preconstruction were also determined to be MODERATE. In addition to the land-use impacts from construction, preconstruction, and operation of the proposed new facilities, this cumulative assessment of land-use impacts also considers impacts associated with past, present, and reasonably foreseeable future actions that could cumulatively impact a geographic area of interest (GAI) encompassing the same land-use resources. For this cumulative analysis, the GAI includes the four counties most likely to experience the indirect impacts on land use from building and operating activities at the CRN Site, which is also the economic region referred to in previous sections. These include Roane County (which is the host county), and Anderson, Knox, and Loudon Counties. These are the same counties identified in Section 2.5 of this EIS as composing the economic region potentially affected by building and operating activities at the CRN Site. The direct and indirect land-use impacts of building and operating two or more new SMRs at the CRN Site would be confined to Roane County, but the cumulative impacts on land use when combined with other actions (discussed below) likely would extend to the other counties of the four-county economic region.

As discussed in Section 2.2.1 of this EIS, the 6-mi vicinity encompassing the CRN Site is dominated by three major land-cover types: forests (principally deciduous hardwoods) (62 percent), open space (19 percent), and previously developed lands (14 percent) (see Table 2-1). Current land uses in the 6-mi vicinity have changed since pre-World War II times, when agriculture and livestock grazing were much more prevalent and reflected a greater share of existing land use (TVA 2017-TN4921). The acquisition of what is now the Oak Ridge Reservation (ORR) converted large tracts of agricultural and pasture lands to Federal ownership and much of those lands have revegetated back to forests, while several areas within the ORR have been converted into industrial land uses (TVA 2017-TN4921). The CRN Site had been partially developed (site preparation and excavation activities) for the Clinch River Breeder Reactor Project (CRBRP) in the early 1980s, but that project was canceled and the site redressed by 1984. Prior to the early 1980s, the CRN Site was part of the ORR.

As discussed in Section 2.2.3 of this EIS, the 50-mi radius surrounding the CRN Site, which encompasses the four counties of the GAI and a much wider area is dominated by three major land-cover types: forests (67 percent); open space (19 percent); and developed lands, including the Knoxville metropolitan area (11 percent) (see Table 2-1). Historically, land uses in the region have reflected these land-cover types, and featured a wide variety of cultivated crop production, livestock production, and hay production on agricultural lands; and a wide variety of residential, commercial, and industrial uses on the developed lands (TVA 2017-TN4921).

Table 7-1 lists projects that, in combination with building and operating two or more new SMRs at the CRN Site, could contribute to cumulative impacts in the region. The continued operation and anticipated building activities associated with the ORR and the U.S. Department of Energy's (DOE's) missions are the closest activities to the CRN Site that also have land-use impacts. DOE's ongoing activities, including research, nuclear weapons cleanup, and other related and concurrent missions, are taking place using the lands of the ORR. DOE also is actively developing the Uranium Processing Facility (UPF), which is expected to result in land clearing and excavation activities on about 35 ac of previously disturbed ORR lands (8 ac for operations) in the Y-12 National Security Complex (Y-12 Complex) (DOE 2011-TN5023). The combined land-use impacts of existing DOE operations, current DOE construction activities, and building and operating activities at the CRN Site primarily affect land-use in eastern Roane County and the immediate vicinity. The ORR lands have been held as a Federal reservation since 1942 and most of the current facility footprint areas were cleared and developed in the early 1940s. The CRN Site also was previously substantially disturbed in the early 1980s for the CRBRP construction activities.

Other projects that occur in close proximity to the CRN Site or that could be affected by the proposed action include several quarries and borrow pits. TVA identifies several facilities that may provide fill material for building activities at the CRN Site (TVA 2017-TN4921). Depending on the eventual plant design requirements, TVA may use these facilities to acquire needed fill material. The review team expects that if these resources are needed, some expansion of the facilities within their existing footprints would be needed, which would cause additional excavation activities to occur at the borrow facilities. The review team assumes that borrow pit or quarry expansion would not be noticeably different than current operations, nor would additional land resources need to be acquired to facilitate expansion.

The Metropolitan Knoxville Airport Authority (MKAA) is in the planning and approval stage of developing a regional airport near the East Tennessee Technology Park (ETTP) on the ORR, in close proximity to the CRN Site. Construction may begin in 2018. The planned airport would parallel the Oak Ridge Turnpike (SR 58), immediately east of the existing facilities and west of the highway (MKAA 2017-TN5021), within the Heritage Center Industrial Park. The MKAA proposal would transfer ownership of 170 ac of DOE lands within the ORR to MKAA ownership. DOE preliminarily estimates that 132 ac of forested land would need to be cleared to facilitate airport construction (DOE 2016-TN5022). DOE's preliminary findings indicate that airport development would not preclude the viability of any current land uses, would be consistent with current applicable land-use planning, and would not be incompatible with adjacent land uses. The review team expects that the planned clearing of 132 ac of forest adjacent to the Oak Ridge Turnpike would be noticeable to the general public, and that when added to the expected land clearing activities associated with the building and operating activities at the CRN Site, would have a noticeable cumulative land-use impact in close proximity to the CRN Site.

Most of the other projects listed in Table 7-1 are not expected to create noticeable cumulative land-use impacts in the GAI when combined with the impacts from building and operating a new nuclear power plant on the CRN Site. The GAI has been and continues to be expanding its manufacturing industries. Most of the recent and continued expansion in the form of new plant construction has been occurring at some distance from the CRN Site, in northern Anderson County and western Knox County. The review team expects that there will be continued residential and commercial development in the GAI in the future as regional employment opportunities expand and people move to the area. The future urbanization activities listed would contribute to cumulative land-use impacts in the region.

In addition, TVA indicated some potential transmission system upgrades could be needed if the plant parameter envelope (PPE) value of 800 MW(e) were to be injected into the grid at the CRN Site. Some of the upgrades may require line reconstruction or other activities may temporarily limit access to public spaces. Other upgrades may require minor land-use impacts from accessing existing transmission line right-of-ways over many miles in length to reconstruct, reconductor, or uprate the lines. The affected corridors may be 100 mi or more from the CRN Site. Because the transmission line upgrades would be confined to existing right-of-ways and not require any additional acquisition or dedication of land, those activities would not substantially contribute to cumulative land-use impacts.

The review team concludes that, based on the long-term dedication of a 935-ac tract of Federally owned land in an industrial setting that would have otherwise been available for other industrial uses, the cumulative effect of building and operating activities at the CRN Site, added to effects associated with past, present, or reasonably foreseeable future projects, would be MODERATE. The impact of the NRC-authorized activities (this includes construction as defined in 10 CFR 51.4 [TN250] and operation) would be MODERATE. The NRC staff concludes that the incremental contribution of the NRC-authorized activities related to construction and operation of two or more new SMRs at the CRN Site would be a significant contributor to the MODERATE cumulative impact.

7.2 Water Use and Quality

This section addresses the cumulative impacts of a new nuclear power plant at the CRN Site and other past, present, and reasonably foreseeable future projects on water use and water quality.

7.2.1 Water-Use Impacts

This section describes the cumulative water-use impacts from building and operation of a new nuclear power plant at the CRN Site and other past, present, and reasonably foreseeable projects.

7.2.1.1 Surface-Water-Use Impacts

The description of the affected environment in Section 2.3 of this EIS serves as a baseline for the cumulative impacts assessment for surface-water use. As described in EIS Section 4.2.2, the impacts on surface-water resources from building activities related to a new nuclear power plant would be SMALL. Also, as stated in EIS Section 5.2.2, the impacts on surface-water resources from operations of a new nuclear power plant would be SMALL.

In addition to impacts from building and operations, the cumulative impacts assessment also includes impacts from other past, present, and reasonably foreseeable projects that could affect surface-water use in the vicinity. These projects are listed in Table 7-1. Because the source of surface water for a new nuclear power plant would be the Clinch River arm of the Watts Bar Reservoir, the review team considered the GAI to be the entire Clinch River basin and that portion of the Tennessee River that has potential effects on the Watts Bar Reservoir. In this analysis, the review team considered all surface-water uses that have occurred in the past, are currently occurring, and are reasonably foreseeable to occur in the future.

Past and present surface-water use in the region surrounding the CRN Site is described in Section 2.3.2 of this EIS. As part of the Tennessee River system, the Clinch River adjacent to the CRN Site is managed by TVA. TVA was created in 1933 through the Tennessee Valley Authority Act (TVA Act) (16 U.S.C. § 831-TN5024) to provide flood control, navigation, and development (including power production), among other purposes, in the Tennessee River basin. TVA currently has additional responsibilities for managing water supply, permitting withdrawals, reducing the impact of droughts, improving water quality, and developing recreation. Surface-water hydrology in the Tennessee River basin has been extensively modified over time by the construction of dams. TVA currently operates more than 40 power-producing and flood-control/recreation dams in the basin. Dams affecting Clinch River at the CRN Site are described in Section 2.3.1 of this EIS and have all been altering flows at the CRN Site for more than 40 years. Because the effects of hydrologic alterations described in EIS Sections 4.2 and 5.2 were based on river flows with the dams operating, the contributions of the dams to the impact evaluations are implicitly included in the review team's assessments, and do not require additional consideration here.

To better manage the surface-water resources of the basin, TVA developed an integrated resource plan to manage energy resources and the associated environmental impacts of energy production and resource development (TVA 2015-TN5025). In conjunction with the resource planning, TVA also periodically evaluates current water use across the basin and provides projections of future water use to assist in the development and revision of its reservoir operating policy, and to identify areas of future water supply concern (Bohac and Bowen 2012-TN5026). The most recent water-use report provides projected water use to 2035 based on 2010 water-use estimates (Bohac and Bowen 2012-TN5026). This report tabulates 2010 offstream water use for thermoelectric power generation, industrial, public supply, and irrigation uses by reservoir catchment area, watershed, and by county. Withdrawals, return flows, and consumptive-use estimates are provided. Water withdrawals in the basin are currently dominated by thermoelectric power generation, while two-thirds of consumptive-water use in the basin is for public supply. Water-use projections for 2035 indicate that basin-wide withdrawals will decrease 21 percent due to the replacement of once-through cooling for thermoelectric power generation by closed-cycle cooling (Bohac and Bowen 2012-TN5026). As a result, thermoelectric consumptive use is projected to increase basin-wide from 52 to 142 Mgd. Population growth and development in the basin are projected to increase public supply water use from 310 to 414 Mgd, industrial use from 75 to 110 Mgd, and irrigation use from 34 to 46 Mgd. Basin-wide consumptive-water use from all use categories is projected to increase by 51 percent between 2010 and 2035.

Based on a review of the history of water use and water-resources planning in the Tennessee River basin, the review team determined that past and present use of the surface waters in the basin has been noticeable, necessitating consideration, development, and implementation of careful planning.

Of the projects listed in Table 7-1, the ones that were considered for cumulative impacts on the surface-water resource are the power plants, ORR, Oak Ridge National Laboratory (ORNL), Y-12 Complex, ETTP, and additional industrial development and urbanization. All other projects listed in Table 7-1 are outside the GAI, do not affect the surface-water resource, or their surface-water use is insignificant.

As described in Section 4.2.2 of this EIS, small amounts of surface water would be used to support building activities at the CRN Site. Surface-water-use impacts for a nuclear power plant at the CRN Site would be dominated by the consumptive demand that would occur under normal operations. Consumptive-water use (average and maximum) is expected to be 28.5 cfs (see Chapter 3). This rate is less than 1 percent of the average discharge from the Melton Hill Reservoir of 4,670 cfs, based on 2004 to 2013 data (TVA 2017-TN4921), and is about 7 percent of the 400 cfs minimum flow through the proposed Melton Hill bypass. The current discharge reflects all upstream dams, as well as the cumulative consumptive use of current water users. Because the current water use by the projects identified in Table 7-1 is reflected in the existing flows in the lower Clinch River, the review team considered future changes in water use by these projects in evaluating cumulative impacts. Furthermore, because any potential impacts would be most noticeable at low flows, the review team evaluated whether these future changes in water use would affect the availability of water to meet the minimum discharge requirement from Melton Hill Reservoir, or necessitate a change in the reservoir operation.

The total consumptive use in 2010 for the Melton Hill and Norris Reservoir catchment areas was about 18 Mgd (Bohac and Bowen 2012-TN5026). If the 2035 consumptive use increases at the projected rate for the Tennessee River basin (51 percent), this will increase the consumptive use in the Melton Hill and Norris Reservoir catchment areas by about 9 Mgd (about 14 cfs). This additional consumptive use is 3.5 percent of the current minimum daily average discharge from the Melton Hill Reservoir (400 cfs), and would be less than 1 percent of the reservoir discharge about 80 percent of the time, based on current releases (TVA 2017-TN4921). This relatively small increase in future upstream consumptive use would have a minimal effect on the availability of water to maintain current Melton Hill Reservoir releases. Furthermore, the current reservoir operating policy was developed with the assumption that consumptive use upstream of the CRN Site in 2030 would be 63 Mgd (97 cfs) (TVA 2017-TN4921). If future water use is more in line with the much smaller projections in TVA's current water-use report (Bohac and Bowen 2012-TN5026), the review team concludes that the future increases in water use upstream of the CRN Site would not necessitate a change in the current reservoir operating policy. Therefore, the review team determined that the cumulative water-use impacts of the projects identified in Table 7-1 on the lower Clinch River would be minor.

The review team concludes that because of extensive past and present modification and use of surface waters from the Clinch River basin, the cumulative effect of the proposed action, added to effects associated with past, present, or reasonably foreseeable future projects, would be MODERATE. The impact of the NRC-authorized activities (this includes construction as defined in 10 CFR 51.4 [TN250] and operation) would be SMALL. The NRC staff concludes that the incremental contribution of the NRC-authorized activities related to construction and operation of two or more new SMRs at the CRN Site would not be a significant contributor to the MODERATE cumulative impact.

7.2.1.2 Groundwater-Use Impacts

The description of the affected environment in Section 2.3 of this EIS serves as a baseline for the cumulative impacts assessment for groundwater use. As described in EIS Section 4.2.2, the impacts on groundwater resources from building activities related to two or more new SMRs at the CRN Site would be SMALL. Also, as stated in EIS Section 5.2.2, the impacts on groundwater resources from the operation of a new nuclear power plant at the CRN Site would be SMALL.

In addition to impacts from building and operations, the cumulative impacts assessment includes impacts from other past, present, and reasonably foreseeable projects that could affect groundwater use in the vicinity of the CRN Site. These projects are listed in Table 7-1. Because groundwater would not be used for operations, would only be extracted during building as necessary for excavation dewatering, and the effects of dewatering are not expected to extend beyond the Clinch River or north of the excavation (as discussed in Section 4.2.1.2 of this EIS), the review team considered the GAI to be the groundwater in the vicinity of the CRN Site. In this analysis, the review team considered all groundwater uses that have occurred in the past, are currently occurring, and are reasonably foreseeable to occur in the future. The GAI was limited to the groundwater within about 1 mile of the site, above an elevation of about 680 ft North American Vertical Datum of 1988 (NAVD88; the approximate depth of the excavation). The GAI was also limited to the groundwater within the Bethel Valley (extended across the Clinch River) due to the hydrogeologic characteristics described in Sections 2.3.1 and 2.8 of this EIS and the temporary nature of excavation dewatering, which limits the spatial extent of potential impacts.

Past and present water use in the Clinch River basin and in the region surrounding the CRN Site is described in Section 2.3.2 of this EIS and the ER (TVA 2017-TN4921). Surface water is the dominant water source in the Tennessee River basin as a whole, and in the lower Clinch

River watershed. Groundwater is primarily used for public water supply. In the lower Clinch River watershed in 2010, 99 percent of groundwater withdrawals were for public supply water use, and these made up about 6 percent of the total public supply withdrawals (Bohac and Bowen 2012-TN5026). None of these groundwater public supplies was located within the GAI. Individual groundwater well users within the GAI are described in EIS Section 2.3.2. Current groundwater conditions described in EIS Section 2.3.1 implicitly consider the effects of these individual wells on groundwater resources. As described in EIS Section 4.2.2, the review team determined that the temporary excavation dewatering would have a SMALL impact on these individual wells.

Of the projects listed in Table 7-1, the ones that were considered for cumulative impacts on groundwater use are the ORR and associated facilities. However, these facilities use surface water from the Clinch River and therefore would not contribute to cumulative impacts on groundwater use. All other projects listed in Table 7-1 either do not affect groundwater resources or their groundwater use is outside the GAI.

Groundwater would not be used for building and operating a nuclear power plant at the CRN Site. In addition, excavation dewatering during building would be temporary and would have limited spatial effect. The review team concludes that because no other past, present, or reasonably foreseeable actions with significant groundwater-use impacts were identified, the cumulative effect of the proposed action, when added to effects associated with past, present, or reasonably foreseeable future projects, would be SMALL.

7.2.2 Water-Quality Impacts

This section describes the cumulative water-quality impacts from building and operation of a new nuclear power plant at the CRN Site and other past, present, and reasonably foreseeable projects.

7.2.2.1 Surface-Water-Quality Impacts

The description of the affected environment in Section 2.3 of this EIS serves as the baseline for the cumulative impacts assessment for surface-water quality. As described in EIS Section 4.2.3, the impacts on surface-water quality from construction and preconstruction activities related to two or more new SMRs at the CRN Site would be SMALL. Also, as stated in EIS Section 5.2.3, the impacts on surface-water quality from the operation of a new nuclear power plant at the CRN Site would be SMALL.

In addition to impacts from building and operation of a new nuclear power plant, the cumulative impacts assessment includes impacts from other past, present, and reasonably foreseeable projects that could affect surface-water quality in the vicinity. These projects are listed in Table 7-1. Because a new nuclear power plant would discharge plant blowdown and other wastewater streams to the Clinch River arm of the Watts Bar Reservoir, the review team considered the GAI to be the entire Clinch River basin and that portion of the Tennessee River that has potential effects on the Watts Bar Reservoir. Of the projects listed in Table 7-1, the ones that were considered for cumulative impacts on the surface-water resource are the fossil power plants, ORR, ORNL, Y-12 Complex, and ETTP, and additional industrial development and urbanization. All other projects listed in Table 7-1 either do not affect surface-water quality or their water-quality effects are unlikely to interact with discharges from the CRN Site. In this analysis, the review team considered all actions that have occurred in the past, are currently occurring, and are reasonably foreseeable to occur in the future that may affect surface-water quality.

The surface-water quality of the Clinch River is described in Section 2.3.3 of this EIS. Under the requirements of Clean Water Act Section 303(d), the Tennessee Department of Environment and Conservation (TDEC) maintains a list of impaired waterbodies, i.e., where water quality does not meet the designated uses. In the lower Clinch River, a number of waterbodies, including the Clinch River arm of the Watts Bar Reservoir and the Melton Hill Reservoir were listed among Tennessee's impaired waterbodies (TDEC 2017-TN5060). The presence of chlordane and polychlorinated biphenyl (PCB) contamination in these waterbodies has led to advisories for fish consumption. The Clinch River arm of the Watts Bar Reservoir is also listed for mercury contamination. A number of the Clinch River tributaries located on the ORR are listed for various contaminants. White Oak Creek, just upstream from the CRN Site, is listed for cesium and strontium contamination. White Oak Creek and the sediment in the Clinch River arm of the Watts Bar Reservoir are regulated by Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Records of Decision (DOE 2016-TN5027). Because continuing issues in the Clinch River basin related to water quality have resulted in careful planning and management, the review team determined that the water-quality impact on the Clinch River basin from past and present actions is noticeable.

As discussed in Section 5.2.3 of this EIS and in the ER (TVA 2017-TN4921), TVA completed local and regional simulations to evaluate the effect of the CRN Site plant blowdown on the lower Clinch River. The local simulations were conducted assuming conservative conditions: maximum blowdown flow rate, minimum river flow, and extreme summer and winter temperatures. Impacts were evaluated assuming a minimum 400 cfs continuous discharge via a Melton Hill Dam bypass structure. Based on a review of the simulation results, the review team determined that the applicable Tennessee water-quality criteria would be met with a circular discharge mixing zone of about 150 ft in diameter, with some local and temporary excursions of high-temperature water beyond the mixing zone due to the unsteady flow conditions. Regional modeling was completed under observed conditions for 2004 (a normal-flow year), 2008 (a low-flow year), and 2013 (a high-flow year), and CRN Site discharge characteristics within (i.e., less than) the PPE flow rate and temperature values. Simulations were completed with no Melton Hill Dam bypass and with a 200 cfs bypass. For the simulated conditions, the review team determined that the effect of the CRN Site discharge on water temperature would be minor in the Clinch River at Clinch River mile (CRM) 6 (upstream from the Emory River confluence) and undetectable in the Tennessee River downstream of the Clinch River confluence. The simulation results show that the Bull Run Fossil Plant located at CRM 48, about 32 mi upstream from the CRN Site discharge, affects the Clinch River temperature at the CRN Site. Because the effects of the Bull Run plant were included in the baseline conditions, the impacts of the CRN Site discharge evaluated in Section 5.2.3 of this EIS include the cumulative effects of the Bull Run plant at the CRN Site discharge location. In addition, while reviewing TVA's future National Pollutant Discharge Elimination System application for a new discharge to the Clinch River, TDEC would have the opportunity to require discharge rules that would protect the aquatic environment. Therefore, the review team determined that the cumulative impact of the CRN Site discharge with the projects in Table 7-1 would not noticeably affect the Clinch River.

Waste-disposal activities in Melton Valley on the ORR have resulted in significant contamination of sediments in White Oak Creek and downstream from the creek's confluence with Clinch River (DOE 2016-TN5027). The review team considered whether future activities that could disturb the existing contaminated sediments would result in cumulative impacts with CRN Site building or operation. Two control structures have been placed on White Oak Creek to reduce the transport of contaminated sediments from the creek to the Clinch River. White Oak Dam, constructed in 1941 and modified in 2010 to withstand major flooding, is located about 0.6 mi upstream from the confluence with Clinch River and controls the water level in White Oak Lake. The White Oak Creek Embayment Sediment Control Dam, constructed in 1992, is located at the Clinch River confluence and was constructed to isolate the embayment (and its contaminated sediments) from significant fluctuations in water levels in the Clinch River arm of the Watts Bar Reservoir. Sediment and water-quality monitoring data indicate that the control structures and remediation activities at Melton Valley waste sites have significantly reduced radionuclide discharges from White Oak Creek (TVA 2017-TN5028; also staff review of OREIS data). Based on the small size of the White Oak Creek basin (6.4 mi^2) relative to the Clinch River basin and the presence of the White Oak Creek control structures, the review team determined that flooding in White Oak Creek would be unlikely to result in significant scouring of sediments in the embayment. In addition, successful waste management activities in Melton Valley have resulted in the most highly contaminated sediments in the embayment being buried over time by the deposition of relatively clean sediments (TVA 2017-TN5028). Based on the information above, the review team determined that future downstream effects from the existing contaminated sediments in the White Oak Creek basin would be minor.

The review team concludes that based on extensive past and present use of and discharges to the Clinch River, the cumulative effect of the proposed action, added to effects associated with past, present, or reasonably foreseeable future projects, would be MODERATE. The impact of the NRC-authorized activities (this includes construction as defined in 10 CFR 51.4 [TN250] and operation) would be SMALL. The NRC staff concludes that the incremental contribution of the NRC-authorized activities related to construction and operation of two or more SMRs at the CRN Site would not be a significant contributor to the MODERATE cumulative impact.

7.2.2.2 Groundwater-Quality Impacts

The description of the affected environment in Section 2.3 of this EIS serves as a baseline for the cumulative impacts assessment for groundwater quality. As described in EIS Section 4.2.3, the impacts on groundwater quality from construction and preconstruction activities related to two or more new SMRs at the CRN Site would be SMALL. Also, as stated in EIS Section 5.2.3, the impacts on groundwater quality from operations of two or more new SMRs at the CRN Site would be SMALL.

In addition to impacts from building and operations, the cumulative impacts assessment includes impacts from other past, present, and reasonably foreseeable projects within the GAI that could affect groundwater quality. The GAI is the same as that described in Section 7.2.1.2 of this chapter for groundwater use. Of the projects listed in Table 7-1, the ORR is the only project considered for cumulative impacts on groundwater quality. Of specific interest are the past, present, and future waste-disposal activities on the ORR that affect groundwater in Bethel Valley. All other projects listed in Table 7-1 either do not affect groundwater quality, are at such a distance from the CRN Site that there would be no interaction with a new nuclear power plant, or affect hydrogeologic units outside Bethel Valley so that their interaction with groundwater at the CRN Site is very unlikely.

Existing groundwater contamination on the ORR is described in DOE 2016-TN5027. Contaminants in groundwater tend to be transported along the geologic strike, resulting in elongated plumes running parallel to the valleys. In Bethel Valley, the identified groundwater contaminant plume on the ORR closest to and upgradient of the CRN Site is that resulting from activities at Solid Waste Storage Area 3 and the Contractor’s Landfill. The westernmost extent of this plume is near State Route 95 and the upper reach of Raccoon Creek. The creek is monitored for contaminants discharged from this groundwater plume.

As discussed in Section 4.2.3.2 of this EIS, impacts on groundwater quality would be localized and temporary during building at the CRN Site. Based on the results of the aquifer pumping test completed at the site, the experience during the CRBRP excavation, the observed reduction with depth of open fractures and joints, and a commitment by TVA to use measures to reduce inflow to the excavation (such as grouting fractures that have higher flows), the review team concludes that the extent of the zone of influence of dewatering during construction would be limited to the CRN Site. Site data and hydrologic principles, as discussed in EIS Section 2.3.1.2, indicate that the Clinch River, which cuts across Bethel Valley on the eastern side of the CRN Site, serves as a discharge point for the shallow groundwater on the CRN Site and the ORR. For these reasons, and because excavation dewatering during building would be temporary, the review team concludes that existing groundwater contamination in Bethel Valley on the ORR would not interact with the shallow groundwater at the CRN Site.

Groundwater would not be used during operations, and no dewatering is planned during operations. There would be no planned releases of contaminants to the groundwater. During building and operation at the CRN Site, it is possible that inadvertent spills could transport pollutants (e.g., gasoline) to groundwater. Accidental releases of pollutants during building or operation activities at the CRN Site would be controlled by emergency plans and best management practices (BMPs), and the TDEC would require cleanup of any spills that may occur at the CRN Site. Therefore, any impacts on groundwater quality at the CRN Site from activities associated with building and operation would be minor.

The review team concludes that because activities on the ORR have noticeably altered the groundwater quality, particularly in localized waste-disposal areas, the cumulative effect of the proposed action, added to effects associated with past, present, or reasonably foreseeable future projects, would be MODERATE. Because the CRN Site groundwater is hydrogeologically isolated from most of the ORR groundwater contamination, and because the CRN Site is a significant distance from the groundwater contamination in Bethel Valley, the temporary excavation dewatering activities at the CRN Site would not result in a noticeable change in groundwater quality. Therefore, the impact of the NRC-authorized activities (this includes construction as defined in 10 CFR 51.4 [TN250] and operation) would be SMALL. The NRC staff concludes that the incremental contribution of the NRC-authorized activities related to construction and operation of two or more SMRs at the CRN Site would not be a significant contributor to the MODERATE cumulative impact.

7.3 Ecology

This section addresses the potential cumulative impacts on ecological resources from building and operating the project at the CRN Site. The evaluation of cumulative impacts also includes consideration of other past, present, and reasonably foreseeable future activities within the GAI. Section 7.3.1 of this EIS discusses the cumulative impacts on terrestrial ecological resources, and Section 7.3.2 discusses the cumulative impacts on aquatic ecological resources.

7.3.1 Terrestrial and Wetland Resources

The description of the affected environment in Section 2.4.1 of this EIS provides the baseline for the cumulative-impact assessments for terrestrial and wetland ecological resources. As described in EIS Section 4.3.1, impacts from NRC-authorized construction would be MODERATE. As described in EIS Section 4.3.1, the review team concludes that the combined impacts of construction and preconstruction would also be MODERATE. As described in Section 5.3.1, the review team concludes that the impacts of operations on terrestrial and wetland resources would be SMALL.

In addition to impacts from construction, preconstruction, and operation, the following cumulative-impact analysis also considers other past, present, and reasonably foreseeable actions that could affect the same terrestrial and wetland resources. For purposes of this cumulative analysis, the review team has defined a GAI comprising lands within 6 mi of the CRN Site (in order to encompass the barge/traffic area [BTA] and the proposed offsite buried 69-kV transmission line), as well as areas within the corridors of the offsite transmission lines that would be upgraded (rebuilt, reconductored, or uprated). The 6-mi radius also includes most of the forested areas of the ORR contiguous to the northern and northeastern perimeters of the CRN Site. Table 7-1 lists projects that would impact terrestrial and wetland resources within the GAI. The review team evaluated the significance of cumulative impacts from projects in the GAI to the same resources considered in Sections 4.3.1 and 5.3.1 of this EIS.

7.3.1.1 Terrestrial Habitats

The CRN Site lies entirely within the Ridge and Valley Ecoregion, which extends from the Saint Lawrence Valley in southeastern New York southwest through the Gulf Coastal Plain in Alabama. It is about 40 mi wide in eastern Tennessee. It is characterized by alternating forested ridges and agricultural valleys that have a variety of geologic materials containing numerous springs and caves (EPA 2013-TN5033; Tucci 1992-TN5034; USGS 2016-TN5035; Woods et al. 1999-TN1805, Woods et al. 2003-TN1806). The greatest land conversion in the Ridge and Valley Ecoregion from 1973 through 2000 was from forested to disturbed land, followed by the reversion of disturbed lands back to forest (USGS 2016-TN5035). Forest and disturbed land are both also being converted to developed land (TNC 2003-TN5036; USGS 2016-TN5035). Three land-cover types dominate the ecoregion: forest (56 percent), agriculture (about 30 percent), and developed areas (about 9 percent) (USGS 2016-TN5035).

The percentages of land-cover types within 6 mi of the CRN Site (the GAI) are provided in Table 2-1. Percentages of forest, agriculture, and development in the GAI are generally similar to those in the ecoregion noted above. The GAI outside the ORR consists of a mosaic of forest on steeper, less arable land and agriculture fields, pastures, and small, privately owned farms interspersed with residential areas and open water associated with the Clinch River arm of Watts Bar Reservoir and its tributaries. More forest and less agricultural and residential development exist within the ORR portion of the GAI, located north of Clinch River and adjacent to the CRN Site. The landscape in the GAI, which once was almost continuously forested, has experienced substantial forest loss and fragmentation, especially outside the ORR.

Agriculture, timber harvest, coal mining, and hydropower generation have played a key role in shaping terrestrial communities in the GAI (TNC 2003-TN5036). These activities largely continue today and maintain much of the area in a relatively rural state (EPA 2002-TN5038; LandScope America 2017-TN5039). However, such disturbances have resulted in forest reduction and fragmentation, leaving a mosaic of habitat types in various stages of succession, a greater amount of forest edge habitat, and a lesser amount of forest interior habitat and forest interior wildlife. These disturbances and resulting forest reduction and fragmentation are more prevalent outside the ORR. Conservation in the form of natural areas and habitat protection areas also plays a role in maintaining a relatively natural landscape and some relatively large blocks of contiguous forest habitat in the GAI (TVA 2009-TN4997). These are much more prevalent within the ORR.

Overlaying the historic activities described above are commercial, industrial, and residential land uses, which tend to more fully and permanently convert the landscape to a more artificial state. Current projects within the GAI include Federal facilities on the ORR; hydropower facilities located within the GAI (i.e., Melton Hill Hydroelectric) or outside the GAI but still affecting upstream riparian and floodplain terrestrial resources within it (i.e., Watts Bar Dam); mining (various locations); transportation (e.g., Oak Ridge Airport); manufacturing (e.g., LeMond Composites) (Table 7-1); natural and habitat protection areas—most of which are located on the ORR; and others (e.g., Diversified Scientific Services, Inc.) (Table 7-1). The proposed development of a general aviation airport on the ORR near the ETTP would noticeably reduce, fragment, and degrade the remaining forest habitat in that part of the ORR, as well as pose a risk of air strikes with birds and increase noise disturbance to wildlife in surrounding areas. The development of most of these projects (most notably the Oak Ridge Airport) has or will further reduce, fragment, and degrade forests and decrease their connectivity beyond that caused by the historical and ongoing activities described above. In contrast, existing and proposed natural and habitat protection areas protect local terrestrial resources for the foreseeable future.

Site preparation and development of the CRN Site and BTA and offsite burial of the 69-kV transmission line would disturb a total of about 749 ac, of which approximately 311 ac are forest that provides habitat for two Federally endangered bat species and one Federally threatened bat species; three additional bat species, one hawk species, and two plant species considered rare in Tennessee; and a number of forest interior bird species. The loss of habitat, particularly forest habitat, would noticeably reduce, fragment, and degrade the remaining forest habitat and decrease its connectivity in the surrounding landscape. Although terrestrial habitat in the landscape has been altered since the time of European settlement (more noticeably outside the ORR since its establishment in the 1940s), habitat impacts from the projects and activities listed above (with the exception of the natural and habitat protection areas) combined with building and operating project facilities, would be noticeable but not destabilizing to terrestrial resources.

Terrestrial vegetation that may be affected during the upgrading of offsite transmission lines (Figure 2-8) is limited to areas within existing transmission line corridors (TVA 2017-TN4921). The affected areas consist of artificially maintained herbaceous and shrub habitat. Vegetation in these areas is influenced by existing TVA transmission line right-of-way vegetation management practices described in Section 5.3.1 of this EIS, as well as in places by landowners using TVA right-of-way easements. Right-of-way management impacts on terrestrial vegetation within existing transmission line corridors would not likely change substantially after the upgrading activities. Thus, impacts from these activities on terrestrial resources, combined with the proposed transmission line upgrades, would be minor.

7.3.1.2 Wetlands

Wetlands typically occur only in small areas and constitute only a small percentage of the surrounding landscape. Bottomland forests are the most common type of wetland in Tennessee and are located primarily in the floodplains of rivers (TWRA 2015-TN5042). Most wetlands near the CRN Site are classified as palustrine forested, scrub/shrub, and emergent wetlands, occurring at lower elevations, primarily in riparian zones of headwater streams and receiving streams and in the Clinch River embayments (DOE 2017-TN5081). It is estimated that Tennessee lost 59 percent of its wetlands from the 1780s to the 1980s (TWRA 2015-TN5042). Agricultural conversion and reservoir development are likely the primary factors that have resulted in wetland reduction to date in the surrounding landscape.

Site preparation and development of the CRN Site and BTA and installation of the 69-kV underground line potentially may disturb up to 4 ac of wetlands, including forested and emergent wetlands. To the extent practicable, the PPE construction footprint was defined to minimize impacts on wetlands. Impacts on 4 ac of wetlands would constitute only about

0.4 percent of the wetlands within a 6-mi radius. In contrast, existing and proposed natural and habitat protection areas protect local wetland resources for the foreseeable future. Although wetland habitat in the GAI has been altered since the time of European settlement, habitat impacts from the activities listed above combined with building and operating two or more new SMRs would be cumulatively minor to wetland resources.

Wetlands that may be affected during the offsite transmission line upgrades (Figure 2-8) are limited to areas within the transmission line corridors. Such wetlands support vegetation that is artificially maintained in an herbaceous and shrub state. These same wetland resources may also be affected by transmission line right-of-way vegetation management practices (EIS Section 5.3.1) and possible changes in land use by landowners within TVA right-of-way easements. TVA's right-of-way management calls first for avoiding wetlands and leaving wetland buffers intact where practicable, and otherwise employing BMPs to minimize impacts on wetlands and protect important wetland functions (TVA 2012-TN4911). Land-use changes within these corridors may occur occasionally but are not expected to be extensive. Further, TDEC requires landowners to implement BMPs to avoid or minimize impacts, and TVA would have to implement any mitigation that may be imposed by the USACE or TDEC. Thus, wetland impacts would be minor.

7.3.1.3 Wildlife

The wildlife occupying a landscape is indicative of the habitat present. Anthropogenic, periodic wildfire played a role in the development and maintenance of pre-settlement oak forests in eastern Tennessee (TWRA 2015-TN5042). This likely resulted in a mosaic of forested and open habitats in various stages of succession at the time of European settlement. Thus, it is likely that wildlife species were present that were adapted to all stages of succession, including those that require large blocks of forest habitat (i.e., avian forest interior specialists), as well as habitat generalists that occupy an interspersion of habitats in various stages of succession (e.g., raccoon [*Procyon lotor*] and opossum [*Didelphus virginiana*]).

The forest clearing and low-intensity agriculture that accompanied European settlement likely increased the amount of early successional (prairie-like) and edge habitat (forest/open habitat interface). However, the quantity and quality of forested and early successional habitats likely has since diminished as a result of suppression of the natural fire cycle, further fragmentation of habitat into even smaller isolated units, land and reservoir development, farmland abandonment, urban encroachment, and encroachment by invasive vegetation. Populations of species requiring specialized forest habitats (e.g., large blocks of unfragmented forest, old-growth forest, and riparian forests) likely also declined during this time period. Consequently, the current habitat mosaic in the GAI generally favors wildlife adapted to early successional habitat of lesser quality and quantity to mid-successional forests, with some species favoring mature forest in portions of the ORR and on some ridgetops. The species most at risk in the Ridge and Valley Ecoregion of Tennessee include those associated with floodplains, riparian areas, old-field/successional habitat, and Appalachian forest (TWRA 2015-TN5042).

Reasonably foreseeable projects and activities within the GAI that could affect wildlife populations include those listed above under the "Terrestrial Habitats" and "Wetlands" subsections. These actions would further contribute to the reduction, fragmentation, and degradation of forests and decrease habitat connectivity. The resulting habitat mosaic would tend to continue to favor wildlife adapted to forest edges, fewer and lower quality openings, and urban areas. Although wildlife resources in the GAI have been significantly altered since the time of European settlement, impacts on wildlife resulting from ongoing and reasonably foreseeable projects and activities, including building and operating activities at the CRN Site, would be noticeable but not destabilizing, fostering the continuation of many trends already present in the GAI (i.e., a reduction of wildlife closely tied to mature forest, large blocks of forest, quality old-field/early successional habitat, riparian areas, and wetlands).

7.3.1.4 Important Species and Habitats

Prior to European settlement the GAI was almost continuously forested. It now exhibits substantial forest reduction, fragmentation, and degradation, which has substantially reduced roosting and foraging habitat for multiple Federally listed bat species (Indiana bat [*Myotis sodalis*], gray bat [*Myotis grisescens*], and northern long-eared bat [NLEB] [*Myotis septentrionalis*]), and other bat species considered rare in Tennessee (eastern small-footed myotis [*Myotis leibii*], tri-colored bat [*Perimyotis subflavus*], and little brown bat [*Myotis lucifugus*]). Reasonably foreseeable future projects and activities within the GAI that could affect habitat for these species include those listed above under the “Terrestrial Habitats” and “Wetlands” subsections. Even considering the reasonably foreseeable losses of suitable forest habitat, including those from CRN Site building and operation activities, extensive and broadly distributed areas of potentially suitable forest habitat are expected to remain in the GAI, especially on the ORR and on area ridge tops. More important to understanding the context of near-term future effects on habitat for these bat species in the GAI, particularly with regard to the potential additive effects of building and operating activities at the CRN Site, are the effects on these species caused by white-nose syndrome (WNS) (described in Section 4.3.1.3 of this EIS).

The breakup of maternity colonies containing infected bats can result in the reaggregation of infected bats with uninfected bats and thereby spread WNS (76 FR 38095 -TN1798; 80 FR 17974 -TN4216). The loss of habitat on the CRN Site and BTA is not expected to cause the breakup of maternity colonies because none are currently known to exist there (EIS Section 2.4.1.3). Building and operating activities at the CRN Site are therefore not expected to influence the spread of WNS in local bat populations. However, any consideration of cumulative effects on susceptible species must consider the effects of WNS.

As of 2016, there were U.S. population declines for the Indiana bat, NLEB, and tri-colored bat due to WNS. A nationwide decline in the eastern small-footed bat was uncertain and there was no apparent decline in gray bats (FWS 2016-TN5030). As of 2016, Tennessee population declines were noted for the NLEB and tri-colored bat based on hibernacula surveys since 2010 (TNBWG 2017-TN5043).

WNS-affected bats exhibit wing damage with varying degrees of scarring, necrosis through injury or disease, and atrophy of flight membranes, which may lead to reduced foraging success, leaving affected bats in poor condition as they prepare for hibernation. Bats with severe wing damage have been found to have significantly lower body mass than those with little or no WNS-induced wing damage, and this may also contribute to reproductive decline or failure. Affected hibernating bats awake from torpor more frequently than normal, accelerating fat loss and starvation (76 FR 38095 -TN1798).

Energy expenditures incurred by the above bat species due to preclusion of future use of suitable roosting habitat on the CRN Site and BTA during summer and fall swarming/spring staging (EIS Section 2.4.1) could further exacerbate or contribute to reproductive decline or failure and failure to overwinter in bats caused by WNS. Two levels of potential cumulative effects are possible. First, individual bats sickened or struggling with infection by WNS may be less able to survive preclusion of future use of suitable habitat on the CRN Site and BTA. Second, already rare bat populations affected by WNS, with smaller numbers and reduced fitness among individuals, may be more prone to extirpation caused by preclusion of future use of suitable habitat on the CRN Site and BTA (80 FR 17974 -TN4216). These potential cumulative effects are particularly noteworthy in the case of the NLEB. Although the effects of forest harvest and fragmentation and isolation alone likely would not be significant enough to cause population-level effects on the species (EIS Section 2.4.1), when combined with the significant population reductions caused by WNS, the resulting cumulative effects could further reduce the local NLEB population. WNS has reduced NLEB populations to the extent that they may be increasingly vulnerable to other stressors such as those caused by building and operating activities at the CRN Site. Recovery from such cumulative effects may be particularly difficult considering the low reproductive rate of the NLEB (EIS Section 2.4.1.3). Energy expenditures incurred due to preclusion of future use of suitable roosting habitat on the CRN Site and BTA could noticeably reduce the fitness of individuals and the viability of local populations of bat species already affected by WNS. Further discussion of cumulative impacts on the NLEB, Indiana bat, and gray bat is provided in the NRC's biological assessment (see Appendix M).

There are no important habitats (as defined in NUREG 1555 [NRC 2000-TN614]) on the CRN Site, one important habitat (providing potential habitat for several rare species) that overlaps the BTA (Figure 2-28), and numerous other important habitats in the GAI (Table 2-13) (TVA 2017-TN4921). Road improvements would unavoidably involve disturbance to and losses of portions of the important habitat in the BTA. There would be potential impacts on four other important habitats in the surrounding landscape (EIS Section 4.3.1.3.1.3). The review team expects that any habitats situated more than 2 mi from the CRN Site or BTA would not be adversely affected by the project. Reasonably foreseeable future projects and activities that could also affect important habitats in the GAI include those listed above under the Terrestrial Habitats and Wetlands subsections. However, effects are not likely to occur due to the higher level of protection generally afforded to important habitats than surrounding areas. These potential impacts, combined with the impacts from building and operating activities at the CRN Site on the important habitats noted above, would be minor.

7.3.1.5 Summary

Cumulative impacts on terrestrial and wetland resources from construction, preconstruction, and operating activities at the CRN Site and other past, present, and reasonably foreseeable activities and projects were estimated based on the information provided by TVA and through the review team's independent evaluation. Terrestrial resources in the GAI have been significantly altered since the time of European settlement, most noticeably outside the ORR. Agriculture, timber harvest, coal mining, and hydropower generation have played key roles in shaping terrestrial and wetland resources in the GAI. These ongoing activities plus current and future commercial, industrial, and residential land uses would continue to reduce, fragment, and degrade terrestrial and wetland resources in the GAI. However, existing and proposed natural areas and habitat protection areas in the GAI, most of which are located on the adjacent ORR, would tend to protect terrestrial resources for the foreseeable future.

The loss of habitat associated with building and operating the proposed new facilities, especially upland forest, but also wetlands and old-field/early successional habitat, and associated wildlife, would noticeably affect but not destabilize terrestrial resources in the GAI. Impacts on important species, in particular several bat species, would be noticeable, but not destabilizing. Impacts on important habitats would be negligible to minor.

The review team concludes that the cumulative effect of the proposed action on terrestrial resources, added to effects associated with past, present, or reasonably foreseeable future actions would be MODERATE. This conclusion primarily reflects the impacts from loss of an extensive area of deciduous forest habitat on the CRN Site, the introduction of industrial noise and human activity to the CRN Site and largely undeveloped surroundings, the potential effects of the forest losses on several bat species experiencing substantial population decreases, and ongoing losses and fragmentation of the remaining forest habitat on the ORR. The NRC staff concludes that the incremental contribution of the NRC-authorized activities related to building and operating activities at the CRN Site would be a significant contributor to the MODERATE cumulative impact. The review team concludes that the incremental contribution of the overall project, including preconstruction, construction, and operation, would be a significant contributor to the MODERATE cumulative impact.

7.3.2 Aquatic Ecosystem

The description of the affected environment in Section 2.4.2 of this EIS provides the baseline for the cumulative-impact assessment for aquatic resources. The combined impacts of construction and preconstruction on aquatic resources are described in EIS Section 4.3.2 and have been determined by the review team to be SMALL, considering the small amounts of aquatic habitat affected, implementation of BMPs to minimize erosion and sedimentation, and the quality of the affected habitat. As described in EIS Section 5.3.2, the review team concludes the impacts of operations on aquatic resources would also be SMALL, considering the requirement for TVA to comply with EPA regulations for intakes and the State of Tennessee's regulations for discharges.

The cumulative analysis also considers other past, present, and reasonably foreseeable future actions potentially affecting the same resources. The review team identified a GAI for cumulative impacts for aquatic ecology that includes the reservoirs and reaches of the Clinch River upstream from the CRN Site to Norris Dam, including associated tributaries. The GAI also includes Clinch River downstream of the CRN Site to the Tennessee River. In defining this GAI, the review team recognized that the dams essentially segment aquatic communities in successive reservoirs, each with its own aquatic communities. Based on the thermal discharge parameters described in Section 2.3.3 of this EIS, the review team expects that the influence of the plant discharge would no longer be measurable somewhere in the stretch of river between the discharge and the confluence of the Clinch and the Emory Rivers (TVA 2009-TN4997). The review team evaluated the significance of cumulative impacts on the same resources considered in Sections 4.3.2 and 5.3.2 of this EIS.

7.3.2.1 CRN Site and Vicinity

Section 2.3.2 of this EIS describes some of the past activities that have already affected waters in the GAI. These activities include the impoundment of Clinch River, which historically was free-flowing and flooded annually. In 1936, TVA completed its first reservoir on Clinch River—Norris Reservoir located at CRM 80. The second TVA dam, Melton Hill Dam, was completed in 1963 at CRM 23, approximately 4 river miles above the CRN Site (Howard et al. 2015-TN5049). The Watts Bar Dam completed in 1942 on the main stem of the Tennessee River impounded the lower part of the Clinch River, including the segment that directly adjoins the CRN Site. The dams have segmented aquatic habitat in the Clinch River system, altered water temperatures, increased sedimentation, increased concentrations of heavy metals and other contaminants in sediments, reduced dissolved oxygen concentrations, and altered flow regimes. This has substantially affected the habitats in the area, which in turn resulted in the loss of diversity and species richness (Neves and Angermeier 1990-TN5053; Etnier and Starnes 1993-TN5054; Neves et al. 1997-TN5051).

The fish populations in the Tennessee River system (including Clinch River) have changed considerably as a result of human activities (e.g., impoundment of the river and introduction of invasive non-native species). Etnier et al. (1979-TN5050) and Neves and Angermeier (1990-TN5053) indicate that the Tennessee River was poorly studied prior to impoundment, especially relative to small fish. In 1977 and 1978, Etnier et al. (1979-TN5050) examined more than 250 samples comprising more than 49,000 fish specimens from the Tennessee River system. Samples were collected by TVA field crews from 1937 to 1943 in the Tennessee River system, prior to impoundment of the river (see Etnier et al. 1979 [TN5050] for a map of locations in the Tennessee River system). Based on an analysis of the specimens that were collected, and a comparison with more recent observations, Etnier et al. (1979-TN5050) 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.

Other past actions that have changed the aquatic fauna in the area include the introduction of non-native species, overfishing, toxic spills, mining, and agriculture. Section 2.4.2.3 of this EIS describes the introduction and success of non-native and invasive fish, invertebrate, and plant species that have clearly destabilized and changed aquatic communities. Aquatic communities change slowly in response to stress. The communities in the impounded reaches of the Clinch and Tennessee Rivers have been changing for a long time, are changing now, and will probably continue to change for the foreseeable future. The aquatic resources are not stable in the sense of persisting as they were in the past or are today. In their review of the Tennessee River, White et al. (2005-TN5052) observed that:

> Because reservoirs create ecosystem conditions that did not exist previously in the basin, conceptually these are "new" ecosystems. Reservoir ecosystems do not reach the longitudinal and temporal equilibriums of the parent river…, producing conditions ripe for invasions of true nonnative plants and animals that are highly adaptable. Although most species occurred in the system prior to impoundment, the dominant species now are those adapted to a new set of environmental conditions.

Other previously or presently operating facilities that have affected the aquatic resources in the GAI are listed in Table 7-1 and include the dams, the Kingston Fossil Plant, the Bull Run Fossil Plant, and the ORR.

The Bull Run Fossil Plant at CRM 77 is approximately 56 river miles above the CRN Site. Because the plant is located on a different reservoir and at a considerable distance from the CRN Site, it is unlikely that there is a measurable cumulative effect on the same aquatic species or habitats potentially affected by building and operating activities at the CRN Site.

The Kingston Fossil Plant is located on a peninsula at the junction of the Emory River and Clinch River, approximately 10 river miles downstream from the CRN Site (TVA 2007-TN5055). The Kingston facility's intake impinges and entrains aquatic biota using a once-through cooling system. TVA conducted impingement studies at the Kingston Fossil Plant from November 16, 2004 through November 16, 2006 (TVA 2007-TN5055) and reported 30 species impinged during the first year and 33 during 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. Threadfin Shad (*Dorosoma petenense*) accounted for 95 percent of the 2-year total of fish TVA collected during 2004 through 2006. Gizzard Shad (*D. cepedianum)*, Channel Catfish (*Ictalurus punctatus*), and Freshwater Drum (*Aplodinotus gruniens*) composed 1 percent each of the total fish impinged for the 2 years. No Federally or State-protected species were identified. A study of the impingement data from 24 power plants for 1 year indicated that approximately 98 percent of the impinged fish belonged to the family Clupeidae, which includes Threadfin Shad and Gizzard Shad (Loar et al. 1978-TN5056). The highest impingement rates were observed in winter months when the water was the coldest.

TVA (2010-TN5273) estimated the Threadfin Shad population to be greater than 20 million when considering the total area of Watts Bar Reservoir, which is composed of coves and embayments. This estimate is based on approximately 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). The population is likely much greater because Threadfin Shad also inhabit the open water areas of the reservoir. Thus, the estimated fraction of the shad population impinged at the Kingston Fossil Plant in 2004–2006 is approximately 2 percent of the Threadfin Shad likely present in Watts Bar Reservoir.

Chemical contamination can also adversely affect aquatic resources. In December 2008, a coal fly-ash slurry spill occurred at the Kingston Fossil Plant, releasing approximately 532,000 cubic yards coal ash into the main Emory River channel immediately upstream from Clinch River. Ash removal from Emory River was completed in May 2010 (EPA and TVA 2014-TN5057). An ecological risk assessment was conducted, and the decision was made to leave the material in place in an effort to avoid disturbing river bottom sediments, rather than dredging or attempting to remove the residual ash from the river. The ecological risk assessment was conducted to determine the risk from leaving the ash in the river system. The risk assessment indicated that benthic invertebrates (snails, mayfly larvae) were at a moderate risk in Emory River and at low risk in Clinch River from the uptake of arsenic and selenium in the contaminated sediments. Fish and amphibians were considered to have a low to negligible risk. The risk was expected to decline over time (TVA 2015-TN5274).

Surface waters from the major industrial facilities at the ORR drain into streams that in turn drain into Clinch River. Streams on the ORR that have brought legacy industrial waste into the Clinch River include East Fork Poplar Creek and Bear Creek, both of which drain into Poplar Creek, which enters the Clinch River at CRM 12 downstream of the CRN Site (Parr and Hughes 2006-TN5058); and White Oak Creek, which enters the Clinch River near CRM 21 upstream of the CRN Site. Starting in the late 1940s and continuing until the early 1980s, various wastewater discharges from the Y-12 Complex resulted in legacy contamination (e.g., mercury, PCBs, uranium) in the streams and Clinch River. During the past 12 to 15 years water-quality-improvement initiatives have focused on these discharges. Surface water also drains from Chestnut Ridge north of ORNL to the Clinch River via White Oak Creek (Howard et al. 2015-TN5049; Parr and Hughes 2006-TN5058).

A study of three species of fish (crappie, Striped Bass, and White Bass) collected from Clinch River and Poplar Creek showed significant differences among species with respect to concentrations of lead, mercury, and selenium in tissues. The concentrations of lead, cadmium, and selenium were significantly higher in White Bass (*Morone chrysops*) from Clinch River as than in White Bass collected in Poplar Creek (Burger and Campbell 2004-TN5059). Mercury levels were highest in Striped Bass (*M. saxatilis*) and higher than the average for the United States, although overall concentrations of other contaminants in fish were lower than those reported generally in the United States. Mercury levels were lower than the concentration at which mercury is associated with adverse effects in fish (Burger and Campbell 2004-TN5059). PCBs and mercury are a long-term hazard to biota. PCBs are known to impair the reproductive, endocrine, and immune systems functions in fish and increase lesions, tumors, and cause death, while mercury is also known to cause reproductive effects. The Clinch River arm of the Watts Bar Reservoir is identified as having an impaired use for fish consumption because of PCBs (TDEC 2017-TN5060). The Poplar Creek embayment has an impaired use advisory for fish consumption due to PCBs and mercury (TDEC 2017-TN5060).

Positive actions are also considered during the analysis of cumulative actions. TVA's Reservoir Release Improvement program that started in 1991 resulted in increased dissolved oxygen levels and water flow that have improved the habitat for aquatic species in Clinch River below Melton Hill Dam (Howard et al. 2015-TN5049; Higgins and Brock 1999-TN5320).

Impacts on the resources that would be affected by building and operation of the SMR units at the CRN Site have already been extensive as a result of impoundment of the river, fossil-fuel plants, and toxic releases. Chapter 2 of this EIS discussed other activities that affect the species and habitats in the vicinity of the CRN Site including the introduction of non-native species, especially zebra mussels and Asiatic clams. Other activities that affect aquatic habitat and species include urbanization, mining, recreational fishing, and agriculture. The environmental effects of the sum of these activities is clearly noticeable and sufficient to destabilize important attributes (e.g., freshwater mussel populations) of the aquatic biota in Clinch River.

7.3.2.2 69-kV Underground Transmission Line

The various streams crossed by the proposed route for the 69-kV underground transmission line are all tributaries of the Clinch River arm of Watts Bar Reservoir and are therefore part of the GAI. In addition to the effects of building and operating the proposed underground transmission line, the streams crossed by the route could be or have been affected by the past and continuing effects of introduction of non-native species; toxic releases on the ORR; mining, agriculture, or urbanization in the upstream watersheds. Of particular note is the possible presence of legacy industrial contamination from the ORR.

7.3.2.3 Offsite Transmission Lines

Streams, ponds, and waterways crossing or adjacent to the existing offsite transmission line right-of-way segment identified by TVA for upgrading (rebuilding, reconductoring, or uprating) overhead transmission lines as part of the building and operating activities at the CRN Site may also have been or be affected by various past, present, or reasonably foreseeable future activities. Such activities include introduction of non-native species, previous toxic releases, industrial activities, mining, agriculture, and urbanization. These streams and other waterways are not however part of the GAI defined by the review team. As noted in Section 4.3.2.2 of this EIS, the potential impacts of upgrading the transmission lines would not substantially affect the streams and waterways, and hence a detailed evaluation of cumulative impacts would not contribute to a better understanding of possible overall impacts from building and operating subject facilities at the CRN Site.

7.3.2.4 Conclusion

The review team concludes that the cumulative impact of building and operating activities at the proposed CRN Site, added to effects associated with past, present, and reasonably foreseeable future projects, on aquatic resources would be LARGE. This conclusion accounts for the cumulative effects of past river impoundments; continuing operation of intake and discharge structures for the Kingston Fossil Fuel Plant; past toxic releases to the Clinch River system from the ORR; past and continuing introduction of non-native aquatic species; past and continuing loss of indigenous mussels; and the continuing effects of recreational fishing, mining, agriculture, and urbanization. The principal contributors to this cumulative impact are the history of river impoundment, introduction of invasive species, and toxic releases to the rivers and their tributaries. The incremental contribution from all elements of building and operating the CRN facilities would however not be substantial. The NRC staff concludes that the incremental contribution of the NRC-authorized activities related to construction and operation of the CRN facilities would not be a significant contributor to the LARGE cumulative impact. The review team concludes that the incremental contribution of building and operating the CRN facilities, including preconstruction, construction, and operations, would also not be a significant contributor to the LARGE cumulative impact.

7.4 Socioeconomics and Environmental Justice

The evaluation of cumulative impacts on socioeconomics and environmental justice from building and operating new SMR units at the CRN Site is described in the following sections.

7.4.1 Socioeconomics

As described in Section 2.5.1 of this EIS, the review team determined that socioeconomic impacts primarily affect the four counties—Anderson, Knox, Loudon, and Roane—that make up the economic region where cumulative impacts would be expected. This economic region is the geographic area of interest (GAI) for cumulative socioeconomic impacts.

The description of the affected environment in Section 2.5 of this EIS serves as a baseline for the cumulative impacts assessment in these resource areas. As described in EIS Section 4.4, the review team concluded that most of the socioeconomic impacts of NRC-authorized construction activities would be SMALL with exceptions discussed here. The review team found that physical impacts near the CRN Site would be SMALL, with the exception of SMALL-to-MODERATE impacts from noise, roadways, and visual aesthetics. The impacts would be MODERATE in close proximity to the site, including areas directly across the Clinch River from the site and SMALL elsewhere. As described in EIS Section 4.4.4, the infrastructure and community services impacts of plant construction on the affected economic region would be SMALL with the following exceptions. The impacts of traffic congestion during the period of peak employment would be MODERATE to LARGE, depending on the effectiveness of expected mitigation activities and the ability of local commuters to adapt to congested conditions. Recreational impacts would be SMALL to MODERATE based on the aesthetic impacts in close proximity to the CRN Site.

As described in Section 5.4 of this EIS, the review team determined that socioeconomic impacts of plant operations would be SMALL with one exception. The physical impacts would be SMALL for all physical categories except aesthetics, which would be MODERATE. Operation of the proposed SMR units would introduce visual intrusions to the immediate vicinity of the CRN Site, including several buildings and other facilities on a nearly vacant peninsula in the Clinch

River and the steam plumes emitted from the cooling towers. SMALL-to-MODERATE recreation impacts would result from these aesthetic impacts during operations.

The impact analyses in Chapters 4 and 5 of this EIS are cumulative in nature in that the expected impacts on each socioeconomic category includes all past and present external impacts. For purposes of this cumulative analysis, the review team analyzed the combined impacts of the proposed project and the reasonably foreseeable future projects listed in Table 7-1 on the GAI. The combined impacts from construction and preconstruction are described in EIS Section 4.4 and were determined to be the same as those described above for NRC-authorized activities. In addition to socioeconomic impacts from preconstruction, construction, and operations, the cumulative analysis considers other past, present, and reasonably foreseeable future actions that could contribute to cumulative socioeconomic impacts.

Section 2.5.2.1 of this EIS highlights the economic characteristics and history of each of the counties in the GAI. Prior to World War II (WWII), the area economy was based on agriculture and nondurable goods manufacturing. WWII brought an economic transformation to the area with the creation of the ORR under the Federal government's Manhattan Project. The Federal government missions at the ORR continue in the present time and automotive parts manufacturing industries have been growing, while the local nondurable goods industry continues to shrink. The recreation, tourism, and healthcare industries also are showing continued growth currently. Knoxville is the economic hub of the GAI, including major retail trade and transportation services, University of Tennessee facilities, and TVA's corporate headquarters.

Table 7-1 lists the present and future projects that could contribute to the cumulative impacts of building and operating two or more new SMRs at the CRN Site. The project with the greatest contribution to cumulative socioeconomic impacts would be continued operations at the sites on the ORR. Recent site employment at ORR facilities ranges between 11,000–12,000 Federal and contractor employees. The current DOE annual investment is approximately $2 billion (ETEC 2014-TN4963). The resulting aggregate economic impacts of the wages, salaries, benefits; local procurements of goods and services; tax revenues; and the induced economic impacts of these primary impacts are substantial and are noticeable throughout the GAI. The ongoing construction of the UPF is expected to be completing by the time building activities at the CRN Site would be ramping up. The review team expects that many workers may find continued local employment moving from UPF construction to the activities at the CRN Site.

The other projects listed in Table 7-1 involve sustained construction of new and expanded manufacturing industrial plants and similar expansion of facilities at the University of Tennessee. Current ongoing and planned construction projects continue to generate substantial demand for construction workers and workers are being recruited from outside the economic region. The proposed project would be expected to contribute to the sustained demand for construction workers within and outside of the GAI. Continued industrial development is contingent on underlying economic conditions. While these conditions remain favorable, economic development of the Knoxville metropolitan is likely to continue to be strong and contribute to cumulative economic impacts, including tax revenue impacts, in the GAI. A growing economy will result in the need for additional community services such as schools, healthcare facilities, and first responders.

The MKAA is in the planning and approval stage of developing a regional airport near the ETTP on the ORR, in close proximity to the CRN Site. Construction may begin in 2018 (Oak Ridge

Today 2018-TN5409). Construction may begin in 2018 (Oak Ridge Today 2018-TN5409). The planned airport would parallel the Oak Ridge Turnpike (SR 58), immediately east of the existing facilities and west of the highway (MKAA 2017-TN5021), within the Heritage Center Industrial Park. The MKAA proposal would transfer ownership of 170 ac of DOE lands within the ORR to MKAA ownership. DOE preliminarily estimates the construction would take 3 years and cost $32 to $50 million (DOE 2016-TN5022). The construction is expected to start soon and be completed prior to the start of construction at the CRN Site. The size of the project is relatively small compared to other construction projects in the area, including the building activities envisioned for the CRN Site. Thus, the socioeconomic impacts would be minimal. The review team expects that adding an operating regional airport to the ORR would create pathways for future economic development that would be likely to generate local economic impacts in and around the cities of Oak Ridge, Clinton, and Kingston.

The review team based its cumulative impacts assessment on the considerations discussed above, TVA's ER (TVA 2017-TN4921), and the review team's independent evaluation and outreach. The review team finds the cumulative physical impacts of building and operating the proposed project, added to effects associated with reasonably foreseeable future projects, would be SMALL, except for SMALL to MODERATE impacts from noise, roadways, and visual aesthetics. Demographic impacts also would be SMALL. Economic and tax impacts would be SMALL and beneficial. Infrastructure impacts of the proposed project, added to effects associated with reasonably foreseeable future projects, would be MODERATE to LARGE and adverse for impacts associated with workforce traffic during building, and SMALL and adverse during operations. The NRC-authorized building activities would be a significant contributor to the MODERATE-to-LARGE traffic impacts. The review team finds the cumulative effect of the operations portion of the proposed project, added to effects associated with reasonably foreseeable future projects, would be SMALL and adverse for all other socioeconomic categories.

7.4.2 Environmental Justice

The description of the affected environment in Sections 2.5 and 2.6 of this EIS serves as a baseline for the cumulative impacts assessment of environmental justice impacts. The combined physical and socioeconomic impacts from construction and preconstruction and from operations are summarized in EIS Sections 4.5.6 and 5.5.6. As discussed in EIS Sections 4.5 and 5.5, the review team concluded that none of the available pathways could result in a disproportionately high and adverse impact on minority or low-income populations. This conclusion applies to NRC-authorized construction activities and the operation of new SMR units at the CRN Site.

In addition to environmental justice impacts from preconstruction, construction, and operation of new SMR units at the CRN Site, the cumulative analysis considers other past, present, and reasonably foreseeable future actions that could contribute to cumulative environmental justice impacts. For this cumulative analysis, the general GAI is considered to be the economic region described in Section 2.5.1 of this EIS.

As shown in Section 2.6 of this EIS, no concentrations of census block groups with minority and low-income populations that meet the criteria discussed in EIS Section 2.6 are located in close proximity to the CRN Site. The closest minority populations are in Anderson County in Oak Ridge, approximately 10 mi north of the site. The closest low-income populations are also in Oak Ridge, approximately 10 mi north of the site.

As discussed in Section 7.4.1 of this EIS for socioeconomic cumulative impacts, continued operations at the ORR have the greatest potential to affect cumulative environmental justice impacts within the region. DOE's activities at the ORR are located in the vicinity of the CRN Site. The review team found no environmental pathways in EIS Sections 4.5 and 5.5 that could result in disproportionately high and adverse human health, environmental, physical, or socioeconomic impacts on minority or low-income populations from building and operating new SMR units at the CRN Site. Additionally, the review team found no environmental pathways from any reasonably foreseeable future activities in the GAI that could result in disproportionately high and adverse human health, environmental, physical, or socioeconomic impacts on minority or low-income populations affected by the proposed project.

As discussed in Section 4.2.2 of this EIS, the specific transmission system impacts of building and operating SMR units at the proposed CRN Site are not known at the ESP stage. TVA indicated some potential transmission system upgrades that could be needed if the PPE value of 800 MW(e) were to be added to the grid at the CRN Site. Some of the upgrades may require line reconstruction or other activities that may temporarily limit access to public spaces. Of the impacts hypothesized by TVA, none are in areas where minority or low-income populations have been identified, and no pathways that could result in disproportionately high and adverse human health, environmental, physical, or socioeconomic impacts affecting these populations have been identified.

On the basis of the above considerations, information provided by TVA, and the review team's independent evaluation and outreach, the review team concludes that there would be no disproportionately high and adverse cumulative impacts on minority or low-income populations beyond those described in Chapters 4 and 5 of this EIS.

7.5 Historic and Cultural Resources

The description of the affected environment in Section 2.7 of this EIS serves as the baseline for the cumulative-impact assessment in this resource area. As discussed in Section 2.7, there are 16 National Register of Historic Places (NRHP) potentially eligible archaeological sites, one NRHP-eligible archaeological site, deeply buried archaeological deposits, one NRHP-eligible historic district (Melton Hill Dam District), and one cemetery located within the onsite and offsite direct and indirect-effects area of potential effect (APE). As described in EIS Section 4.6, impacts on historic and cultural resources from NRC-authorized construction activities would be SMALL and no further mitigation would be warranted. As described in EIS Section 5.6, the review team concludes that the impacts on historic and cultural resources from operations would be SMALL. As a Federal land-managing agency, TVA is responsible for following the National Historic Preservation Act (NHPA) Section 106 Review process to address potential impacts on historic and cultural resources from ongoing operation and maintenance activities. TVA is also responsible for complying with the NHPA (54 U.S.C. § 300101 *et seq*.-TN4157), Archaeological Resources Protection Act (16 U.S.C. § 470aa *et seq*.-TN1687), Native American Graves Protection and Repatriation Act (25 U.S.C. § 3001 *et seq*.-TN1686), Archeological and Historic Preservation Act (AHPA; 54 U.S.C. § 312501 *et seq*.-TN4844), American Indian Religious Freedom Act (42 U.S.C. § 1996 *et seq*.-TN5281), and Executive Order 13007 (TN5250), "Indian Sacred Sites" and Executive Order 13175 (TN4846), "Consultation and Coordination with Indian Tribal Governments." TVA also maintains procedures and management plans that take into consideration impacts on cultural resources during operations. These include procedures for inadvertent discovery that require stop work and consulting party notifications (TVA 2017-TN4922:E3-3, and E3-6-E3-7.

The combined impacts from construction and preconstruction are described in Section 4.6 of this EIS and were determined to be MODERATE to LARGE by the review team. TVA has a Programmatic Agreement in place committing TVA to avoiding, minimizing, or mitigating construction and preconstruction impacts on historic and cultural resources in accordance with NHPA Section 106. Offsite APEs for other activities (i.e., rebuild, reconductor, and upgrade of offsite 161-kV transmission lines and borrow source areas) have not been delineated because plans have not been finalized for these areas. These offsite activities could also result in direct and indirect impacts on historic and cultural resources through ground-disturbing activities and alterations to the visual setting. Impacts on these resources would be addressed under the auspices of TVA's Programmatic Agreement.

In addition to the impacts from preconstruction, construction, and operation of the proposed new facilities, this cumulative analysis of historic and cultural resources impacts also considers impacts associated with other past, present, and reasonably foreseeable projects located within the GAI. The review team defined the GAI for this assessment of potential cumulative impacts as the onsite and offsite direct- and indirect-effects APEs for historic and cultural resources at the CRN Site (see EIS Section 2.7). The cumulative impacts assessment considers the eligibility of historic properties for listing in the NRHP.

The cultural background for the CRN Site is described in Section 2.7.1 of this EIS. The area contains a rich record of prehistoric human habitation; thus, there are habitation, burial, and other types of sites throughout the region. Historically, several groups of Native Americans, including the Overhill Cherokee and the Cherokee Indians, lived in Tennessee. Between 1794 and 1838, these groups were forcibly removed from their ancestral homelands located at and in the vicinity of the CRN Site by the U.S. Government, and were required to relocate to Oklahoma at the time of the Trail of Tears. TVA established its first dam project at Norris Dam, upstream from the CRN Site, in 1936. With the establishment of the ORR as part of the Manhattan Project in 1943, several small farming communities located within the CRN Site were relocated. It wasn't until the 1970s that TVA initiated plans to construct the CRBRP at the CRN Site and ground-clearing activities commenced. The project was canceled in the early 1980s due to insufficient funding. Between 1960 and 1964, TVA constructed the Melton Hill Dam, which is located upstream from the CRN Site but is part of the offsite APE and within the GAI. Regional historic land use has resulted in minor alterations to historic and cultural resources located within the GAI.

Projects within the GAI that may have a potential cumulative impact on historic and cultural resources include ongoing infrastructure improvements and future urbanization. These could include projects listed in Table 7-1, such as the ORR, ETTP, and ongoing operation of the Melton Hill Hydroelectric Facility. Development of such projects could affect historic and cultural resources if ground-disturbing activities occur, depending upon the extent of damage caused to archaeological resources and the extent of mitigation required. If new aboveground structures are constructed as part of present and reasonably foreseeable projects located in the GAI, there could be significant cumulative impacts on the NRHP-eligible Melton Hill Dam District. However, in most instances, visual impacts can be minimized through creative design and the presence of vegetation screening.

Historic and cultural resources are nonrenewable, hence certain activities can result in an irretrievable loss of the resource. Therefore, the impact of destruction on historic and cultural resources is cumulative. Overall, when combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts on historic and cultural resources of building and operating two or more SMR units on the CRN Site would be sufficient to alter noticeably, and potentially destabilize important attributes of existing historic and cultural resources within the GAI. Therefore, based on the information provided by TVA and the review team's independent review, the review team concludes that the cumulative impact on historic and cultural resources would be MODERATE to LARGE. The potential impact of onsite preconstruction activities on 16 potentially NRHP-eligible archaeological sites, one NRHP-eligible archaeological site, and deeply buried archaeological deposits located at the CRN Site is the principal contributor to the MODERATE to LARGE rating of cumulative impacts. The NRC staff further concludes that the incremental impacts associated with the onsite NRC-authorized activities would not significantly contribute to the overall cumulative impact.

7.6 Air Quality

The description of the affected environment in Section 2.9 of this EIS serves as the baseline for the cumulative-impact assessment for air quality. As described in EIS Section 4.7, the review team concludes that the impacts on air quality from construction and preconstruction would be SMALL, and that no further mitigation would be warranted. As described in EIS Section 5.7, the review team concludes that the impacts on air quality from operations would be SMALL, and that no further mitigation would be warranted.

7.6.1 Criteria Pollutants

In addition to the impacts from construction, preconstruction, and operations, this cumulative analysis also considered other past, present, and reasonably foreseeable future actions that could contribute to cumulative impacts on air quality. For this cumulative analysis of criteria pollutants, the GAI is Roane County, Tennessee. This GAI was chosen because EPA air-quality designations are made on a county-by-county basis.

As discussed in Section 2.9.2 of this EIS, air quality in Roane County is in attainment with or better than the National Ambient Air Quality Standards for all criteria pollutants. EIS Section 4.7 discusses air-quality impacts associated with construction and preconstruction activities at the CRN Site. Emissions from these activities primarily would be fugitive dust from ground-disturbing activities and engine exhaust from heavy equipment and workforce vehicles. Emissions are expected to be temporary and limited in magnitude and are anticipated to be SMALL. EIS Section 5.7 discusses air-quality impacts during operations. Emissions during operation would primarily be from operation of the cooling towers, auxiliary boilers, diesel generators and/or gas turbines, and commuter traffic. Stationary sources (e.g., diesel generators and/or gas turbines [operating infrequently] and auxiliary boilers [operating mostly during winter months]) would be operated according to State and Federal regulatory requirements. Impacts on air quality during operations are expected to be SMALL.

Six major sources of air emissions in Roane County have existing Clean Air Act Title V operating permits (TDEC 2017-TN5017). One new Title V operating permit is under draft in Roane County at the American Zinc Recycling Corp located in Rockwood, Tennessee, approximately 17.5 mi west of the CRN Site. These existing sources include the energy and industrial projects listed in Table 7-1. The permitted air emission source closest to the CRN Site is in Kingston, Tennessee, approximately 8 mi west southwest of the CRN Site. The addition of emission sources associated with a new nuclear power plant at the CRN Site may require a new Title V operating permit based on final reactor design selection (TVA 2017-TN4921). Title V operating permits are legally enforceable documents issued for all major sources by State and local permitting authorities (as delegated by the EPA) after the source has begun to operate. The permits include all air pollution requirements that apply to the source, including emissions limits on the types and amounts of emissions allowed, operating requirements for pollution control devices or pollution prevention activities, and monitoring and record-keeping requirements. These permits also require the source to report its compliance status with respect to permit conditions to the permitting authority. These permits aid the State in meeting National Ambient Air Quality Standards, thereby limiting potential air-quality impacts.

Future development near the CRN Site also could lead to increases in gaseous and particulate emissions related to transportation. Table 7-1 lists limited potential for growth within the area surrounding the CRN Site. Most projects listed in Table 7-1 would not increase air emissions enough to exceed current air-quality standards. Given the limited potential for growth in the area, and the minor contribution of emissions from building and operation of a new nuclear power plant at the CRN Site, the cumulative impact on air quality with exception of greenhouse gas (GHG) emissions would be minimal.

7.6.2 Greenhouse Gas Emissions

As stated in the state of the science report issued by the U.S. Global Change Research Program (GCRP), "The majority of the warming at the global scale over the past 50 years can only be explained by the effects of human influences, especially the emissions from burning fossil fuels (coal, oil, and natural gas) and from deforestation. Oil used for transportation and coal used for electricity generation are the largest contributors to the rise in carbon dioxide that is the primary driver of observed changes in climate over recent decades" (GCRP 2014-TN3472).

GHG emissions associated with building, operating, and decommissioning a nuclear power plant are addressed in Sections 4.7, 5.7, 6.1.3, and 6.3 of this EIS. The review team concluded that the atmospheric impacts of the GHG emissions associated with each aspect of building, operating, and decommissioning a single nuclear power plant, such as the CRN Site SMR, would be SMALL. The review team also concluded that the impacts of the combined emissions for the full plant life cycle would be minimal.

It is difficult to evaluate cumulative impacts of a single source or combination of GHG emission sources for the following reasons:

- The impact is global rather than local or regional.
- The impact is not particularly sensitive to the location of the release point.
- The magnitude of individual GHG sources related to human activity, no matter how large compared to other sources, is small when compared to the total mass of GHGs that exist in the atmosphere.
- The total number and variety of GHG emission sources are extremely large and ubiquitous.

The above points are illustrated by the comparison of annual emission rates of carbon dioxide equivalent (CO_2e), as shown in Table 7-2.

In the United States, the national annual GHG emission rate was 6.3 billion metric tons (MT) CO_2e in 2015, and of that amount, 5.0 billion MT CO_2e was from fossil-fuel combustion (EPA 2017-TN4924). The total GHG emissions in Tennessee were estimated to be 100 million MT of gross CO_2e in 2015 and, of that total, the energy-related emissions from electricity generation, residential/commercial/industrial fuel combustion, transportation, and fossil-fuel industry were estimated to be about 70 million MT CO_2e (EPA 2015-TN4925). Appendix A to Attachment 1 of the *Interim Staff Guidance on Environmental Issues Associated with New*

Reactors (NRC 2014-TN3767) provides details of the review team's estimate for a reference 1,000-MW(e) nuclear power plant. The review team estimated the total nuclear power plant life-cycle footprint to be 10,500,000 MT CO_2e, with a 7-year construction and preconstruction

Table 7-2. Comparison of Annual Carbon Dioxide Equivalent (CO_2e) Emissions

Source	Metric Tons per Year[(a)]
Global emissions from fossil-fuel combustion (2014)	3.4×10^{10}[(b)]
United States emissions from fossil-fuel combustion (2015)	5.0×10^{9}[(b)]
Tennessee energy-related emissions (2015)	7.0×10^{7}[(c)]
1,000-MW(e) nuclear power plant (including fuel cycle) emissions	260,000[(d)]
1,000-MW(e) nuclear power plant (operations only) emissions	4,500[(d)]
Average U.S. passenger vehicle emissions	5[(e)]

1 MT = 1.1 U.S. ton (at 2,000 lb per U.S. ton).
(a) Expressed in MT per year of CO_2e, except MT per year of CO_2 for global emissions and US emissions from fossil-fuel combustion.
(b) Source: EPA 2017-TN4924.
(c) Source: EPA 2015-TN4925; includes emissions from power plants, petroleum and natural gas systems, and refineries. Published estimates capture about half of emissions. Thus, the value listed in this table is twice the estimate from large emitting facilities.
(d) Source: Appendix K of this EIS.
(e) Source: EPA 2017-TN5270.

phase, 40 years of operation, and 10 years of decommissioning. This value would not significantly differ for a new nuclear power plant at the CRN Site based on the fact that the staff used an 80 percent capacity factor for the 1,000-MW(e) reference nuclear power plant and the applicant used an 90 to 98 percent capacity factor for the 800-MW(e) CRN SMR; therefore, the estimated emissions are comparable. The uranium fuel-cycle phase is projected to generate the highest emissions (see Appendix K in this EIS). Table 7-2 (in Section 7.12) lists GHG emissions from normal operations, including the uranium fuel cycle, as 260,000 MT CO_2e per year. The applicant also provided an analysis that produced an estimated GHG emission (including fuel cycle) of 210,000 MT CO_2e. From this perspective, the independent analysis conducted by the review team provides a bounding estimate of emissions for plant operations, including the uranium fuel cycle. These emissions are significantly less than the GHG emissions projected for Tennessee or from fossil-fuel combustion in the United States for the year 2015.

Even though GHG emission estimates from normal operations are minimal compared to other sources, the applicant should consider measures that would reduce GHG emissions. These could include, but would not necessarily be limited to, energy-efficient design features and features to reduce space heating and air-conditioning energy requirements, use of renewable energy sources, use of low-GHG-emitting vehicles, and other policies to reduce GHG emissions from vehicle use, such as anti-idling policies and vanpooling or carpooling.

An evaluation of the cumulative impacts of GHG emissions requires the use of a global climate model. The U.S. GCRP report (GCRP 2014-TN3472) provides a synthesis of the results of numerous climate modeling studies; hence, the cumulative impacts of GHG emissions around the world as presented in the U.S. GCRP report provide an appropriate basis for the evaluation of cumulative impacts. Based primarily on the scientific assessments of U.S. GCRP and the National Research Council, the EPA Administrator issued a determination in 2009 (74 FR 66496-TN245) that GHGs in the atmosphere may reasonably be anticipated to endanger public health and welfare, based on the observed and projected effects of GHGs, their impact on climate change, and the public health and welfare risks and impacts associated with such climate change. Therefore, the review team concludes that national and worldwide cumulative impacts of GHG emissions are noticeable but not destabilizing, with or without the contribution of GHG emissions from a new nuclear power plant at the CRN Site. The review team recognizes that GHG emissions, including CO_2, from individual stationary sources and cumulatively from multiple sources, can contribute to climate change.

7.6.3 Summary

Cumulative impacts on air-quality resources are estimated based on the information provided by TVA and the review team's independent evaluation. Other past, present, and reasonably foreseeable future activities exist in the GAIs (local and regional for criteria pollutants and global for GHG emissions) that could affect air-quality resources. The cumulative impacts on criteria pollutants from emissions of effluents from two or more new SMRs at the CRN Site and other projects would not be noticeable. The new CRN Site plant and the other projects listed in Table 7-1 would have minimal impacts. The national and worldwide cumulative impacts of GHG emissions are noticeable but not destabilizing. The review team concludes that the cumulative impacts would be noticeable but not destabilizing, with or without the GHG emissions from a new nuclear power plant at the CRN Site.

The review team concludes that cumulative impacts from the proposed action and other past, present, and reasonably foreseeable future actions on air-quality resources in the geographic areas of interest would be SMALL for criteria pollutants and MODERATE for GHGs. The incremental contribution of NRC-authorized activities on air-quality resources for both criteria pollutants and GHGs would not be a significant contributor to the cumulative impact.

7.7 Nonradiological Health

The description of the affected nonradiological environment, including public and occupational health, air quality, noise, etiological agents, and transporting workers to and from the proposed site in Section 2.10 of this EIS serves as a baseline for the nonradiological health cumulative-impact assessment. As described in EIS Section 4.8, the impacts from building activities on nonradiological health would be SMALL to MODERATE because of impacts on members of the public from noise. As described in EIS Section 5.8, the review team concludes that the impacts of operations on nonradiological health would be SMALL.

In addition to the impacts from building activities and operations, the cumulative analysis also considers other past, present, and reasonably foreseeable future actions that could contribute to cumulative impacts on nonradiological health. Most of the nonradiological impacts of building and operation would be localized and would not have significant impact at offsite locations beyond the 6-mi vicinity. However, activities such as vehicle emissions from transport of personnel to and from the site would encompass a larger area. Therefore, for nonradiological health impacts associated with the influence of vehicle and other air emissions sources, the GAI for cumulative impacts analysis includes projects within a 50-mi radius of the proposed CRN Site, which would be inclusive of the commuting distance for workers during both construction and operation phases. For cumulative impacts associated with transmission lines, the GAI is the transmission line corridor. These geographical areas are expected to encompass areas where cumulative impacts on public and worker health could occur in combination with any past, present, or reasonably foreseeable future actions.

Past and current projects in the GAI that would contribute to the cumulative impacts for nonradiological health in a way similar to the building and operating activities at the CRN Site are listed in Table 7-1. These projects include past and current energy projects (i.e., nuclear, coal, hydropower etc.) that discharge their cooling water into the Clinch River arm of the Watt's Bar Reservoir, current projects that give off emissions and require workers to commute to the sites, and current projects that produce noise and would incur injuries/illnesses to workers during building and operating.

Future projects could also contribute to the cumulative nonradiological health impacts of occupational injuries. Existing and potential development of new transmission lines could increase nonradiological health impacts from exposure to acute electromagnetic fields (EMFs). However, as stated in Section 5.8.3 of this EIS, adherence to Federal criteria and State utility codes would create minimal cumulative nonradiological health impacts. With regard to the chronic effects of EMFs, the scientific evidence on human health does not conclusively link extremely low frequency EMFs to adverse health impacts. Cumulative impacts from noise and vehicle emissions are expected to occur associated with future construction and operation of proposed and planned projects and current urbanization within the region. However, as discussed in Sections 4.8 and 5.8 of this EIS, the CRN Site contribution to these impacts would be temporary and minimal, and existing facilities would likely comply with local, State, and Federal regulations governing noise and emissions.

The low incidence of waterborne diseases in the GAI indicates that the public use of the receiving waters for recreation is carried out in a manner that minimizes their potential exposure to these organisms. As stated in Section 2.10.1.3 of this EIS, there is limited angling and no public swimming beaches along the Clinch River downstream of the discharge structure where mixing would occur. Signage could also be placed in this area to keep the public at a safe distance away from the discharge structure (TVA 2017-TN4921).

The review team concludes that based on impacts on members of the public, all cumulative nonradiological health impacts would be SMALL with the exception of building-related noise, which would be SMALL to MODERATE for the project. The NRC-authorized portion of construction noise would also be SMALL to MODERATE. The NRC staff concludes that the incremental contribution of the NRC-authorized activities related to construction and operation of two new SMRs at the CRN Site would be a significant contributor to the SMALL-to-MODERATE cumulative impact. The review team acknowledges, however, that there is still uncertainty associated with chronic effects of EMFs.

7.8 Radiological Impacts of Normal Operation

The description of the affected environment in Section 2.11 of this EIS serves as the baseline for the cumulative impacts assessment in this resource area. As described in EIS Section 4.9, the NRC staff concludes that the radiological impacts on construction workers engaged in building activities would be SMALL, radiological impacts from NRC-authorized construction would be SMALL, and no further mitigation would be warranted. As described in EIS Section 5.9, the NRC staff concludes that the radiological impacts from normal operations would be SMALL, and no further mitigation would be warranted.

The radiological impacts from construction and preconstruction were described in Section 4.9 of this EIS and determined to be SMALL. In addition to impacts from construction and operations, this cumulative analysis also considers other past, present, and reasonably foreseeable future actions that could contribute to cumulative radiological impacts. For the purposes of this analysis, the GAI is the area within a 50-mi radius of the CRN Site. Historically, the NRC has used the 50-mi radius as a standard bounding geographic area to evaluate population doses from routine releases from nuclear power plants. This region contains several radiological projects or facilities. Within the GAI, reasonably foreseeable planned Federal projects on the ORR include the Sludge Buildout Project at the Transuranic Waste Processing Center, the UPF at the Y-12 Complex, the ETTP (former K-25 Gaseous Diffusion Plant) undergoing cleanup for ultimate conversion to a private-sector industrial park, and a new disposal area to replace the Environmental Management Waste Management Facility, which have the potential to contribute to cumulative radiation exposures in addition to the contributions from operations at the proposed CRN Site described in Section 5.9 of this EIS. Other major currently operating ORR nuclear facilities include the High Flux Isotope Reactor, a nuclear research reactor located at ORNL, and the ORNL Spallation Neutron Source. Other radiological projects or facilities outside of ORR include TVA's Watts Bar Nuclear Power Plant Units 1 and 2 (30 mi SW) and American Nuclear Corporation (closed in 1970). American Nuclear Corporation was operational from 1962–1970 and, although cleaned up, may still be contributing to groundwater contamination in the region. The facilities identified in Table 7-1 have the potential to contribute to cumulative radiation exposures in conjunction with the proposed SMRs at the CRN Site.

Ongoing activities on the ORR will likely continue to release small quantities of radionuclides to the environment. The ORR *Annual Site Environmental Report* (DOE 2017-TN5081) provides estimated annual doses to a hypothetical maximally exposed individual (MEI) to radionuclides released from all DOE facilities on the ORR considering all potential pathways. The most recent report estimates the maximum annual radiation dose to the MEI in 2016 to be 0.2 millirem (mrem) from air pathways, 1.15 mrem from water pathways (i.e., drinking, consuming fish, swimming and other recreational uses), and 1.25 mrem from wildlife consumption (e.g., deer, geese, and turkey) harvested on ORR (DOE 2017-TN5081). The combined 2016 dose was estimated to be approximately 2.6 mrem (DOE 2017-TN5081). During the 15-year period from 2002 to 2016 the estimated annual all-pathways dose to the MEI has trended downward from a peak of about 12 mrem in 2002 to a low of about 2.4 mrem in 2015 (DOE 2017-TN5081).

In addition, there are several non-DOE radiological facilities on or near the ORR that could potentially contribute to cumulative impacts on members of the public. Based on its review of responses from 10 nearby non-DOE facilities regarding potential radiation doses to members of the public, DOE concluded the combined annual doses from both DOE and non-DOE sources would be less than 100 mrem (DOE 2016-TN5031). Three non-DOE facilities reported air-pathway annual doses of 0.27 mrem, 0.2 mrem, and <10 mrem. One facility reported a release to sewers not exceeding the sum of ratios in 10 CFR Part 20 (TN283). According to Appendix B, Table 3 of 10 CFR Part 20, not exceeding the sum of ratios for releases to sewers would result in an annual committed effective dose equivalent no greater than 500 mrem if the sewage release were the only source of water ingested. It is unlikely that an individual would directly ingest sewage release as a sole source of drinking water prior to its treatment either as effluent that limits annual exposure to 50 mrem (Appendix B, Table 2, 10 CFR Part 20 [TN283]) or as drinking water that limits annual exposure to 4 mrem (66 FR 76708-TN5061). Annual doses from direct radiation from the non-DOE facilities ranged from 0 to 25 mrem in 2016 (DOE 2017-TN5081).

As described in Section 4.9 of this EIS, the estimated doses to construction workers during site preparation and construction activities for the BWXT mPower™, Holtec, and Westinghouse SMR designs do not exceed the regulatory limit of 100 mrem/yr designed to protect the health of individual members of the public (10 CFR 20.1301 [TN283]). The estimated doses to construction workers during site preparation and construction activities for the NuScale SMR design do not exceed the regulatory limit of 5,000 mrem/yr designed to protect the health of occupational workers (10 CFR 20.1201 [TN283]). This estimate includes exposure to construction workers from operational units during construction (TVA 2017-TN4921). The dose to the MEI from existing units and the proposed SMRs at the CRN Site would be within the EPA's regulatory standard of 40 CFR Part 190 (TN739). Based on the NRC staff's evaluation of the estimates of doses from the proposed SMRs at the CRN Site to biota other than humans given in EIS Section 5.9, the NRC staff concludes that the cumulative radiological impact on biota other than humans would not be significant.

Therefore, the NRC staff concludes that the cumulative radiological impacts of constructing and operating the SMRs at the CRN Site, along with the existing sources of radiation nearby, would be SMALL, and no further mitigation would be warranted.

7.9 Nonradiological Waste Systems

Cumulative impacts on water and air from nonradiological waste are discussed in Sections 7.2 and 7.6 of this EIS, respectively. As discussed in Sections 4.10 and 5.10 of the EIS, the review team determined that all nonradiological waste impacts from building and operations activities would be SMALL. The cumulative impacts of nonradioactive waste destined for land-based treatment and disposal are primarily related to the available capacity of area treatment and disposal facilities and the amount of waste generated by the proposed project and other reasonably foreseeable projects.

During construction, offsite land-based waste treatment and disposal would be minimized by production and delivery of modular plant units, by segregation of recyclable materials, and by management of vegetative waste onsite. Building activities would generate construction debris that would be disposed of at the onsite landfill and any excess wastes would be shipped to a licensed offsite disposal facility. The construction workforce is expected to produce small quantities of municipal solid waste. Most of the projects listed in EIS Table 7-1 would generally either not coincide with the construction of the proposed building and operating activities at the CRN Site or would produce waste streams of a different nature.

TVA estimates that the CRN Site would generate an average of approximately 3,480 T of nonradioactive, nonhazardous, residual solid waste annually, equivalent to less than 3 percent of the annual projection of 118,072 T of municipal solid waste to be managed in Roane County in 2017 (TVA 2017-TN4922; TDEC 2017-TN5399). As of 2017, Tennessee had 34 municipal solid waste landfills and 5 waste-to-energy plants, and additional landfill capacity is being added (TDEC 2017-TN5399).

TVA anticipates that the CRN Site would be classified as a small-quantity generator under the Resource Conservation and Recovery Act of 1976, as amended (42 U.S.C. § 6901 *et seq*.-TN1281). Small-quantity generators combined generate only 23 percent of the hazardous waste produced in Tennessee (TDEC 2017-TN5399). No known capacity constraints exist for the treatment or disposal of hazardous wastes either within Tennessee or for the nation (TDEC 2017-TN5399).

Of the projects listed in EIS Table 7-1, the operation of Watts Bar Nuclear Power Plant, the facilities on the ORR that work with radioactive materials, and the hospitals and industrial facilities that use radioactive material have the potential to generate mixed waste. None of the considered projects is expected to generate mixed waste in significant quantities above current rates, and therefore cumulative impacts would be minimal.

Based on the quantity of nonradioactive and mixed waste projected to be generated during CRN Site operation and the available treatment and disposal capacity, the review team concludes that the cumulative impacts of nonradioactive and mixed waste would be SMALL.

7.10 Postulated Accidents

As described in Section 5.11.4 of this EIS, the NRC staff concludes that the potential environmental impacts (risks) of a postulated accident from the operation of a surrogate SMR at the CRN Site would be SMALL. EIS Section 5.11 considers both design basis accidents (DBAs) and severe accidents. As described in Section 5.11.1, the staff concludes that the environmental consequences of DBAs at the CRN Site would be SMALL for a surrogate SMR. 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.

As described in Section 5.11.2 of this EIS, the NRC staff concludes that the severe-accident probability-weighted consequences (i.e., risks) of a surrogate SMR at the CRN Site would be small compared to risks associated with operation of the current-generation reactors, and no further mitigation would be warranted. 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 50 mi of the CRN Site. The 50-mi radius was selected to cover any potential overlaps from two or more nuclear plants. Existing reactors that contribute to risk within the GAI include the Sequoyah Nuclear Plant Units 1 and 2 and the Watts Bar Nuclear Power Plant Units 1 and 2.

As presented in Table 7-1, there are several DOE nuclear facilities within 50 mi of the CRN Site. In accordance with DOE regulations in 10 CFR Part 830 (TN5271), Nuclear Safety Management and DOE-STD-3009, *Preparation of Nonreactor Nuclear Facility Documented Safety Analysis* (DOE 2014-TN5272), the DOE nuclear facilities within 50 mi of the CRN Site must perform hazards analyses to demonstrate adequate protection of the public as provided in Documented Safety Analysis reports. Based on each DOE nuclear facility's Documented Safety Analysis, safety features are appropriately implemented to minimize the risk from accidental releases of radioactive materials. Therefore, based on these nuclear facilities meeting DOE's nuclear safety regulations, their contribution to the CRN Site cumulative risk is considered small.

Tables 5-17 and 5-18 in Section 5.11.2 of this EIS provide comparisons of estimated risk for the surrogate SMR and current-generation reactors. The estimated population dose risk for the surrogate SMR is well below the mean and median values for current-generation reactors. In addition, estimates of average individual early fatality and latent cancer fatality risks are well below the Commission's safety goals (51 FR 30028 -TN594). For existing nuclear generating stations within the GAI (Sequoyah Nuclear Plant Units 1 and 2 and Watts Bar Nuclear Power Plant Units 1 and 2), the Commission has determined that the probability-weighted consequences of severe accidents are small (10 CFR Part 51 -TN250, Appendix B, Table B-1). On this basis, the NRC staff concludes that the cumulative risks of severe accidents at any location within 50 mi of the CRN Site likely would be SMALL and no further mitigation would be warranted.

7.11 Fuel Cycle, Transportation, and Decommissioning

The cumulative impacts related to the fuel cycle, radiological and nonradiological aspects of transportation, and facility decommissioning for two or more new SMRs at the CRN Site are described below.

7.11.1 Fuel Cycle

As described in Section 6.1 of this EIS, the NRC staff concludes that the environmental impacts of the fuel cycle due to operation of SMRs at the CRN Site would be SMALL. Fuel-cycle impacts would occur not only at the CRN Site, but also at other locations in the United States or, in the case of foreign-purchased uranium, in other countries, as described in Section 6.1 of this EIS.

Existing commercial nuclear facilities in close proximity (i.e., within a 50-mi radius) to the proposed CRN Site include Watts Bar Nuclear Power Plant Units 1 and 2. Other nuclear facilities located within 50 mi of the CRN Site include those associated with ORNL and the Y-12 Complex. These facilities would not add to the cumulative impacts from the uranium fuel cycle. The net environmental impacts of fuel-cycle activities for two or more SMRs at the CRN Site combined with the existing Watts Bar Nuclear Power Plant units would be approximately 3 times those presented in Table S–3 of 10 CFR 51.51 (TN250). Only a small portion of this impact would be realized near the CRN Site. The NRC staff concludes that the cumulative fuel-cycle impacts of operating the proposed new nuclear power plant at the CRN Site would be minor, and additional mitigation would not be warranted.

The *Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel* (NUREG-2157, NRC 2014-TN4117) examines the incremental impacts of continued storage on each resource area analyzed in NUREG-2157 in combination with other past, present, and reasonably foreseeable future actions. Section 6.5 of NUREG-2157 indicates that potential cumulative impacts range from SMALL to LARGE for multiple resource areas. These ranges of impact are primarily driven by activities other than the continued storage of spent fuel at the reactor site; the impacts from these other activities would occur regardless of whether spent fuel is stored during the continued storage period. In the short-term time frame, which is the most likely time frame for the disposal of the fuel, the potential impacts of continued storage for at-reactor storage are SMALL and would, therefore, not be a significant contributor to the cumulative impacts. Because the impacts during the short-term time frame are SMALL, continued storage would not be a significant contributor to the cumulative impacts. In the longer time frames for at-reactor storage, or in the less likely case of away-from-reactor storage, some of the impacts from the storage of spent fuel could be greater than SMALL. However, other Federal and non-Federal activities occurring during the longer time frames, as noted in NUREG-2157, contribute additional uncertainty to the cumulative impacts. All of these uncertainties lead to the ranges in cumulative impacts, as discussed throughout Chapter 6 of NUREG-2157. The overall ranges of cumulative-impact conclusions would not be changed if the impacts of continued storage were removed. Based on the analysis and impact determination in NUREG-2157, and taking into account the impacts that the NRC can predict with confidence, which are SMALL; the uncertainty reflected by the ranges in some impacts; and the relative likelihood of the time frames, the staff finds that the impacts in NUREG-2157 support an overall finding that the cumulative impacts from radiological wastes from the fuel cycle (which includes the impacts associated with spent fuel storage during operation and any continued storage period) would be minor (NRC 2014-TN4117).

7.11.2 Transportation of Radioactive Material

As described in Section 6.2 of this EIS, the NRC staff concludes that the impacts of transporting unirradiated fuel to the CRN Site and irradiated fuel and radioactive waste from the site would be SMALL. In addition to impacts from preconstruction, construction, and operations, the cumulative analysis considers other past, present, and reasonably foreseeable future actions that could contribute to cumulative transportation impacts. For this analysis, the GAI is the 50-mi region surrounding the CRN Site.

Historically, the radiological impacts on the public and environment associated with transportation of radioactive materials in the 50-mi region surrounding the CRN Site have been associated with shipments of fuel and waste to and from the existing Watts Bar Nuclear Generating Station. The Watts Bar Nuclear Generating Station is located 31 mi southwest of the CRN Site and consists of two operating pressurized water reactors rated at 3,459 MW(t) each. Radiological impacts of transporting radioactive materials would occur along the routes leading to and from the CRN Site, Watts Bar Nuclear Generating Station, and fuel-fabrication facilities and waste-disposal sites located in other parts of the United States.

Based on Table S-4 in 10 CFR 51.52 (TN250), the impacts of transporting unirradiated fuel to the Watts Bar Nuclear Generating Station and irradiated fuel and radioactive waste from the Watts Bar Nuclear Generating Station would be minimal. When combined with the impacts of transporting unirradiated fuel to the CRN Site and irradiated fuel and radioactive waste from the site, the cumulative impacts of transporting unirradiated fuel to the CRN Site and to the Watts Bar Nuclear Generating Station, as well as irradiated fuel and radioactive waste from the CRN Site and from the Watts Bar Nuclear Generating Station, also would be minimal.

Other identified activities that have the potential for cumulative radiological transportation impacts in the 50-mi region surrounding the CRN Site include shipments of radioactive waste to and from Federal facilities located adjacent to the CRN Site. These Federal facilities are summarized in Table 7-1 and include the ORR, ORNL, Y-12 Complex, ETTP, Environmental Management Waste Management Facility, and UPF. Using data from the U.S. Department of Energy Waste Management Information System (WIMS 2017-TN5070) for the period 2017–2050, an average of about 50,000 m^3/yr of radioactive waste are estimated to be shipped to and from these facilities. Shipments of radioactive waste from the CRN Site are estimated to be 142 m^3/yr, less than 0.3 percent of the volume shipped from the Federal facilities. The past, present, and reasonably foreseeable future impacts in the region surrounding the CRN Site are also a small fraction of the impacts from natural background radiation.

Advances in reactor technology and operations since the development of Table S-4 would reduce environmental impacts relative to the values in Table S-4 (10 CFR Part 51 -TN250); therefore, the values in Table S-4 remain bounding. For example, improvements in fuel management have been adopted by nuclear power plants to achieve higher performance and reduce fuel requirements. This leads to fewer unirradiated fuel and spent fuel shipments than the 1,000-MW(e) reference reactor discussed in 10 CFR 51.52 (TN250). In addition, advances in shipping cask designs to increase capabilities would result in fewer shipments of spent fuel to offsite storage or disposal facilities. This would reduce the cumulative impacts of transporting unirradiated fuel to the CRN Site and to the Watts Bar Nuclear Generating Station and irradiated fuel and radioactive waste from the CRN Site and from the Watts Bar Nuclear Generating Station.

Therefore, the NRC staff considers the cumulative impacts of transporting unirradiated fuel to and irradiated fuel and radioactive waste from a new nuclear power plant at the CRN Site to be minor.

7.11.3 Decommissioning

As discussed in Section 6.3 of this EIS, environmental impacts from the eventual decommissioning of the proposed two or more new SMRs at the CRN Site are expected to be SMALL because the licensee would have to comply with decommissioning regulatory requirements.

In this cumulative analysis, the GAI is the area within a 50-mi radius of the CRN Site. Watts Bar Units 1 and 2 are located within 50 mi of the CRN Site. Other nuclear facilities located within 50 mi of the CRN Site include those associated with ORNL and the Y-12 Complex. The low levels of radioactive materials that may be released from these facilities would not contribute significantly and likely not even be noticeable, and therefore would not add to the cumulative impacts of decommissioning activities at the CRN Site. In Supplement 1 to NUREG-0586, *Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities*, the NRC found the impacts on radiation dose to workers and the public, waste management, water quality, air quality, ecological resources, and socioeconomics to be SMALL (NRC 2002-TN665). In addition, in Section 6.3 of this EIS, the NRC staff concluded that the impact of GHG emissions on air quality during decommissioning would be minimal. Therefore, the cumulative impacts from decommissioning the new nuclear power plant proposed for the CRN Site would be SMALL.

7.11.4 Summary of Cumulative Fuel Cycle, Transportation, and Decommissioning Impacts

Based on the analysis above, the cumulative impacts from fuel-cycle activities, transportation of radioactive material, and decommissioning would be SMALL.

7.12 Conclusions

The review team considered the potential cumulative impacts resulting from construction, preconstruction, operation and decommissioning of two or more new SMRs at the CRN Site together with other past, present, and reasonably foreseeable future actions. The specific resources that could be affected by the proposed action and other past, present, and reasonably foreseeable actions in the geographic areas of interest were assessed. This assessment included the impacts of construction and operations for two or more new SMRs as described in Chapters 4 and 5 of this EIS, respectively; impacts of preconstruction activities as described in Chapter 4; impacts of fuel-cycle, transportation, and decommissioning impacts as described in Chapter 6; and impacts of other past, present, and reasonably foreseeable future Federal and non-Federal actions (listed in Table 7-1) that could affect the same resources as the proposed action.

Table 7-3 summarizes the cumulative impacts by resource area. The cumulative impacts for most of the resource areas would be SMALL, although there are MODERATE or LARGE cumulative impacts for some resources, as described below.

Table 7-3. Cumulative Impacts on Environmental Resources, Including the Impacts of Two or More SMRs at the CRN Site

Resource Category	Comments	Impact Level
Land-Use	The long-term dedication of a 935-ac tract of Federally owned land in an industrial setting that would have otherwise been available for other industrial uses. The NRC-authorized activity would be a significant contributor to the impact.	MODERATE
Water-Related		
Surface-Water Use	Extensive past and present modification and use of surface waters in the Clinch River basin. The incremental contribution of the NRC-authorized activities related to construction and operation at the CRN Site would not be a significant contributor.	MODERATE
Groundwater Use	Groundwater would not be used for building and operating a nuclear power plant at the CRN Site. In addition, excavation dewatering during building would be temporary and would have limited spatial effect. No other past, present, or reasonably foreseeable actions with significant groundwater-use impacts were identified.	SMALL
Surface-Water Quality	Extensive past and present use of and discharges of wastes to the Clinch River. The incremental contribution of the NRC-authorized activities related to construction and operation at the CRN Site would not be a significant contributor.	MODERATE
Groundwater Quality	Activities on the ORR have noticeably altered the groundwater quality. The CRN Site groundwater is hydrogeologically isolated from most of the ORR groundwater contamination, and the CRN Site is a significant distance from the groundwater contamination in Bethel Valley. The incremental contribution of the NRC-authorized activities related to construction and operation at the CRN Site would not be a significant contributor.	MODERATE
Ecology		
Terrestrial Ecosystems and Wetlands	Impacts due to historical and ongoing loss of upland forest habitat and potential effects on important species. The NRC-authorized activity would be a significant contributor to the impact.	MODERATE
Aquatic Ecosystems	Impacts due to historical river impoundment, toxic spills/releases, introduction of non-native species, recreational fishing, mining, agriculture, and urbanization in the Clinch River and its tributaries. The incremental contribution of the NRC-authorized activities related to construction and operation at the CRN Site would not be a significant contributor.	LARGE
Socioeconomic Resources		
Physical Impacts		SMALL to MODERATE
Demography		SMALL

Table 7-3. (contd)

Resource Category	Comments	Impact Level
Taxes and Economy	Beneficial aggregate economic impacts of the wages, salaries, benefits; local procurements of goods and services; tax revenues.	SMALL
Infrastructure and Community Services	Impacts associated with workforce traffic. The NRC-authorized activity would be a significant contributor to the impact.	MODERATE to LARGE
Environmental Justice		NONE[(a)]
Historic and Cultural Resources	The potential adverse effect on 16 potentially NRHP-eligible, one eligible archaeological resource, deeply buried archaeological deposits, and the NRHP-eligible Melton Hill Dam Historic District due to preconstruction activities. The incremental contribution of the NRC-authorized activities related to construction and operation at the CRN Site would not be a significant contributor.	MODERATE to LARGE
Air Quality		
Criteria Pollutants		SMALL
Greenhouse Gas Emissions	National and worldwide cumulative impacts of GHG emissions are noticeable but not destabilizing, with or without the GHG emissions of SMRs at the CNR Site. The incremental contribution of the NRC-authorized activities related to construction and operation at the CRN Site would not be a significant contributor.	MODERATE
Nonradiological Health	Impacts on members of the public from noise. All other impacts would be SMALL. The NRC-authorized activity would be a significant contributor to the impact.	SMALL to MODERATE
Radiological Impacts of Normal Operation	Public and occupational doses predicted from operating a new nuclear power plant at the CRN Site would be below regulatory limits and standards. The cumulative radiological impact on nonhuman biota would not be significant. The cumulative radiological impacts of operating two or more new SMRs at the CRN Site, along with the existing units at Watts Bar and the influence of activities at ORNL and Y-12 Complex, would be minimal.	SMALL
Nonradioactive Waste	The quantity of nonradioactive and mixed waste projected during CRN Site operation would be within the available treatment and disposal capacity.	SMALL
Postulated Accidents	The probability-weighted consequences (i.e., risks) of severe accidents would be SMALL.	SMALL
Fuel Cycle, Transportation, and Decommissioning	The cumulative impacts related to the fuel cycle, transportation of radioactive materials (fuel and waste), and facility decommissioning would be minimal.	SMALL

(a) The entry “None” for Environmental Justice does not mean there are no adverse impacts on minority or low-income populations from the proposed action. Rather, “None” means that, while adverse impacts may exist, they do not affect minority or low-income populations in any disproportionate manner, relative to the general population.

8.0 NEED FOR POWER

The Tennessee Valley Authority (TVA), has submitted to the U.S. Nuclear Regulatory Commission (NRC) an application for an early site permit (ESP) for a site in Roane County, Tennessee for new nuclear power units demonstrating small modular reactor technology. 10 CFR 51.50, Section (b)(2) (TN250) does not require an assessment of need for power in an ESP application; The TVA ESP application did not address the need for power. In accordance with 10 CFR 51.75(b) (TN250) the EIS for an ESP does not address the need for power if the application did not address the need for power.

9.0 ENVIRONMENTAL IMPACTS OF ALTERNATIVES

This chapter describes alternatives to the proposed U.S. Nuclear Regulatory Commission (NRC) action for an early site permit (ESP) for the Clinch River Nuclear (CRN) Site in Tennessee. This chapter also discusses the environmental impacts of alternatives to the proposed NRC action. Section 9.1 discusses the no-action alternative. Section 9.2 is reserved to address alternative energy sources if a future application leads to a supplement to this environmental impact statement (EIS). Section 9.3 reviews the TVA region of interest (ROI) evaluated in the site selection process, its alternative site selection process, and issues common or generic to all of the alternative sites and summarizes and compares the environmental impacts for the proposed and alternative sites. Section 9.4 examines plant design alternatives.

The need to compare the proposed action with alternatives arises from the requirement in Section 102(2)(c)(iii) of the National Environmental Policy Act of 1969, as amended (NEPA; 42 U.S.C. § 4321 *et seq*.-TN661), that EISs include an analysis of alternatives to the proposed action. The NRC implements this requirement through regulations in Title 10 of the *Code of Federal Regulations* (CFR) Part 51 (TN250) and its Environmental Standard Review Plan (ESRP) (NRC 2000-TN614, NRC 2007-TN5141). Furthermore, Subpart A of 10 CFR Part 52 (TN251) sets forth the NRC regulations related to ESPs.

In this EIS, the environmental impacts of the alternatives are evaluated using the NRC three-level standard of significance—SMALL, MODERATE, or LARGE—developed using Council on Environmental Quality (CEQ) guidelines (40 CFR Part 1508-TN428) and set forth in the footnotes to Table B-1 of 10 CFR Part 51, Subpart A, Appendix B (TN250). The issues evaluated in this chapter are the same as those addressed in NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS) (NRC 2013-TN2654).

Although NUREG–1437 was developed for license renewal, it provides useful information for this review and is referenced throughout this chapter. Additional guidance on conducting environmental reviews is provided in *Interim Staff Guidance on Environmental Issues Associated with New Reactors* (NRC 2014-TN3767).

9.1 No-Action Alternative

For purposes of an application for an ESP, the no-action alternative refers to a scenario in which the NRC would deny the ESP request. Upon such a denial by the NRC, the construction and operation of a new nuclear power plant at the proposed location on the CRN Site in accordance with the 10 CFR Part 52 (TN251) process referencing an approved ESP would not occur. Under the no-action alternative the NRC would not issue the ESP. There are no environmental impacts associated with not issuing the ESP, and the impacts predicted in this EIS associated with building and operating two or more SMRs at the CRN Site or at any one of the alternative sites would not occur.

In this context, the no-action alternative would accomplish none of the benefits intended by the ESP process, which would include (1) early resolution of siting issues prior to large investments of financial capital and human resources in new plant design and construction, (2) early resolution of issues related to the environmental impacts of construction and operation of new nuclear units that fall within the plant parameters for small modular reactor (SMR) nuclear generation units, (3) the ability to bank sites on which nuclear plants might be located, and (4) the facilitation of future decisions about whether to construct new nuclear power-generation facilities.

9.2 Energy Alternatives

The purpose and need for the NRC-proposed action (i.e., ESP issuance) as identified in Section 1.3 of this draft EIS is to provide for early resolution of site safety and environmental issues, which provides stability in the licensing process. As stated in 10 CFR 51.50(b)(2) and 10 CFR 51.75(b) (TN250), the analysis of energy alternatives for the proposed TVA SMR project is not required for an ESP, was not addressed in the environmental report for the ESP application, and is therefore not addressed in this EIS.

9.3 Alternative Sites

The NRC regulations require that the EIS prepared in conjunction with an application for an ESP include an evaluation of alternatives to the proposed action (10 CFR Part 51-TN250). As discussed in Chapter 1.0 of this EIS, the NRC's proposed action related to the TVA application is the issuance of an ESP for the CRN Site approving the site as suitable for the future demonstration of the construction and operation of two or more SMRs. The consideration of alternative sites is one portion of the review of alternatives. The NRC guidance in Section 9.3 of the ESRP (NRC 2000-TN614, NRC 2007-TN5141) regarding the site selection process calls for the identification of an ROI followed by successive screenings of candidate areas, potential sites, candidate sites, and the proposed site. Section 9.3.1 of this chapter presents a discussion of the TVA site selection process, which includes identification of the ROI for possible siting of two or more SMRs. This discussion is followed by the review team evaluation of the alternatives sites (Section 9.3.2).

The review of alternative sites consists of a two-part sequential test (NRC 2007-TN5141). The first part of the test determines whether any of the alternative sites are environmentally preferable. To determine if a site is environmentally preferable, the NRC staff considers whether the applicant has (1) reasonably identified candidate sites, (2) evaluated the likely environmental impacts of the proposed action at these sites, and (3) used a logical means of comparing sites that led to selection of the proposed site. Based on its independent review, the NRC staff determines whether any of the alternative sites are environmentally preferable to the applicant's proposed site. If the NRC staff determines that one or more alternative sites are environmentally preferable, it then proceeds with the second part of the test.

The second part of the test determines if an environmentally preferable alternative site is not simply marginally better, but obviously superior to the proposed site. The NRC staff examines whether (1) one or more important aspects, either singly or in combination, of an acceptable and available alternative site are obviously superior to the corresponding aspects of the applicant's proposed site, and (2) the alternative site does not have offsetting deficiencies in other important areas. Included in this part of the test is the consideration of estimated costs (i.e., environmental, economic, and time of building the proposed plant) at the proposed site and at the environmentally preferable site or sites (NRC 2007-TN5141).

The specific resources and components that could be affected by the incremental effects of the proposed action and other actions in the same geographic area are assessed. For the purposes of this alternative sites evaluation, the impacts evaluated include NRC-authorized construction and operation and other cumulative impacts including preconstruction activities.

Section 9.3.2 provides site-specific descriptions of the environmental impacts of locating two or more SMRs at each alternative site based on issues such as land use, air quality, water resources, terrestrial and aquatic ecology, socioeconomics and environmental justice, and cultural resources and historical properties. Section 9.3.3, which summarizes the impacts of the proposed action and alternative sites, contains a table with the NRC staff characterization of the impacts at the alternative sites in comparison to the impacts at the proposed site to determine whether there are any alternative sites that are environmentally preferable or obviously superior to the CRN Site.

9.3.1 Alternative Site Selection Process

The TVA site selection process is described in the TVA Environmental Report (ER) (TVA 2017-TN4921) and in greater detail in the *Tennessee Valley Authority Site Selection Report* and related supplemental documents (TVA 2016-TN5040, TVA 2017-TN4920, TVA 2017-TN5028). TVA's alternative site selection process began with the selection of an ROI. Within that ROI, TVA applied screening criteria sequentially to establish candidate areas, potential sites, and finally candidate sites, leading to the selection of alternative sites (see Figure 9-1). The process that TVA used to select its alternative sites was based on the *Advanced Nuclear Technology: Site Selection and Evaluation Criteria for New Nuclear Power Generation Facilities* (Electric Power Research Institute [EPRI] Siting Guide) (EPRI 2015-TN5285) and is described in the following sections.

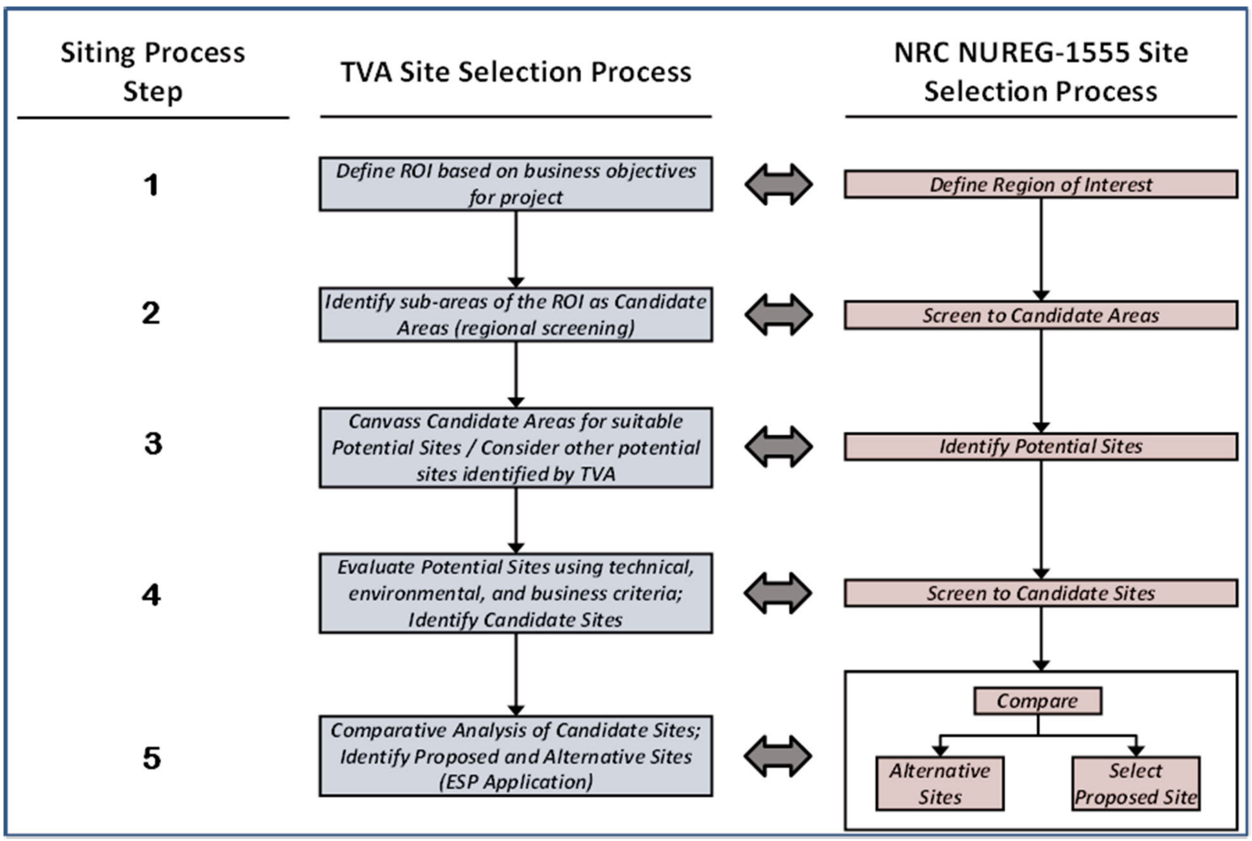

Figure 9-1. TVA Site Selection Process (Source: TVA 2017-TN4921)

9.3.1.1 Selection of the Region of Interest

In general, the ROI is the geographic area considered in searching for candidate sites (NRC 2007-TN5141). The ROI is typically the state in which the proposed site is located or the relevant service area for the proposed plant (NRC 2007-TN5141).

TVA identified the TVA Power Service Area as the ROI for the SMR project (Figure 9-2). The TVA service area includes most of Tennessee and portions of six adjacent states (Alabama, Kentucky, Georgia, Mississippi, North Carolina, and Virginia). It consists of the Tennessee River watershed, the Cumberland River watershed, and areas surrounding these watersheds. Overall, the TVA service area covers 81,000 square miles and includes 201 counties in the same seven states. The environment within the ROI is diverse, ranging from riparian habitat along the rivers and lakes to rugged mountain ranges to lowlands (TVA 2014-TN4957). The following section describes how TVA narrowed the ROI down to the candidate areas.

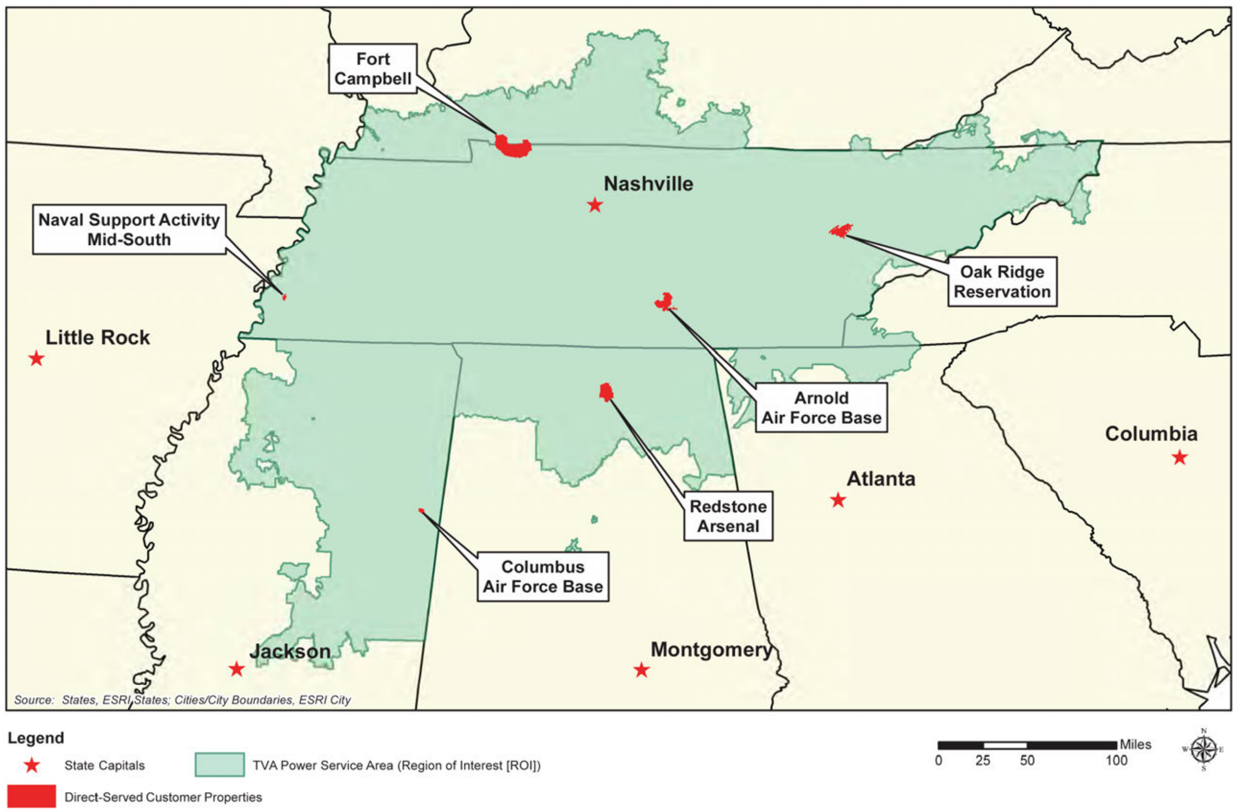

Figure 9-2. The Region of Interest and Candidate Areas (Source: TVA 2017-TN4921)

9.3.1.2 Selection of Candidate Areas

TVA, as the initial step of the site selection process, identified candidate areas within the ROI by constructing digitized geographic information system maps of the entire ROI. TVA then applied exclusionary criteria to eliminate areas that were either considered to be unsuitable for siting a nuclear power plant or significantly less suitable than other potential siting areas. Suitability was based on the objectives of the project to demonstrate power generation by the SMR technology to address energy security issues and assist in carbon-reduction goals at Federal government facilities. The exclusionary criteria applied by TVA covered factors that might make the licensing, permitting, or development of two or more SMRs impractical. TVA exclusionary criteria included seismology considerations, population density, cooling-water availability, and proximity to targeted customers. The targeted customers for the SMR project are Federal installations (e.g., U.S. Department of Defense [DoD] or U.S. Department of Energy [DOE] facilities) directly served by TVA.

TVA's application of exclusion criteria to the ROI initially resulted in the identification of six candidate areas scattered throughout the ROI (see Figure 9-2). The candidate areas included areas around DOE's Oak Ridge Reservation (ORR) near Oak Ridge, Tennessee, as well as three DoD sites in Tennessee (Fort Campbell, Arnold Airforce Base, and Naval Support Activity [NSA] Mid-South), Redstone Arsenal in Alabama, and Columbus Air Force Base in Mississippi.

Each candidate area was further evaluated for safety siting considerations, such as seismic activity, cooling-water availability, and relative population density in the area. Based on this evaluation, Fort Campbell and NSA Mid-South were eliminated from further evaluation as potential sites due to their distances from a water source and, for NSA Mid-South only, seismic considerations. Arnold and Columbus Airforce bases were eliminated because the nearby cooling-water sources were inadequate. Thus, the potential sites were drawn from the remaining Redstone Arsenal and ORR candidate areas.

9.3.1.3 Selection of Potential Sites

To identify potential sites within the Redstone Arsenal and ORR candidate areas, TVA consulted with these Federal site customers to identify areas that would be suitable for SMR siting, which included the requirement that it be a contiguous 120-ac site. TVA-owned property that was adjacent to the Redstone and ORR candidate areas was included for selection of potential sites. Potential sites were evaluated based on consistency with TVA objectives for the project (e.g., proximity to targeted customers), as well as land-use plans and other requirements associated with existing missions and activities (TVA 2016-TN5040, TVA 2017-TN4921).

Topographical maps and aerial photographs of each candidate area were examined to identify locations that would provide sufficient land for the suitable arrangement of two or more SMRs and other required facilities and a reasonable site boundary. The principal considerations at this step included availability of land, proximity to a water source, proximity to sensitive resources such as wetlands, proximity to transmission lines, proximity to existing transportation infrastructure, obvious topographic concerns, and flexibility to optimize site layout and design for environmental and cost mitigation purposes (TVA 2016-TN5040, TVA 2017-TN4921).

Locations were identified as satisfying the above conditions if a minimum of 120 contiguous acres were available, preferably in a square configuration. Because up to 151 ac of additional laydown areas could be required during construction, nearby parcels were evaluated for use as laydown area and parking area that could accommodate the construction of two or more SMRs at the alternative site (TVA 2017-TN5028). Because access to a water source is essential, preference was given to sites immediately adjacent to or within 0.5 mi of a primary water source. Easy access to transmission lines (onsite or within 5 mi) and availability of existing transportation infrastructure were also considered.

Fifteen potential sites were identified within the two candidate areas (eight sites within the ORR Candidate Area and seven sites within the Redstone Candidate Area).

9.3.1.4 Selection of Candidate Sites and Proposed Site

Candidate sites are sites within the ROI that are considered to be among the best sites that can be reasonably identified and made available for the siting of two or more SMRs. To determine the candidate sites, the 15 potential sites were evaluated using general siting criteria as described in the *Tennessee Valley Authority Site Selection Report* (TVA 2016-TN5040, TVA 2017-TN4921), which include health and safety criteria, environmental criteria, socioeconomic criteria, and engineering and cost criteria. Based on this evaluation, each potential site received a composite site-suitability score (TVA 2016-TN5040, TVA 2017-TN4921).

TVA selected the candidate sites based on the more detailed evaluation of the 15 potential sites; the three potential sites with the highest three composite scores from the ORR Candidate Area and one additional site, which had the highest composite score in the Redstone candidate area, were identified as the candidate sites. Although the ORR potential sites all had higher composite scores than the Redstone Arsenal sites, one Redstone site was included for further evaluation as a candidate site to add geographic diversity to the list of candidate sites under consideration. The rankings of the candidate sites listed below are listed in Table 9-1 and the site locations are shown in Figure 9-3. and Figure 9-4.

- Redstone Arsenal Site 12 in Madison County, Alabama
- ORR Site 8 in Roane County, Tennessee
- ORR Site 2 in Roane County, Tennessee
- ORR Site 3 (also called the proposed site or the CRN Site) in Roane County, Tennessee.

Table 9-1. Rankings of the Candidate Sites Based on Total Numerical Scores

Site	Total Composite Score
ORR Site 3	757
ORR Site 8	742
ORR Site 2	733
Redstone Arsenal Site 12	639

Higher numerical scores are better.
Source: TVA 2016-TN5040, TVA 2017-TN4921

TVA selected ORR Site 3 (CRN Site) as the proposed site.

9.3.1.5 Review Team Evaluation of the TVA Site Selection Process

TVA chose the TVA Power Service Area as the ROI (Figure 9-2). This area includes most of Tennessee and portions of six adjacent states (Alabama, Kentucky, Georgia, Mississippi, North Carolina, and Virginia). The designated ROI is consistent with the guidance in the NRC ESRP (NRC 2000-TN614, NRC 2007-TN5141) because it encompasses the TVA service territory. Therefore, the review team concludes that the ROI used in the TVA ESP application is reasonable for consideration and analysis of potential sites. The extent of the ROI is sufficiently expansive to ensure that an adequate slate of potential sites could be found. The review team also finds that the TVA basis for defining the ROI did not arbitrarily exclude desirable candidate locations because TVA included its entire service territory.

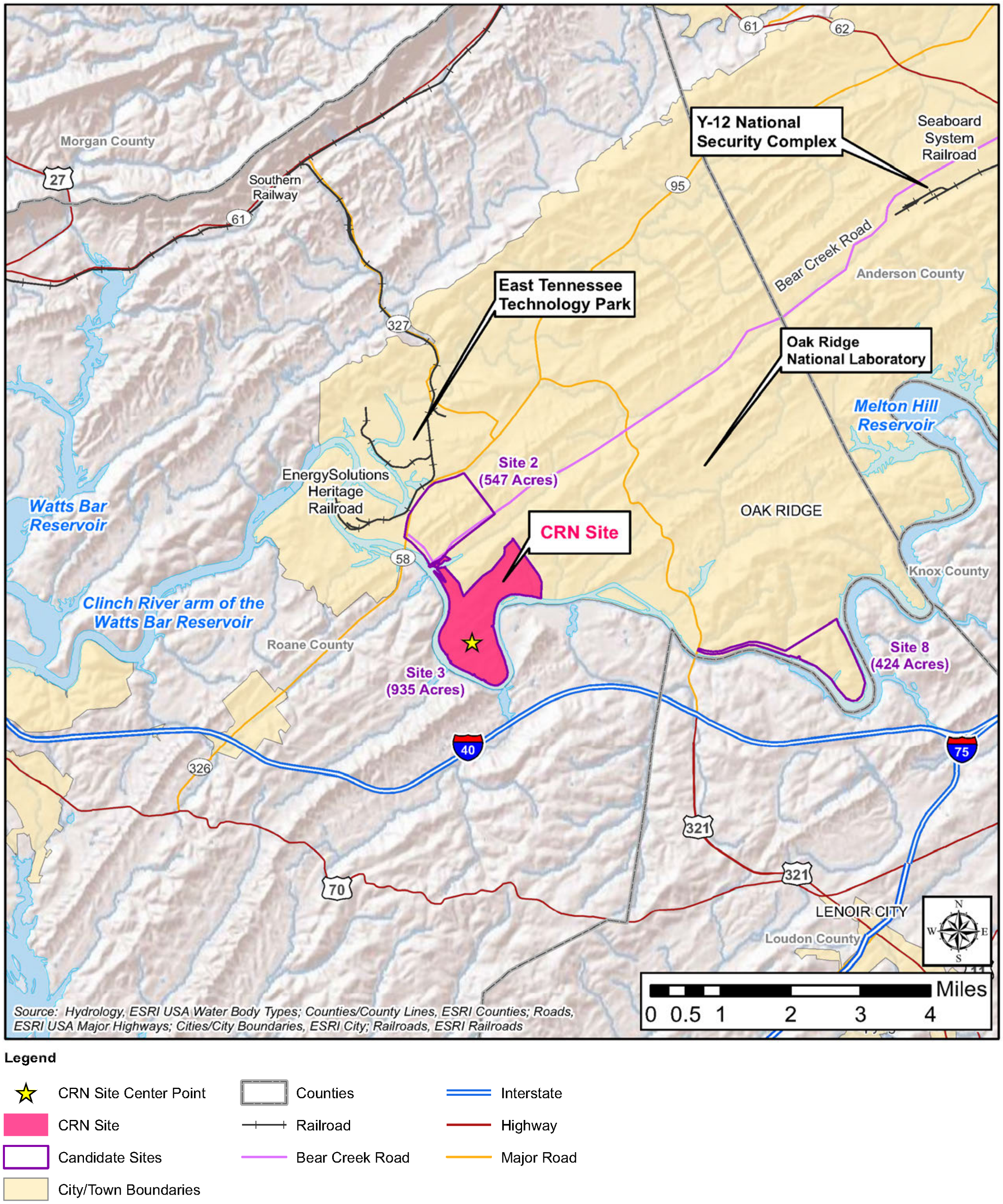

Figure 9-3. ORR Candidate Sites (Source: TVA 2017-TN4921)

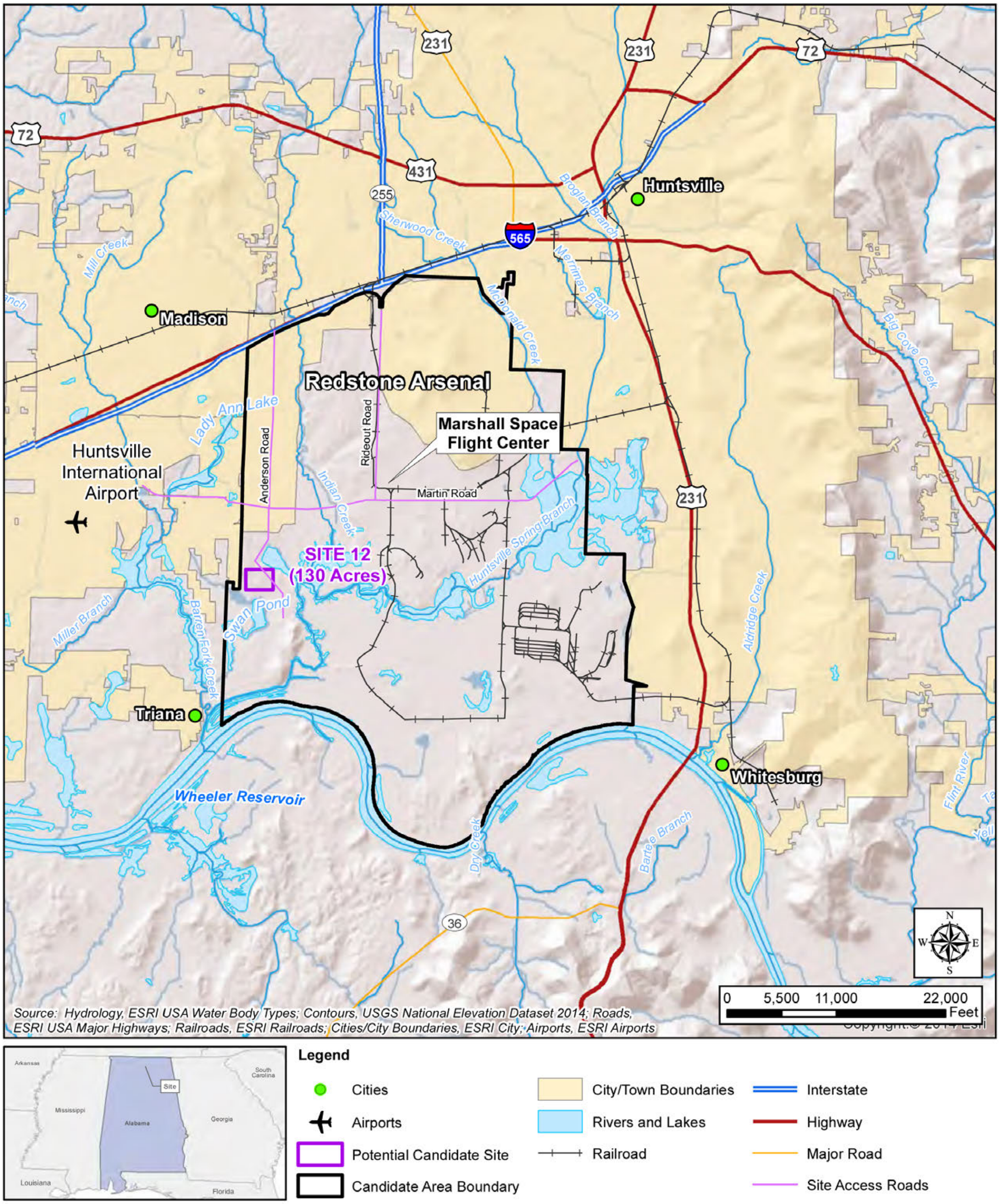

Figure 9-4. Redstone Arsenal Candidate Sites (Source: TVA 2017-TN4921)

TVA next identified candidate areas within the ROI. TVA used exclusionary criteria based on seismology considerations, population density, cooling-water availability, and proximity to targeted customers. The use of such exclusionary criteria is consistent with the guidance in the NRC ESRP (NRC 2000-TN614, NRC 2007-TN5141). The exclusionary criterion related to proximity to targeted customers was based on project objectives associated with assisting Federal facilities to meet carbon-reduction objectives and supplying Federal mission-critical loads with reliable power generation. TVA identified two candidate areas—ORR and the Redstone Arsenal—based on the exclusionary criteria. The review team concludes that the approach used by TVA to identify ORR and Redstone Arsenal as the final two candidate areas within the TVA service area is consistent with that described in the ESRP (NRC 2007-TN5141); therefore, the review team concludes that the method used by TVA to identify candidate areas is reasonable.

To identify potential sites, TVA used topographical maps and aerial photographs to determine where suitable land area for siting a new nuclear plant would be available within each of the candidate areas (i.e., inclusionary criteria). TVA also consulted with knowledgeable staff from each respective Federal site considered a candidate area. TVA developed preliminary plant footprint layouts for this purpose. TVA also considered other required conditions at each site, including ground slope and proximity to water supply, transmission, and transportation resources. In addition, TVA gave consideration to the proximity of each site to floodplains, wetlands, and other sensitive land features. In all, TVA identified 15 potential sites. The review team notes that the 15 potential sites identified by TVA cover a wide geographic area and range of environmental conditions. The approach used by TVA in identifying potential sites is consistent with that described in the ESRP (NRC 2007-TN5141); therefore, the review team concludes that the TVA process for identifying potential sites is reasonable.

TVA reviewed the 15 potential sites in more detail to narrow the list to a group of candidate sites (TVA 2016-TN5040, TVA 2017-TN4921). This portion of the TVA review included subjecting the 15 sites to more detailed evaluation of suitability criteria, including obtaining more detailed information about the environmental and technical conditions at each site. Criteria considered by TVA included hydrology, ecology and wetlands, land use/zoning, and socioeconomics. The focus of the TVA evaluation was on the environmental and socioeconomic suitability of the sites as well as other factors such as health and safety issues considered when making major nuclear licensing decisions and major engineering issues related to cost or difficulty of constructing and operating a new nuclear plant at the site.

In this step of its site selection process, TVA eliminated 11 of the 15 potential sites. According to the TVA siting study (TVA 2016-TN5040, TVA 2017-TN4921), 3 of the 15 potential sites were among the highest scoring sites in terms of environmental and socioeconomic criteria within their respective candidate areas. Although Redstone Arsenal Site 12 had lower overall environmental scores than all ORR potential sites, it was included as an alternative site for geographical diversity, which the staff finds acceptable.

The review team concludes that the process used by TVA at this stage is consistent with the process described in the ESRP (NRC 2007-TN5141). Because the process used by TVA to select candidate sites would not improperly eliminate sites from consideration, the review team concludes that it is reasonable.

The TVA evaluation of the remaining four candidate sites included field reconnaissance site visits to each site. For each candidate site under consideration, TVA considered the impacts of offsite corridors for water supply pipelines, transmission lines, rail lines, and primary roads. TVA used the total weighted scores for each site to determine that ORR Site 3 was the most suitable of the four candidate sites.

TVA considered both environmental criteria and technical criteria in its scoring of the sites; however, the ESRP guidance (NRC 2007-TN5141) considers only environmental factors in the comparison of the sites to determine whether any is environmentally preferable. Therefore, the review team examined the TVA scores for each of the candidate sites based only on the numerical scores for the environmental issues and concluded that although the proposed CRN Site (ORR Site 3) did not receive the highest environmental score (including both ecological and socioeconomic factors), the scores of all the ORR sites were similar. The review team also examined the numerical values of the importance weighting factors that were applied by TVA to each of the 35 site characteristics and concluded that no single one of these weighting factors was by itself sufficient to significantly skew the total score obtained by TVA for any one site or to alter the ranking for the top two sites. The review team concluded that TVA's consideration of non-environmental factors did not inappropriately affect the outcome of the TVA analysis. This conclusion is based on TVA's comparison of the sites in Sections 9.3.4 and 9.3.5 of its ER (TVA 2016-TN5040, TVA 2017-TN4921) based on environmental factors. This comparison was independent of the numerical rankings in the siting study.

The review team concludes that the TVA final site selection process is reasonable, makes full use of the available candidate site data, and presents the data in a manner that permits valid comparisons between the candidate sites. Overall, the review team concludes that TVA used a logical approach that adequately satisfied applicable NRC guidance for the identification of sites that are among the best in the ROI. Consequently, in addition to the proposed site (ORR Site 3), the review team has chosen the remaining three alternative sites identified by TVA (i.e., ORR Site 8, ORR Site 2, Redstone Arsenal Site 12) for the review team's independent analysis.

In accordance with Section 9.3 of the ESRP (NRC 2007-TN5141), the review team performed an independent comparison of the proposed and alternative sites. The three alternative sites (ORR Site 8, ORR Site 2, and Redstone Arsenal Site 12) are examined in detail in Section 9.3.2 of this chapter relative to the following subject areas: land use, water resources, terrestrial and aquatic ecology, socioeconomics and environmental justice, cultural resources and historic properties, air quality, nonradiological health, radiological health, and postulated accidents. The review team visited the proposed site and each alternative site (NRC 2018-TN5386, NRC 2015-TN5275). EIS Section 9.3.3, which summarizes the impacts of the proposed action at the CRN Site and alternative sites, contains a table with the review team's characterization of the cumulative impacts of building and operating two or more SMRs at the proposed site and at each of the alternative sites (Table 9-14). ORR Site 2 is a 547-ac site in Roane County, Tennessee, located adjacent to the CRN Site to the north-northwest (see Figure 9-3). ORR Site 8 is a 424-ac site located in Roane County, Tennessee, to the west of the CRN Site (see Figure 9-3). Redstone Arsenal Site 12 is a 130-ac site located in Madison County, Alabama, about 200 mi west-southwest of the CRN Site (see Figure 9-4). However, TVA has stated that additional land would be required beyond the boundaries of Site 12 for laydown and parking during construction, and potentially during outages (TVA 2017-TN5028). TVA identified a 377-ac parcel of land that could be developed for this purpose. However, the review team found that this parcel overlapped Site 12 with an overlapping area of 58 ac. Therefore, the combination of Site 12 and the additional land has an area of 449 ac.

Following the guidance in Section 9.3 of the ESRP (NRC 2000-TN614, NRC 2007-TN5141), the review team collected and analyzed reconnaissance-level information for each site. The review team then used the information provided in the ER (TVA 2017-TN4921), supplemental information provided by TVA (2016-TN5040, TVA 2017-TN4920, TVA 2017-TN5028, TVA 2017-TN4921), information from other Federal and State agencies, and information gathered during the review team visits to each alternative site to evaluate the cumulative impacts of building and operating a new nuclear power plant at those sites. The analysis therefore includes the impacts of NRC-authorized construction and operation and potential impacts associated with other actions affecting the same resources. Cumulative impacts occur when the effects of an action are added to or interact with other effects in a particular place and within a particular time; as a result, the cumulative impact assessment entails a more extensive and broader review of possible effects of the action beyond the site boundary.

The cumulative analysis of the impacts at the alternative sites was performed in the same manner as discussed in Chapter 7 of this EIS for the proposed site, except, as specified in Section 9.3 of the ESRP (NRC 2007-TN5141), a reconnaissance-level analysis was conducted for the alternative sites. To inform the cumulative impacts analysis, TVA conducted a search to identify other relevant projects in the vicinity of each of the alternative sites (TVA 2017-TN4921). The review team independently developed tables of the major projects near the proposed and alternative sites that were considered relevant in the analysis of cumulative impacts (Table 7-1 and Table 9-2). See EIS Chapter 7.0 for a description of the process used to develop the tables. The review team used this information to perform an independent evaluation of the direct and cumulative impacts of the proposed action at the alternative sites to determine whether one or more of the alternative sites were environmentally preferable to the proposed site.

Included in the cumulative analysis are past, present, and reasonably foreseeable Federal, non-Federal, and private actions that could have meaningful cumulative impacts with the proposed action. For the purposes of this analysis, the past is defined as the time period before receipt of the ESP application. The present is defined as the time period from the receipt of the ESP application until the beginning of activities associated with building two or more SMRs at the CRN Site. The future is defined as the beginning of building activities (construction and preconstruction activities) associated with a new nuclear plant at the CRN Site through operation and eventual decommissioning.

Using the analyses in Chapter 7 of this EIS as a guide, the specific resources and components that could be affected by the incremental effects of building and operating a new nuclear plant at each of the alternative sites and other actions in the same geographic areas were identified. The affected environment that serves as the baseline for the cumulative impacts analysis is described for each alternative site, and a qualitative discussion of the general effects of past actions is included. The geographic area over which past, present, and future actions could reasonably contribute to cumulative impacts is defined and described in later sections for each resource area. The analysis for each resource area at each alternative site concludes with a cumulative impact finding (SMALL, MODERATE, or LARGE). For those cases in which the impact level to a resource was greater than SMALL, the review team also discussed whether building and operating a new nuclear plant would be a significant contributor to the cumulative impact. In the context of this evaluation, “significant” is defined as a contribution that is important in reaching that impact-level determination.

Cumulative impacts are summarized for each resource area at each site in Section 9.3.2 of this chapter. The level of detail is commensurate with the significance of the impact for each resource area. The findings for each resource area at the CRN Site and each alternative site then are compared in Table 9-14 in EIS Section 9.3.3. The results of this comparison are used in Section 9.3.3 to determine whether any of the alternative sites are environmentally preferable to the proposed site. If any alternative site is determined to be environmentally preferable, the review team would evaluate whether that specific alternative site was obviously superior to the proposed site.

The impacts described in Chapter 6 of this EIS (e.g., nuclear fuel cycle, decommissioning) would not vary significantly from one site to another. This is true because all of the alternative sites and the proposed site are in low-population areas and because the review team assumes the same reactor plant parameter envelope (PPE) is applicable for each of the sites, and, therefore, the same fuel cycle technology, transportation methods, and decommissioning methods are applicable. Because of this, these impacts would not differentiate between the sites and would not be useful in the determination of whether an alternative site is environmentally preferable to the proposed site. For this reason, these impacts are not discussed in the evaluation of the alternative sites.

Similarly, the nonradiological waste impacts described in EIS Sections 4.10 and 5.10 would not vary significantly from one site to another. The types and quantities of nonradiological and mixed waste would be about the same at any of the alternative sites. For each alternative site, all wastes destined for land-based treatment or disposal would be transported off the site by licensed contractors to existing, licensed disposal facilities operating in compliance with all applicable Federal, State, and local requirements, and all nonradioactive liquid discharges would be discharged in compliance with the provisions of an applicable National Pollutant Discharge Elimination System (NPDES) permit. Also, the amount of nonradioactive, nonhazardous municipal solid waste to be generated annually at the proposed site would be a relatively small percentage of the total solid waste generated within the geographic area of interest (GAI) of any of the alternative sites.

Finally, as stated in EIS Section 7.9, activities at the proposed site would generate a very small percentage of the hazardous waste produced in Tennessee, and no known capacity constraints exist for the treatment or disposal of hazardous wastes either within the State of Tennessee or for the nation as a whole. For these reasons, these impacts are not discussed separately in the evaluations of each alternative site; however, radiological and nonradiological health impacts are assessed for each alternative site.

9.3.2 Review Team Evaluation of Alternative Sites ORR 2, ORR 8, and Redstone 12

The alternative sites are summarized as follows. ORR Site 2 covers approximately 547 ac in Roane County, Tennessee (Figure 9-5). It is located on the ORR between the current CRN Site and the East Tennessee Technology Park (ETTP) and is bordered by State Route (SR) 58 on the west and Bear Creek Road on the south and east. Undeveloped ORR land borders the site to the northeast. The site is largely undeveloped and over 92 percent forested. The site partially overlaps the barge/traffic area described for the CRN Site. An existing transmission line corridor traverses the site.

ORR Site 8 is located on approximately 424 ac of undeveloped land on the ORR (Figure 9-5). It is a peninsula in the former Clinch River (now a peninsula defined by portions of the Clinch River arm of Watts Bar Reservoir and Melton Hill Reservoir) and is over 92 percent forested, with an existing transmission line corridor traversing the site from north to south. Access is restricted on ORR lands and no public access is currently available to these sites. The topography is similar to that of the CRN Site. ORR Site 8 is situated almost completely within the ORR National Environmental Research Park (NERP) (DOE 2016-TN5031).

The Redstone Arsenal Site 12 is located on the western edge of the Redstone Arsenal, south of Huntsville, Alabama, near the southern edge of the TVA service area (Figure 9-6). The site occupies 130 ac. Proposed laydown areas and other potentially developable contiguous land is approximately 319 ac in size. The combined site area (449 ac) is nearly 93 percent forested,

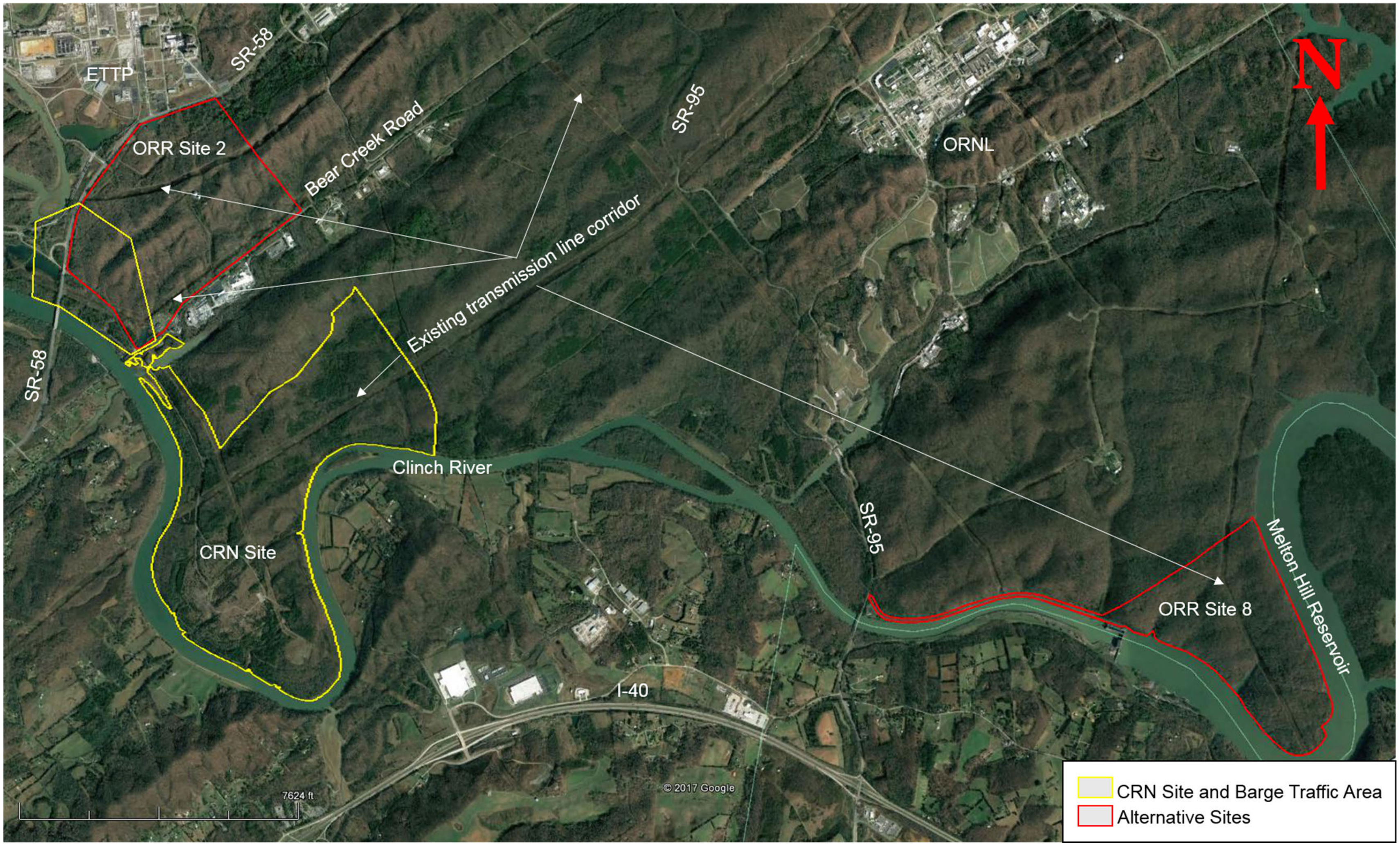

Figure 9-5. Location of ORR Alternative Sites Relative to the CRN Site (Google Earth image captured 3/7/2017)

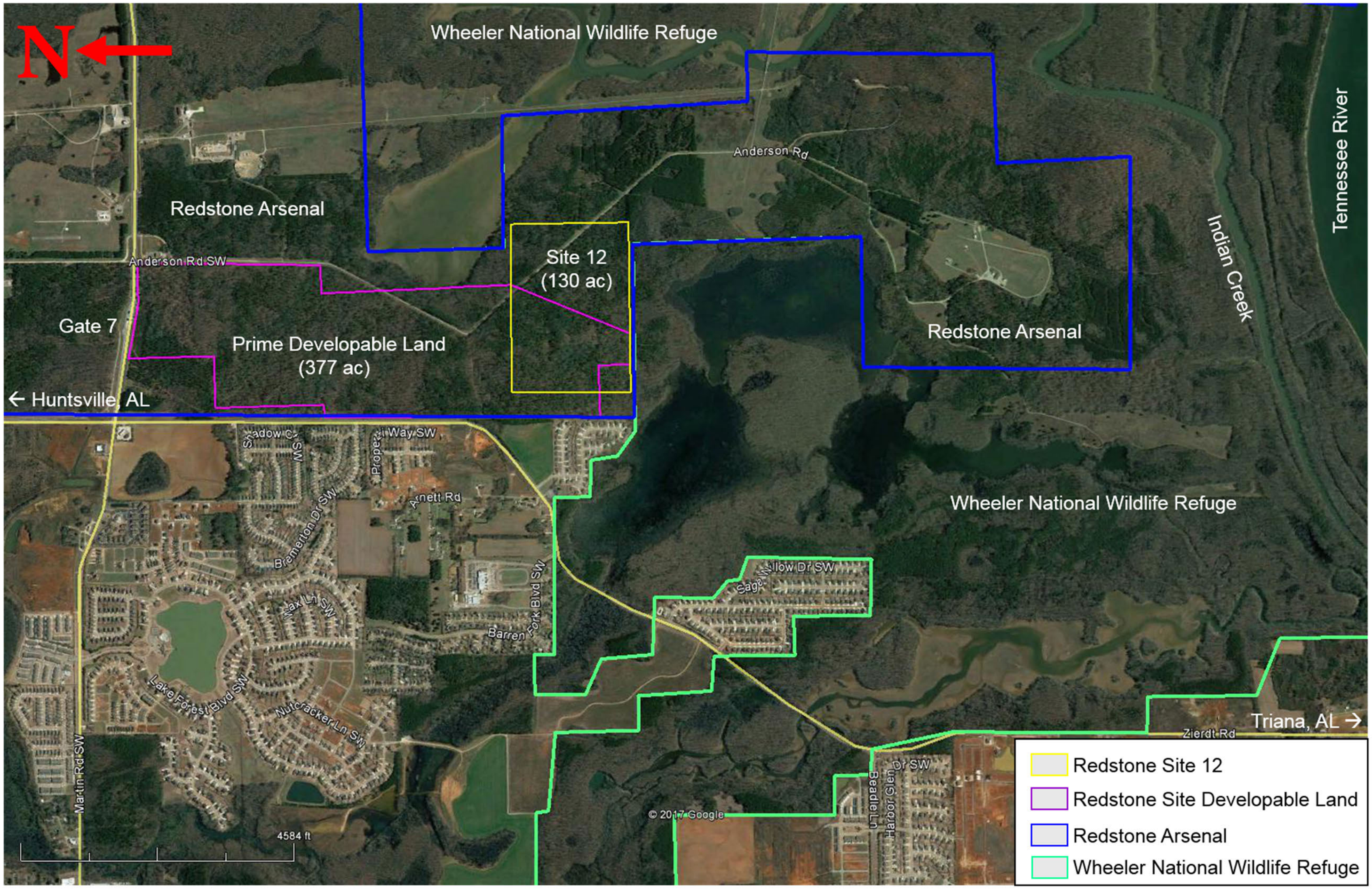

Figure 9-6. Aerial Overview of the Redstone Alternative Site (Google Earth image captured 2/15/2017)

including over 11 percent of the site being woody wetlands (NASS 2017-TN5144). The site is undeveloped and there is no public access, although there is an existing gravel access road through the site originating within the Arsenal. The site is adjacent to two off-base residential subdivisions immediately outside the western fence line of the Arsenal. The Wheeler National Wildlife Refuge borders the site on the northeast and is immediately adjacent to the southern and western extent of the Redstone Arsenal.

Because of the close proximity of ORR Sites 2, 8, and the CRN Site (ORR Site 3), the regional projects and other actions considered for cumulative impact assessments are the same as those listed in Table 7-1 (see Table 7-1 of this EIS for a list of projects considered for ORR Sites 2 and 8 cumulative impact assessment).

The assessment also considered the specific resources and components that could be affected by the incremental effects of a new nuclear power plant at Redstone Arsenal Site 12, including impacts of the NRC-authorized construction and operations and impacts of preconstruction activities. Also included in the assessment are past, present, and reasonably foreseeable future Federal, non-Federal, and private actions in the same geographical area that could have meaningful cumulative impacts when considered together with a new nuclear power plant if such a plant were to be built and operated at Redstone Arsenal Site 12. Other actions and projects considered in this cumulative analysis are listed in Table 9-2.

Table 9-2. Projects and Other Actions Considered in the Cumulative Impacts Analysis for Redstone Arsenal Site 12

Project Name	Summary of Project	Location	Status
Nuclear Projects			
Browns Ferry Nuclear Plant	Three boiling water reactor units capable of producing 3,400 MW	23 mi ESE	Unit 1 began operation in 1973 and is licensed through 2033; Unit 2 in 1974 and is licensed through 2034; Unit 3 in 1976 and is licensed through 2036 (TVA 2016-TN5100)
Bellefonte Nuclear Generating Station	Units 1 & 2 are permitted, but partially complete; combined construction permit and operating license application was submitted in 2007 for Units 3 & 4, but TVA withdrew the application.	45 mi ENE	Never operational; the site was sold in late 2016 to Nuclear Development, LLC, which may complete Units 1 and 2 (TVA 2016-TN5101)
Sequoyah Nuclear Generating Station Units 1 and 2	The station consists of two operating pressurized water reactors rated at 3,455 MW(t) each	100 mi NE	Unit 1 began operation in 1981 and is licensed through 2040; Unit 2 in 1982 and is licensed through 2041 (NRC 2016-TN4641; NRC 2016-TN4640; TVA 2016-TN4639)

Table 9-2. (contd)

Project Name	Summary of Project	Location	Status
Energy Projects			
Hydroelectric			
Guntersville Dam	4 generating units with a net capacity of 124 MW	23 mi SE	Operational since 1939 (TVA 2016-TN5102)
Wheeler Dam	11 generating units with a net capacity of 361 MW	40 mi NW	Operational since 1936 (TVA 2016-TN5103)
Tims Ford Dam	1 generating unit with a net capacity of 36 MW	47 mi NE	Operational since 1970 (TVA 2016-TN5104)
Natural-Gas-Fired			
Covanta Huntsville, Inc.	Two 365-ton/day waterwall furnaces process 690 tons of solid waste and sewage sludge per day to produce ~89,000 lb of steam per hour; in addition, 4 oil- and gas-fired boilers produce 100,000 lb of steam per hour	7 mi NE	Operational (Covanta 2016-TN5105)
Mining Projects			
Various gas and oil projects	Gas and oil wells	Throughout the region	Operational (TDEC 2016-TN4674)
Parks and Recreation Activities			
Federal			
Wheeler National Wildlife Refuge	Established in 1938 as a refuge and breeding area for migratory birds and other wildlife	Adjacent	Operational (FWS 2017-TN5112)
Fern Cave National Wildlife Refuge	Established in 1981 to provide protection for endangered gray and Indiana bats	24 mi ENE	Operational (FWS 2014-TN5113)
William B Bankhead National Forest	Established in 1918, and renamed in 1942; includes 181,230 ac of Federal forest lands	30 mi SW	Operational (USDA 2017-TN5115)
Sauta Cave National Wildlife Refuge	Purchased in 1978; includes 264 ac designated as protection for Federally endangered gray and Indiana bats and their critical habitat	33 mi E	Operational (FWS 2009-TN5114)

Table 9-2. (contd)

Project Name	Summary of Project	Location	Status
State			
Monte Sano State Park	Includes 2,140 ac offering, cabins, camping, hiking, and biking	15 mi NE	Operational (Alapark 2016-TN5107)
Cathedral Caverns State Park	Comprised of 493 ac, includes a large cavern with stalagmites, as well as camping and backpacking, hiking	29 mi E	Operational (Alapark 2016-TN5106)
Lake Guntersville State Park	Resort park on 6,000 ac, includes an 18-hole golf course, beach, nature center, hiking, biking, fishing, camping, cabins, lodge, and convention center	33 mi SE	Operational (Alapark 2016-TN5108)
Joe Wheeler State Park	Resort park on 2,550 ac, includes an 18-hole golf course, marina, camping, cottages, and boating	38 mi NW	Operational (Alapark 2016-TN5109)
Buck's Pocket State Park	Currently a day park, offers fishing, boating, and hiking	39 mi ESE	Operational (Alapark 2016-TN5110)
Tim's Ford State Park	Comprised of 2,200 ac, offers hiking, camping, cabins, an 18-hole golf course, boating, fishing	49 mi NE	Operational (Alapark 2016-TN5111)
Non-Hydroelectric Dams			
Duck River Dam	Newly constructed for water storage and recreation; 650-ac reservoir; trails are open and other recreation will be available when construction is concluded	35 mi S	Reservoir is full; final construction is ongoing (Duckriver.org 2017-TN5116). Dam is leaking (Cullman Times 2017-TN5117)
Transportation			
Airports	Several airports including Huntsville International, South Huntsville, Moontown, Frerichs, Scottsboro Muni-Word Field, Redstone Army Airfield	Throughout region	Operational
Miscellaneous transportation projects	Road and traffic projects; bridge replacements	Throughout region	Ongoing (TDOT 2016-TN4687)

Table 9-2. (contd)

Project Name	Summary of Project	Location	Status
Other Actions/Projects			
Redstone Arsenal	U.S. Army Garrison offering logistics, space operations, and missile defense; threat analysis and explosives research and training; Superfund Site; active National Priority List site for soils, sediments, surface water, and groundwater. Includes parks, recreation, camps, shooting ranges, landfills, wastewater-treatment plants, stores, laboratories, golf course, stadiums, health center	Adjacent	Operational Site (DA 2016-TN5118); no current Federal Facilities Agreement (EPA 2016-TN5119)
Air emissions sources			
Goodman Company, L.P.	Manufacturer of air-conditioning and heating units	38 mi NNE	Operational (TDEC 2016-TN5120)
Latham Pool Products, Inc.	Manufacturer of fiberglass pools	39 mi NNE	Operational (TDEC 2016-TN5121)
Various hospitals and industries that use radioactive materials	Medical and other industrial isotopes	Throughout the region	Operational
Various wastewater-treatment plant facilities	Sewage treatment		Operational
Misc. golf courses	Golf courses	Throughout the region	Operational
Manufacturing			
Kohler Company	Plastics and rubber products manufacturing	4 mi NNW	Operational (EPA 2016-TN5122)
Vishay Americas Inc.	Manufacturer of semiconductors and passive components	4 mi N	Operational (Vishay 2016-TN5126)
TDY Industries, LLC	Metal manufacturing	6 mi NNE	Operational (EPA 2016-TN5123)
Ridge Instrument Co	Manufacturer of missile launchers; production of electronic, cable, and electromechanical and circuit card assemblies	6 mi NNE	Operational (Ridge 2016-TN5127)

Table 9-2. (contd)

Project Name	Summary of Project	Location	Status
HDT Global – DRASH	Manufacturer of a deployable rapid assembly shelter that integrates shelter, mobility, lighting, heating, cooling and energy efficient power into one package	10 mi ENE	Operational (HDT 2017-TN5131)
Industrial Manufacturing Specialties Inc.	Designing and manufacturing of rubber and molds and machining	11 mi SW	Operational (IMS 2016-TN5129)
Ropak Manufacturing Co. Inc.	Packaging machines	15 mi SW	Operational (Ropak 2016-TN5128)
National Copper and Smelting Company	Manufacturer of copper tubing and copper fabrication	16 mi NE	Operational (EPA 2016-TN5124)
Toyota Motor Manufacturing Alabama Inc.	Manufacturer of Toyota engines	16 mi NNE	Operational (EPA 2016-TN5125)
Micor Industries	Manufacturing of machined parts, coating processes, welding, laser marking, assembly	18 mi W	Operational (Micor 2016-TN5130)
Various Iron Works	Iron manufacturers including Fleming, E.L., New Market, Tuscumbia, and Ironworks Co.	Throughout the region	Operational
Other manufacturing	Other manufacturing plants	Throughout the region	
Future urbanization	Construction of housing units and associated commercial buildings; roads, bridges, and rail; and water and/or wastewater-treatment and distribution facilities and associated pipelines as described in local land-use planning documents	Throughout the region	Construction would occur in the future, as described in State and local land-use planning documents

9.3.2.1 Land Use

This section describes the review team’s assessment of impacts on land use associated with building and operating a new nuclear power plant at ORR Site 2, ORR Site 8, and Redstone Arsenal Site 12. The analysis also considers cumulative impacts from other past, present, and reasonably foreseeable future actions, including the other Federal and non-Federal projects listed in Table 7-1 and Table 9-2 that could affect land use.

As stated in Section 9.3.2, these sites are all undeveloped. As sites on a Federally owned reservation, local land-use plans and zoning ordinances do not directly apply to them. However, both the DOE and the Department of the Army have current strategic plans governing the use of their lands, and developing SMR units at these sites would be consistent with established strategies (TVA 2016-TN5040, TVA 2017-TN4921).

Table 9-3 provides the estimated land-cover information for each alternative site. As indicated, each site is nearly entirely forested. Data for Redstone Arsenal Site 12 includes the 130-ac site plus 319 ac of adjoining land potentially usable for construction laydown.

Table 9-3. 2016 Land Cover by Alternative Site

	ORR Site 2		ORR Site 8		Redstone Site 12	
Land Cover	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
Open Water	5.3	1.0	11.6	2.7	0.7	0.1
Open Space/Herbaceous	8.5	1.5	3.6	0.8	24.5	5.4
Existing Development	13.1	2.4	4.0	0.9	0.4	0.1
Deciduous Forest	480.9	87.9	377.8	89.1	199.4	44.4
Evergreen Forest	8.5	1.5	6.2	1.5	112.3	25.0
Mixed Forest	4.9	0.9	6.4	1.5	52.0	11.6
Shrubland	1.6	0.3	4.2	1.0	5.6	1.2
Grass/Pasture	12.5	2.3	9.8	2.3	1.8	0.4
Woody Wetlands	11.8	2.2	0.4	0.1	52.5	11.7
Totals	547.0	100.0	424.0	100.0	449.0	100.0

Source: (NASS 2017-TN5144)

9.3.2.1.1 Building Impacts

According to TVA, for ORR Site 2 the power block, cooling towers, offices, and other facilities of the project would cover approximately 120 ac within the site. In addition, linear corridors for an access road and cooling-water intake and discharge pipelines within the site would cover approximately 8.5 ac. Of this total corridor acreage, most would be within the site boundary, and approximately 2 ac would be within the portion of the intake and discharge pipeline corridors that would extend from the site boundary to the shoreline of the reservoir. Likewise, for building SMR units on ORR Site 8, the power block, cooling towers, offices, and other facilities of the project would cover approximately 120 ac within this site. In addition, linear corridors for an access road and cooling-water intake and discharge pipelines within the site would cover approximately 25 ac (likely to be entirely within the site). On Redstone Arsenal Site 12, the power block, cooling towers, offices, and other facilities would cover approximately 120 ac within the site. Linear corridors for offsite transmission line and cooling-water intake and discharge pipelines would cover an additional 96 ac.

The review team expects that the actual footprint of disturbance for any site TVA might actually select would be substantially greater than the 120 ac that TVA used for identifying potential sites. The footprint of disturbance identified for the CRN Site was not 120 ac but was 357 ac. While it might be theoretically possible to fit the necessary facilities into 120 ac, an optimal spacing most conducive to efficient operation of the facilities would likely be more than 120 ac. The review team also recognizes that the 120-ac estimate likely does not account for optimal construction laydown, road improvements, and new transmission line construction. Therefore, for purpose of comparative analysis, the review team has assumed that TVA would at least temporarily clear 300–400 ac at any alternative site used.

Because each site is currently undeveloped, the clearing and grading required for building and operating the nuclear plant would be substantial. Site preparation and clearing required would permanently convert substantial tracts of forested lands to industrial development. Use of any of the sites would reduce the availability of large tracts of land on ORR or Redstone Arsenal for future industrial projects. Additionally, use of ORR Site 8 would reduce the area of the ORR NERP by approximately 424 ac, which could interfere with some ongoing NERP research activities and noticeably reduce the value of the NERP to future ecological research.

Offsite transmission corridors likely would be affected by upgrade activities similar to those discussed for the CRN Site. TVA hypothesized such impacts for the proposed action at the CRN Site by assuming the PPE electric capacity value of 800 MW would be injected to the grid at the CRN Site (TVA 2017-TN4921). This impact analysis was based on hypothetical conditions and would need to be revisited in the event of a combined construction permit and operating license (combined license or COL) application. However, the review team expects that some form of transmission line upgrading would also be required for implementation of the proposed action at any of the alternative sites. These activities could include rebuilding, reconductoring, or upgrading multiple segments of transmission lines within TVA's service territory to accommodate increased capacity resulting from the project. For the Redstone Site, it would be necessary to build a new transmission line to connect the site to the nearest existing transmission line. This would require the clearing of forest from a new corridor approximately 150–250 ft wide, depending on the expected line specifications.

In addition, to accommodate the security aspects of the project, some undergrounding of transmission lines may be expected. The review team assumes that TVA would build an underground 69-kV transmission line from the selected alternative site to existing developed facilities on the ORR or Redstone Site, given the purpose of and need for the project. Rebuilding or undergrounding of transmission lines likely would require some ground disturbance to clear right-of-ways, trench or excavate in the right-of-ways, and construct new towers or other infrastructure as components of the rebuilding. The land-use impacts from these activities would likely be similar or slightly more noticeable than those expected for the proposed action at the CRN Site. While the underground line for the CRN Site would follow an existing transmission line right-of-way from the site to the tie-in, inspection of aerial photographs by the review team suggests that no direct routes are available that entirely follow existing right-of-ways from the alternative sites to a suitable tie-in. The review team therefore expects that TVA would have to convert at least some undeveloped forest land or other land to new right-of-way in order to build an underground transmission line serving any of the alternative sites.

9.3.2.1.2 Operational Impacts

In general, the land-use impacts of operating the proposed new facilities at any of the alternative sites would be similar to those expected for the CRN Site. Onsite impacts would be minimal and limited to facility maintenance and property management such as vegetation control. Little or no additional ground disturbance would be expected during operations.

As would be true if the CRN Site were used, offsite areas such as transmission line corridors and intake/discharge pipeline corridors would require periodic vegetation control and other equipment maintenance activities that would not be expected to have land-use impacts.

For each alternative site, the addition of cooling towers would introduce a visual intrusion where none currently exists. Steam plumes from operating cooling towers would be visible in close proximity to each site. Impacts would be visible from offsite areas and would be expected to be generally similar to those described for the CRN Site. Cumulative Impacts

The GAI for consideration of cumulative land-use impacts at ORR Sites 2 and 8 is the same four-county economic region as that identified for the CRN Site. The GAI for Redstone Site 12 is that site's economic region, which includes Limestone, Madison, Marshall, and Morgan Counties in Alabama. The cumulative impacts for the ORR sites would not be expected to differ from those identified for the CRN Site because of the close proximity of the sites. The ORR sites are affected by the same past, present, and reasonably foreseeable future projects identified for the CRN Site and the cumulative impacts would therefore be expected to be mostly the same. Additional fragmentation of the NERP would occur by developing ORR Site 8, which could interfere with some ongoing NERP research activities and noticeably reduce the value of the NERP to future ecological research. Developing the CRN Site or ORR Site 2 would not further fragment the NERP, which encompasses most of ORR Site 8 but extends to only about 27 ac of ORR Site 2 (Baranski 2009-TN5133). Impacts to the NERP are described in more detail in Section 9.3.2.3.

Cumulative impacts expected from locating the proposed new facilities at the Redstone alternative site would include continued operations at the Redstone Arsenal, activities at the Wheeler National Wildlife Refuge areas contiguous to the site, ongoing industrial development immediately west of the site, and continued urbanization immediately west of the site in southeastern Madison County, Alabama. Operation of the Arsenal includes the interface between land use on the property and urban land uses immediately adjacent to the property. Arsenal land-use plans would need to be adjusted to accommodate the location of SMR units in close proximity to the bordering residential areas outside the Redstone fenceline (TVA 2017-TN4921). Operation of the cooling towers on the Redstone site would introduce steam plumes that would be visible from lands outside of the arsenal, but the review team does not expect these plumes to interfere with land uses.

Private lands to the west of and immediately adjacent to the Redstone Arsenal have been actively in development over the last 15 years. Several new subdivisions have been built there and continue to be under construction. New industrial sites have been cleared and industrial development is continuing as a result of manufacturing recruitment to the Huntsville area. The southwestern portion of Madison County is mostly prime farmland and has been classified as high-quality farmland at high risk for development by the American Farmland Trust (AFT 2003-TN5132). Because Redstone Site 12 is on a Federal reservation, no prime farmland assessment has been done to determine if such lands would be affected by its development, but it is reasonably foreseeable that the adjacent lands to the west of the Arsenal would be expected to see continued development and continued noticeable conversion of prime farmland to urban uses.

9.3.2.1.3 Summary of Land-Use Impacts at Alternative Sites

Overall, when combined with other past, present, and reasonably foreseeable future actions, the cumulative land-use impacts of building and operating SMR units on either of the ORR sites would be sufficient to alter noticeably, but not destabilize, important attributes of existing land uses within the GAI. Therefore, based on the information provided by TVA and the review team's independent review, the review team concludes that the cumulative land-use impacts would be MODERATE. This conclusion is primarily because of the long-term dedication of hundreds of acres of Federally owned land in an industrial setting that would have otherwise been available for other industrial uses and reduce future land-use flexibility on the ORR. The incremental contribution to cumulative land-use impacts from building and operating two or more SMRs at the ORR 2 and ORR 8 would be a significant contributor to the MODERATE impacts.

Overall, when combined with other past, present, and reasonably foreseeable future actions, the cumulative land-use impacts of building and operating the proposed new facilities at Redstone Site 12 (along with associated offsite transmission line and other utility corridors) would be sufficient to alter noticeably, but not destabilize, important attributes of existing land uses in in the GAI. Therefore, based on the information provided by TVA and the review team's independent review, the review team concludes that the cumulative land-use impacts of using Redstone Site 12 would be MODERATE. The incremental contribution of building and operating two or more SMRs at Redstone Arsenal Site 12 would be a significant contributor to the MODERATE impact.

9.3.2.2 Water Use and Quality

This section describes the review team's assessment of impacts on water use and water quality associated with building and operating a new nuclear power plant at ORR Site 2, ORR Site 8, and Redstone Arsenal Site 12. The analysis also considers cumulative impacts from other past, present, and reasonably foreseeable future actions, including the other Federal and non-Federal projects listed in Table 7-1 and Table 9-2 that could affect water use and quality.

The Clinch River is the source of water for building and operation at ORR Sites 2 and 8, as it is for the CRN Site. Similarly, discharges for ORR Sites 2 and 8 would be to the Clinch River. Because of this, the surface-water GAI for ORR Sites 2 and 8 is the same as for the CRN Site, and consists of the Clinch River basin and the portion of the Tennessee River that has potential effects on the Watts Bar Reservoir. ORR Site 2 is approximately 547 ac of largely undeveloped and forested land located north of Bear Creek Road, about 1 to 2 mi north of the CRN Site. The site has moderate topographic relief with elevations ranging from about 740 ft MSL where the site lies along the Clinch River, to about 1,000 ft MSL along the northeast-trending ridge that runs down the center of the site. The cooling-water intake for a plant at ORR Site 2 would be located near Grassy Creek at about Clinch River mile (CRM) 14.5 with the discharge located about one-half mile downstream (TVA 2017-TN4921). ORR Site 8 is approximately 424 ac of undeveloped, forested land located about 5 mi east of the CRN Site. ORR Site 8 lies mostly along and north of Melton Hill Reservoir just upstream from Melton Hill Dam, but includes a narrow stretch of land along the Clinch River just downstream of Melton Hill Dam. Topographic relief on the site is moderate with elevations on the main part of the site ranging from about 795 ft MSL at Melton Hill Reservoir to about 1,080 ft MSL in the interior of the site. The plant intake for ORR Site 8 would be located on the Melton Hill Reservoir at about CRM 26 with the discharge located about 3,000 ft downstream of Melton Hill Dam at about CRM 22.5 (TVA 2017-TN4921).

Redstone Arsenal Site 12 is approximately 130 ac of mostly forested land located along the westernmost boundary of Redstone Arsenal, outside Huntsville, Alabama. The site has low topographic relief with elevations ranging from about 560 to 630 ft MSL. Cooling water for a plant located at Redstone Arsenal Site 12 would be obtained from Wheeler Reservoir on the Tennessee River. The intake for the site would be located at about Tennessee River mile (TRM) 323 with the discharge located about 1 mi downstream from the intake (TVA 2016-

TN5040). As a result, the surface-water GAI for Redstone Arsenal Site 12 is the Wheeler Reservoir and the upstream portion of the Tennessee River basin.

Because groundwater would not be used for operations, and would only be extracted during building as necessary for excavation dewatering, the review team considered the groundwater GAI to be the groundwater in the vicinity of the alternative sites. As described in EIS Sections 2.3.1 and 2.8, the Valley and Ridge Physiographic Province in the region of the CRN Site is characterized by a northeast-trending sequence of repeated geologic units separated by closely spaced thrust faults. ORR Site 2 lies to the southeast of Whiteoak Mountain fault (see Figure 2-33); this site is underlain by the Rome Formation and the geologic units of the Conasauga Group. ORR Site 8 lies to the northwest of Beaver Valley fault and is underlain by geologic units of the Knox Group. Groundwater at ORR Sites 2 and 8 is likely to occur primarily in the weathered rocks near the surface and in the fractures and bedding planes of unweathered rocks at greater depths. Flow is expected to occur primarily along the geologic strike with recharge along the ridges and discharge to springs, streams, and rivers. Because of these hydrogeologic characteristics and the temporary nature of excavation dewatering, the GAI at ORR Sites 2 and 8 was limited to the groundwater within about 1 mi of the sites, above a depth of about 145 ft (the approximate depth of the excavation).

Redstone Arsenal Site 12 lies in the Interior Low Plateaus Physiographic Province, a region characterized by flat-lying, sedimentary rocks with limestone exposed at the surface, or overlain by residuum in the lowland areas (Miller 1990-TN550). The limestone units serve as major aquifers in the province, as do the thinly bedded, siliceous limestone and chert of the Fort Payne Chert unit. On the valley floors of the province, groundwater circulation is shallow, with recharge mainly from precipitation, and rapid percolation through the residuum to the underlying limestone (Miller 1990-TN550). Karst development is common on the valley floors. A review of well data in the Redstone Arsenal area showed that all geologic units penetrated contained groundwater flow zones, the majority of which were along bedding planes, many of which were enlarged from dissolution (Cook et al. 2015-TN5074). Recharge on the Redstone Arsenal was estimated to be 6.9 in./yr, with the general direction of groundwater flow occurring from north to south across the site, and groundwater discharging to the Tennessee River (Cook et al. 2015-TN5074). Aquifers on the Redstone Arsenal are semi-confined or unconfined, depending on the presence of confining sediments with residuum varying from minimal to about 80 ft thick in wells evaluated by Moss and Cook (2008-TN5073). Local variations in topography across the Redstone Arsenal result in local effects on groundwater flow directions and local discharge to wetlands and streams (Moss and Cook 2008-TN5073). Where karst features are connected to surface waterbodies, interactions with groundwater readily occur; however, significant flows of groundwater over long distances are uncommon (Cook et al. 2015-TN5074). Based on the description provided above, the groundwater GAI for Redstone Arsenal Site 12 consists of the limestone and Fort Payne Chert aquifers beneath and surrounding the site and between the site and the Tennessee River.

9.3.2.2.1 Building Impacts

Because building activities at ORR Sites 2 and 8 and at Redstone Arsenal Site 12 would be similar to those for the CRN Site, the review team assumed the amount of water needed for building activities at the alternative sites would be the same as that required for building activities at the CRN Site: about 231,660 gal/day (0.23 Mgd). The review team also assumed that water for building at ORR Sites 2 and 8 would be supplied from the same sources as proposed for the CRN Site: primarily the City of Oak Ridge municipal supply, and about 5,000 gal/day obtained directly from the Clinch River for purposes such as dust control. As described in EIS Section 4.2.2, the review team determined that the average water demand for building activities is about 3 percent of the average available capacity of the City of Oak Ridge system, and the resulting effect on water resources would be minor. The review team determined that the small amount of water obtained directly from the Clinch River for building activities would have no noticeable effects on the river. TVA did not identify a source of water for building a plant at Redstone Arsenal Site 12. Public supply withdrawals were about 64 Mgd in Madison County during 2005 (TVA 2017-TN4922), with about 60 percent obtained from surface-water sources, including Wheeler Reservoir. The review team determined that the 0.23 Mgd required for building (about 0.4 percent of the current public supply withdrawals in Madison County) would have a minor effect on the area's water resources.

The review team assumed that the intake and discharge structures for a plant at the alternative sites would be similar in design to those proposed for the CRN Site and that building the structures would require in-water activities similar to building at the CRN Site, i.e., some underwater excavation, but no dredging. Additional disturbance to the shoreline and river bottom may occur from building a new barge-docking facility at ORR Site 8, if needed. Structures would be located to minimize impacts on shoreline wetlands (TVA 2016-TN5040). During installation of these structures, some additional turbidity in the river would be expected because of disturbance of bottom sediments. However, these sediments would be localized to the area needed to install the structures and engineering measures such as silt curtains and cofferdams would be in place as part of best management practices (BMPs) to minimize movement of the disturbed sediment beyond the immediate work area (TVA 2017-TN4922). These effects would also be temporary and would not occur after the structures are installed. Building the intake and discharge structures, and the barge dock, at the alternative sites would be subject to the same (or similar) regulatory and monitoring conditions as those described in EIS Section 4.2 for the CRN Site. Therefore, the review team determined that the effects on river flows and water quality of building the intake and discharge structures would be temporary and limited to a small portion of the river and shoreline.

A plant at ORR Site 2 would require new intake and effluent discharge pipelines to be built from the site approximately 3,000 ft to the Clinch River. TVA estimated no wetlands or open water would be affected by building the pipelines (TVA 2016-TN5040). A plant at ORR Site 8 would require building a new intake pipeline about 1,300 ft to Melton Hill Reservoir and a new discharge pipeline about 4,200 ft long to the Clinch River downstream of Melton Hill Dam. TVA estimated that the discharge pipeline would affect 0.2 ac of open water (TVA 2016-TN5040). An additional 0.3 ac of wetlands would be affected by road construction at ORR Site 8 (TVA 2016-TN5040). A plant at Redstone Arsenal Site 12 would require building about 4.7 mi of new pipelines to Wheeler Reservoir on the Tennessee River for the intake and discharge. TVA estimated that these pipelines would affect 1.2 ac of open water and 1.7 ac of wetlands. Building project facilities at Redstone Arsenal Site 12 would affect 1.9 ac of wetlands on the site, and a new transmission line would affect 5 ac of wetlands north of the site. Mitigation of wetlands impacts would occur as required by U.S. Army Corps of Engineers permits (TVA 2017-TN4922). The review team assumed that these building activities would conform to applicable local and State requirements so that impacts on the affected water resources would be localized and temporary.

Surface-water quality could be affected by stormwater runoff during building of a plant at the alternative sites. Existing streams on ORR Site 2 drain to Poplar Creek, Grassy Creek, and directly to the Clinch River. ORR Site 8 drains to the Melton Hill Reservoir and the Clinch River below Melton Hill Dam. Redstone Arsenal Site 12 drains to Indian Creek and Swan Pond, both of which are part of the Wheeler National Wildlife Refuge and drain to Wheeler Reservoir.

Building activities at the alternative sites would be required to conform to the conditions of a NPDES permit issued by the Tennessee Department of Environment and Conservation (TDEC) for ORR Sites 2 and 8, and by the Alabama Department of Environmental Management for Redstone Arsenal Site 12. An erosion and sediment control plan would be required as part of the NPDES permit, which would identify BMPs to be used to control the impacts of stormwater runoff. The review team assumed that engineered structures such as stormwater-management ponds would be used to control site runoff and minimize sediment transport offsite. As a result, stormwater runoff is not anticipated to affect the water quality of the local waterbodies.

No groundwater would be used to build a plant at the alternative sites. Dewatering would be required at the alternative sites during building to limit inflow to the power-block excavation. The review team determined in EIS Section 4.2 that the effects on groundwater use and quality of dewatering at the CRN Site would be minor. Because of their proximity to the CRN Site, the review team expects the occurrence and movement of groundwater at ORR Sites 2 and 8 to be similar to those at the CRN Site. The primary difference between the alternative sites on the ORR is the geologic units in which the excavations would occur. Excavation at ORR Site 2 would be in Conasauga Group formations, which are generally of low transmissivity and contain few karst features, with the exception of the uppermost unit, the Maynardsville Limestone. This unit is a significant pathway for contaminant transport in the eastern part of Bear Creek Valley on the ORR (DOE 2016-TN5072). At ORR Site 2, however, the Maynardsville Limestone formation occurs southeast of Bear Creek Road and outside the power-block excavation area (DOE 2013-TN5075). Excavation at ORR Site 8 would be in Knox Group formations. The majority of mapped karst features in the CRN Site region occur in the Knox Group (see Figure 2-34). Formations of the Knox Group are the most transmissive and serve as the principal source of groundwater in the region (TVA 2017-TN4922). Because of these hydrogeological differences, the review team expects that the rate of dewatering at ORR Site 2 would be less than at the CRN Site, and the rate of dewatering at ORR Site 8 would be larger than at the CRN Site. However, because the surface elevation of ORR Site 8 is higher than that at the CRN Site, the review team expects that the depth to groundwater may be greater at ORR Site 8, which would reduce the inflow of groundwater during excavation and would reduce the potential effects of dewatering on the surrounding groundwater. Like the CRN Site, ORR Site 8 is surrounded on three sides by the Clinch River, the likely discharge point for groundwater on the site, which also would reduce the potential offsite impacts of dewatering. The hydrogeological factors discussed above would limit the effects of dewatering on the surrounding groundwater. In addition, impacts from dewatering would be limited due to the temporary time frame of building. The review team also assumed that mitigation measures, such as grouting of significant fractures exposed during excavation, would be used at ORR Sites 2 and 8 as proposed for the CRN Site. Therefore, the review team concludes that the groundwater-use impacts of building a new nuclear power plant at ORR Sites 2 and 8 would be minor.

Based on the hydrogeologic description of the Interior Low Plateaus Physiographic Province and of Redstone Arsenal provided above, the review team assumed that groundwater at Redstone Arsenal Site 12 is shallow (it was stated to be 6–12 ft below ground surface in TVA 2016-TN5040), that the excavation would extend into the underlying aquifer, that there is significant karst development in the limestone aquifer, and that the shallow groundwater is connected to the nearby wetlands and surface waterbodies. Based on this description, the review team considered that dewatering of the excavation would be required, which would lower groundwater levels in the surrounding area. The review team assumed the dewatering rate required at Redstone Arsenal Site 12 would be larger than that at the CRN Site due to the differing groundwater conditions, with noticeable effects on the surrounding groundwater levels.

The review team assumed that the effect from dewatering at Redstone Arsenal Site 12 would be managed as described in Site Safety Analysis Report Section 2.5.4.6.2 (TVA 2017-TN5387), by grouting solution openings and fractures that conduct significant amounts of water, by using horizontal relief wells to lower groundwater levels behind the excavation walls, and by monitoring groundwater levels and nearby surface waterbodies potentially affected by the dewatering. Because there would be no groundwater use at Redstone Arsenal Site 12, the review team concludes that the effect of building activities on groundwater levels would be minor except during dewatering.

During building activities for a new nuclear power plant at the alternative sites, groundwater quality could be affected by dewatering discharge and leaching of spilled effluents into the subsurface. Discharge of water pumped from the excavation would be regulated under the NPDES permit. The review team assumes that the BMPs TVA has proposed for the CRN Site to prevent spills would also be in place at ORR Sites 2 and 8 and at Redstone Arsenal Site 12 during building activities, and therefore the review team concludes that any spills would be quickly detected and remediated. In addition, any effect on groundwater quality would be limited to the duration of these building activities, and therefore would be temporary. Therefore, the review team concludes that the effect on groundwater quality from building activities at ORR Sites 2 and 8 and Redstone Arsenal Site 12 would be minimal.

9.3.2.2.2 Operational Impacts

As described above, the source of water for plant cooling during operations at all three alternative sites would be surface water from a nearby reservoir. The review team assumed that water withdrawal and consumptive use during operations at the alternative sites would be identical to the flows for operating a plant at the CRN Site: an average withdrawal of 41.0 cfs (maximum of 68.4 cfs), and average (and maximum) consumptive use of 28.5 cfs. A plant at ORR Site 2 would withdraw water from the Clinch River arm of Watts Bar Reservoir just downstream from the CRN Site. A plant at ORR Site 8 would withdraw water from the Melton Hill Reservoir. Because Melton Hill Reservoir is operated by TVA as a run-of-the-river reservoir, the flow through the reservoir is approximately equivalent to the release from the dam. As described in EIS Section 2.3.1, although the flow in the Clinch River at the CRN Site is influenced by the operation of Watts Bar and Fort Loudon Dams, the average flow at the CRN Site is largely determined by the releases from Melton Hill Dam. Therefore, the flow characteristics at ORR Sites 2 and 8 are similar to the description of flow at the CRN Site provided in EIS Section 2.3.1.

Current reservoir operations policy requires a minimum daily average release from Melton Hill Reservoir of 400 cfs. The review team assumed that this minimum release would be provided continuously by the installation of the Melton Hill Dam bypass as proposed for the CRN Site (TVA 2017-TN4921). The minimum monthly release from Melton Hill Reservoir during the period 2004 to 2013 was 589 cfs, and the minimum annual average flow was 2,010 cfs during the relatively dry year of 2008 (EIS Section 2.3.1). The maximum withdrawal and consumptive use for a plant at the CRN Site, respectively, are 17.1 and 7.1 percent of the minimum required flow from Melton Hill Reservoir. Withdrawal and consumptive use, respectively, are 11.6 and 4.8 percent of the minimum monthly flow, and 3.4 and 1.4 percent of the minimum annual flow over the period 2004 to 2013. Because the ORR Site 2 intake and discharge would both be located on the Clinch River arm of the Watts Bar Reservoir, the review team determined that water-use impacts would arise from the plant's consumptive use, which is less than 10 percent of the minimum required flow at the site. These effects would be similar to those at the CRN Site, which the review team determined in EIS Section 5.2 would be minor. Because the intake for ORR Site 8 would be located on Melton Hill Reservoir and the discharge would be located below the dam, water-use impacts at ORR Site 8 would arise from the plant's withdrawals. The maximum withdrawal rate exceeds 10 percent of the minimum monthly release from Melton Hill Reservoir during the period 2004 to 2013. Based on this, the review team concludes that withdrawals of this magnitude may potentially result in noticeable effects on the reservoir level during extended drought periods.

A plant at Redstone Arsenal Site 12 would withdraw water from Wheeler Reservoir on the Tennessee River. Average flow through the Wheeler Reservoir is about 5.7 times the average flow through the Melton Hill Reservoir, and the 7-day, 10-year low flow (7Q10; i.e., the lowest flow for 7 consecutive days, expected to occur once per decade) in the Wheeler Reservoir (6,300 cfs) is about 16 times larger than the corresponding low flow in the Melton Hill Reservoir (TVA 2016-TN5040). Because the withdrawal and consumptive use during operations of a plant at Redstone Arsenal Site 12 would be the same as for a plant at the CRN Site, the review team determined that the larger flows through the Wheeler Reservoir would reduce the potential water-use impacts during operations at Redstone Arsenal Site 12 compared to the water-use impacts at the CRN Site. Therefore, the review team concludes that the effects of water use at Redstone Arsenal Site 12 on the water resource would be minor.

The review team assumed that plant discharges at the alternative sites would be the same as discharges at the CRN Site. Because the ORR Site 2 discharge is located about 1.5 mi downstream from the CRN Site discharge, the Clinch River water quality, flow characteristics, and river cross section are expected to be similar at both locations. Therefore, the review team determined that the water-quality impacts from operation of a plant at ORR Site 2 would be similar to those determined for a plant at the CRN Site. With the operation of a bypass at Melton Hill Dam discharging continuously at a rate of 400 cfs, the review team concludes that the surface-water-quality impacts from operation of a plant at ORR Site 2 would be minor. The discharge for a plant at ORR Site 8 would be located below Melton Hill Dam and about 4.5 mi upstream from the CRN Site intake. Water quality at the ORR Site 8 discharge location is expected to be similar to the water quality at the CRN Site discharge location. Because of its upstream location and close proximity to the Melton Hill Dam, the water depth and stream width at the ORR Site 8 discharge are expected to be less than those at the CRN Site discharge and the flow velocities are expected to be higher. Because the flow characteristics at the ORR Site 8 discharge location are somewhat different than at the CRN Site, the review team expects that the extent of the thermal plume would be somewhat different than that determined for the CRN Site discharge. However, because the average flow rates at ORR Site 8 would be similar to those at the CRN Site, the review team expects that the impacts of the discharge at the two sites would be similar. Prior to operation, TDEC would have the opportunity to specify conditions as part of the NPDES permit to minimize the impacts of the discharge. With the operation of a bypass at Melton Hill Dam discharging continuously at a rate of 400 cfs, the review team concludes that the effects on surface-water quality from operation of a plant at ORR Site 8 would be minor.

Discharges from a plant at Redstone Arsenal Site 12 would be to the Tennessee River Wheeler Reservoir south of the site. Designated uses for Wheeler Reservoir in Madison County are public water supply, swimming, and fish and wildlife, and the reservoir in the area of the discharge for Redstone Arsenal Site 12 was listed in 2016 as being impaired by agricultural nutrients (ADEM 2016-TN5097). There were no health-based restrictions on fish consumption from the Wheeler Reservoir in the area of the discharge in 2016 (ADPH 2016-TN5098). In 2011, TVA described the ecological health of the Wheeler Reservoir inflow as "Good" for fish and bottom life indicators, the mid-reservoir ecological health as "Good" for dissolved oxygen and sediment indicators, "Fair" for fish and bottom life indicators, and "Poor" for the chlorophyll indicator (TVA 2017-TN5099). As described above, the average flow and the 7Q10 low flow through the Wheeler Reservoir are significantly larger than the corresponding flows in the Clinch River arm of the Watts Bar Reservoir. In addition, the Tennessee River at the point of discharge for Redstone Arsenal Site 12 is about four times as wide as the Clinch River at the location of the CRN Site discharge. Because the discharge at Redstone Arsenal Site 12 would be the same as at the CRN Site discharge, but would be entering a much larger river with significantly greater flow, the review team expects that the area impacted by Redstone Arsenal Site 12 discharge would be similar to, or less than, the area impacted by the CRN Site discharge. In addition, the Alabama Department of Environmental Management would have the opportunity to specify conditions as part of the NPDES permit to minimize the impacts of the discharge. Therefore, the review team concludes that the effects on surface-water quality from operation of a plant at Redstone Arsenal Site 12 would be minor.

Groundwater would not be used during operations at any of the alternative sites. Therefore, there would be no groundwater-use impacts during operations. During operation at any of the alternative sites, impacts on groundwater quality could result from accidental spills. Spills that might affect the quality of groundwater would be prevented and mitigated by using BMPs as described above. Because BMPs would be used to mitigate spills and no intentional discharge to groundwater would occur, the review team concludes that the effects on groundwater quality from operation of a plant at the alternative sites would be minor.

9.3.2.2.3 Cumulative Impacts

In addition to water-use and water-quality impacts from building and operations activities, this cumulative analysis considers past, present, and reasonably foreseeable future actions that could affect the same water resources as those proposed for use by a new nuclear plant at an alternative site. For the cumulative analysis of impacts on surface water, the GAI for ORR Sites 2 and 8 is considered to be the same as that for the CRN Site, as described in EIS Section 7.2.1: the Clinch River basin and that portion of the Tennessee River that has potential effects on the Watts Bar Reservoir. The surface-water GAI for Redstone Arsenal Site 12 is that portion of the Tennessee River basin draining to Wheeler Reservoir. Because groundwater would not be used for operations, and would only be temporarily extracted during building as necessary for excavation dewatering, the review team considered the GAI for the cumulative analysis of impacts on groundwater to be the groundwater in the vicinity of the alternative sites.

As described in EIS Section 7.2, the surface-water hydrology in the Tennessee River basin has been extensively modified over time by the construction and operation of more than 40 power-producing and flood-control/recreation dams in the basin. The effects of these past modifications and current water uses are implicitly included in the current flows of the Clinch and Tennessee Rivers at the alternative sites. Future water-use projections in the basin, described in Section 7.2, indicated that water withdrawals for power production will decrease, while water use for public supply, industrial, and irrigation purposes will increase. Basin-wide consumptive water use from all use categories is projected to increase by 51 percent between 2010 and 2035 (Bohac and Bowen 2012-TN5026).

Based on a review of the history of water use and water resources planning in the Tennessee River basin, the review team determined that past and present use of the surface waters in the basin has been noticeable, necessitating consideration, development, and implementation of careful planning.

Of the projects listed in Table 7-1, the ones that were considered for cumulative impacts on the surface-water resource at ORR Sites 2 and 8 are the same as those considered for the CRN Site: the power plants, ORR, Oak Ridge National Laboratory, the Y-12 National Security

Complex (Y-12 Complex), ETTP, and additional industrial development and urbanization. All other projects listed in Table 7-1 either do not affect the surface-water resource or their surface-water use is insignificant. Because of their proximity to and use of Clinch River water, the cumulative surface-water-use impacts at ORR Sites 2 and 8 would be similar to those described in EIS Section 7.2 for the CRN Site, which were based on the review team's evaluation of whether future changes in water use would affect the availability of water to meet the minimum discharge requirement from Melton Hill Reservoir or necessitate a change in the reservoir operation. The projected increase in consumptive use in the Melton Hill and Norris Reservoir catchment areas of 9 Mgd (about 14 cfs) is 3.5 percent of the current minimum daily average discharge from the Melton Hill Reservoir (400 cfs), and would be less than 1 percent of the reservoir discharge about 80 percent of the time, based on current releases (TVA 2017-TN4921). The review team determined that the increase in future upstream consumptive use would have a minimal effect on the availability of water to maintain current Melton Hill Reservoir releases, and would not necessitate a change in the current reservoir operating policy. Therefore, the review team concludes that the cumulative surface-water-use effects of a plant at ORR Site 2 or 8 and the projects identified in Table 7-1 would be minor.

Of the projects listed in Table 9-2, the the ones that were considered for cumulative impacts on the surface-water resource at Redstone Arsenal Site 12 are the power plants, Redstone Arsenal, and additional industrial development and urbanization. All other projects listed in Table 9-2 either do not affect the surface-water resource or their surface-water use is insignificant. Within the Wheeler Reservoir watershed, total withdrawals in 2010 were dominated by surface-water withdrawals for thermoelectric power-generation use. Total consumptive water use in the same area was 76 Mgd (118 cfs) in 2010, 73 percent of which was for public water supply. Sixty-four percent of public water supply withdrawals were from surface-water sources. (Withdrawal and consumptive use data are from Bohac and Bowen 2012-TN5026). If the 2035 consumptive use for the Wheeler basin increases at the rate estimated by Bohac and Bowen (2012-TN5026) (a 51 percent increase from 2010 to 2035), this will increase the consumptive use in the Wheeler basin by about 39 Mgd (60 cfs). This additional consumptive use is about 1 percent of the current 7Q10 low flow for the Wheeler Reservoir. Even if all the future growth in consumptive use was obtained from the Wheeler Reservoir, this relatively small increase in future use would have a minimal effect on the availability of water to maintain current Wheeler Reservoir releases. Therefore, the review team determined that the cumulative surface-water-use impacts of a plant at Redstone Arsenal Site 12 and the projects identified in Table 9-2 would be minor.

Based on the proposed or possible projects listed in Table 7-1, additional impacts on groundwater use at ORR Sites 2 and 8 are expected to be minimal. Most of the projects are located outside the GAIs for groundwater at ORR Sites 2 and 8. In addition, surface water is the primary water source in the region and none of the projects in Table 7-1 are expected to significantly increase the overall use of groundwater. Groundwater is not proposed for use at ORR Sites 2 and 8, and any effects on groundwater from excavation dewatering at the alternative sites is limited by the hydrogeology of the area. Therefore, the review team determined that the cumulative groundwater-use impacts of a plant at ORR Sites 2 or 8 and the projects identified in Table 7-1 would be minor.

Because groundwater extraction at Redstone Arsenal Site 12 would only be for temporary dewatering of the power-block excavation, and because the general flow of groundwater is from the site south to the Tennessee River, the review team considered the GAI to be the groundwater within about 1 mi of the power-block area and between the site and the Tennessee River. Groundwater is used extensively in Madison County: 29 Mgd were withdrawn in 2010

(42 percent of total withdrawals in Madison County), 96 percent of which was for public supply use (Bohac and Bowen 2012-TN5026). Of the public water systems in Madison County identified in the U.S. Environmental Protection Agency's (EPA's) Safe Drinking Water Information System database, most rely primarily on surface water (TVA 2017-TN4922), and those that rely primarily on groundwater are located outside the GAI. Huntsville Utilities, which supplies drinking water to the City of Huntsville, relies primarily on surface water, but also obtains groundwater from a well located about 1 mi to the northwest of the Redstone Arsenal Site 12 power-block area. This well has the capacity to pump 4.5 Mgd from the limestone aquifer, but it is used only for emergency purposes, and its wellhead protection area is north of the Redstone Arsenal Site 12 power-block area (PNNL 2017-TN5460). Because this well is infrequently used and excavation dewatering would be temporary, the review team concludes that these activities would not be a significant contributor to cumulative groundwater-use impacts.

As described in EIS Section 7.2.2, continuing water-quality concerns in the lower Clinch River basin have led to impaired status, fish-consumption advisories, and Comprehensive Environmental Response, Compensation, and Liability Act actions for the Clinch River arm of the Watts Bar Reservoir. As a result, the review team determined that the water-quality impact on the Clinch River basin from past and present actions is noticeable.

The projects listed in Table 7-1 may result in alterations to the land surface, surface-water drainage pathways, and waterbodies. These projects would need Federal, State, and local permits that would require implementation of BMPs. Therefore, the impacts on surface-water quality from these projects are not expected to be noticeable. The discharge for a plant at ORR Site 2 is about 1 mi downstream from the CRN Site discharge location. Because these two discharge locations are so close, the review team determined that the cumulative water-quality impacts for ORR Site 2 would be comparable to those for the CRN Site described in EIS Section 7.2.2. The ORR Site 8 discharge is about 7 mi upstream from the CRN Site location, but the ORR Site 8 discharge is below Melton Hill Dam and the water quality of the Clinch River arm of the Watts Bar Reservoir is similar at both locations. Cumulative impacts from upstream projects is therefore expected to be similar to those at the CRN Site. The ORR Site 8 discharge is located about 1.5 mi upstream from the confluence with White Oak Creek. However, the review team determined in EIS Section 7.2.2 that successful waste management activities in the Melton Valley have minimized the potential for significant future downstream effects on Clinch River water quality from contamination in White Oak Creek. The review team concludes that there would be no significant cumulative water-quality impacts from ORR activities and a plant at ORR Site 8.

Because of extensive past and present use of and discharges to the Clinch River, the review team concludes that the cumulative impacts on surface-water quality in the Clinch River basin are noticeable. However, the cumulative impacts of building and operating a new nuclear power plant at ORR Site 2 or ORR Site 8 would not contribute significantly to the cumulative impacts in the GAI.

As described above, continuing water-quality concerns in Wheeler Reservoir have led to impaired status and concerns about ecological health. As a result, the review team determined that the water-quality impact on the Wheeler Reservoir portion of the Tennessee River from past and present actions is noticeable. The projects listed in Table 9-2 may result in alterations to the land surface, surface-water drainage pathways, and waterbodies. These projects would need Federal, State, and local permits that would require implementation of BMPs. Therefore, the impacts on surface-water quality from these projects are not expected to be noticeable. The discharge for a plant at Redstone Arsenal Site 12 is located south of the site in the Wheeler

Reservoir. None of the projects identified in Table 9-2 would produce a significant water-quality impact in the Wheeler Reservoir that would interact with the plume from the Redstone Arsenal Site 12 discharge.

Because of extensive past and present use of and discharges to the Tennessee River, the review team concludes that the cumulative impacts on surface-water quality in the Wheeler Reservoir are noticeable. However, the cumulative impacts of building and operating a new nuclear power plant at Redstone Arsenal Site 12 would not contribute significantly to the overall cumulative impacts in the GAI.

Past activities on the ORR and the Redstone Arsenal have noticeably altered the groundwater quality, particularly in localized waste-disposal areas. Therefore, the review team concludes that the cumulative groundwater-quality impacts of past, present, and reasonably foreseeable future projects would be noticeable. Based on the proposed or possible projects listed in Table 7-1 and Table 9-2, additional impacts on groundwater quality at ORR Sites 2 and 8 and at Redstone Arsenal Site 12 are expected to be minimal. Most of the projects are located outside the GAIs for groundwater at the alternative sites. As discussed above, BMPs would be implemented to minimize groundwater contamination and quickly remediate any inadvertent spills at the alternative sites. Activities in the prime developable land north of the Redstone Arsenal Site 12 power-block area may be restricted because a portion of this land lies within the wellhead protection area for the City of Huntsville's water supply. Engineering controls would be used to limit the impacts of dewatering activities during building, and dewatering would be temporary. No groundwater would be used during building or operation of plants at any of the alternative sites. Therefore, the review team concludes that the cumulative groundwater-quality impacts of a new plant at the alternative sites would not be significant.

9.3.2.2.4 Summary of Water-Use and Water-Quality Impacts at Alternative Sites

Mainly because of extensive past and present use of surface waters from the Tennessee and Clinch Rivers, the review team concludes that the cumulative surface-water use and surface-water-quality impacts from past and present actions and building and operating a new nuclear power plant at each of the three alternative sites would be MODERATE. However, the review team further concludes that a new plant's incremental contribution to the cumulative impacts at each of the sites would not be significant.

Groundwater has not been used extensively in the past in the area of ORR Sites 2 and 8 and its use is not expected to increase significantly in the future. Groundwater is used extensively in Madison County, but these uses are outside the GAI for Redstone Arsenal Site 12, with the exception of an emergency well that is part of the City of Huntsville's water supply system. Because a new nuclear power plant at ORR Sites 2 and 8 would not use groundwater, and the effects of dewatering at the sites would be limited by the local hydrogeology and by engineering controls, the review team concludes that the cumulative groundwater-use impacts at ORR Sites 2 and 8 would be SMALL. Although a new nuclear power plant at Redstone Arsenal Site 12 would not use groundwater, there would be noticeable effects on local groundwater levels during dewatering. Therefore, the review team concludes that the cumulative groundwater-use impacts at Redstone Arsenal Site 12 would be MODERATE during the temporary period of dewatering and SMALL otherwise. A new plant's incremental contribution to the cumulative groundwater-use impacts would be significant during the period of dewatering.

Mainly because of past activities on the ORR and the Redstone Arsenal, the review team concludes that the cumulative groundwater-quality impacts of past, present, and reasonably foreseeable future projects at each of the three alternative sites would be MODERATE.

Because no groundwater would be used at the alternative sites, and dewatering would be temporary, the review team concludes that a new plant's incremental contribution to the cumulative groundwater-quality impacts at each of the alternative sites would not be significant.

9.3.2.3 Terrestrial and Wetland Resources

The following analysis includes potential impacts on terrestrial and wetland resources resulting from building and operating at least two SMRs on ORR Site 2, ORR Site 8, and Redstone Arsenal Site 12. The analysis also considers other past, present, and reasonably foreseeable future actions that may impact terrestrial and wetland resources, including the other Federal and non-Federal projects listed in Table 7-1 and Table 9-2. For the analysis of terrestrial ecological impacts at ORR Site 2 and ORR Site 8, the GAI is defined as being within about 6 mi of each site in order to encompass an offsite buried 69-kV transmission line that would connect each to the Bethel Valley Substation (similar to the buried 69-kV transmission line proposed for the CRN Site). In accordance with ESRP Section 9.3 (NRC 2000-TN614, NRC 2007-TN5141), the alternative site evaluation requires the use of reconnaissance-level information. Reconnaissance-level information is data readily available from agencies and other public sources (e.g., scientific literature, books, and Internet websites) and information obtained from site visits. Consequently, TVA did not conduct a transmission interconnection study to identify the offsite transmission lines that would need upgrades (rebuilding, reconductoring, or uprating) for ORR Site 2 and ORR Site 8. However, TVA has stated that many or all of the transmission lines TVA identified that would need to be upgraded for the CRN Site, likely would also require upgrades for ORR Site 2 and ORR Site 8. Thus, the review team assumes for ORR Site 2 and ORR Site 8 the same impacts that would result from upgrading the offsite transmission lines for the CRN Site (see EIS Sections 4.3.1.2 and 4.3.1.3). For the analysis of terrestrial ecological impacts at Redstone Arsenal Site 12, the GAI is defined as being within about 6 mi of the site in order to encompass a new offsite transmission line and the intake and discharge pipeline corridors (TVA 2016-TN5040). TVA has stated that some existing offsite transmission lines likely would also need to be upgraded for Redstone Site 12. Lacking a transmission interconnection study to identify these lines, the review team will likewise assume for Redstone Site 12 the same impacts that would result from upgrading the offsite transmission lines for the CRN Site. Because offsite transmission line upgrades cannot be used to differentiate impacts from use of the CRN Site, ORR Site 2, ORR Site 8, and Redstone Site 12, they will not be discussed further.

To identify terrestrial resources at ORR Site 2, ORR Site 8, and Redstone Site 12, the review team relied primarily on the following information:

- tours of ORR Sites 2 and 8 by the review team as part of the site audit in May 2017 (NRC 2018-TN5386)
- tour of Redstone Arsenal Site 12 by the review team during pre-application in July 2015 (NRC 2015-TN5408)
- provision of supplemental information by TVA (TVA 2016-TN5040, TVA 2017-TN4920, TVA 2017-TN5028)
- correspondence from Federal and State agencies regarding important species and habitats (discussed in EIS Section 4.3.1.3).

ORR Site 2 and ORR Site 8 are located in Roane County, Tennessee, in close proximity to the CRN Site (roughly 2 mi and 5 mi to the west and east, respectively) and are similarly situated adjacent to the north shoreline of the Clinch River (Figure 9-5). Based on proximity and landscape similarity, site visit observations, and the information provided by TVA in its ER

(TVA 2017-TN4921), the review team believes that ORR Site 2 and ORR Site 8 support terrestrial and wetland resources generally similar to those described in EIS Section 2.4.1.1 for the CRN Site. One notable difference is that ORR Sites 2 and 8 support more forest cover that is less fragmented than that on the CRN Site, which had previously been partially cleared for the terminated Clinch River Breeder Reactor Project. There also appear to be fewer streams and wetlands on ORR Site 8 than on the CRN Site or ORR Site 2. Forest cover on both ORR Site 2 and ORR Site 8 exceeds 90 percent (Table 9-3), whereas land-cover percentages indicative of past disturbance on the sites are less than 10 percent (Table 9-3). There is therefore more contiguous forest and less forest edge habitat on both ORR sites than on the CRN Site. ORR Sites 2 and 8 may also support a greater diversity and/or abundance of forest interior species owing to greater expanses of contiguous forest cover. There are about 12 ac of wetland cover on ORR Site 2 but less than 1 ac of wetland cover on ORR Site 8 (Table 9-3).

Redstone Arsenal Site 12 is located in Madison County, Alabama, and is situated in the Eastern Highland Rim subdivision of the Interior Plateau ecoregion. The Interior Plateau ecoregion extends from southern Indiana and Ohio into central Kentucky and Tennessee, and covers a portion of northern Alabama (Wiken et al. 2011-TN2744). Landforms in this subdivision consist mostly of weakly dissected plateaus and irregular plains, nearly level to gently rolling; some sinkholes and depressions; low-to-moderate gradient gravel- and bedrock-bottomed streams; and springs (EPA 2017-TN5135). Elevations range from 450 to 950 ft MSL (EPA 2017-TN5135). Natural vegetation is mostly oak-hickory forest, but transitional between the more xeric oak-hickory forest to the west and the more mesic mixed mesophytic forest to the east, with areas of cedar glades and bottomland hardwoods (EPA 2017-TN5135). Land uses in the ecoregion are a mix of forest, woodlots, pasture, and cropland with some expanding urban areas (Wiken et al. 2011-TN2744; EPA 2017-TN5135).

At Redstone Arsenal, pines occur in association with hardwoods in isolated stands. Forested habitats on the Arsenal include hardwood, mixed hardwood and pine, pine, and riparian and bottomland hardwood forest. Approximately 50 percent of the pine area on Redstone Arsenal consists of pine plantations. The most extensive forest type is hardwood, which occurs mainly in bottomland areas and in a few large stands on rocky slopes. Redstone Arsenal contains extensive wetland areas associated with the Tennessee River and several local springs. Wetlands cover over 20 percent of Redstone Arsenal (TVA 2017-TN4921).

Redstone Arsenal Site 12 is located in an area that is almost entirely forested. Forest composes the majority of land cover on the site, a little more than half of which is deciduous forest, followed by evergreen and mixed forest types (Table 9-3). Much of Redstone Site 12 is bottomland, as indicated by the extensive deciduous forest (about 199 ac) onsite. Extensive woody wetlands compose about 12 percent of the land cover (Table 9-3).

Regarding important species, TVA provided no new field survey information for ORR Site 2 and ORR Site 8 and the review team is unaware of any field surveys at these locations. The presence or absence of Federally listed, State-listed, and State-ranked species and communities in the project footprints cannot be ascertained without field surveys.

A query of the Tennessee Natural Heritage Program database (TNHP 2017-TN5361) produced a list of important species within 2 mi of ORR Site 2 and within 2 mi of ORR Site 8 (Table 9-4). The list in Table 9-4 also applies (but is not specific) to the intake and discharge pipelines for both ORR Site 2 and ORR Site 8, because all four pipelines are less than 2 mi long (TVA 2016-TN5040). The list in Table 9-4 also applies (but is not specific) to the first 2 mi of the two new buried 69-kV transmission lines (one each for ORR Site 2 and ORR Site 8), but not to the more

1 **Table 9-4. Important Species within 2 Mi of ORR Site 2 and ORR Site 8 (TNHP 2017-TN5361).**

Scientific Name	Common Name	Alternative Site	Federal Status[a]	State Status[a]	State Rank[b]	Potentially Suitable Habitat Onsite[c]	Habitat
Mammals							
Myotis grisescens	gray bat	ORR 2	E	E	S2	Y	Cave obligate year-round; frequents forested areas; migratory (TDEC 2017-TN5217).
Sorex dispar	long-tailed shrew	ORR 2, ORR 8		D	S2	Y ORR Site 8	Mountainous, forested areas with loose talus (TDEC 2017-TN5217).
Birds							
Accipiter striatus	sharp-shinned hawk	ORR 2, ORR 8		D	S3B	Y	Forests and open woodlands (TDEC 2017-TN5217). Young, dense, mixed or coniferous woodlands are preferred for nesting (LeGrand et al. 2015-TN5188).
Aimophila aestivalis	Bachman's sparrow	ORR 2, ORR 8		E	S1B	Y	Dry open pine with an undercover of grasses and shrubs, hillsides with patchy brushy areas, overgrown fields with thickets and brambles, grassy orchards, and large clear-cuts. Breeding habitat is overgrown fields with scattered saplings, and open woods with thick grass cover (LeGrand et al. 2015-TN5188).
Amphibians							
Aneides aeneus	green salamander	ORR 2, ORR 8			S3S4	Y	Damp crevices in shaded rock outcrops and ledges; beneath loose bark and cracks of trees and sometimes in/or under logs (TDEC 2017-TN5217).
Reptiles							
Ophisaurus attenuatus longicaudus	eastern slender glass lizard	ORR 2, ORR 8		D	S3	Y	Dry upland areas including brushy, cut-over woodlands and grassy fields (TDEC 2017-TN5217).
Pituophis melanoleucus	northern pinesnake	ORR 2, ORR 8		T	S3	Y	Well-drained sandy soils in pine/pine-oak woods (TDEC 2017-TN5217).

Table 9-4. (contd)

Scientific Name	Common Name	Alternative Site	Federal Status[(a)]	State Status[(a)]	State Rank[(b)]	Potentially Suitable Habitat Onsite[(c)]	Habitat
Plants							
Agalinis auriculata	earleaved false-foxglove	ORR 2		E	S2	N	Barrens (TDEC 2017-TN5217).
Aureolaria patula	spreading false-foxglove	ORR 2, ORR 8		S	S3	Y	Oak woods and edges (TDEC 2017-TN5217).
Bolboschoenus fluviatilis	river bulrush	ORR 8		S	S1	Y	Marshes (TDEC 2017-TN5217).
Delphinium exaltatum	tall larkspur	ORR 2		E	S2	N	Glades and barrens (TDEC 2017-TN5217).
Draba ramosissima	branching whitlow-grass	ORR 2		S	S2	Y ORR Site 8	Calcareous bluffs (TDEC 2017-TN5217).
Eurybia schreberi	Schreber's aster	ORR 8		S	S1	Y ORR Site 8	Mesic woods and seepage slopes (TDEC 2017-TN5217).
Helianthus occidentalis	naked-stem sunflower	ORR 2		S	S2	N	Limestone glades and barrens (TDEC 2017-TN5217).
Juglans cinerea	butternut	ORR 8		T	S3	Y	Rich woods and hollows (TDEC 2017-TN5217).
Liatris cylindracea	slender blazing-star	ORR 2		T	S2	N	Barrens (TDEC 2017-TN5217).
Oligoneuron album	prairie goldenrod	ORR 2		E	S1S2	N	Barrens (TDEC 2017-TN5217).
Panax quinquefolius	American ginseng	ORR 2, ORR 8		S-CE	S3S4	Y	Rich woods and hollows (TDEC 2017-TN5217).
Platanthera flava var. herbiola	tubercled rein-orchid	ORR 2		T	S2	Y	Swamps and floodplains (TDEC 2017-TN5217).
Pseudognaphalium helleri	Heller's catfoot	ORR 2		S	S2	Y	Dry sandy woods (TDEC 2017-TN5217).
Spiranthes lucida	shining ladies'-tresses	ORR 2		T	S1S2	Y	Alluvial woods and moist slopes (TDEC 2017-TN5217).

(a) E = endangered; T = threatened; S = special concern; D = deemed in need of management; CE = commercially exploited; B=breeding.
(b) S1 = extremely rare, having 5 or fewer occurrences in the State; S2 = very rare, having 6 to 20 occurrences in the State; S3 = rare and uncommon, having 21 to 100 occurrences in the State.
(c) Single “Y” or “N” applies to both ORR Site 2 and ORR Site 8, unless otherwise indicated.

distant portions (roughly 3 mi) of these two lines that would connect to the Bethel Valley Substation. TVA did not provide possible routings for these two new buried 69-kV transmission lines at ORR Site 2 and ORR Site 8, but stated they would be collocated with other transmission lines within existing corridors. Thus, it is likely that the number of important species potentially within these corridors is low, such as within the existing corridor that would contain the new buried 69-kV transmission line at the CRN Site.

With few exceptions, the same important species likely to occur within 2 mi of the CRN Site are also likely to occur within 2 mi of ORR Sites 2 and 8 (Table 9-4 and 2.2-4). Of the species listed in Table 9-4, only the gray bat (*Myotis grisescens*) is Federally listed under the Endangered Species Act. Although the Tennessee Natural Heritage Program data presented in Table 9-4 do not indicate the possible presence of the Indiana bat (*Myotis sodalis*) or northern long-eared bat (*Myotis septentrionalis*), the review team considers both to be potentially present, considering the proximity of the sites to the CRN Site and the presence of similar deciduous forest habitat. The life histories of these three species are provided in EIS Section 2.4.1.11.

Notable differences between ORR Site 2 and ORR Site 8 and the CRN Site also include overlapping important habitats on the two alternative sites. ORR Site 2 encompasses the 20-ac Northwest Pine Ridge Natural Area (Baranski 2009-TN5133), the 7-ac ETTP Filtration Plant Wetland Natural Area (Baranski 2009-TN5133), a Potential Habitat Area (a designation that indicates it may support a commercially exploited, State-listed species), and a small portion of the Grassy Creek Powerline Area (51 ac managed cooperatively among agencies for special purposes such as wildlife management) (TVA 2017-TN4921). The Northwest Pine Ridge Natural Area and ETTP Filtration Plant Wetland Natural Area have been ranked as belonging to priority group II (medium priority for protection) and III (low priority for protection), respectively, of ORR natural areas based on size, number of rare species (Federally listed, State listed, State ranked), number of endangered or threatened species, rarity of endangered or threatened species on the ORR, community and landscape diversity, integrity and quality, disturbance, defensibility, and manageability, and other factors (Baranski 2009-TN5133). The Nature Conservancy has assigned half of the Northwest Pine Ridge Natural Area a biodiversity significance rank of 2 (BSR-2; very high significance—one of most outstanding examples of any community element; areas containing intermediate-ranked elements and occurrences; concentrations of intermediate-ranked elements) (range from BSR-1 outstanding significance to BSR-5 general biodiversity interest) (Baranski 2009-TN5133). No BSR level was assigned to the ETTP Filtration Plant Wetland Natural Area (Baranski 2009-TN5133). About 27 ac of ORR Site 2 (comprising the above two natural areas) is located within the 20,000 ac on the ORR that have been designated a DOE NERP, an International Biosphere Reserve, and part of the Southern Appalachian Man and the Biosphere Cooperative (Baranski 2009-TN5133).

ORR Site 8 is overlapped by three ORR natural areas. Approximately half of ORR Site 8 is overlapped by the 293-ac Tower Shielding Bluffs Natural Area (Baranski 2009-TN5133) located along the shoreline of Melton Lake southeast of the Tower Shielding Facility (AFORR 2011-TN5134). This area includes oak-hickory forest with some mesic species such as sugar maple (*Acer saccharum*), steep slopes, and two rare or uncommon plant species—spreading false-foxglove (*Aureolaria putula*) (Table 9-4) and Carey saxifrage (*Saxifraga careyana*) (AFORR 2011-TN5134). Much of the remainder of Site 8 is within the 108-ac Melton Dam River Bluffs Natural Area (Baranski 2009-TN5133). This natural area supports diverse forest community types: tulip tree mixed hardwood with pine, Ridge and Valley Ecoregion calcareous mixed mesophytic forest, chestnut oak tulip tree-northern red oak-hickory, chestnut oak-tuliptree-northern red oak-hickory-white oak, and hickory-red cedar-Virginia pine. Forests are mostly open second growth, with some older stands. There are recent disturbances from fire management roads (Baranski 2009-TN5133). Landscape features in this natural area include caves, limestone sinkholes, steep slopes, limestone outcrops, calcareous cliffs, moist ravines, springs, seeps, and forested wetlands (AFORR 2011-TN5134). The natural area supports rare or uncommon plants that include heavy sedge (*Carex gravida*), American ginseng (*Panax quinquefolius*) (Table 9-4), Pursh's wild-petunia (*Ruellia purshiana*), and three-parted violet (*Viola tripartita* var. *tripartita*) (AFORR 2011-TN5134). The narrow western portion of ORR Site 8 lies within the 519-ac Dry River Bluffs and Cave Natural Area. This area supports a large variety of communities, including oak-hickory-ash limestone woodland, oak-hickory, mixed pine/hardwood, natural mature white pine, cedar forest, and forested wetlands. Forests are mostly open second growth. Landscape elements include sinkholes, caves, ravines, calcareous steep cliffs, outcrops, springs, seeps, ponds, etc. (Baranski 2009-TN5133). The Tower Shielding Bluffs Natural Area and Melton Dam River Bluffs Natural Area have been ranked as belonging to priority group II (medium priority for protection), and Dry River Bluffs and Cave Natural Area has been ranked as belonging to priority group I (high priority for protection). The Nature Conservancy has assigned much or part of the Melton Dam River Bluffs Natural Area and the Dry River Bluffs and Cave Natural Area a biodiversity significance rank of BSR-3 (high significance—lower ranked occurrences of lower ranked elements but excellent examples of any community) (Baranski 2009-TN5133). No BSR level was assigned to the Tower Shielding Bluffs Natural Area (Baranski 2009-TN5133). Most of ORR Site 8 (comprising the above three natural areas) is located within the 20,000 ac of the ORR that has been designated a DOE NERP, an International Biosphere Reserve, and part of the Southern Appalachian Man and the Biosphere Cooperative (Baranski 2009-TN5133).

TVA provided no new field survey information for Redstone Site 12, and the review team is unaware of any field surveys at this location. The presence or absence of specific species cannot be ascertained without field surveys.

The Alabama Natural Heritage Program database (ANHP 2017-TN5398) was queried regarding important species within 2 mi of Redstone Site 12 and within 0.125 mi of the new offsite transmission line that would be required to connect the site to the grid. The query for within 2 mi of Redstone Site 12 also applies to the intake and discharge pipelines, because both are about 2 mi long (TVA 2016-TN5040). Only one species—the gray bat—was noted as occurring within 2 mi of Redstone Site 12. No species were noted as occurring within 0.125 mi of the new transmission line (TVA 2016-TN5040). No important habitats were noted within 2 mi of Redstone Site 12 within 0.125 mi of the new transmission line.

9.3.2.3.1 Building Impacts

The review team reasonably assumes that the entirety of the 547-ac ORR Site 2 and the 424-ac ORR Site 8 (Table 7-1) would be permanently or temporarily disturbed to build two or more SMRs and associated support facilities, laydown areas, etc. About 27 ac of the disturbance on ORR Site 2 would include the two ORR natural areas described in the previous subsection that are part of the ORR NERP. Most of the disturbance on ORR Site 8 would include portions of the three ORR natural areas described above that are part of the ORR NERP. The acreages of the land-cover types on ORR Site 2 and ORR Site 8 that would be developed for construction and preconstruction of at least two SMRs are provided in Table 9-3. About 494 ac and 390 ac of upland forest habitat (deciduous, mixed, and evergreen) would be disturbed by development of ORR Site 2 and ORR Site 8, respectively (Table 9-3). About 12 ac and 0.4 ac of woody wetlands would be affected on ORR Site 2 and on ORR Site 8, respectively (Table 9-3).

The acreages in Table 9-3 do not include the corridors that would need to be cleared for the intake and discharge pipelines at ORR Site 2 and ORR Site 8. Clearing the corridors would impact primarily an unquantified additional amount of forest habitat at each site. The acreages in Table 9-3 also do not include the burial of a new 69-kV transmission line which, as noted above, would likely be within existing transmission line corridors that connect ORR Site 2 and ORR Site 8 to the Bethel Valley Substation. Thus, burial of the 69-kV transmission lines would affect artificially maintained right-of-way habitat and may affect any wetlands in these corridors for each site. The acreages in Table 9-3 also do not include the installation of an access road for ORR Site 8 (there is an existing road with access to ORR Site 2), which would further fragment and degrade forest habitat.

The impacts on upland forest habitat on ORR Site 2 and ORR Site 8 and on wetlands on ORR Site 2 would be noticeable and the loss of forest would fragment and degrade the surrounding forest habitat. It would also affect 27 ac of the ORR NERP within ORR Site 2 (i.e., the two ORR natural areas described in the previous subsection), about 10 ac of which support terrestrial resources of very high biological significance. It would also affect the portion of the ORR NERP that occurs within ORR Site 8 (i.e., most of the site is overlapped by the three ORR natural areas described in the previous subsection), much of which supports terrestrial resources of high biological significance. The review team also recognizes that use of either ORR site could reduce foraging habitat available to the Indiana bat, northern long-eared bat, and gray bat.

The review team reasonably assumes that the entirety of the 449-ac Redstone Site 12 (TVA 2017-TN5028) (Figure 9-6) would be disturbed for construction of two or more SMRs. The acreages of the land-cover types on Redstone Site 12 that would be affected by construction and preconstruction of at least two SMRs are provided in Table 9-3. About 364 ac of upland forest habitat (deciduous, evergreen, and mixed) would be disturbed by development of Redstone Site 12 (Table 9-3). About 53 ac of woody wetlands would be affected onsite (Table 9-3).

The acreages in Table 9-3 do not include the corridors that would need to be cleared for the intake and discharge pipelines or for the new offsite buried 69-kV transmission line. Clearing these corridors would impact an unquantified amount of additional forest habitat.

The impacts on upland forest habitat and to wetlands on Redstone Site 12 would be noticeable and the loss of forest and wetland would fragment and degrade the surrounding forest and wetland habitat.

9.3.2.3.2 Operation Impacts

Impacts on terrestrial ecological resources from operation of two or more SMRs at either ORR Site 2 or ORR Site 8 would be minor and similar to those for the proposed CRN Site, as described in EIS Section 5.3.1.

Impacts on terrestrial ecological resources from operation of two or more SMRs at Redstone Site 12 would also be minor and similar to those for the proposed CRN Site, as described in EIS Section 5.3.1. The review team expects operation of the units at Redstone Site 12 would involve use and maintenance of generally similar facilities in a mostly forested landscape similar to the landscape surrounding the CRN Site. The review team also recognizes that the GEIS (NRC 2013-TN2654) for license renewal of nuclear power plants concludes that impacts on terrestrial resources from operations nuclear plants are SMALL.

9.3.2.3.3 Cumulative Impacts

The GAIs for ORR Site 2 and ORR Site 8 have been exposed to historic and ongoing land-use changes similar to the GAI for the CRN Site (see EIS Section 7.3.1.1). The portion of the GAIs that is south of the Clinch River has been open to development since European settlement, whereas much of the land north of the river has had limited development since establishment of the ORR in the 1940s. Because of the close proximity of the CRN Site to ORR Site 2 and ORR Site 8, the past, present, and reasonably foreseeable land-use activities are considered to be similar in all three GAIs. Thus, as described for the CRN Site in EIS Section 7.3.1.1, terrestrial and wetland resources in the GAIs of ORR Site 2 and ORR Site 8 have also been significantly altered since the time of European settlement, mostly by agriculture, timber harvest, coal mining, and hydropower development. This is reflected in the percentages of land cover that is forest in the 6-mi vicinity of ORR Site 2 and ORR Site 8 (Table 9-5). This forest reduction is most notable outside the ORR (compare 90 percent forest cover within ORR Site 2 and ORR Site 8 [described above] with roughly 60 and 50 percent forest cover in their respective GAIs in Table 9-5).

Table 9-5. 2016 Land Cover in the 6-Mi GAI of the Alternative Sites

	ORR Site 2		ORR Site 8		Redstone Site 12	
Land Cover	Acres	Percent	Acres	Percent	Acres	Percent
Open Water	2,662.1	3.7	3,387.5	4.7	5,043.7	7.0
Crops	602.0	0.8	892.5	1.2	6,792.4	9.4
Barren	174.8	0.2	281.0	0.4	126.3	0.2
Existing Development	10,242.6	14.2	16,193.7	22.4	13,513.1	18.7
Deciduous Forest	43,358.7	59.9	35,451.9	49.0	17,533.6	24.2
Evergreen Forest	1,738.2	2.4	1,645.1	2.3	7,023.9	9.7
Mixed Forest	1,342.6	1.9	1,210.0	1.7	1,781.8	2.5
Shrubland	670.5	0.9	265.1	0.4	2,954.3	4.1
Grass/Pasture	10,572.9	14.6	12,340.0	17.0	9,619.2	13.3
Herbaceous Wetlands	2.7	<0.1	1.8	<0.1	8.2	<0.1
Woody Wetlands	1,016.6	1.4	714.1	1.0	7,987.1	11.0
Totals	72,382.7	100.0	72,383.7	100.0	72,383.6	100.0

Source: (NASS 2017-TN5144).

Overlaying the historic and ongoing activities noted above are commercial, industrial, and residential land uses, which tend to more fully and permanently convert the landscape to a more artificial state. Current projects within the GAIs of ORR Site 2 and ORR Site 8 include Federal facilities on the adjacent ORR (e.g., Uranium Processing Facility); hydropower facilities that either are located within the GAI (Melton Hill Hydroelectric) or outside the GAI but still affect upstream riparian and floodplain terrestrial resources within it (Watts Bar Dam); mining (various); transportation (e.g., Oak Ridge Airport and miscellaneous road and traffic projects); manufacturing (e.g., LeMond Composites, Proton Power) (Table 7-1); natural and habitat protection areas, most of which are located on the ORR (Table 2-5 and Figure 2-28); and others (e.g., Diversified Scientific Services, Inc., Energy Solutions, LLC Bear Creek Facility, Materials and Energy Corporation) (Table 7-1). Also included are areas of suburban/residential development, mostly in the communities of Farragut and Lenoir City located south of the Clinch River within the GAI of ORR Site 8. The development of a general aviation airport on the ORR would noticeably reduce, fragment, and degrade surrounding forest habitat both on the ORR and in the GAI (as has the existing ETTP and housing development on the ORR), as well as pose a risk of air strikes with birds and noise disturbance to wildlife in surrounding areas. The development of most of these projects has or will further reduce, fragment, and degrade forests and decrease their connectivity in the GAI beyond that caused by the historical and ongoing activities described above. Development would also tend to locally decrease forest interior wildlife in favor of forest edge wildlife. In contrast, existing ORR natural areas (Baranski 2009-TN5133) protect local terrestrial resources, particularly large, contiguous blocks of forest and associated forest interior wildlife, for the foreseeable future.

The GAI for Redstone Site 12 has been exposed to historic and ongoing land-use changes both within and outside the Redstone Arsenal. Prior to Army acquisition of the area in 1941, the area that is now Redstone Arsenal included rural communities of small farms. Since 1941, Redstone Arsenal has experienced limited development, mostly within the area of the headquarters located to the northeast and within the GAI of Redstone Site 12. This is reflected in the relatively high percentage of land cover that is forest within Redstone Site 12 (Table 9-3) compared to much lower forest cover in the 6-mi vicinity of (Table 9-5). More extensive agricultural development in the GAI has occurred to the west and south of Redstone Site 12. Agricultural development has played a role in shaping terrestrial and wetland resources in the GAI of Redstone Site 12.

Overlaying the historic and ongoing activities described above are commercial, industrial, and residential land uses, which tend to more fully and permanently convert the landscape to a more artificial state. Current projects within or bordering the GAI of Redstone Site 12 include energy projects (e.g., natural-gas-fired plants such as Covanta Huntsville, Inc.); miscellaneous transportation projects); various manufacturing companies (e.g., Kohler Company); urban and suburban residential development in the City of Madison (which abuts the northwest boundary of the Arsenal); Wheeler National Wildlife Refuge (adjacent to the southern boundary of Redstone Arsenal along the Tennessee River); and others (including facilities on Redstone Arsenal) (Table 9-2). The development of most of these projects has or will further reduce, fragment, and degrade forests and wetland habitat and decrease their connectivity beyond that caused by the historical and ongoing agricultural described above. In contrast, Wheeler National Wildlife Refuge protects large areas of forest and forested wetlands along the Tennessee River in perpetuity.

9.3.2.3.4 Summary of Terrestrial and Wetland Resource Impacts at Alternative Sites

Impacts on terrestrial ecology resources are estimated based on the sources of information listed in the introduction and the review team's independent evaluation. Site preparation and development of ORR Site 2 and ORR Site 8 (including intake and discharge water pipelines at each site and an access road for ORR Site 8) and burial of an offsite 69-kV transmission line within existing corridors at each site, would noticeably and permanently affect forest habitat and forest interior wildlife. There are also 1 Federally listed and several State-listed and State-ranked species that potentially occur on ORR Site 2 and ORR Site 8 (Table 9-4), as well as important habitats (ORR natural areas that are part of the ORR NERP), that would also be affected. Removal of portions or all of these ORR natural areas on ORR Site 2 and ORR Site 8 would reduce the size of and further fragment the NERP and therefore compromise its integrity. Combined with the cumulative effects of other forest removal on the ORR due to existing and future projects, this would compromise the landscape-scale integrity of terrestrial resources on the ORR, which has been recognized over past decades for its unfragmented forests and high biodiversity. There are also past, present, and future activities and projects in the GAIs of ORR

Site 2 and ORR Site 8 that are outside of the ORR and have affected and would continue to affect the same habitat, wildlife, and important species and habitats in ways similar to site preparation and development of ORR Site 2 and ORR Site 8.

The review team concludes that the cumulative impacts from past, present, and reasonably foreseeable future actions, including two or more new SMRs at ORR Site 2 or ORR Site 8, on baseline conditions for terrestrial ecological resources in the GAIs of these sites would be LARGE. The LARGE conclusion is based primarily on the fact that use of either ORR Site 2 or 8 would further reduce and fragment the blocks of deciduous forest composing the NERP, which has provided a relatively undisturbed block of deciduous forest for use by ecological researchers for several decades. Building and operating two or more SMRs at ORR Site 2 and ORR Site 8 would be a significant contributor to the LARGE impact for both sites.

Impacts on terrestrial ecology resources for Redstone Site 12 are estimated based on the sources of information listed in the introduction and the review team's independent evaluation. Site preparation and development of Redstone Site 12 (including intake and discharge water pipelines and new transmission line corridor), would noticeably and permanently affect forest habitat, forested wetlands, and forest interior wildlife. There is one Federally listed species that potentially occurs on Redstone Site 12 that would also be affected. There are also past, present, and future activities and projects in the GAI of Redstone Site 12, especially outside but also within the Redstone Arsenal, which have affected and would continue to affect the same habitat, wildlife, and important species in ways similar to site preparation and development of Redstone Site 12.

The review team concludes that the cumulative impacts from past, present, and reasonably foreseeable future actions, including two or more new SMRs at Redstone Site 12, on baseline conditions for terrestrial ecological resources in the GAI of this site would be MODERATE. Building and operating two or more new SMRs at Redstone Site 12 would be a significant contributor to the MODERATE impact.

9.3.2.4 Aquatic Resources

The analysis in this section evaluates the impacts from building activities and operations on aquatic ecology resources at ORR Site 2, ORR Site 8, and Redstone Arsenal Site 12. The analysis also considers cumulative impacts from other past, present, and reasonably foreseeable future actions, including the other Federal and non-Federal projects listed in Table 7-1 and Table 9-2 that could affect aquatic resources. In developing this EIS, the review team relied on reconnaissance-level information to perform the alternative site evaluation in accordance with ESRP 9.3 (NRC 2000-TN614, NRC 2007-TN5141). Reconnaissance-level information is data that are readily available from regulatory or resources agencies (e.g., State of Tennessee, U.S. Fish and Wildlife Service, U.S. Geological Survey) and other public sources such as scientific literature, books, and Internet websites. It can also include information obtained through site visits and documents provided by the applicant.

9.3.2.4.1 Affected Environment

The affected aquatic environment for the alternative sites consists of the Clinch River for ORR Sites 2 and 8 (as described for the CRN Site) and the Wheeler Reservoir for Redstone Arsenal Site 12 as well as ponds and/or streams located on all three alternative sites. ORR Site 2 is located on the Clinch River just downstream of the CRN Site. ORR Site 2 would use the Clinch River arm of the Watts Bar Reservoir for cooling water. The intake would be built at CRM 14.5, and the discharge would be slightly downstream at CRM 14.2, slightly downstream of the Grassy Creek embayment, and just east of the Gallaher Road/Oak Ridge Turnpike Bridge crossing (TVA 2017-TN4921). ORR Site 8 is on a peninsula that is bordered by the Clinch River on the northeast, south, and southwest. ORR Site 8 would use the Melton Hill Reservoir as the source of cooling water. The intake would be built in the Melton Hill Reservoir at approximately CRM 26.0 and the discharge would be built below the Melton Hill Dam in the inflow area of the Melton Hill Dam at approximately CRM 22.7 (TVA 2017-TN4921). Redstone Site 12 is located on Wheeler Reservoir, and it would use the Tennessee River for cooling water. The intake and discharge would fall between TRM 321 and 322 (TVA 2017-TN4921).

Aquatic Habitats

ORR Site 2 contains various ponds on the northern edge of the site and two unnamed streams on the south, west, and east sides (TVA 2017-TN4921). The site is adjacent to the Grassy Creek wetlands. According to U.S. Geological Survey 7.5-minute quadrangle maps, ORR Site 8 contains only intermittent and ephemeral streams, all flowing directly into the Clinch River in either the Clinch River arm of Watts Bar Reservoir or into Melton Hill Reservoir. The Redstone Arsenal Site 12 contains springs and streams and man-made ponds. The largest streams in the vicinity of Redstone Arsenal Site 12 are Indian Creek, Huntsville Spring Branch and Swan Pond (TVA 2017-TN4921).

Commercial/Recreational Species

There is no commercial fishing on the Watts Bar arm of the Clinch River in the vicinity of ORR Sites 2 or ORR 8 (TWRA 2016-TN5171). Commercial fishing for freshwater fish is allowed on Wheeler Reservoir. Commercial fishing for mussels is allowed on the Wheeler Reservoir, although restrictions are in place related to specific location, targeted species, gear, and catch (AL Admin Code 220-2-TN5183).

Recreational fishing in in the vicinity of ORR Sites 2 and ORR 8 is similar to that discussed in EIS Chapter 2 for the CRN Site. Recreational fishing on Wheeler Reservoir includes Black and White Crappie (*Pomoxis nigromaculatus* and *P. annularis*), Sauger (*Stizostedion canadense*), Striped, Hybrid and White Bass (*Morone saxatilis*, *M. saxatilis* × *M. chrysops*, and *M. chrysops*), Largemouth Bass (*Micropterus salmoides*), Smallmouth Bass (*M. dolomieu*), Spotted Bass (*M. punctulatus*), Bluegill (*Lepomis macrochirus*), Longear and Redear Sunfish (*L. megalotis and L. microlophus*) and Blue, Channel, and Flathead Catfish *(Ictiobus cyprinellus, I. bubalus and Pylodictis olivaris)* (TVA 2017-TN5190; Outdoor Alabama 2017-TN5191; NRC 2005-TN5192, NRC 2005-TN5192).

Non-Native and Nuisance Species

The non-native nuisance species in the vicinity of ORR 2 and ORR 8 are similar to the list provided in Chapter 2 for the CRN site. Non-native nuisance species that have been documented in Wheeler Reservoir in the vicinity of Redstone Arsenal Site 12 include mollusks such as Asian clam (*C. fluminea*) and zebra mussel (*Dreissena polymorpha*), fish such as , Grass Carp (*Ctenopharyndogon idella*), Silver Carp (*Hypophthalmichthys molitrix*), Bighead Carp (*H. nobilis*) and aquatic plants such as parrot feather (*Myriophyllum aquaticum*), Eurasian watermilfoil (*Myriophylum spicatum*), hydrilla (*Hydrilla verticillata*), spinyleaf naiad (*Najas minor*) (USGS 2017-TN5065; TWRA undated-TN5276).

Federally and State-Listed Species

Table 9-6 provides the list of Federal and State-listed aquatic species in the vicinity of the CRN Site. Because of the close proximity of ORR Sites 2 and 8, the same species list applies to both sites (FWS 2017-TN5090, FWS 2017-TN5091). The pink mucket (*Lampsilis abrupta*) and sheepnose mussel (*Plethobasus cyphyus*) prefer sand-gravel or coarse/rocky substrates, and are typically found in large river systems with moderate to strong currents (pink mucket) or riffles (sheepnose) (Mirarchi et al. 2004-TN5174; Parmalee and Bogan 1998-TN5166). The pink mucket was last observed in 1983 in the vicinity at CRM 19.1 between ORR Site 2 and ORR Site 8, while the sheepnose mussel was last observed in 1994 at CRM 21.4 downstream of ORR Site 8 (TNHP 2017-TN5361). The Spotfin Chub (*Eriomonax monachus*) was not identified in the vicinity of the site although there are known populations in Roane County, Tennessee. If individuals moved into tributaries near ORR Sites 2 and 8, the boundaries of the regulated populations would be expanded (50 CFR Part 17-TN1648). The hellbender (*Cryptobranchus alleganiensis*) is a large salamander that is currently petitioned for listing (FWS 2017-TN5091). It was last observed near ORR Site 8 in the tailwaters below Melton Hill Dam. This species prefers clear creeks and rivers with large shelter rocks (Mayasich et al. 2003-TN5179).

Table 9-6. Federally and State-Listed Aquatic Species in the Vicinity of CRN at ORR Site 2 and Site 8 in Tennessee

Scientific Name	Common Name	Federal Status	Tennessee Status
Lampsilis abrupta	Pink Mucket	Endangered	Endangered
Plethobasus cyphyus	Sheepnose Mussel	Endangered	—
Erimonax monachus	Spotfin Chub	Threatened	—

Source: FWS 2017-TN5091.

Table 9-7 provides the list of Federal and State-listed aquatic species in the vicinity of Redstone Arsenal Site 12 in Alabama. The State of Alabama includes only a designation of “State Protected” under specific regulations and “Partial Status Mussels”; however, the Partial Status Mussels are only protected in specific areas of Wheeler Reservoir that are upstream of Redstone Arsenal Site 12.

Table 9-7. Federally and State-Listed Aquatic Species in the Vicinity of Redstone Arsenal Site 12 in Alabama

Scientific Name	Common Name	Federal Status	Alabama Status	Location
Cryptobranchus alleganiensis	Hellbender	Species of Concern	State Protected	Tennessee River
Elassoma alabamae	Spring Pygmy Sunfish	Threatened	State Protected	Tennessee River
Etheostoma tuscumbia	Tuscumbia Darter	—	State Protected	Tennessee River, Redstone Site 12, Redstone Transmission Line
Typhlichthys subterraneus	Southern Cavefish	—	State Protected	Tennessee River
Lampsilis abrupta	Pink Mucket	Endangered	State Protected	Tennessee River
Plethobasus cyphyus	Sheepnose	Endangered	State Protected	Tennessee River
Pleurobema plenum	Rough Pigtoe	Endangered	State Protected	Tennessee River

Table 9-7. (contd)

Scientific Name	Common Name	Federal Status	Alabama Status	Location
Pleurobema rubrum	Pyramid Pigtoe	—	State Protected	Tennessee River
Pleurobema sintoxia	Round Pigtoe	—	State Protected	Tennessee River
Athearnia anthonyi	Anthony's Riversnail	Endangered	State Protected	Tennessee River

Source: Data from Alabama Natural Heritage Program.

9.3.2.4.2 Building Impacts

Impacts from building the proposed CRN plant at any of the alternative sites would generally be similar to those at the CRN Site. Limited dredging activities may be necessary in the Clinch River (for ORR Site 2 and ORR Site 8) or Tennessee River (for Redstone Site 12) to build the intake and discharge structures. It is anticipated that the installation of the intake would result in the loss of a small area of aquatic habitat and any benthic organisms contained therein. However, the potentially affected aquatic habitats and biota at the three sites appear to be generally similar to other areas of the respective reservoirs, are not known to include rare species, and are not known to have exceptionally high biologically diversity.

Building the discharge and intake structures at ORR Site 2 or Redstone Site 12 would have only a temporary and localized effect on aquatic habitat and biota. Building a discharge downstream below Melton Hill Dam at ORR Site 8 could affect the hellbender (a salamander), which has been reported in the tailwaters of Melton Hill Dam. But because the hellbender is a large, mobile species, it would likely move out of the way to escape injury.

Like the CRN Site, ORR Site 2 is located close to an existing inactive barge terminal at CRM 14.2, near Bear Creek Road. As for the CRN Site, TVA would likely refurbish, repair, and enlarge the existing retaining wall and install steel or wooden pilings or mooring posts to secure the barges. The review team does not expect that TVA would have to conduct further dredging at this barge location, but it might have to drive new piles, which could affect small areas of habitat. Although most fish species would likely avoid the underwater noise of pile driving, some species such as lake sturgeon, are highly sensitive to underwater noise and accompanying pressure waves, as discussed in EIS Section 4.3.2.

There are no barge docks close to ORR Site 8. The review team does not know whether TVA would reactivate the same existing barge dock near the CRN Site and ORR Site 2 (and have to truck components a greater distance from the barge to the site) or if TVA might build a new barge dock closer to the site. Even if TVA chose to build a new dock, potential impacts on aquatic habitat and biota would be limited to a small area, as described above for the existing dock. The review team expects that TVA would use an existing barge dock already present at Redstone Arsenal if they were to barge components to Redstone Site 12. The review team does not expect that use of this existing barge dock could substantially affect aquatic habitats or biota.

The tie-ins for the transmission lines for ORR Sites 2 and 8, as shown in figures in the ER (TVA 2017-TN4921) are relatively short because of the proximity of existing transmission line corridors to the potential site for the power block at each site and likely would not cross streams or waterbodies. The potential transmission line connector for Redstone Arsenal Site 12 is considerably longer and appears (TVA 2017-TN4921) to cross multiple waterbodies.

If TVA chose the ORR Site 2, the review team expects that TVA would build an underground 69-kV transmission line following much of the same route described for the CRN Site, with some changes made to access the site. It is unclear what route TVA might use to extend an underground transmission line to ORR Site 8 or Redstone Site 12. However, the review team expects that building any such underground transmission line could temporarily disturb streams crossed by the route, as described for the CRN Site. A difference, however, is that the stream impacts for lines serving ORR Site 8 or Redstone Site 12 may not be confined to streams crossing an existing transmission right-of-way.

9.3.2.4.3 Operational Impacts

During operation of a new nuclear power plant at ORR Site 2 and ORR Site 8, there would be few impacts on the small freshwater streams on the sites. Operation of the cooling and service water systems would withdraw water from and discharge it back to the Clinch River. The intake and discharge for Redstone Arsenal Site 12 would be to the Tennessee River on Wheeler Reservoir. Wheeler Reservoir is a much larger body of water that has an average monthly flow of 42,230 cfs (TVA 2017-TN4921), substantially greater than that for the Clinch River arm of the Watts Bar Reservoir, which has an average flow rate in excess of 1,000 cfs (TVA 2017-TN4921).

The aquatic habitats at the CRN Site, ORR Site 2, and ORR Site 8 are similar because of their proximity to one another. The largest difference is that the intake for ORR Site 8 is located above Melton Hill Dam and the discharge is located below the dam. In contrast, both the intake and discharge for the CRN Site and the ORR Site 2 are from the Clinch River arm of the Watts Bar Reservoir. The thermal discharge for Redstone Arsenal Site 12 is to a much larger waterbody that has a much higher flow rate.

Compliance with EPA's regulations addressing cooling-water intake structures for new facilities (Subpart I of 40 CFR Part 125 [TN4818]) is generally protective of fish and shellfish populations and usually does not result in detectable effects on populations of aquatic organisms from impingement or entrainment (66 FR 65256-TN243). Intake structures at all three alternative sites would be designed to meet the regulations in 40 CFR Part 125, Subpart I (TN4818). The potential for substantial adverse harm to aquatic biota from impingement or entrainment at any of the sites would therefore be minor.

9.3.2.4.4 Cumulative Impacts

The GAIs for cumulative impacts for aquatic resources for ORR Sites 2 and 8 are the same as those described in EIS Section 7.3.2 for the CRN Site. As described for the CRN Site, cumulative impacts on aquatic resources have already been extensive as a result of impoundment, fossil fuel plants, toxic spills, and other factors. Other activities that have affected the species and habitats in the vicinity of ORR Site 2 and ORR Site 8 include the introduction of non-native species especially zebra mussels and Asiatic clams, as discussed in EIS Section 7.3.2. Urbanization, mining, recreational fishing, and agriculture affect the aquatic habitat and species. The environmental effects of the sum of these activities are clearly noticeable and sufficient to have already destabilized important attributes (e.g., freshwater mussel populations) of the aquatic biota in the Clinch River. The potential for further adverse impacts on aquatic biota from the new facilities, if built at either of the ORR sites, would however be minimal, and the proposed units would not make a significant incremental contribution to the destabilizing effects.

The GAI for cumulative impacts for aquatic resources for Redstone Arsenal Site 12 includes the area from Guntersville Dam upstream at TRM 348 and as far downstream as the Browns Ferry Nuclear Site at TRM 294. As for the Clinch River, aquatic biota in the Tennessee River impoundments near Redstone Arsenal has experienced a history of destabilization. In addition to impoundment and the introduction of non-native species (including zebra mussels and Asiatic clams), aquatic biota may have been affected by legacy wastes at the Redstone Arsenal including arsenic, mercury, perchlorates, and polycyclic aromatic hydrocarbons (EPA 2017-TN5277). Although the Browns Ferry Nuclear Plant operates at a location approximately 29 river miles downstream, it is unlikely that the aquatic resources there would be affected by thermal discharges from SMR units at Redstone Arsenal. Urbanization, mining, recreational fishing, and agriculture have affected the aquatic habitat and species in the vicinity of Redstone Arsenal Site 12. However, the review team anticipates that any effects from the proposed units would be minimal, and the proposed units would not make a significant incremental contribution to the destabilizing effects.

9.3.2.4.5 Summary of Aquatic Resource Impacts at Alternative Sites

The review team concludes that, based on a history of cumulative effects of impoundment, fossil fuel plant operations, toxic spills, introduction of non-native species, recreational fishing, mining, agriculture, and urbanization, the cumulative effect of the proposed action, added to effects associated with past, present or reasonably foreseeable future projects would be LARGE at each of the alternative sites. However, the incremental contribution of the proposed project at any of these sites would not be a significant contributor to these cumulative impacts.

9.3.2.5 Socioeconomics

The demographic region and the economic region for ORR Site 2 and ORR Site 8 are the same as for the CRN Site and include Anderson, Knox, Roane, and Loudon Counties. The demographic region and the economic region for Redstone Arsenal Site 12 is composed of Limestone, Madison, Marshall, and Morgan Counties in Alabama, based on the residence patterns of Arsenal employees (University of Chicago 2012-TN5136).

9.3.2.5.1 Building and Operational Impacts

<u>Physical Impacts</u>

Physical impacts include impacts on workers and the general public, noise, air quality, buildings, and roads. The physical impacts on workers at each alternative site would be similar to those described for the CRN Site. Noise impacts would be similar to those expected at the CRN Site. There would be sensitive receptors (local residents) in close proximity at all ORR sites. Little sound attenuation would be expected for residents living along the south bank of the Clinch River or the Melton Hill Reservoir. Transportation routes would receive impacts at ORR Sites 2 and 8 similar to those expected for the CRN Site. The review team expects that roadway modifications very similar to those identified for the CRN Site would be needed to make ORR Site 2 accessible to the construction and operations workforces. ORR Site 8 also would require similar access upgrades, but these access upgrades would affect SR 95 and the existing TVA access road on the north bank of the Clinch River, approaching ORR Site 8 from the west. The review team expects that some form of signalization and turn lane improvements (either widening or creating off/on ramps) would be required on SR 95 at the intersection with the TVA access road on the north bank of the river. These impacts would be noticeable, but not destabilizing, to local roadways.

Physical impacts at Redstone Site 12 also would be similar to those expected at the CRN Site and the other ORR sites. However, given the proximity of several residential subdivisions immediately outside the Arsenal fenceline and Redstone Site 12 boundary, the impacts likely would be noticeable to many more people than for sites at the ORR and could lead to calls for mitigation measures to prevent destabilizing impacts. Local roadways in the immediate vicinity of the Redstone Arsenal currently are undergoing various upgrades including widening and creating new turn lanes. The review team expects that further upgrades would be required to facilitate access to Redstone Site 12 by the construction workforce at the peak of building activities. These impacts would be noticeable in the local vicinity of the western entrance to the Arsenal. The visual impact of the cooling-tower plumes may be noticeable at Redstone Site 12, due to the proximity of residential subdivisions within less than a mile of the site.

Demography

Like the CRN Site, the ORR Sites 2 and 8 are located in Roane County in close proximity to each other. All three sites are within the Oak Ridge city limits. Thus, the review team concludes that the demographic impacts of construction and operations that have been assessed for the CRN Site would be similar for ORR Sites 2 and 8. The current and projected populations of the GAI are sufficiently large and the estimated in-migrating populations sufficiently small that the in-migrating workers would represent less than 1 percent of the total population in any of the counties where these employees would reside (see Table 9-8 for construction; Table 9-9 for operations). The review team concluded that the temporary increase in population during peak building employment and the more permanent increase associated with in-migrating operations workers would not noticeably affect the demographic character of the demographic region or any of its counties individually; therefore, the impacts expected at these alternative sites also would be minimal.

Table 9-8. Construction Impacts Estimated Population Increase for the ORR Site 2 and ORR Site 8

County	In-Migrating Workers	Population Increase	Projected 2025 Population[(a)]	Percent Increase
Anderson	301	762	80,713	0.9
Knox	557	1,409	516,603	0.3
Loudon	67	170	62,151	0.3
Roane	189	478	56,805	0.8
Total	**1,114**	**2,819**	**714,968**	**0.4**

Source: For projected 2025 population is Table 2-24.

Table 9-9. Operations Impacts Estimated Population Increase for the ORR Site 2 and ORR Site 8

County	In-Migrating Workers	Population Increase	Projected 2025 Population[(a)]	Percent Increase
Anderson	67	170	80,713	0.21
Knox	125	316	516,603	0.06
Loudon	15	38	62,151	0.06
Roane	43	109	56,805	0.19
Total	**250**	**633**	**714,968**	**0.09**

(a) Source: For projected 2025 population is Table 2-24.

For the Redstone alternative site, the review team made workforce distribution assumptions similar to those made for the CRN Site. The expected residency distribution of workers migrating to the demographic region was assumed to follow the same residency pattern seen for the overall Redstone Arsenal workforce (military and civilian) (University of Chicago 2012-TN5136). Assuming the migrating workers would relocate their families for the duration of plant construction or during plant operations, each migrating worker was multiplied by the average household size in Alabama (USCB 2017-TN5137) of 2.55 persons. Table 9-10 and Table 9-11 summarize the population impacts expected at the Redstone alternative site. Comparisons are made to the projected county population in 2025, around the time of expected peak workforce levels.

Table 9-10. Construction Impacts Estimated Population Increase for Redstone Arsenal Site 12

County	Redstone Arsenal Workforce[(a)]	Percent	In-Migrating Workers	Population Increase	Projected 2025 Population[(b)]	Percent Increase
Limestone	2,035	6.1	68	173	108,021	0.2
Madison	28,352	84.8	945	2,410	392,382	0.6
Marshall	1,448	4.3	48	122	98,049	0.1
Morgan	1,603	4.8	53	135	120,464	0.1
Total	**33,439**	**100.0**	**1,114**	**2,840**	**718,916**	**0.4**

Sources:
(a) University of Chicago (2012-TN5136).
(b) Center for Business and Economic Research (CBER 2017-TN5138).

Table 9-11. Operations Impacts Estimated Population Increase for Redstone Arsenal Site 12

County	In-Migrating Workers	Population Increase	Projected 2025 Population[(a)]	Percent Increase
Limestone	15	38	108,021	0.03
Madison	212	541	392,382	0.14
Marshall	11	28	98,049	0.03
Morgan	12	31	120,464	0.03
Total	**250**	**638**	**718,916**	**0.09**

(a) Source: Center for Business and Economic Research (CBER 2017-TN5138).

The demographic impacts reflected in the tables for all three alternative sites are similar to those estimated for the CRN Site. The review team concludes these impacts would be minimal in relation to the current populations in the respective demographic regions.

Economic and Tax Impacts

Building and operations at ORR Site 2 and ORR Site 8 would have economic and tax revenue impacts within the economic region that the review team expects would be similar to those expected at the CRN Site. Economic impacts result from the jobs and income generated within the economic region from the proposed action. These include indirect and induced jobs and income generated by construction and operations supplier industries and industries that meet the demand created by the migration of construction and operations workers to the economic region. The review team analyzed the potential economic impacts of the proposed action in EIS Sections 4.4.3 and 5.4.3 for the CRN Site. These impacts are expected to be SMALL for both building and operating SMR units at the CRN Site, and similar impacts would be expected if the plants were built at either of the ORR alternative sites.

Building and operations at Redstone Arsenal Site 12 would have economic impacts similar to those expected for the CRN Site and discussed in EIS Sections 4.4.3 and 5.4.3. In those sections, the review team hypothesized potential construction and operations costs for the proposed PPE plant capacity and capacity factor values in order to facilitate economic impact estimation. The review team expects that these cost estimates would need to be revisited in the event of a COL application, because TVA did not supply any cost information. The review team expects that the cost estimates used in EIS Sections 4.4.3 and 5.4.3 would not vary substantially based on building and operating the plant in Alabama compared to Tennessee. However, the review team assumes that the nuclear construction and operation industries of the Knoxville economy (see EIS Section 2.5.2.2) would be somewhat more concentrated than they would be in the Huntsville economy. This would suggest that the economic multiplier effect would be smaller in the Huntsville economy than in the Knoxville economy.

Using the Regional Input-Output Modeling System II economic multipliers TVA obtained for the Knoxville economic region, the aggregate impact supported by the proposed action includes approximately 5,750 direct, indirect, and induced jobs and $364 million annually in direct, indirect and induced labor income during peak construction activities. The peak employment impact generated by the infusion of 1,252 new construction workers would result in an additional 929 indirect and induced jobs in the economic region, for a net employment impact of 2,181 jobs. The economic impact of the labor income generated by the newly hired workers would create $37.1 million in additional labor income in the economic region, for a net income impact of $90.1 million. Though in absolute terms these numbers appear substantial, the net impacts represent relatively minor new economic impacts in the context of the wider economy of the Knoxville economic region. Based on the discussion above (see also EIS Section 2.5.2.2), the review team expects that economic multiplier values for employment and income would be lower in the GAI for Redstone Site 12. Thus, the economic impacts would be somewhat smaller. Therefore, the review team concludes that economic impacts of the proposed action built and operated at Redstone Site 12 also would be minor and beneficial to that site's economic region.

The tax structure for the economic region around the CRN Site is discussed in EIS Section 2.5.2.2. Tax revenue impacts are discussed in EIS Sections 4.4.3 and 5.4.3. Primary tax revenues associated with building and operations activities at ORR Sites 2 and 8 would be the same as for the CRN Site and would come from (1) State sales taxes on worker expenditures, (2) worker property taxes, (3) State sales taxes on some purchases of materials and supplies, and (4) TVA payments in lieu of taxes based on the location and construction of power-generation facilities.

Primary tax revenues associated with building activities at Redstone Site 12 would be similar to those of the CRN Site and would come from (1) State sales taxes on worker expenditures, (2) worker property taxes, (3) State sales taxes on some purchases of materials and supplies, and (4) TVA payments in lieu of taxes based on the location and construction of power-generation facilities.

As indicated in EIS Section 2.5.2.2, TVA makes payments in lieu of taxes to jurisdictions affected by power plant construction activities. In addition, payments are made to affected counties as summarized in Table 2-22. TVA indicates that it cannot provide estimates of impact-related payments at the ESP stage (TVA 2017-TN4921). Such estimates would be based on estimated costs for the proposed project, which also are not available. The review team will need to revisit these impacts if the NRC receives a COL application regarding the proposed action. If the estimated payments were known, the review team expects that the additional payments to the counties of the economic region affected by the proposed action would be minor in relation the other existing revenue streams currently available.

EIS Section 2.5.2.2 discusses the TVA payment-in-lieu-of-taxes revenue that accrues annually to individual counties and municipalities affected by TVA operations or served by TVA utilities in Tennessee. The Redstone Site 12 economic region currently receives substantially greater TVA revenues than those received by the economic region of the CRN Site and the other ORR sites in Tennessee. The Alabama Department of Revenue (ALRev 2016-TN5139) indicates that the counties of the Redstone GAI currently receive several times the revenue from TVA than the counties of the CRN Site's demographic region receive. These revenues are summarized in Table 9-12. This source of revenue has been generally declining over the 6-year period reported. These absolute declines would be expected to translate to declining shares of county revenue over this period for each of the affected counties. However, TVA revenues represent a somewhat greater proportion of county revenues in the Redstone economic region than in the CRN economic region.

Table 9-12. TVA Tax-Equivalent Payments to the State of Alabama and Local Counties from FY 2011 through FY 2016

Fiscal Year	Total Distribution to State	Total Distribution to all Counties	Limestone County	Madison County	Marshall County	Morgan County
2010-2011	$115.5	$95.7	$8.8	$21.3	$7.1	$16.9
2011-2012	$122.6	$101.8	$9.4	$22.7	$7.6	$18.5
2012-2013	$110.9	$92.0	$8.6	$20.5	$6.9	$17.0
2013-2014	$106.1	$88.1	$8.4	$19.6	$6.6	$16.2
2014-2015	$102.6	$85.1	$8.3	$19.0	$6.4	$16.3
2015-2016	$94.2	$78.2	$8.0	$17.4	$5.9	$14.7

Source: Alabama Department of Revenue (ALRev 2016-TN5139). All monetary values in millions of dollars.

Workers would spend some of their income on goods and services that may be taxed. Alabama imposes a 4.0 percent sales tax and Tennessee imposes a 7.0 percent sales tax. Counties and cities in the economic region levy local option-use taxes in addition to the base sales tax. Similar to the case in Tennessee, the net economic impact of the proposed action is expected to be relatively minor, and the review team expects a minimal, beneficial, impact on State sales tax revenue from in-migrating, previously unemployed, and indirect worker expenditures during peak construction activities and during operations at the ORR alternative sites and at Redstone Site 12.

Some project-related building and operations expenditures may be subject to sales taxes. Neither the distribution of expenditures across the localities, nor the expected sales of goods not exempt from sales tax are known at the ESP stage. As indicated in EIS Section 2.5.2.2, TVA is not subject to sales tax, and the expected revenues from project purchases would be a minimal proportion of expected revenue impacts regardless of the site chosen. Therefore, the review team believes that there would be a minimal, positive impact on sales tax revenues during the building and operating of SMR units at Redstone Site 12.

Because Redstone Site 12 would be located on an existing Federal reservation and TVA is a Federal agency, no property taxes would be collected on the real property built and operated by TVA. The majority of property taxes that would be paid by the in-migrating workforce would result from property ownership transfer, rather than from an increase in local real property to be taxed. Based on these expectations, the review team determined there would be minimal property tax impacts from relocating construction and operations workers, regardless of the site chosen.

Based on the information provided by TVA and the review team's independent evaluation and outreach, the review team concluded that the combined impacts on tax revenues from building and operating two or more SMRs would be minimal. The impact would roughly be the same for any of the alternative sites.

<u>Infrastructure and Community Service Impacts</u>

This section provides the review team's estimated impacts on infrastructure and community services, including transportation, recreation, housing, public services, and education.

<u>Traffic</u>. Road access to the ORR Site 2 area is provided primarily from the Oak Ridge Turnpike (SR 58), similar to the CRN Site. Many of the same road improvements needed for the CRN Site also would be required the ORR Site 2. ORR Site 8 is located in close proximity to the CRN Site and ORR Site 2. ORR Site 8 also would require similar access upgrades, but these access upgrades would affect SR 95 and the existing TVA access road on the north bank of the Clinch River, approaching ORR Site 8 from the west. The review team expects that some form of signalization and turn lane improvements (either widening or creating off/on ramps) would be required on SR 95 at the intersection with the TVA access road on the north bank of the river.

Primary road access to Redstone Site 12 would enter the Arsenal from the west via the Gate 7 entrance road (Martin Road), a four-lane arterial (two eastbound and two westbound). The access to Martin Road from the Huntsville and Madison areas is from the north on Zierdt Road. Currently, that route is being substantially widened to a divided roadway with two to three lanes each traveling southbound and northbound. The review team expects that Redstone Site 12 also would require additional traffic modifications to mitigate the effects of traffic accessing the site during the period of peak employment, thereby preventing substantial backups of vehicles turning left into the Arsenal at the Gate 7 intersection.

As noted in EIS Section 4.4.4.1, TVA commissioned a traffic impact study (TIA) for the CRN Site. The TIA is based on a combination of peak construction employment, operations workforce, and baseline background traffic. The peak construction workforce is assumed to occur during construction months 42 through 47. Without mitigation, the review team expects the traffic impacts from building would be destabilizing because the level of service would deteriorate to level F. Inbound traffic delays could exceed 15 minutes at some intersections during several hours of the work day for a period of 6 months. If the mitigation activities recommended in the TIA were undertaken, the review team expects the local impact on traffic would be reduced, but adverse impacts on access routes in the ORR would still be noticeable during peak building employment and estimated delays at SR 95 and Bear Creek Road would still exceed 7 minutes during the afternoon peak commute time. Such substantial delays could be destabilizing, and without additional mitigation, commuters would need to temporarily adapt to the deteriorated conditions during afternoon commutes during peak construction. The review team expects that similar impacts for ORR Site 2, given its close proximity to the CRN Site and use of the same roadways for site access. Access to ORR Site 8 also would use the same roadways as those expected to be used for the CRN Site, but SR 95 would be the principal arterial affected, as opposed to SR 58. The review team expects that impacts similar to those detailed in the TIA would be likely for ORR Site 8.

For Redstone Site 12, the baseline situation is somewhat different, because ingress to and egress from the site would require the use of the same route. No alternatives for accessing the site from different approaches are readily available, without procuring access across the Arsenal from the east or north. However, the affected access route would have multiple lanes available in each direction to and from the site entry, which could mitigate traffic impacts somewhat, compared to those expected at the CRN Site. No TIA has been completed for Redstone Site 12, but the review team expects that with the suggested measures in the TIA for the CRN Site, substantial and disruptive traffic impacts during peak employment can be avoided. The review team concludes that traffic impacts from building and operating two or more SMR units at Redstone Site 12 would still be noticeable with mitigation, and could be destabilizing without any mitigation.

Recreation. The review team expects that the recreation resource impacts for the ORR sites would be similar to those expected for the CRN Site (see EIS Sections 4.4.4.2 and 5.4.4.2). In addition, ORR Site 8 is located on a prominent peninsula of the Melton Hill Reservoir that has been largely undisturbed since the ORR was created in 1942. The expected site preparation activities, including timber harvesting, excavating, grading, and leveling, and subsequent building and operating of the plant would be noticeable to the general public using the reservoir for recreation and to residents living on the south shore of the reservoir. The noticeable impacts would include noise and aesthetic impacts during building and operations.

Recreation areas in close proximity to the Redstone Arsenal include primarily dispersed recreation available on the Wheeler National Wildlife Refuge. The refuge provides access to the north bank of the Tennessee River for residents of Madison and Limestone Counties. It is not expected that use of recreation resources would be noticeably affected by building and operating two or more SMR units at Redstone Site 12. Substantial vegetative screening exists to prevent visual intrusions for recreationists using the Tennessee River or the Wheeler National Wildlife Refuge. The cooling-tower plume may be visible temporarily during winter conditions, but would present only a minor visual intrusion to local recreation resources.

Because 34 percent of the construction workforce would be expected to relocate either temporarily or permanently to the economic region, the review team expects some minor stresses to be placed upon the capacity of recreational facilities near any of the alternative sites. Local campgrounds may experience increased occupancy, especially during weekdays, to accommodate temporary workers. The local parks and recreational facilities of the affected economic regions have sufficient capacity to accommodate in-migrating workers and their families, and the review team expects minimal impacts at any affected recreation sites (see EIS Sections 4.4.4.2 and 5.4.4.2).

Housing. Impacts on housing resources from building and operating two or more SMR units at ORR Sites 2 or 8 would be similar to those expected for the CRN Site. Workers relocating to the economic region would have generally the same residency pattern as that expected for the CRN Site. As indicated in EIS Table 4-14, only minimal change in the vacancy rate would be expected from the relocating workforce during the period of peak employment at any of the ORR sites.

For Redstone Site 12, residency patterns are assumed to be much the same as would be expected for the CRN Site. The in-migrating workers and families may choose to buy available vacant housing or rent, or they may bring temporary housing with them such as recreational vehicles. Table 9-13 shows the estimated impact on housing availability for the relocating families, assuming all in-migrating families would acquire local housing. Comparisons are made to 2015, but in reality, the housing stock will continue to develop between now and the expected peak of construction activities. Thus, the minimal impacts suggested would be even smaller by 2024. In addition to the housing stock for owner-occupied housing and rental units, there is also sufficient stock of temporary housing in the economic region, if workers decide to stay in hotels, motels, or campgrounds.

Table 9-13. Estimated Housing Impacts in the Redstone Site 12 Economic Region at Peak Employment

County	Peak Construction In-Migrating Families	2015 Vacant Units	2015 Total Housing Units	2015 Vacancy Rate	Proposed Action Vacant Units	Proposed Action Vacancy Rate
Limestone	68	3,144	35,357	8.9	3,076	8.7
Madison	945	14,953	152,720	9.8	14,008	9.2
Marshall	48	6,109	40,370	15.1	6,061	15.1
Morgan	53	5,176	51,411	10.1	5,123	10.0
Total	**1,114**	**29,382**	**279,858**	**10.5**	**28,268**	**10.1**

Source: USCB 2017-TN5140.

Given the large supply of vacant housing relative to the in-migrating workforce during peak building employment and the availability of short-term accommodations, the review team expects sufficient housing to be available for workers relocating to the area and that there would be minimal impacts on the housing supply or prices in the local area. In addition, given the large supply of vacant housing, the short-term accommodations, and the temporary nature of the construction workforce in the area, the review team does not expect the in-migrating workers and families would stimulate new housing in the Redstone economic region.

Based on the information provided by TVA, interviews with local officials, and its own independent review, the review team expects there would be minimal impacts in the economic region on the price and availability of housing related to building and operating new SMR units at any of the alternative sites.

Education. The review team found that similar to the housing and other community service resources, only minimal impacts would be expected on the affected school systems in the economic region of the CRN Site. These impacts would be the same for ORR Sites 2 and 8. These impacts are discussed in EIS Sections 4.4.4.5 and 5.4.4.5, and indicate that student-teacher ratios would be only minimally affected and the effect would not be noticeable in the districts likely to be affected.

For Redstone Site 12, the number of new students affecting the districts in the economic region during the building and operating of two or more SMR units would be similar to the number expected for the CRN Site. Based on the expected demographic impacts illustrated in Table 9-10 and Table 9-11, the review team expects less than a one-half of 1 percent increase in the population of the economic region. These impacts are of the same magnitude as those anticipated for the proposed site (a minimal impact). Therefore, the review team expects that the minimal influx of students to the Redstone economic region would have only a minor influence on baseline student-teacher ratios in the schools of the affected counties.

Summary of Infrastructure and Community Service Impacts. Based on the information provided by TVA and the review team's independent evaluation and outreach, the review team concluded that nearly all infrastructure and community impacts would be minimal for each alternative site. However, traffic impacts at all three alternative sites would be noticeable and potentially destabilizing during the building phase. In addition, because of the prominence of ORR Site 8 on a peninsula in the Melton Hill Reservoir and the location of recreational facilities and residences directly across the reservoir, aesthetic impacts on lake-based recreation resources at ORR Site 8 would be noticeable, but not destabilizing.

9.3.2.5.2 Cumulative Impacts

For cumulative socioeconomic impacts, the review team determined that the GAI would be the affected economic region, as was determined for the CRN Site. Thus, the GAI for ORR Sites 2 and 8 is the same as for the CRN Site. For Redstone Site 12, the GAI is the same as the site's economic region and includes Limestone, Madison, Marshall, and Morgan Counties. These regions are the area in which the majority of direct and indirect effects of the proposed action would be expected to occur.

The review team discusses information pertaining to the GAI for ORR Sites 2 and 8 in EIS Sections 2.5 and 7.4.1. Table 9-2 lists the past, present, and reasonably foreseeable future activities associated with these sites. Building and operating a new nuclear power plant at the ORR sites could result in cumulative impacts on the demographics, economy, and community infrastructure of the economic region counties in conjunction with those reasonably foreseeable future actions. These impacts would be very similar to those described for the CRN Site, given its close proximity.

As discussed in EIS Section 7.4.1, the project with the greatest contribution to cumulative socioeconomic impacts would be continued operations at the facilities on the ORR. Recent site employment at ORR facilities ranges between 11,000 and 12,000 Federal and contractor employees. The current DOE annual investment is approximately $2 billion. The resulting aggregate economic impacts of the wages, salaries, benefits; local procurements of goods and services; tax revenues; and the induced economic impacts of these primary impacts are substantial and noticeable throughout the GAI. The ongoing construction of the Uranium Processing Facility (UPF) is expected to be wrapping up by the time the proposed action at the CRN site is ramping up. The review team expects that many workers may find continued local employment moving from the UPF construction to the activities at the CRN Site.

The other projects listed in Table 7-1 involve sustained construction of new and expanded manufacturing industrial plants and similar expansion of facilities at the University of Tennessee. Current ongoing and planned construction projects continue to generate substantial demand for construction workers and workers are being recruited from outside the economic region. The proposed action would be expected to contribute to the sustained demand for construction workers within and outside of the GAI. Continued industrial development is contingent on underlying economic conditions. As long as these conditions remain favorable, economic development of the Knoxville metropolitan is likely to continue to be strong and contribute to cumulative economic impacts, including tax revenue impacts, in the GAI. A growing economy will result in the need for additional community services such as schools, healthcare facilities, and first responders.

The Metropolitan Knoxville Airport Authority (MKAA) is in the planning and approval stage of developing a regional airport near the ETTP on the ORR, in close proximity to the CRN Site. Construction may begin by the end of 2018 (Oak Ridge Today 2018-TN5409). The planned airport would parallel the Oak Ridge Turnpike (SR 58), immediately east of the existing facilities and west of the highway (MKAA 2017-TN5021), within the Heritage Center Industrial Park. The MKAA proposal would transfer ownership of 170 ac of DOE lands within the ORR to MKAA ownership. DOE preliminarily estimates the construction would take 3 years and cost $32 to $50 million (DOE 2016-TN5022). The construction is expected to start soon and be completed prior to the start of construction at the CRN Site. The size of the project is relatively small compared to other construction projects in the area, including the proposed action at the CRN Site. Thus, the socioeconomic impacts would be minimal. The review team expects that adding an operating regional airport to the ORR would create pathways for future economic development that would be likely to generate local economic impacts in and around the cities of Oak Ridge, Clinton, and Kingston.

On the basis of the above considerations, TVA's ER, and the review team's independent evaluation and outreach, the review team concludes that there would be noticeable impacts to roads and noticeable and potentially destabilizing short-term cumulative adverse impacts associated with traffic during the building phase in the vicinity of ORR Sites 2 and 8. For all other socioeconomic impact categories, the review team concludes that the cumulative impacts would be minor and adverse for both building and operations within the GAI, except for tax revenue impacts, which would be minor and beneficial. Building two or more SMRs at the ORR Sites 2 and 8 would be a significant contributor to the traffic impacts during the building phase.

Table 9-2 lists the past, present, and reasonably foreseeable future activities associated with Redstone Site 12. Building and operating a new nuclear power plant at Redstone Site 12 could result in cumulative impacts on the demographics, economy, and community infrastructure of the economic region counties in conjunction with those reasonably foreseeable future actions.

Within the Redstone GAI, the project with the greatest potential to affect cumulative socioeconomic impacts would be the continued operation of the Redstone Arsenal. Several other nearby projects involve continuation of industrial and residential development of the western Madison County area, adjacent to the Redstone Arsenal, and are included in county comprehensive plans and in other public agency planning processes. Redstone Arsenal employs a civilian and military workforce of more than 30,000, and the increasing urbanization of the western Madison County area is causing sustained growth since the economic recession of 2009. Infrastructure and community services are continuing to expand to keep up with demand and additional property tax revenues are generated by this type of economic expansion. The Arsenal is responsible for a substantial portion of the local economic activity, including over $4 billion in annual Federal investment and nearly half of the gross domestic product of the Huntsville economic region (University of Chicago 2012-TN5136).

On the basis of the above considerations, TVA's ER, and the review team's independent evaluation and outreach, the review team concludes that there would be noticeable impacts to roads and aesthetics, and noticeable and potentially destabilizing short-term cumulative adverse impacts associated with traffic during the building phase in the vicinity of Redstone Site 12. For all other socioeconomic impact categories, the review team concludes that the cumulative impacts would be minor and adverse for both building and operations within the GAI, except for tax revenue impacts, which would be minor and beneficial. Building two or more SMRs at Redstone Site 12 would be significant contributor to the traffic impacts during the building phase.

9.3.2.5.3 Summary of Socioeconomic Impacts

Based on information provided by TVA, a review of existing reconnaissance-level documentation, and its own independent evaluation, and the activities listed in Table 7-1 for ORR Sites 2 and 8, the review team concludes that building activities at these sites would have short-term SMALL cumulative impacts on all impact categories, except SMALL to MODERATE and adverse impacts on roads, MODERATE-to-LARGE and adverse impacts associated with workforce traffic, and SMALL and beneficial tax revenue impacts within the GAI. The review team concludes that, during operations and outages, there would be SMALL cumulative impacts for all categories, except for tax revenue impacts, which would be SMALL and beneficial within the GAI.

For Redstone Site 12, the review team concludes that building activities would have short-term SMALL cumulative impacts on all impact categories, except SMALL to MODERATE and adverse impacts on roads and aesthetics, MODERATE-to-LARGE and adverse impacts associated with workforce traffic, and SMALL and beneficial tax revenue impacts within the GAI. The review team concludes that, during operations and outages, there would be SMALL cumulative impacts for all categories, except for tax revenue impacts, which would be SMALL and beneficial within the GAI.

9.3.2.6 Environmental Justice

Environmental justice impacts are assessed for the demographic region of each alternative site. For the ORR sites, the demographic region is the same as that for the CRN Site, and includes Anderson, Knox, Loudon, and Roane Counties in Tennessee. For Redstone Site 12, the demographic region includes Limestone, Madison, Marshall, and Morgan Counties.

Figure 2-29 and Figure 2-30 show the locations of minority and low-income populations, respectively, in the demographic region for sites on the ORR. Figure 9-7 and Figure 9-8 identify minority and low-income populations, respectively, for Redstone Site 12.

As discussed for the CRN Site in EIS Section 2.6, no minority or low-income populations were identified in close proximity to the CRN Site or any ORR site. Also, no impact pathways were identified for sites on the ORR by which disproportionately high and adverse impacts could be expected for minority or low-income populations. Thus, the review team does not expect environmental justice impacts at ORR Sites 2 or 8.

For Redstone Site 12, the town of Triana, Alabama, immediately southwest of the site, is a predominately minority population. TVA indicates that the residents of Triana have been known to depend heavily on fish from Huntsville Spring Branch as both a food source and a source of income (TVA 2017-TN4921). Thus, pathways exist for adverse (i.e., both harmful and significant) and disproportionate impacts on a minority community due to project-related effects on water quality and aquatic resources. As discussed in Section 9.3.2.4.2, the potentially affected aquatic habitats and biota at the three sites appear to be generally similar to other areas of the respective reservoirs, are not known to include rare species, and are not known to have exceptionally high biologically diversity. For operations, intake structures at all three alternative sites would be designed to meet the regulations in 40 CFR Part 125, Subpart I (TN4818). The potential for substantial adverse harm to aquatic biota from impingement or

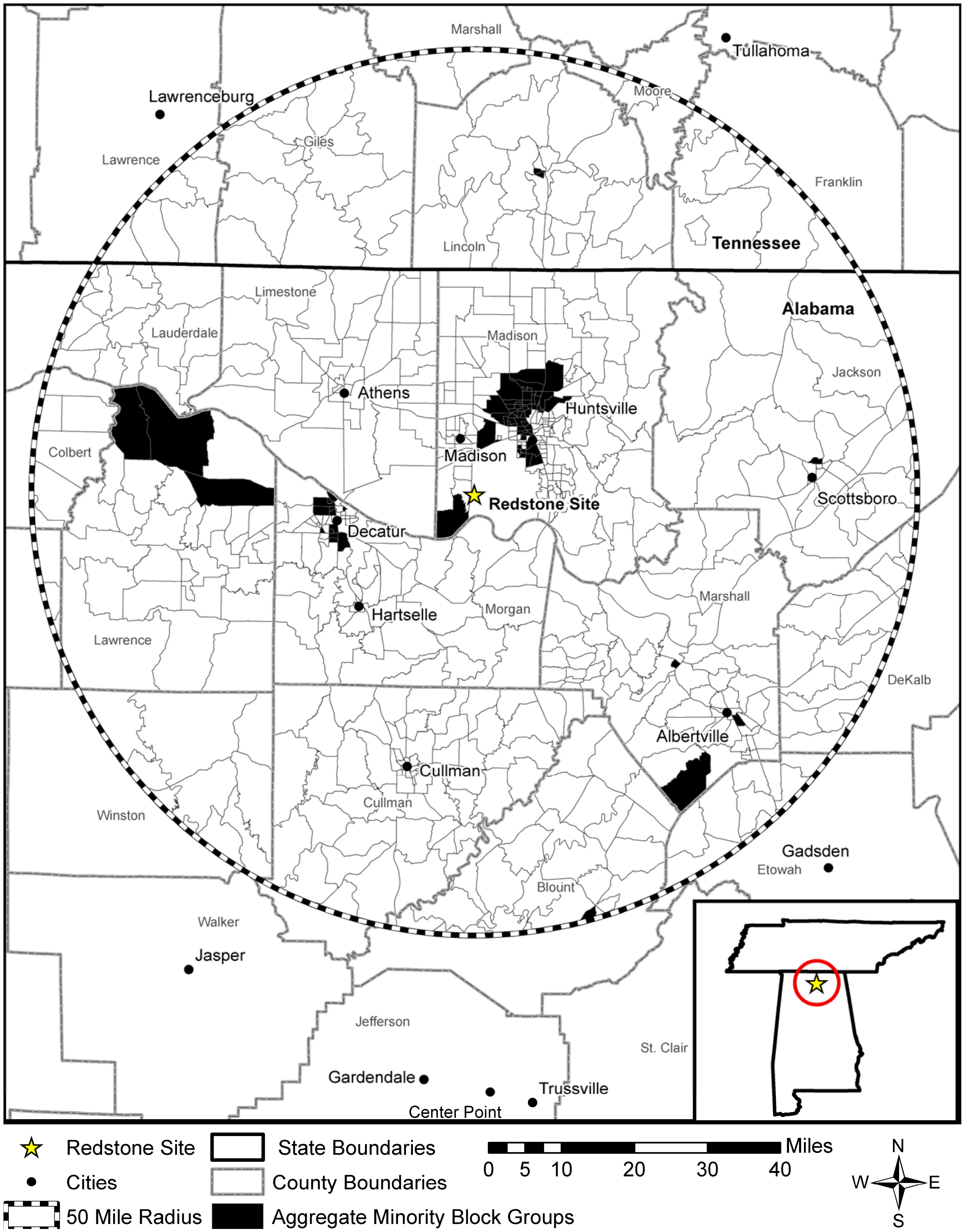

Figure 9-7. Minority Populations within 50 Mi of the Redstone Arsenal

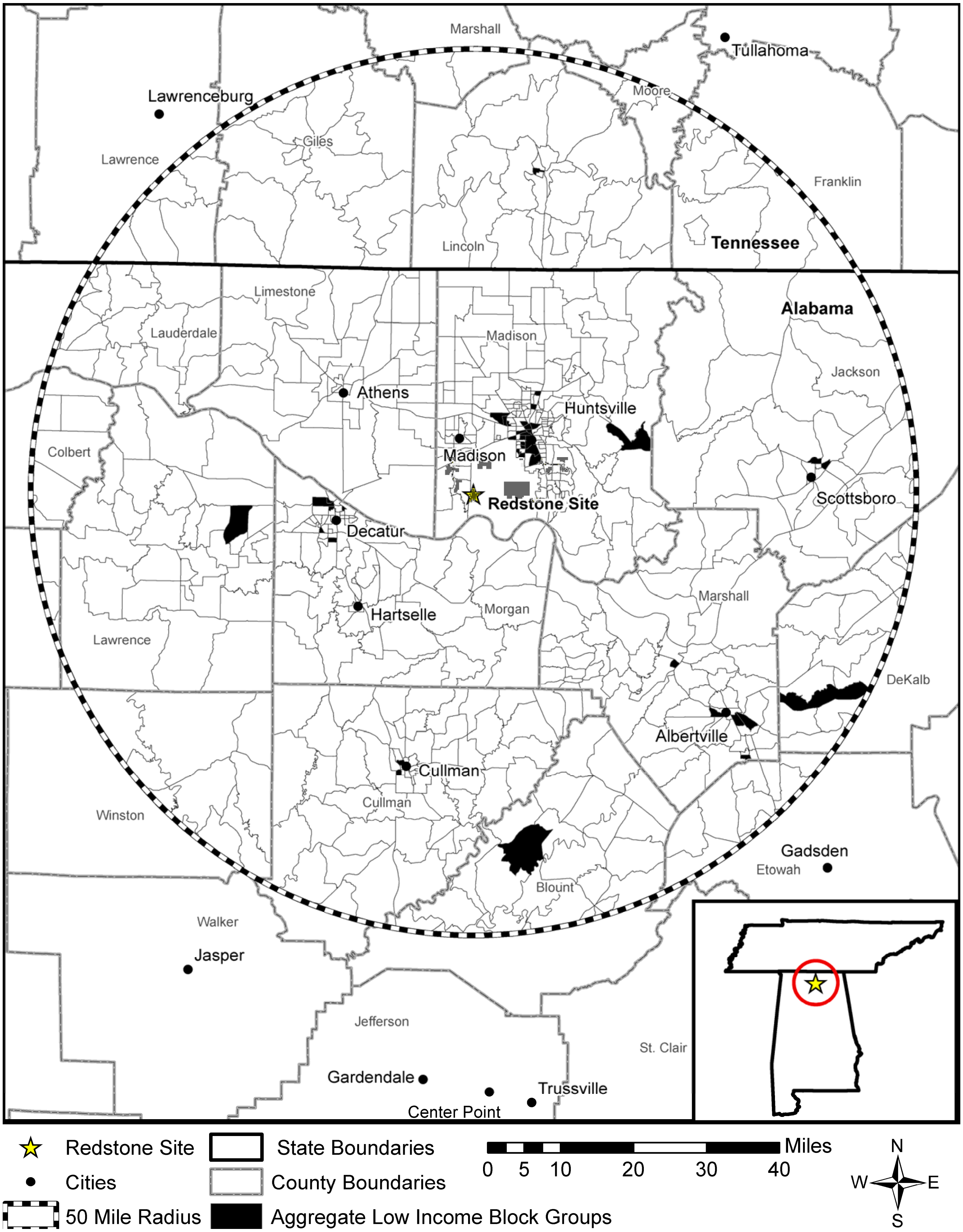

Figure 9-8. Low-Income Populations within 50 Mi of the Redstone Arsenal

entrainment at any of the sites is therefore low. Therefore, the review team determined that impacts of the proposed action at Redstone Site 12 on these resources would be similar to the impacts expected for the CRN Site. Therefore, the review team expects no disproportionately high and adverse impacts. No other affected populations were identified for Redstone Arsenal Site 12.

9.3.2.7 Historic and Cultural Resources

The following cumulative impact analysis addresses impacts on historic and cultural resources from building and operating two or more SMRs at ORR Site 2 and ORR Site 8, both located in Tennessee, and Redstone Arsenal Site 12, located in Alabama. The analysis also considers other past, present, and reasonably foreseeable future actions that could affect historic and cultural resources, including other Federal and non-Federal projects listed in Table 7-1 and Table 9-2. For the analysis of historic and cultural resource impacts at ORR Site 2, ORR Site 8, and Redstone Arsenal Site 12, the GAI is considered to be the area of potential effect (APE) that would defined for this proposed undertaking. This includes the direct-effects APE, defined as the area physically affected by the site development and operation activities at the site and any offsite area that would be required for additional facilities (i.e., rail, roads, barge facilities, transmission lines). The indirect-effects APE is defined as 0.5-mi area around lands being cleared of vegetation.

Reconnaissance-level activities in this cultural resource review have a particular meaning. Typically, they include preliminary field investigations to confirm the presence or absence of cultural resources. However, in developing this EIS, the review team relied upon reconnaissance-level information to perform alternative site evaluations in accordance with ESRP 9.3 (NUREG 1555, NRC 2007-TN5141). Reconnaissance-level information consists of data that are readily available from agencies and other public sources. It can also include information obtained through visits to the alternative site area.

9.3.2.7.1 Affected Environment at ORR 2

The following sources of information were used to identify the historic and cultural resources at ORR Site 2:

- TVA ER (TVA 2017-TN4921)
- Johnson 2015 (TN5220)
- Fielder (1974-TN5338)
- Fielder 1975 (TN4978)
- Hunter et al. 2015(TN4971)
- Angst and Kirkmeyer (2007-TN5336)
- Jolley 1982 (TN4977)
- Jacobs (1995-TN5339)
- McKee and Karpynec (2006-TN5340)
- Pace 1995 (TN4969)
- Valk et al. 2011 (TN4972).

As discussed in EIS Section 9.3.2, ORR Site 2 covers 547 ac in Roane County, Tennessee, (Figure 9-5) that is primarily undeveloped and would require a considerable amount of infrastructure development to support the construction of two or more SMRs. ORR Site 2 is owned by the Federal government and managed by DOE. Approximately 130 ac would need to be disturbed to construct the power block, cooling towers, ancillary facilities, as well as linear corridors for siting an access road and cooling-water intake and discharge pipelines (TVA 2016-TN5040).

The entire onsite area has been inventoried for archaeological resources several times between 1974 and 2015 (Fielder 1974-TN5338, Fielder 1975-TN4978; Angst and Kirkmeyer 2007-TN5336; Hunter et al. 2015 (TN4971); Jacobs 1995-TN5339; Jolley 1982-TN4977; McKee and Karpynec 2006-TN5340; Pace 1995-TN4969; Valk et al. 2011-TN4972). A total of four archaeological sites and one historic cemetery have been recorded on ORR Site 2 (Johnson 2015-TN5220). Two sites (40RE233 and 40RE577) are associated with the National Register of Historic Places (NRHP)-eligible historic-era Happy Valley Worker Camp. The other two archaeological sites include pre-contact site 40RE138 (Hunter et al. 2015-TN4971) and historic site 40RE575 (McKee and Karpynec 2006-TN5340). Site 40RE138 remains unevaluated but was recommended for avoidance or additional investigation (Hunter et al. 2015-TN4971). Site 40RE575 is likely not NRHP-eligible due to lack of integrity and research potential (McKee and Karpynec 2006-TN5340). The Wheat Community African American Burial Ground (40RE219) has been recommended for avoidance, and additional investigation to delineate potentially unmarked graves if ground-disturbing activities are proposed in the area (Hunter et al. 2015-TN4971). The review team expects that there is a high potential for deeply buried archaeological deposits to be present at ORR Site 2. An independent review of Tennessee Historical Commission architectural survey files revealed that there are no architectural resources or NRHP-listed architectural resources known to be located within the onsite direct-effects APE. Two architectural resources are located within the onsite indirect-effects APE. These include the NRHP-listed George Jones Baptist Memorial Church (RE1371) (Thomason and Associates 1991-TN5354) and the Smith House (RE1439).

9.3.2.7.2 Affected Environment at ORR Site 8

The following information was used to identify the historic and cultural resources at ORR Site 8:

- TVA ER (TVA 2017-TN4921)
- Johnson 2015-(TN5220)
- Fielder (1974-TN5338)
- DuVall and Souza (1996-TN5337).

As discussed in EIS Section 9.3.2, ORR Site 8 covers 424 ac in Roane County, Tennessee (Figure 9-5), and is primarily undeveloped. It would require a considerable amount of infrastructure development to support the construction of two or more SMRs. ORR Site 8 is owned by the Federal government and managed by DOE. Approximately 145 ac would need to be disturbed to construct the power block, cooling towers, ancillary facilities, as well as linear corridors for siting an access road and cooling-water intake and discharge pipelines (TVA 2016-TN5040). The onsite project area was surveyed for historic and cultural resources in 1974 by Fielder (1974-TN5338) and in 1996 by DuVall and Souza (1996-TN5337). Four pre-contact era archaeological sites (40RE99A, 40RE99B, 40RE100, 40RE117) have been recorded on ORR Site 8. DuVall and Souza (1996-TN5337) revisited these locations in 1996. Site 40RE99A is an NRHP-eligible village site that has been inundated by construction of the Melton Hill Dam. Site 40RE99B is a mound recommended as being NRHP-eligible. Site 40RE100 has been destroyed and is no longer extant and 40RE117 (a cave site) warrants further investigation to determine its NRHP eligibility (DuVall and Souza 1996-TN5337). The review team expects that there is a high potential for deeply buried archaeological deposits to be present at ORR Site 8.

DuVall and Souza's 1996 inventory also located the remains of four pre-World War II structures (i.e., foundations, partially standing structures). These include Structures 61A, 61B, 68A, and 70A. None of these were recommended as being NRHP-eligible (DuVall and Souza 1996-TN5337).

The NRHP-eligible Melton Hill Dam District is located within the indirect-effects APE. The district comprises 14 contributing structures, sites, and buildings. In addition, there are four unevaluated architectural resources (RE-620; an abandoned early 20th century house, RE621; Goodwin Place—a bungalow style house, RE622; Mills-Pickle-Luttrell early 20th century house, and RE174; early 20th century traditional style house with bungalow influences) located within the indirect-effects APE for ORR Site 8.

9.3.2.7.3 Affected Environment at Redstone Arsenal Site 12

The following information was used to identify historic and cultural resources located at Redstone Arsenal Site 12:

- TVA ER (TVA 2017-TN4921)
- Johnson 2015 (TN5220)
- Alexander et al. 2000 (TN5317)
- Alexander et al. 2003 (TN5316)
- Alexander and Redwine 2008 (TN5315).

The Redstone Arsenal Site 12 is located on the western edge of the Redstone Arsenal, south of Huntsville, Alabama, near the southern edge of the TVA service area. The site is primarily undeveloped and there is no public access, although an existing access road runs through the site. Redstone Arsenal Site 12 is owned by the Federal government. Approximately 449 ac would need to be disturbed to construct the power block, cooling towers, ancillary facilities, as well as linear corridors for siting a transmission line, and cooling-water intake and discharge pipelines (TVA 2017-TN5028, TVA 2016-TN5040).

Most of the onsite area has been surveyed for archaeological resources by three different field investigations (Alexander et al. 2000-TN5317; Alexander et al. 2003-TN5316; Alexander and Redwine 2008-TN5315). Five historic-era archaeological sites dating to the late nineteenth/early twentieth century are located at the Redstone Arsenal Site 12 in the onsite direct-effects APE (1MA879, 1MA880, 1MA882, 1MA1552, and 1MA553). While none of these sites have been formally evaluated for NRHP eligibility, four (1MA879, 1MA880, 1MA882, and 1MA1552) are recommended as being potentially eligible and one is recommended as potentially NRHP-ineligible (1MA1553) (Alexander and Redwine 2008-TN5315; Alexander et al. 2000-TN5317). According to Johnson (2015-TN5220), three architectural surveys have been completed within the Redstone Arsenal Site 12 onsite direct-effects APE. No known architectural resources or NRHP-listed architectural resources have been identified within the onsite direct-effects APE (Johnson 2015-TN5220). Architectural resource surveys have not been completed within the indirect-effects APE at Redstone Arsenal Site 12, so it is possible that architectural resources exist.

Site-specific data were not obtained on archaeological resources located within the linear corridors proposed for the cooling-tower intake and discharge pipelines. As currently proposed, the pipelines cross segments of Indian Creek and the Tennessee River. There is a high potential for significant archaeological resources to be located near these waterways.

9.3.2.7.4 Building Impacts

Direct impacts on historic and cultural resources could occur from the construction of two or more SMRs at all alternative sites. Impacts could result in the irretrievable loss of historic and cultural information and therefore destabilize the resource. Both NRHP-eligible and unevaluated archaeological sites are located within the onsite direct-effects APE at all alternative sites. Building-related activities occurring near waterways at ORR Site 2, ORR Site 8 and Redstone Arsenal Site 12 have a high potential to result in significant direct impacts on archaeological resources.

Indirect impacts on historic and cultural resources could occur from the construction of two or more SMRs at all alternative sites. Impacts could result in the permanent alteration of the view shed which could destabilize the resource. ORR Site 2 and ORR Site 8 contain NRHP-eligible and unevaluated architectural resources that could potentially be directly or indirectly affected by building activities. There do not appear to be any architectural resources within the direct- and indirect-effects APE at Redstone Arsenal Site 12, but this would need to be confirmed by additional historic and cultural resource investigation if this site were to be selected. Given the topography of the area and the abundance of vegetation at all alternative sites, impacts could likely be minimized or avoided.

TVA would need to conduct additional historic and cultural resource investigations and NRHP evaluations to assure that all resources (i.e., archaeological, architectural, and traditional cultural properties) are identified within the direct- and indirect-effects APE at each of the alternative sites as well as at offsite areas if one of these alternative sites were to be selected. If avoidance is not possible, impacts would need to be minimized or mitigated. The review team expects that TVA would amend its APE and evaluate historic and cultural resources in accordance with stipulations outlined in its Programmatic Agreement (PA) (TVA 2017-TN4921). This PA would commit TVA to avoiding, minimizing, or mitigating building impacts on historic and cultural resources in accordance with the National Historic Preservation Act (NHPA) Section 106 process. The PA would also contain NHPA Section 106 requirements and Native American Graves Protection and Repatriation Act (NAGPRA) inadvertent discovery procedures which would include stop work and notification provisions.

9.3.2.7.5 Operational Impacts

Impacts on historic and cultural resources could occur from operation of two or more SMRs located at ORR Site 2, ORR Site 8, and Redstone Arsenal Site 12. Impacts are expected to be minimal because most of them would occur during building activities. Long-term visual impacts on historic structures located within indirect-effects APE are possible, but these impacts would have been addressed and mitigated, if required, under the auspices of the PA. The review team assumes that because TVA is a Federal land-managing agency, TVA is responsible for following the NHPA Section 106 Review process to address potential impacts on historic and cultural resources from ongoing operation and maintenance activities. TVA is also responsible for complying with the NHPA (54 U.S.C. § 300101 *et seq*.-TN4157), Archaeological Resources Protection Act (16 U.S.C. § 470aa *et seq*.-TN1687), NAGPRA (25 U.S.C. § 3001 *et seq*.-TN1686), and Archaeological and Historic Preservation Act (54 U.S.C. § 312501 *et seq*.-TN4844), American Indian Religious Freedom Act (42 U.S.C. § 1996 *et seq*.-TN5281), Executive Order (EO) 13007 (TN5250), “Indian Sacred Sites” and EO 13175 (TN4846), “Consultation and Coordination with Indian Tribal Governments.” TVA also maintains procedures and management plans that take into consideration of impacts on cultural resources during operations.

9.3.2.7.6 Cumulative Impacts

Past actions in the GAI that have similarly affected historic and cultural resources at all alternative sites include limited rural development. Past actions also include land-disturbing activities such as road development at ORR Site 2 and Redstone Arsenal Site 12. Table 7-1 and Table 9-2 list past, present, and reasonably foreseeable projects and other actions that may contribute to cumulative impacts on historic and cultural resources in the GAI. Future urbanization such as new and expanded roads and other infrastructure are projects that could occur in the GAI and may contribute to cumulative impacts on historic and cultural resources at all alternative sites. ORR operations are a project that is in the GAI that could contribute to cumulative impacts on historic and cultural resources at both ORR Site 2 and ORR Site 8. In addition, ongoing operation of the Melton Hill Dam is a project that falls in the GAI and may contribute to cumulative impacts on historic and cultural resources at ORR Site 8. Operations at Redstone Arsenal, the Wheeler National Wildlife Refuge, and future urbanization such as new and expanded roads and other infrastructure are projects in the GAI that could contribute to cumulative impacts on historic and cultural resources at Redstone Arsenal Site 12. These projects may significantly affect historic and cultural resources in a manner similar to those associated with building and operation of two or more SMR units. If building activities result in significant alterations of historic and cultural resources, either physical or visual, then cumulative impacts on historic and cultural resources would be greater.

9.3.2.7.7 Summary of Historic and Cultural Resource Impacts at Alternative Sites

Cultural resources are nonrenewable; therefore, the impact of destruction or visual alteration of historic and cultural resources is cumulative. Based on the information provided by TVA and the review team's independent evaluation of reconnaissance-level information collected for this EIS, the review team concludes that cumulative impacts from building and operating two or more SMRs at all alternative sites would be MODERATE to LARGE. The impact-level determination reflects the fact that (1) there are NRHP-eligible and unevaluated historic and cultural resources located within the direct- and indirect-effects APE at all alternative sites, (2) it is possible these resources would be destroyed if they cannot be avoided, (3) the potential for deeply buried archaeological deposits at all alternative sites is high, and, (4) TVA would execute a PA. Building and operating two or more SMRs at each of the alternative sites would be a significant contributor to the impacts.

9.3.2.8 Air Quality

9.3.2.8.1 Criteria Pollutants

The air-quality impacts of building and operating a new nuclear power plant and offsite facilities at ORR Site 2 and ORR Site 8 would be similar to the impacts expected for the CRN Site, as described in EIS Chapters 4 and 5. ORR Site 2 is a largely undeveloped site in Roane County, Tennessee, and is adjacent to the CRN Site, while ORR Site 8 is an undeveloped site, approximately 4 mi to the east of the CRN Site. The emissions for construction and preconstruction activities as well as operations of a new nuclear power plant at these sites are expected to be the same as the emissions at the CRN Site. The ORR Site 2 and ORR Site 8 meteorological conditions are similar to those at the CRN Site; therefore, dispersion conditions are expected to be similar to those at the CRN Site. These sites are all in Roane County, which is in attainment for all National Ambient Air Quality Standard pollutants (40 CFR 81.343-TN5012).

The air-quality impacts of building and operating a new nuclear power plant and offsite facilities at Redstone Arsenal Site 12 would be similar to the impacts expected for the CRN Site, as described in EIS Chapters 4 and 5. The emissions for construction and preconstruction activities as well as operations of a new nuclear power plant at Redstone Site 12 are expected to be the same as the emissions at the CRN Site. Wind speeds at Redstone Site 12 are approximately two times greater than at the CRN Site; therefore, dispersion at Redstone Site 12 is expected to be greater than at the CRN Site. The county in which Redstone Arsenal Site 12 is located—Madison County, Alabama—is in attainment for all National Ambient Air Quality Standard pollutants (40 CFR 81.301-TN5011).

As discussed in EIS Section 4.7, emissions of criteria pollutants from construction and preconstruction activities are expected to be temporary and limited in magnitude. Emissions from these activities would be primarily fugitive dust from ground-disturbing activities and engine exhaust from heavy equipment and workforce vehicles. These impacts would be similar to the impacts associated with any large construction project. During building activities, air-quality permits from either the State of Tennessee or Alabama would be required, which would prescribe emissions limits and mitigation measures to be implemented. The applicant plans to implement a fugitive dust control program (TVA 2017-TN4921).

EIS Section 5.7 discusses air-quality impacts during operations. Emissions during operations would be primarily from the operation of the cooling towers, auxiliary boilers, diesel generators, gas turbines, and commuter traffic. Stationary sources such as the diesel generators and gas turbines (which operate infrequently) and auxiliary boilers (which operate primarily during winter months) would be operated according to State and Federal regulatory requirements.

A Title V operating permit administered through either the State of Tennessee or Alabama would ensure compliance with National Ambient Air Quality Standards and other applicable regulatory requirements and prescribe mitigation measures to ensure compliance. There are six major sources of air emissions in Roane County, Tennessee, that have existing Title V renewal permits (TDEC 2017-TN5017). These include the energy and industrial projects listed in Table 7-1. There are three major sources of air emissions in Madison County, Alabama, that have existing Title V renewal permits (ADEM 2017-TN5048), as listed in Table 9-2. Existing energy and industrial projects, and planned development and transportation projects would contribute to air-quality impacts in Roane County, Tennessee, as well as in Madison County, Alabama. However, the impacts on air quality in the county from emissions from ORR Site 2, ORR Site 8, or Redstone Site 12 would be temporary and not noticeable when combined with other past, present, and reasonably foreseeable future projects. The cumulative air-quality impacts of building and operating a nuclear power plant at ORR Site 2, ORR Site 8, or Redstone Site 12 would be minor.

9.3.2.8.2 Greenhouse Gases

The cumulative impacts of greenhouse gas (GHG) emissions related to nuclear power are discussed in EIS Section 7.6. The impacts of the emissions are not sensitive to the location of the source. Consequently, the discussion in Section 7.6 would be applicable to a nuclear power plant located at ORR Site 2, ORR Site 8, or Redstone Site 12. The review team concludes that the national and worldwide cumulative impacts of GHG emissions are noticeable but not destabilizing. The review team further concludes that the cumulative impacts would be noticeable but not destabilizing, with or without the GHG emissions of a nuclear power plant at ORR Site 2, ORR Site 8, or Redstone Site 12.

9.3.2.8.3 Summary of Air-Quality Impacts at Alternative Sites

The review team concludes that the cumulative impacts from other past, present, and reasonably foreseeable future actions on air-quality resources in the GAIs would be SMALL for criteria pollutants and MODERATE for GHG emissions. The incremental contribution of impacts on air-quality resources from building and operating a new nuclear power plant at the ORR Site 2, ORR Site 8, or Redstone Site 12 would not be a significant contributor to the MODERATE impacts for GHG emissions.

9.3.2.9 Nonradiological Health

The following impact analysis considers nonradiological health impacts from building activities and operations on the public and workers from two or more SMRs at ORR Site 2 or ORR Site 8, which are both located in Roane County, Tennessee, adjacent to the CRN Site, or Redstone Arsenal Site 12 in Madison County, Alabama, about 200 mi west-southwest of the CRN Site. The analysis also considers other past, present, and reasonably foreseeable future actions that could affect nonradiological health, including other Federal and non-Federal projects within the GAI. Because of the close proximity of ORR Sites 2 and 8, projects and other actions considered for cumulative impacts associated with building and operating new nuclear units at both sites are covered in Table 7-1. Projects and other actions considered for cumulative impacts associated with building and operating new nuclear units at the Redstone Arsenal Site 12 are covered in Table 9-2.

The building-related activities that have the potential to affect the health of members of the public and workers include exposure to dust and vehicle exhaust, occupational injuries, noise, and the transport of construction materials and personnel to and from the site. All building-related activities would be temporary in duration. The operation-related activities that have the potential to affect the health of members of the public and workers include exposure to etiological agents, noise, and electromagnetic fields, and transport of workers to and from the site. Operation-related activities would occur throughout the life of the plant.

Most of the nonradiological impacts of building and operation would be localized and would not have significant impact at offsite locations beyond the 6-mi vicinity. However, activities such as vehicle emissions from transport of personnel to and from the site would encompass a larger area. Therefore, for nonradiological health impacts associated with the influence of vehicle and other air emissions sources, the GAI for cumulative impacts analysis includes projects within a 50-mi radius of ORR Site 2, ORR Site 8, and Redstone Arsenal Site 12. For cumulative impacts associated with transmission lines, the GAI is the transmission line corridor. These geographical areas are expected to encompass areas where cumulative impacts on public and worker health could occur in combination with any past, present, or reasonably foreseeable future actions.

Alternative ORR Sites 2 and 8 and the preferred CRN Site are substantially the same in terms of characteristics due to their proximity to each other. The CRN Site and vicinity is described in detail in EIS Chapter 2. For the purposes of the alternatives analysis for nonradiological health, ORR Sites 2 and 8 will be discussed together.

9.3.2.9.1 Building Impacts

Nonradiological health impacts from building two or more SMRs on construction workers and members of the public at ORR Site 2, ORR Site 8, and Redstone Arsenal Site 12 would be similar to those evaluated in EIS Section 4.8. They include occupational injuries, noise, vehicle exhaust, and dust. Applicable Federal and State regulations on air quality and noise would be complied with during the site preparation and building phase. ORR Sites 2 and 8 are both located in rural areas, similar to the CRN Site, and building impacts would likely be noticeable to the closest sensitive receptors, primarily from noise generated by construction equipment and increased traffic, but negligible on the surrounding populations.

Redstone Arsenal Site 12 is an undeveloped site located in a rural area that is not owned by TVA. The 130-ac site is north of the Tennessee River and would require infrastructure upgrades and improvements prior to use (TVA 2017-TN4921). Similar to ORR Sites 2 and 8, building impacts at Redstone Arsenal Site 12 would likely be noticeable to the closest sensitive receptors, primarily from noise generated by construction equipment and increased traffic, but negligible on the surrounding populations. The review team determined the occupational injury incidence rates would be similar to those at the CRN Site; therefore, impacts on workers from occupational injuries would be negligible.

9.3.2.9.2 Operational Impacts

Nonradiological health impacts on members of the public and workers from operating two or more SMRs at the CRN Site are fully described in EIS Section 5.8. Based on the configuration of the proposed new units at ORR Site 2, ORR Site 8, and Redstone Arsenal Site 12, etiological agents would not likely increase the incidence of waterborne diseases in the vicinity of the sites. Impacts on workers' health from noise and electric fields would be similar. Noise and electric fields would be monitored and controlled in accordance with applicable Occupational Safety and Health Administration regulations. Occupational injuries at ORR Site 2, ORR Site 8, and Redstone Site 12 would be similar to those described in EIS Section 5.8; therefore, impacts on workers from occupational injuries would be negligible.

9.3.2.9.3 Cumulative Impacts

Past and present actions within the GAI that could contribute to cumulative nonradiological health impacts at ORR Sites 2 and 8 and Redstone Arsenal Site 12 include the development and operations of nuclear and other energy projects listed in Table 7-1 and Table 9-2, respectively, as well as vehicle emissions and existing urbanization throughout the GAI.

Proposed future actions that would affect nonradiological health in a similar way to development and operations at ORR Sites 2 and 8 and Redstone Arsenal Site 12 would include construction and operations of nuclear and other energy projects listed in Table 7-1 and Table 9-2, respectively; transmission line creation and/or upgrading throughout the designated GAI, and future urbanization. The review team concludes that the cumulative impacts on nonradiological health from building two or more SMRs and associated transmission lines at the alternative sites would be minimal, except for noise impacts which would be noticeable. The review team also concludes that the impacts on nonradiological health from operating new SMRs and associated transmission lines at the alternative sites would be minimal.

9.3.2.9.4 Summary of Nonradiological Health Impacts at the Alternative Sites

Cumulative impacts on nonradiological health from the building and operation of two or more SMRs and associated transmission lines at the alternative sites when added to past, present, and reasonably foreseeable future actions are estimated based on the information provided by TVA and the review team's independent evaluation. The review team concludes that the nonradiological health cumulative impacts of activities associated with the three alternative sites would be SMALL for all categories with the exception of noise, which would be MODERATE during the building phase. Building two or more SMRs at the three sites would be a significant contributor to the MODERATE cumulative noise impact.

9.3.2.10 Radiological Impacts of Normal Operations

The following analysis considers radiological impacts on the public and workers from building activities and operations for new SMRs constructed at ORR Site 2, ORR Site 8, or Redstone Arsenal Site 12. ORR Site 2 and ORR Site 8 are both located in Roane County, Tennessee, adjacent to the CRN Site. The analysis also considers other past, present, and reasonably foreseeable future actions that could affect radiological health, including other Federal and non-Federal projects and the nuclear-related projects listed in Table 7-1 and Table 9-2 that are within the GAI. The GAI is the area within a 50-mi radius of each alternative site. The past, present, and reasonably foreseeable nuclear-related actions are shared by ORR Sites 2 and 8 and are listed in Table 7-1 (Oak Ridge Reservation, Oak Ridge National Laboratory, Y-12 Complex, ETTP, Environmental Management Waste Management Facility, and Watts Bar Nuclear Plant Units 1 and 2). As a result of the close proximity of ORR Sites 2 and 8 to the CRN Site, the past, present, and reasonably foreseeable nuclear-related actions listed in Table 7-1 are the same as those for the CRN Site. The past, present, and reasonably foreseeable nuclear-related actions for Redstone Arsenal Site 12 located in Madison Country, Alabama, are included in Table 7-1 (Browns Ferry Nuclear Plant Units 1, 2, and 3). In addition, medical, industrial, and research facilities that use radioactive materials are likely to be within 50 mi of each alternative site.

9.3.2.10.1 Building Impacts

Radiological health impacts on the construction workers from building two or more SMRs at each of the alternative sites (ORR Site 2, ORR Site 8, and Redstone Arsenal Site 12) would be similar to those from building two or more SMRs at the CRN Site, as evaluated in EIS Section 4.9. Those impacts were found to be minor and meet the regulatory requirements in 10 CFR Part 20 (TN283). The radiological impacts include doses from direct radiation and liquid and gaseous effluents from any newly completed units that begin operation during ongoing construction of subsequent units. These pathways would result in doses to humans that would be below regulatory limits. Impacts at the alternative sites are expected to be similar to those estimated for the CRN Site, because the primary contributor to dose is the startup of new units during ongoing construction that would occur at the alternative sites in a manner similar to that for the CRN Site that was evaluated in EIS Section 4.9.

9.3.2.10.2 Operational Impacts

Radiological health impacts on occupational health of workers and members of the public from operation of two or more SMRs at each of the alternative sites (ORR Site 2, ORR Site 8, and Redstone Arsenal Site 12) would be similar to those evaluated in EIS Section 5.9 at the CRN Site. The ORR sites are proximate to and similar to the CRN Site. The CRN Site is situated in a rural location but it includes residential, commercial, and recreational areas very near its site boundary, all of which were included in the evaluation of radiological health impacts in EIS Section 5.9. Although the Redstone Arsenal facility has residential communities closer to its boundary, the impacts on workers and members of the public from normal operations would still be minor and meet the regulatory limits of 10 CFR Part 20.

9.3.2.10.3 Cumulative Impacts

Past, present, and reasonably foreseeable actions within the GAI for the alternative sites that could contribute to cumulative radiological health impacts include the nuclear-related projects listed in Table 7-1 and Table 9-2 as well as medical, industrial, and research facilities that use radioactive materials likely to be within 50 mi of each alternative site. The cumulative impacts at the alternative site locations would be similar to those at the CRN Site, as described in EIS Section 7.8, and would be minor.

9.3.2.10.4 Summary Radiological Impacts at Alternative Sites

Based on the information provided in the TVA ER (TVA 2017-TN4921) and the review team's independent evaluation, the review team concludes that the impacts on radiological health from building and operating two or more SMRs at one of the alternative sites (ORR Site 2, ORR Site 8, or Redstone Arsenal Site 12) would be similar to the impacts evaluated for the CRN Site. Although there are varying past, present, and reasonably foreseeable future activities within the GAI for each of the alternative sites that could affect radiological health, the impacts at the alternative sites would be localized and managed through adherence to existing regulatory requirements, and are expected to be similar in nature and level to those evaluated for the CRN Site. The review team concludes, therefore, that the radiological health impacts and the cumulative impacts on radiological health of building and operating two or more SMRs at one of the alternative sites would be SMALL.

9.3.2.11 Accidents

The following analysis considers radiological impacts from postulated accidents related to the operation of a new SMR at the alternative sites—ORR Site 2, ORR Site 8, or Redstone Arsenal Site 12. ORR Site 2 and ORR Site 8 are both located in Roane County, Tennessee, adjacent to the CRN Site (i.e., within about 2 and 5 mi of the CRN Site, respectively). The analysis also considers other past, present, and reasonably foreseeable future actions that could affect radiological health from postulated accidents, including other Federal and non-Federal projects and those projects listed in Table 7-1 and Table 9-2 that are within the GAI.

The GAI considers all existing and proposed nuclear power plants that have the potential to increase the probability-weighted consequences (i.e., risks) from a severe accident at any location within 50 mi of the site. As a result of the close proximity of ORR Sites 2 and 8 to the CRN Site, the past, present, and reasonably foreseeable nuclear-related actions listed in Table 7-1 are essentially the same as those for the CRN Site (Oak Ridge Reservation, Oak Ridge National Laboratory, Y-12 Complex, ETTP, Environmental Management Waste Management Facility, and Watts Bar Nuclear Plant Units 1 and 2). The past, present, and reasonably foreseeable nuclear-related actions for Redstone Arsenal Site 12 located in Madison Country, Alabama, provided in Table 9-2 include Browns Ferry Nuclear Plant Units 1, 2, and 3, and Sequoyah Nuclear Plant Units 1 and 2.

As described in EIS Section 5.11, the NRC staff concludes that the environmental consequences of design basis accidents (DBAs) at the CRN Site would be minimal for the surrogate SMR. DBAs are addressed specifically to demonstrate that any of the SMR designs considered is sufficiently robust to meet the NRC safety criteria. The reactor designs are independent of site conditions, and the meteorological conditions at ORR Site 2 and ORR Site 8 are similar to those at the CRN Site given their close proximity to the CRN Site (i.e., approximately 2 and 5 mi., respectively). Therefore, the NRC staff concludes the environmental impacts of DBAs at any of the alternative sites would also be minimal.

The population density in proximity to Redstone Arsenal Site 12 is considerably higher than that for the CRN Site and the site likely has different meteorological conditions. Given that the meteorological conditions at the CRN Site often consist of very stable conditions and low wind speeds, which tend to maximize consequences, the expected impact of different meteorology at Redstone Arsenal Site 12 alone would be to decrease population risk if that was the only consideration. However, the population density in close proximity to this site is considerably higher than that at the CRN Site due to the building of housing developments abutting the Redstone Arsenal boundary. Therefore, the population risk of an accident at that Redstone Arsenal Site 12 could be higher than at the CRN Site.

Because the meteorology, population distribution, and land use for ORR Site 2 and ORR Site 8 are similar to those at the CR Site, risks from a severe accident for a new nuclear power plant located at these alternative sites are expected to be similar to those analyzed for the CRN Site. As previously discussed, the risks from a severe accident at Redstone Arsenal Site 12 is expected to be higher than at the CRN Site, but should still be small. The risks for the CRN Site are presented in Table 5-14 through Table 5-16 for the three evaluated Emergency Planning Zones (EPZ). Table 5-18 shows that the risks are well below the mean and median values for current-generation reactors for any of the three EPZs evaluated. In addition, as discussed in EIS Section 5.11.2.1, estimates of average individual early fatality and latent cancer fatality risks are well below Commission safety goals (51 FR 30028-TN594).

As shown in EIS Section 5.11.2, the risk of a severe accident is small at the CRN Site for any of the three EPZs, and the SMR design is independent of any site. Therefore, the NRC staff concludes that because the risk of a severe accident at the CRN Site is small, the environmental impacts of severe accidents at any of the alternative sites would also be minimal.

For existing nuclear power plants within the GAI (i.e., whose 50-mi radius overlaps with the 50-mi radius around the alternative sites) the Commission determined the probability-weighted consequences of severe accidents are small (10 CFR Part 51, Appendix B, Table B-1 [TN250]). The existing nuclear facilities within the GAIs for ORR Sites 2 and 8, consists of Oak Ridge Reservation, Oak Ridge National Laboratory, Y-12 Complex, ETTP, Environmental Management Waste Management Facility, and Watts Bar Nuclear Plant Units 1 and 2. For the Redstone Arsenal Site 12, the existing nuclear facilities within the GAI consist of the Browns Ferry Nuclear Plant Units 1, 2, and 3, and Sequoyah Nuclear Plant Units 1 and 2. Because of the NRC safety review criteria and DOE nuclear safety regulations as discussed in EIS Section 7.10, the NRC staff expects that risks for any new reactors and other nuclear facilities within the GAI for any of the alternative sites would be below the risks for current-generation reactors and would meet Commission safety goals. The severe accident risk due to any particular nuclear power plant and nuclear facilities becomes smaller as the distance from that plant increases. However, the combined risk at any location within 50 mi of the alternative sites would be bounded by the sum of risks for all of the operating nuclear power plants and other nuclear facilities, whose individual environmental risks were determined to be small. Therefore, the additional risk from an SMR unit would be minimal. On this basis, the NRC staff concludes that the cumulative risks of postulated accidents at any location within 50 mi of the alternative sites would be SMALL.

9.3.3 Comparison of the Impacts of the Proposed Action at Alternative Sites

This section summarizes the review team's characterization of the cumulative impacts related to building and operating two or more SMRs at the proposed CRN Site and at each of the three alternative sites. The sites selected for detailed review as part of the alternative sites environmental analysis included the three sites designated as ORR Site 2, ORR Site 8, and Redstone Arsenal Site 12 (see Figure 9-3 and Figure 9-4). Comparisons are made between the CRN Site and the alternative sites to determine whether one of the alternative sites would be "environmentally preferable" to the CRN Site.

The need to compare the CRN Site with alternative sites arises from the requirement in NEPA Section 102(2)(c)(iii) (42 U.S.C. § 4321 *et seq*.-TN661) that EISs include an analysis of alternatives to the proposed action. The NRC criteria to be used in assessing whether a proposed site is to be rejected in favor of an alternative site are based on whether the alternative site is "obviously superior" to the site proposed by the applicant (PSCO v. NRC 1978-TN2633). An alternative site is obviously superior to the proposed site if it is "clearly and substantially" superior to the proposed site (NRC 1978-TN2636). The standard of obviously superior "is designed to guarantee that a proposed site will not be rejected in favor of an alternate unless, on the basis of appropriate study, the Commission can be confident that such action is called for" (NECNP v. NRC 1978-TN2632).

The "obviously superior" test is appropriate for two reasons. First, the analysis performed by the NRC in evaluating alternative sites is necessarily imprecise. Key factors considered in the alternative site analysis such as population distribution and density, hydrology, air quality, aquatic and terrestrial ecological resources, aesthetics, land use, and socioeconomics are difficult to quantify in common metrics. Given this difficulty, any evaluation of a particular site must have a wide range of uncertainty. Second, the CRN Site has been analyzed in detail, with the expectation that most adverse environmental impacts associated with the site have been identified (see EIS Chapters 4, 5, 6, and 7). The alternative sites have not undergone a comparable level of detailed study. For these reasons, a proposed site may not be rejected in favor of an alternative site when the alternative site is marginally better than the proposed site, only when it is obviously superior (NRC 1978-TN2636). NEPA does not require that a nuclear plant be constructed on the single best site for environmental purposes. Rather, "all that NEPA requires is that alternative sites be considered and that the effects on the environment of building the plant at the alternative sites be carefully studied and factored into the ultimate decision" (NECNP v. NRC 1978-TN2632).

The NRC staff review of alternative sites consists of a two-part sequential test (NRC 2000-TN614, NRC 2007-TN5141). The first part of the test determines whether any of the alternative sites are environmentally preferable to the applicant-proposed site. The NRC staff considers whether the applicant has (1) reasonably identified candidate sites, (2) evaluated the likely environmental impacts of building and operation at these sites, and (3) used a logical means of comparing sites that led to applicant selection of the proposed site. Based on the independent NRC review, the NRC staff determines whether any of the alternative sites are environmentally preferable to the applicant-proposed site. If the NRC staff determines that one or more alternative sites are environmentally preferable, then it would compare the estimated costs (i.e., environmental, economic, and time) of constructing the proposed plant at the applicant-proposed site and at the environmentally preferable site or sites (NRC 2000-TN614, NRC 2007-TN5141). The second part of the test determines whether an environmentally preferable alternative site is obviously superior to the applicant-proposed site. The NRC staff must determine that (1) one or more important aspects, either singly or in combination, of an environmentally preferable alternative site are obviously superior to the corresponding aspects of the applicant-proposed site, and (2) the alternative site does not have offsetting deficiencies in other important areas. An NRC staff conclusion that an alternative site is obviously superior to the applicant-proposed site would normally lead to a recommendation that the application for the permit be denied.

Section 9.3.3.1 reviews the cumulative environmental impacts of building and operating two or more SMRs at the CRN Site. Cumulative impact levels for the CRN Site (from EIS Chapter 7) and the three alternative sites (from Section 9.3.2) are given in Table 9-14. Sections 9.3.3.2 and 9.3.3.3 discuss the cumulative environmental impacts of two or more SMRs at the CRN Site in relation to the alternative sites as they relate to “environmentally preferable” and “obviously superior” evaluations.

9.3.3.1 Comparison of Cumulative Impacts Associated with CRN Site and Alternative Sites

The review team characterizations of the cumulative environmental impacts of building and operating two or more SMRs at the CRN Site and at the three alternative sites are listed by resource area in Table 9-14.

The review team evaluated the environmental resource areas listed in Table 9-14 using the NRC three-level standard of impact significance: SMALL, MODERATE, or LARGE. These levels were developed using the CEQ guidelines and are set forth in the footnotes to 10 CFR Part 51, Subpart A, Appendix B, Table B-1 (TN250).

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

The review team performed reconnaissance-level reviews of each of the three alternative sites and reviewed information provided in the TVA ER (TVA 2017-TN4921) and supplemental information provided by TVA, information from other Federal and State agencies, and information gathered during visits to each alternative site. The review team found that TVA implemented a reasonable process for selecting alternative sites and used a logical process to compare the impacts of the CRN Site to those of the alternative sites. The following discussion summarizes the review team’s independent assessment of the CRN Site and alternative sites.

Full explanations for the cumulative impact characterizations are provided in EIS Chapter 7 for the CRN Site and in Section 9.3.2 for the three alternative sites. The review team assignment of impact category levels is based on professional judgment, experience, and consideration of controls likely to be imposed under required Federal, State, or local permits that would not be acquired until an application for a construction permit or combined license were under way. These considerations and assumptions were similarly applied at each of the alternative sites to provide comparisons of impact levels at the CRN Site and each of the three alternative sites.

Table 9-14. Comparison of Cumulative Impacts at the Proposed CRN Site and Three Alternative Sites

Resource Area	CRN Site	ORR Site 2	ORR Site 8	Redstone Arsenal Site 12
Land Use	MODERATE	MODERATE	MODERATE	MODERATE
Water Use and Quality				
Surface-Water Use	MODERATE	MODERATE	MODERATE	MODERATE
Groundwater Use	SMALL	SMALL	SMALL	MODERATE
Surface-Water Quality	MODERATE	MODERATE	MODERATE	MODERATE
Groundwater Quality	MODERATE	MODERATE	MODERATE	MODERATE
Terrestrial and Wetland Resources	MODERATE	LARGE	LARGE	MODERATE
Aquatic Resources	LARGE	LARGE	LARGE	LARGE
Socioeconomics				
Physical Impacts	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE
Demography	SMALL	SMALL	SMALL	SMALL
Taxes and Economy	SMALL (beneficial)	SMALL (beneficial)	SMALL (beneficial)	SMALL (beneficial)
Infrastructure and Community Services	MODERATE to LARGE	MODERATE to LARGE	MODERATE to LARGE	MODERATE to LARGE
Environmental Justice	None	None	None	None
Historic and Cultural Resources	MODERATE to LARGE	MODERATE to LARGE	MODERATE to LARGE	MODERATE to LARGE
Air Quality				
Criteria pollutants	SMALL	SMALL	SMALL	SMALL
Greenhouse gas emissions	MODERATE	MODERATE	MODERATE	MODERATE
Nonradiological Health	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE
Radiological Health	SMALL	SMALL	SMALL	SMALL
Waste Management	SMALL	SMALL	SMALL	SMALL
Postulated Accidents	SMALL	SMALL	SMALL	SMALL

9.3.3.2 Environmentally Preferable Sites

Neither the CRN Site nor any of the three alternative sites appear to have inherent characteristics that would completely preempt building a nuclear plant at that location. However, as shown in Table 9-14, the cumulative impacts of building and operating two or more SMRs at the proposed CRN Site or at one of the alternative sites vary across the impact categories.

The cumulative impacts of building and operating two or more SMRs at the CRN Site or at any one of the alternative sites are SMALL for several impact categories (e.g., radiological health, postulated accidents). The resource categories for which the impact level at an alternative site would be the same as for the proposed site do not contribute to the alternative site being judged to be environmentally preferable to the proposed site (e.g., land use, surface water use and quality, aquatic resources, historic and cultural resources, taxes and economy, and air quality). Therefore, these resource categories are not discussed further in determining whether an alternate site is environmentally preferable to the proposed site. Where there is a range of impacts for a resource category, the upper value of that range is used for the comparison. In addition, for the cases in which the cumulative impacts for a resource category would be greater than SMALL, consideration is given to the cases in which the impacts of the project at the specific site would not make a significant contribution to the cumulative impact level.

9.3.3.2.1 ORR Site 2

For most resources, the environmental impacts at ORR Site 2 would be similar to the impacts at the CRN Site. The cumulative impacts on terrestrial ecology are LARGE, however, for ORR Site 2, while the terrestrial ecology impacts for the CRN Site are MODERATE. This is because the building two or more SMRs on ORR Site 2 would require the removal of portions of this site from the ORR NERP, which could potentially compromise the integrity of this research park. Based on this comparison of the sites, ORR Site 2 is not environmentally preferable to the CRN Site.

9.3.3.2.2 ORR Site 8

For most resources, the environmental impacts at ORR Site 8 would be similar to the impacts at the CRN Site. As with ORR Site 2, and for the same reasons, the cumulative impacts on terrestrial ecology impacts are LARGE for ORR Site 8 because building two or more SMRs on this site would remove portions of this site from the ORR and potentially compromise the integrity of the NERP. Based on this comparison of the sites, ORR Site 8 is not environmentally preferable to the CRN Site.

9.3.3.2.3 Redstone Arsenal Site 12

For most resources, the environmental impacts at Redstone Arsenal Site 12 would be similar to the impacts at the CRN Site. However, Table 9-14 shows greater impacts at Redstone Arsenal Site 12 for groundwater use during dewatering while the plant is being built. Building and operating two or more SMRs on Redstone Arsenal 12 would be a significant contributor the groundwater impacts. Based on this comparison of the sites, Redstone Arsenal Site 12 is not environmentally preferable to the CRN Site.

9.3.3.3 Obviously Superior Sites

None of the alternative sites was determined to be environmentally preferable to the proposed CRN Site. Therefore, the NRC staff concludes that none of the alternative sites would be obviously superior to the CRN Site.

9.4 System Design Alternatives

The review team evaluated design alternatives for the heat-dissipation and circulating-water systems (CWS) described in EIS Section 3.2 and in ER Section 3.4 (TVA 2017-TN4921). The CWS for a new nuclear power plant at the CRN Site would be a closed-cycle system composed of mechanical draft cooling towers cycling water through the condenser. Makeup water for the cooling towers would be obtained from the Clinch River using a new intake structure, and blowdown from the cooling towers would be routed to a holding pond before being discharged through a new structure located in the Clinch River downstream from the intake.

Although there may be other plant systems that require cooling, such as the service water system (SWS), the review team evaluated heat-dissipation alternatives only for the CWS. The SWS is not described in the ER, but the review team assumed that the SWS heat-dissipation needs would be a small fraction of the 5.593×10^9 BTU/hr heat dissipation required from the

CWS. The review team evaluated alternative intake and discharge designs, as well as alternative CWS water supply sources. Water treatment is not described in the ER; the review team did not evaluate CWS water-treatment alternatives, water-treatment needs are not resolved in this EIS and would have to be resolved as part of any application that references an associated ESP. The PPE values (see EIS Appendix I) for the heat-dissipation rate and system flow rates were considered by the review team in its evaluation of the system design alternatives discussed below.

9.4.1 Heat-Dissipation System Alternatives

About two-thirds of a commercial nuclear reactor's thermal generation is rejected to the environment as waste heat via either latent heat exchange (e.g., by evaporating water) or sensible heat exchange (e.g., by warming air or water). The majority of the heat dissipation for the proposed plant at the CRN Site would be via evaporation of water in the mechanical draft (wet) cooling towers. In ER Section 9.4.1, TVA evaluated several alternative heat-dissipation systems. This section describes the alternatives to the mechanical draft cooling towers considered by the review team.

9.4.1.1 Once-Through Cooling

A once-through cooling system would withdraw water from the Clinch River, circulate the water through the condenser where heat exchange would warm the circulating water, and discharge virtually the same amount of water back to the Clinch River. Typical water use by a nuclear power plant using once-through cooling is about 700 gpm/MW (EPRI 2004-TN4990), which would require a withdrawal from the Clinch River of about 1,250 cfs for an 800-megawatt electric (MW(e)) plant at the CRN Site. This withdrawal rate, and the corresponding thermal discharge, would be about 25 percent of the average discharge from the Melton Hill Dam. This withdrawal rate would not meet the best available technology requirement of Section 316(b) of the Clean Water Act. In addition, based on the evaluation of the much smaller thermal discharge described in EIS Section 5.2, the review team concludes that the discharge from a once-through cooling system would produce a large thermal plume that would not meet the applicable temperature-related Tennessee water-quality criteria (TNSOS 2017-TN5071). Therefore, the review team concludes that once-through cooling at the CRN Site is obviously unsuitable due to (1) the large fraction of river flow withdrawn, (2) the large thermal plume generated, and (3) inability to meet the requirements of the Clean Water Act.

9.4.1.2 Closed-Cycle Cooling

Closed-cycle cooling systems circulate water between the condenser and a separate cooling component, such as the mechanical draft cooling towers proposed for the CRN Site. Closed-cycle cooling systems withdraw less water than a once-through system and reduce the thermal impact on the waterbody receiving discharge, but may increase consumptive water use and cause other environmental impacts, such as plume visibility and water-treatment chemical discharges. Closed-cycle cooling alternatives considered by the review team include natural draft cooling towers, wet/dry cooling towers, dry cooling towers, cooling ponds, and spray ponds.

The review team first evaluated the land- and water-use requirements of the alternative closed-cycle cooling systems to determine whether any of the considered alternatives are obviously unsuitable for the CRN Site (see Table 9-15). Land-use estimates shown in Table 9-15 were based primarily on the summary of environmental effects provided by Najjar et al. (1979-

TN4994), scaled to an 800-MW(e) power plant. Water-use estimates for cooling towers were based on the range for existing nuclear plants provided by Macknick et al. (2012-TN4993); water-use estimates for the cooling/spray ponds are from Najjar et al. (1979-TN4994). Estimated land and water use from these references for mechanical draft cooling towers and from the CRN Site PPE (TVA 2017-TN4921) are included in Table 9-15 for comparison. The review team observed that the PPE values are larger than the mechanical draft cooling tower literature values. The review team assumed that the PPE values are conservative estimates and thus not directly comparable to the literature values. The review therefore referenced the literature values for the mechanical draft cooling tower in comparing the land- and water-use requirements of the alternative heat-dissipation systems.

Table 9-15. Estimated Land Use and Consumptive Water Use of Alternative Closed-Cycle Cooling Systems for an 800-MW(e) Nuclear Power Plant

	Land Use (ac)	Water Use (cfs)
Natural Draft (Wet) Cooling Towers	5.6	17.3 – 25.1
Mechanical Draft (Wet) Cooling Towers	9.6	17.3 – 25.1
Wet/Dry Cooling Towers	9.6 – 25.6	4.5 – 16.7
Dry Cooling Towers	16	0.0
Cooling Ponds	800 – 1,600	16.6 – 21.4
Spray Ponds	80 – 160	16.6 – 21.4
CRN Site (PPE, ER Table 3.1-2)	21	28.5

Based on Table 9-15, the review team determined that the cooling pond alternative is obviously unsuitable for the CRN Site because the land use required would likely exceed the area of the entire CRN Site. The spray pond alternative would require a substantial fraction of the land area of the CRN Site, but is not obviously unsuitable. None of the cooling systems is screened out as being obviously unsuitable based on the water-use estimates. Other environmental factors considered by the review team for the heat-dissipation alternatives are described below and compared to the proposed mechanical draft system.

9.4.1.2.1 Natural Draft (Wet) Cooling Towers

A natural draft cooling tower operates on the same heat-dissipation principles as a mechanical draft (wet) cooling tower with the exception that the movement of air up through the tower is induced without the use of a mechanical fan. Instead, the tower draft is induced by the buoyancy of the lower density, heated air that rises within the tower and thereby draws cooler air in at the base of tower. Because operating the fan in a mechanical draft tower requires power (less than 1 percent of plant power [EPA 2001-TN2384]), the natural draft tower will be marginally more power efficient. Land use required for a natural draft tower is somewhat less than a mechanical draft tower system and consumptive water use is similar (see Table 9-15). To generate adequate air flow, natural draft cooling towers are generally several hundred feet tall, much taller than a mechanical draft tower. The height of a natural draft tower reduces the potential for local impacts from drift contamination and fogging/icing relative to a mechanical draft tower. However, the greater height increases the visibility of the tower and the visibility and shading of the associated plume. Because there is no fan, noise from a natural draft tower may be lower than from a mechanical draft tower.

Because a natural draft cooling-tower system would not uniformly reduce the environmental impacts of the proposed system, a natural draft cooling-tower system would not be environmentally preferable.

9.4.1.2.2 Dry Cooling Towers

A heat-dissipation system using dry cooling relies on sensible heat exchange to the ambient air without using water for evaporative cooling. In one possible configuration (indirect dry cooling), cooling water circulating in the condenser would be sent to a dry cooling tower where fans are used to induce a draft across a heat exchanger. Alternatively, the turbine exhaust steam could be cooled directly in an air-cooled condenser, although this is considered an unlikely cooling system for a nuclear plant (EPRI 2012-TN4991). No existing U.S. nuclear plant uses a dry cooling system.

By eliminating water use for cooling, a dry cooling system would virtually eliminate the impacts associated with makeup water withdrawal and blowdown discharge. (The review team assumed that impacts of radiological waste discharge to the river would be unchanged.) A dry cooling system is less efficient than a wet system because the theoretical approach temperature is limited to the dry bulb temperature instead of the lower wet bulb temperature. Relative to a wet mechanical draft system, this may result in a loss of steam turbine efficiency (particularly during high ambient temperature conditions), a larger cooling system, and more energy use by the dry cooling fans. Estimates of the total average annual energy penalty for a nuclear plant using dry cooling towers (vs. wet cooling towers) range from about 3 to 7 percent of plant output (24 to 56 MW(e) for a plant at the CRN Site) (EPA 2001-TN2384; EPRI 2012-TN4991). As shown in Table 9-15, a dry tower is expected to occupy about two-thirds more land area than a (wet) mechanical draft tower. The EPA (2001-TN2384) states that dry cooling towers generally occupy three to four times the area of wet cooling towers providing comparable cooling capacity. Noise from the larger/more numerous dry cooling fans is expected to be greater than the wet system. In addition, the loss of generation efficiency translates into increased impacts on the fuel cycle. Dry cooling would eliminate any impacts from a cooling-tower plume, including drift contamination, fogging/icing, and visibility.

The primary environmental benefit of a dry cooling system is the virtual elimination of impacts associated with water use and blowdown discharge. Because the review team has determined in EIS Chapters 4 and 5 that water-use, water-quality, and plume-associated impacts from construction and operation of a wet mechanical draft heat-dissipation system would be SMALL, and because a dry cooling system would increase fuel cycle, land-use, and noise impacts, a dry cooling system is not environmentally preferable to the proposed system.

9.4.1.2.3 Wet/Dry Cooling Towers

A heat-dissipation system using wet/dry cooling towers comprises both wet and dry cooling tower sections. Depending on the ambient air temperature, relative humidity and the system design, the system may be operated to dissipate heat entirely in the wet section, entirely in the dry section, or using the combined wet and dry sections. Overall water withdrawal and consumptive use depend on the fraction of time during plant operation that the dry tower section is operating. Because the dry tower section is more efficient at lower temperatures, the wet tower section is likely to be most needed during the summer months. The availability of evaporative cooling in the wet section reduces the average annual energy penalty of the wet/dry cooling system when compared to a dry cooling system. The average annual energy penalty for the wet/dry cooling system evaluated in the EPRI (2012-TN4991) case study was 3 percent at the five sites considered (which would be 24 MW(e) for a plant at the CRN Site), compared to the wet cooling system.

For the wet/dry cooling tower, the review team assumed that the wet section would be a mechanical draft cooling tower, which is typical practice. The wet and dry sections of a wet/dry tower system could be stacked or placed side-by-side and could be operated in series or in parallel (EPRI 2012-TN4991). The land-use range in Table 9-15 for the wet/dry tower reflects these alternative configurations assuming the use of a mechanical draft cooling tower for the wet section of the system. Land use for the wet/dry tower system would be equal to or greater than that for the proposed wet mechanical draft system. Consumptive water use for a wet/dry cooling-tower system may range from 20 to 80 percent of a wet tower system (EPRI 2004-TN4990). The upper limit of the range provided in Table 9-15 represents a wet/dry system with the dry section providing about one-third of the cooling requirement. Water use for the wet/dry cooling system evaluated in the EPRI (2012-TN4991) case study ranged from 36 to 69 percent at the five sites considered, compared to the wet cooling system. Impacts from blowdown discharge would be correspondingly reduced for the wet/dry cooling system. Noise from a wet/dry cooling system is expected to be greater than for a wet mechanical draft system because of the larger fan used for the dry cooling section. In addition, the energy penalty for the wet/dry cooling system is expected to increase fuel cycle impacts compared to the proposed cooling system. While relying exclusively on the dry section of the wet/dry cooling system, impacts from a cooling-tower plume, including drift contamination, fogging/icing, and visibility would be eliminated.

The primary environmental benefit of a wet/dry cooling-tower system is the reduction of impacts associated with water use and blowdown discharge. Because the review team has determined in EIS Chapters 4 and 5 that water-use, water-quality, and plume-associated impacts from construction and operation of a wet mechanical draft heat-dissipation system would be SMALL, and because a wet/dry cooling system would increase fuel cycle and noise impacts, a wet/dry cooling system is not environmentally preferable to the proposed system.

9.4.1.2.4 Spray Ponds

Cooling ponds are man-made bodies of water used in closed-cycle cooling systems in place of cooling towers. Sensible heat is transferred to the atmosphere and to the ground and latent heat transfer occurs through evaporation from the pond surface. Spray ponds are cooling ponds that use water spray to enhance heat transfer, primarily by increasing evaporation. Like wet cooling towers, spray ponds require makeup water from an external source and occasionally discharge water to a receiving waterbody to control the concentration of dissolved solids. Because spray ponds are open features, their performance may depend on unique characteristics, such as site ground conditions (ponds may need to be lined), pond volume and depth, wind speeds, and solar load.

As shown in Table 9-15, land use for a spray pond cooling system is expected to be significantly larger than for the proposed mechanical draft tower system. Because a spray pond system would rely primarily on evaporative cooling, water use is expected to be similar to the proposed system. The review team assumed that makeup water requirements and blowdown discharge for a spray pond cooling system would be no more than for the proposed system (and potentially less depending on the spray pond system design). The review team assumed that drift and plume impacts (fogging/icing, visibility) would be comparable to a mechanical draft tower, although potentially more localized because emissions would be closer to the ground surface. These localized impacts could be of concern depending on the location of the spray ponds. The review team assumed that noise from a spray pond cooling system would be less than from a mechanical draft cooling tower due to the lack of fans. The review team also assumed that the energy required to operate a spray pump system would be similar to that required to operate a mechanical draft tower system, so that no energy penalty/benefit would be applicable in comparing the spray pond alternative to the proposed cooling system.

A spray pond cooling system may offer some environmental benefit in the reduction of makeup water withdrawal and blowdown discharge, and produce less noise. Because the review team has determined in EIS Chapters 4 and 5 that water-withdrawal and water-quality impacts from construction and operation of a wet mechanical draft heat-dissipation system would be SMALL, and because a spray pond cooling system would require substantially more land and may increase local impacts from drift, a spray pond cooling system is not environmentally preferable to the proposed system.

9.4.2 Circulating-Water System Alternatives

The review team evaluated alternatives to the intake and discharge structures proposed for the CRN Site CWS. The review team also evaluated alternatives to the proposed CWS water supply. Capacity requirements for the water supply, intake, and discharge are determined by the proposed heat-dissipation system; for the CRN Site this is a closed-cycle system using mechanical draft cooling towers. As described in EIS Chapter 3, makeup water for the cooling towers would be obtained from the Clinch River using a new intake structure at CRM 17.9, withdrawing at an average rate of 41.0 cfs and a maximum rate of 68.4 cfs. Consumptive water use by the proposed CWS would be 28.5 cfs. Blowdown from the cooling towers would be routed to a holding pond before being discharged through a new structure located in the Clinch River downstream from the intake at RM 15.5, with an expected discharge rate of 9.5 cfs and a maximum rate of 28.5 cfs.

9.4.2.1 Intake Alternatives

The proposed intake system is described in EIS Section 3.2.2.2 and consists of an intake structure about 50 ft long and 50 ft wide and two pipelines to the plant area. The intake structure would be located along the bank of the Clinch River, but would require some excavation to ensure a forebay of sufficient depth during minimum river levels. Bar screens and traveling screens would be used to keep debris out of the pump bays. The intake would be designed to meet Clean Water Act 316(b) requirements for protection of aquatic life, with maximum intake and screen velocities less than 0.5 ft/s. As described in EIS Chapters 4 and 5, the review team determined that the construction and operation impacts of the intake system would be SMALL. In ER Section 9.4.2.2.1, TVA evaluated alternatives to the proposed intake system (TVA 2017-TN4921, TVA 2016-TN5243). The review team considered alternatives to the proposed intake system, including a mid-channel intake pipe, an intake canal, a radial collector well system, and alternative intake structure locations.

9.4.2.1.1 Mid-Channel Intake

A mid-channel intake would consist of one or more intake pipes located in the middle of the Clinch River channel and connected to a shoreline pumping structure. A mid-channel intake would require installation of perforated pipes on the riverbed, potentially supported by a constructed substrate (such as a gravel bed). Pipes would be designed to minimize entrainment of sediment and aquatic organisms while providing sufficient flow.

Construction of a mid-channel intake system would disturb river bottom sediments along the length of the required piping and would potentially involve dredging and placement of additional materials (such as gravel) in the river. In addition, maintenance activities would likely disturb river sediments. As described in EIS Chapter 2, Clinch River sediments in the area of the proposed intake are contaminated by ORR operations. Any activities that could result in disturbance of these sediments would require coordination with the Watts Bar Interagency Working Group. A mid-channel intake would require an onshore pumping structure, but shoreline dredging or excavation could be reduced relative to the proposed intake structure. Because the review team determined in EIS Chapters 4 and 5 that impacts from construction and operation of the proposed intake system would be SMALL, and because a mid-channel intake system would significantly increase disturbance of contaminated sediment, this alternative is not environmentally preferable to the proposed intake system.

9.4.2.1.2 Intake Canal

An intake canal would be constructed at the location of the proposed intake and extend inland to an intake structure that would likely be similar to the proposed structure. An intake canal may provide some advantage in managing intake velocities, but would still require pipelines to the plant area and some shoreline dredging and excavation during construction. The canal would require excavation and disturbance of land during construction and some dredging and spoils disposal during operation. An intake canal would use a larger area of land for operation than the proposed intake system. Because the review team determined in EIS Chapters 4 and 5 that impacts from construction and operation of the proposed intake system would be SMALL, and because a canal intake system would require additional land use, this alternative is not environmentally preferable to the proposed intake system.

9.4.2.1.3 Radial Collector Wells

A radial collector well consists of a number of lateral well screens extending horizontally out from a large central collector caisson. These wells are generally installed with the lateral well screens adjacent to or underneath a surface waterbody that is in direct contact with the groundwater. This arrangement allows the collector well to extract a mixture of groundwater and surface water filtered through the riverbed and riverbank sediments. A radial collector well eliminates entrainment of aquatic organisms and reduces intake water turbidity compared to direct surface-water withdrawal. Construction requires some land disturbance at the location of each collector well, but the lateral well screens are installed without any in-water activities. The number of radial collector wells needed for a project depends on the water requirements and the hydraulic properties of the sediments.

A radial collector well system at the CRN Site would need to be located in a significant deposit of sediments. Site Safety Analysis Report Figure 2.5.1-26 (TVA 2017-TN5387) shows that there are no suitable deposits in the area of the proposed intake. Significant colluvial and/or alluvial deposits on the CRN Site occur in the floodplain and river terrace areas upriver near Grubb Island and downriver near RM 17. Colluvium is weathered rock residuum. Alluvial deposits at the CRN Site are described as primarily silt, with sand and gravel present in varying amounts (TVA 2017-TN5387). The thickness of these deposits is not well-defined, but is stated to be less than 40 ft (NRC 2008-TN5142). In ER Section 9.4.2.2.1.3 (TVA 2017-TN4921), TVA evaluated the potential yield of a radial collector well system at the CRN Site and estimated that it would require nine collector wells occupying an area of about 40 ac. This exceeds the estimated extent of the alluvial aquifers at the site. Because of the limited extent and thickness of the suitable sediments, and their high silt content, the review team determined that a radial collector well intake system is unlikely to be suitable at the CRN Site.

9.4.2.1.4 Alternative Intake Structure Locations

The review team considered alternative locations on the Clinch River for the proposed intake structure. Alternative locations on the east side of the CRN Site would require piping water a similar or increased distance compared to the proposed location. Alternative intake locations on the west side of the CRN Site would require that the cooling water be piped over a shorter distance, but these locations would be much closer to the discharge, increasing the potential for interaction. Because the review team determined in EIS Chapters 4 and 5 that impacts from construction of the proposed intake system would be SMALL, and because an alternative location for the intake structure that reduces the distance to the cooling towers would increase the potential interaction of the intake and discharge, alternative intake locations are not environmentally preferable to the proposed location.

9.4.2.2 Discharge Alternatives

The proposed discharge system is described in EIS Section 3.2.2.2 and consists of a holding pond (about 5 ac in area), twin discharge pipes with diffuser ports, and pipelines to transport effluents between the plant area, holding pond, and discharge pipes. The discharge pipes would extend to the approximate center of the Clinch River channel west of the main plant area, with pipe diameter, diffuser length, and diffuser port size designed to produce discharge velocities of 8 to 10 ft/s. Discharge would be regulated by an NPDES permit to be issued by TDEC. As described in EIS Chapters 4 and 5, the review team determined that the construction and operation impacts of the discharge system would be SMALL with mitigation of a minimum 400 cfs discharge from the Melton Hill Dam continuously maintained via a new bypass structure at the dam. The review team nonetheless considered the alternatives to the proposed discharge system described in ER Section 9.4.2.2.2 (TVA 2017-TN4921), which included alternatives with and without the Melton Hill Dam bypass.

In its ER (TVA 2017-TN4921), TVA considered an alternative using the proposed pipeline discharge to the river without the bypass and the holding pond. TVA evaluated a similar alternative that used an oriented spray cooling system (OSCS), which TVA determined would lower the discharge temperature by 2°F. TVA concluded that the OSCS would have a minimal effect on the thermal impacts of the discharge. Because operation of the dams can produce quiescent conditions in the Clinch River at the discharge location, the review team determined that these alternatives without the Melton Hill Dam bypass are unlikely to meet mixing zone requirements and water-quality standards for temperature (particularly during winter). The review team therefore concluded that these alternatives are likely to be unsuitable for the CRN Site and are not environmentally preferable to the proposed system.

TVA considered direct discharge to the river (no holding pond) with two options for the Melton Hill Dam bypass design. However, both designs would maintain a minimum continuous discharge from the dam of 400 cfs, so the thermal impacts of the discharge would be identical for the two bypass options. Because the discharge temperature of the proposed system was assumed to be unaffected by the holding pond, the review team determined that the thermal impact of these discharge alternatives is equivalent to the proposed system, and that the alternatives are therefore not environmentally preferable to the proposed system.

TVA considered an alternative that did not use a bypass at the Melton Hill Dam, but increased the cooling-system cycles of concentration by a factor of two. This would reduce the amount of blowdown by one-half relative to the proposed system and increase chemical concentrations in the discharge, but would not affect the discharge temperature. TVA evaluated a similar alternative that included an OSCS, which would lower the discharge temperature by 2°F. Because these alternatives would potentially violate water-quality standards for temperature during quiescent conditions in the Clinch River, and because chemical concentrations in the discharge would be increased, the review team determined that these alternatives are not environmentally preferable to the proposed system.

TVA considered an alternative that did not use a bypass at the Melton Hill Dam, but included a holding pond used to store blowdown when Melton Hill Dam is idle. Discharges would occur as large batch releases during periods when Melton Hill Dam is operating. This alternative increases the rate of discharge relative to the proposed system, but avoids discharges during quiescent river conditions. TVA evaluated a similar alternative that included an OSCS, which would lower the discharge temperature by 2°F. TVA concluded that the large rate of discharge required with these alternatives would be unlikely to meet mixing zone requirements, and the discharge could potentially have impacts on navigation and recreation. Because these discharge alternatives would require large discharge rates to avoid violating water-quality standards for temperature, the review team determined that they are likely to violate mixing zone requirements, and therefore are not environmentally preferable to the proposed system.

Because the review team determined in EIS Chapters 4 and 5 that impacts from construction and operation of the proposed discharge system would be SMALL with mitigation of a minimum 400 cfs discharge from the Melton Hill Dam continuously maintained via a new bypass structure at the dam, and because the alternative discharge systems considered would be unlikely to meet mixing zone requirements or water-quality standards for temperature, none of the discharge system alternatives considered is environmentally preferable to the proposed discharge system.

9.4.2.3 Water Supply Alternatives

The proposed source of water for the CRN Site CWS is the Clinch River adjacent to the site. With the proposed bypass, discharge from the Melton Hill Dam would be a minimum of 400 cfs; the median historical daily average discharge is about 3,600 cfs (TVA 2017-TN4921). The CRN Site average makeup water withdrawal rate is 41.0 cfs (18,423 gpm), or 10 percent of the minimum discharge from Melton Hill Dam, and the maximum withdrawal rate is 68.4 cfs (30,708 gpm), or about 17 percent of the minimum discharge from Melton Hill Dam (EIS Section 3.4.2.2). In ER Section 9.4.2.2.3, TVA evaluated alternatives to the proposed water supply (TVA 2017-TN4921, TVA 2016-TN5243). The review team considered alternative sources of makeup water for the CWS, including groundwater, the City of Oak Ridge municipal supply, and reclaimed wastewater.

As described in EIS Section 2.3.2, groundwater use in the vicinity of the CRN Site is limited and well yields tend to be small. Total groundwater use in 2010 for the five counties surrounding the CRN Site was 3.5 Mgd (2,431 gpm) (TVA 2017-TN4921), which is much less than the CWS makeup requirement. The largest estimated yield for the individual wells located within 1.5 mi of the CRN Site was 75 gpm (TVA 2017-TN4921), less than 1 percent of the sustained yield required for the average makeup supply. Because groundwater use in the CRN Site region and well yields in the vicinity of the site are both insufficient to satisfy the makeup water requirements, the review team determined that a groundwater supply for the CWS is obviously unsuitable.

The City of Oak Ridge obtains water from the Clinch River upstream of Melton Hill Dam. Maximum available unused capacity for the City's water-treatment plant is 12 to 15 Mgd (8,333 to 10,417 gpm) (City of Oak Ridge 1999-TN4995), which is less than the CWS makeup requirement. Even if the City had an adequate excess supply, infrastructure would need to be constructed to transport the water from the City's system to the CRN Site, which would have additional land-use and other impacts. Because the City of Oak Ridge's existing water supply is insufficient to satisfy the makeup water requirements, the review team determined that this alternative water supply for the CWS is obviously unsuitable.

The City of Oak Ridge wastewater-treatment plants have a combined utilization rate of 5 to 7 Mgd (3,472 to 4,861 gpm). If this entire wastewater supply was reclaimed for use at the CRN Site, it would be insufficient to meet the CWS makeup requirement. No other nearby significant sources of wastewater are available. Development of a sufficient supply of wastewater for use at the CRN Site would require significant infrastructure development to transport the water supply (e.g., from the Knoxville wastewater-treatment plant). This infrastructure would have additional land-use and other impacts. Because the available wastewater is insufficient to satisfy the makeup water requirements without significant infrastructure development, the review team determined that reclaimed wastewater would not be environmentally preferable to the proposed water supply for the CRN Site CWS.

9.4.3 Summary

The review team considered alternative system designs that included evaluation of alternatives to the proposed heat-dissipation system, as well as alternatives to the proposed intake system, the proposed discharge system, and the proposed water supply. The review team did not evaluate CWS water-treatment alternatives because the proposed water treatment for the CWS was not described in the ER. The review team did not resolve CWS water-treatment needs in this EIS. As described above, the alternative system designs evaluated by the review team were either obviously unsuitable, or were not environmentally preferable to the proposed plant system designs.

10.0 CONCLUSIONS AND RECOMMENDATIONS

The U.S. Nuclear Regulatory Commission (NRC) received an application from the Tennessee Valley Authority (TVA), for an early site permit (ESP) for the Clinch River Nuclear (CRN) site in Roane County, Tennessee. The CRN Site is located in Oak Ridge, Tennessee, approximately 10 mi south of the Oak Ridge urban center and approximately 25 mi west-southwest of Knoxville. An ESP does not authorize construction or operation of a nuclear power plant; however, the ESP process (Title 10 of the *Code of Federal Regulations* [CFR] Part 52, Subpart A [TN251]) allows resolution of many issues associated with siting a nuclear plant—environmental, safety, and emergency preparedness issues—in advance of actually building and operating any nuclear reactors. To resolve environmental issues at the ESP stage, the NRC analyzes the impacts as if a nuclear plant were to be built and operated.

The proposed action related to the TVA application is the NRC issuance of an ESP for the CRN Site. As part of the permitting process for developing the proposed CRN Site and associated infrastructure and improvements, TVA would need to submit an application to the U.S. Army Corps of Engineers (USACE) Nashville District and the Tennessee Department of Environment and Conservation for activities associated with the alteration of any stream, river, lake, or wetland in Tennessee.

Section 102 of the National Environmental Policy Act of 1969, as amended (NEPA, 42 U.S.C. § 4321 *et seq*. -TN661), directs that an environmental impact statement (EIS) is required for major Federal actions that significantly affect the quality of the human environment. Section 102(2)(C) of NEPA requires that an EIS include information about the following:

- the environmental impacts of the proposed action,
- any adverse environmental effects that cannot be avoided if the proposal is implemented,
- alternatives to the proposed action,
- the relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity, and
- any irreversible and irretrievable commitments of resources that would be involved if the proposed action were implemented.

The NRC has set forth regulations for implementing NEPA (42 U.S.C. § 4321 *et seq*. -TN661) in 10 CFR Part 51 (TN250). Subpart A of 10 CFR Part 52 (TN251) contains the NRC regulations related to ESPs. As set forth in 10 CFR 51.18 (TN250), the Commission determined that the issuance of an ESP is an action that requires an EIS.

The environmental review described in this draft EIS was conducted by a joint NRC-USACE team. The review team consisted of the NRC staff, NRC contractor staff at Pacific Northwest National Laboratory, and the USACE staff. Included in this draft EIS are (1) the results of the review team preliminary analyses, which consider and weigh the environmental effects of the proposed action; (2) the mitigation measures for reducing or avoiding adverse effects; (3) the environmental impacts of alternatives to the proposed action; and (4) the NRC staff's preliminary recommendation regarding the proposed action based on its environmental review.

During the course of preparing this draft EIS, the review team reviewed the TVA Environmental Report (ER) (TVA 2017-TN4921), the CRN Site Safety Analysis Report (TVA 2017-TN5387), and supplemental documentation from TVA. The review team consulted with Federal, State, Tribal, and local agencies and followed the guidance set forth in Regulatory Guide 4.2, Revision 2 (NRC 1976-TN89), in NUREG–1555, *Environmental Standard Review* Plan—Standard *Review Plans for Environmental Reviews for Nuclear Power Plants* (NRC 2000-TN614), and in NUREG–0800, *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants* (NRC 2007-TN613). The review team also followed guidance provided in NRC Interim Staff Guidance COL/ESP-ISG-26, *Interim Staff Guidance on Environmental Issues Associated with New Reactors* (NRC 2014-TN3767) and NRC Interim Staff Guidance COL/ESP-ISG-27, *Interim Staff Guidance on Specific Environmental Guidance for Light Water Small Modular Reactor Reviews* (NRC 2014-TN3774).

The NRC staff also considered the public comments related to the environmental review received during the scoping process. These comments are provided in Appendix D of this draft EIS.

The USACE role as a cooperating agency in the preparation of this EIS is to ensure to the maximum extent practicable that the information presented is adequate to fulfill the requirements of the USACE regulations. Section 404(b)(1) of the Clean Water Act, "Guidelines for Specification of Disposal Sites for Dredged or Fill Material" (40 CFR Part 230-TN427), contains the substantive environmental criteria used by the USACE in evaluating discharges of dredged or fill material into waters of the United States. Although the USACE, as part of the review team, concurs with the designation of impact levels for terrestrial and aquatic resources, insofar as waters of the United States are concerned, the USACE must conduct a quantitative comparison of impacts on waters of the United States as part of the 404(b)(1) evaluation. In addition, the USACE regulations (33 CFR 320.4 [TN424]) direct the USACE to conduct a public interest review (PIR) that requires consideration of a number of factors as part of a balanced evaluation process. The USACE PIR and 404(b)(1) evaluation will be part of the USACE permit decision document, and such factors may not be fully addressed in this EIS. The USACE independent regulatory permit decision documentation will reference relevant analyses from the EIS and, as necessary, include a supplemental PIR, Clean Water Act 404(b)(1) evaluation, evaluation of cumulative impacts, compensatory mitigation plan that is in accordance with 33 CFR Part 332 (TN1472), "Compensatory Mitigation for Losses of Aquatic Resources," and other information and evaluations that may be outside the NRC scope of analysis and not included in this EIS but are required by the USACE to support the USACE permit decision.

Environmental issues are evaluated in this draft EIS using the three-level standard of significance—SMALL, MODERATE, or LARGE—developed by the NRC using guidelines from the Council on Environmental Quality (CEQ) (40 CFR 1508.27 [TN428]). Table B-1 of 10 CFR Part 51, Subpart A, Appendix B (TN250), provides the following definitions of the three significance levels:

> 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.

Mitigation measures were considered for each environmental issue and are discussed in the appropriate sections. During the environmental review, the review team considered planned activities and actions that TVA indicates it and others would likely take should TVAreceive a license from the NRC and proceed to build and operate two or more SMRs at the CRN Site. In addition, TVA provided estimates of the environmental impacts resulting from the building and operation of two or more small modular reactors (SMRs) at the proposed CRN Site.

10.1 Impacts of the Proposed Action

In a final rule dated October 9, 2007 (72 FR 57416 -TN260), the Commission limited the definition of "construction" to those activities that fall within its regulatory authority in 10 CFR 51.4 (TN250). Many of the activities required to build a nuclear power plant are not part of any future NRC action to license the plant. Activities associated with building the plant that are not within the purview of the NRC are grouped under the term "preconstruction." Preconstruction activities include clearing and grading, excavating, erection of support buildings and transmission lines, and other associated activities. Because the preconstruction activities are notunder the purview of the NRC, their impacts are not reviewed as a direct effect of the NRC action. Rather, the impacts of the preconstruction activities are considered in the context of cumulative impacts. In addition, certain activities defined as preconstruction by the NRC require authorization from the USACE and other Federal, State, and local agencies.

Chapter 4 of this EIS describes the relative magnitude of the impacts of construction and preconstruction activities associated with building two or more SMRs at the CRN Site, and a summary of those impacts is given in Section 4.12, Table 4-14. Impacts associated with operating two or more SMRs at the CRN Site are discussed in EIS Chapter 5, and are summarized in Section 5.13, Table 5-20. EIS Chapter 6 describes the impacts associated with the fuel cycle, transportation, and decommissioning. EIS Chapter 7 describes the cumulative impacts associated with construction and preconstruction activities, operation and decommissioning of two or more SMRs at the CRN Site when considered along with other past, present, and reasonably foreseeable future projects in the geographic region around the site.

10.1.1 Unavoidable Adverse Environmental Impacts

NEPA Section 102(2)(C)(ii) (42 U.S.C. § 4321 *et seq*. -TN661) requires that an EIS include information about any adverse environmental effects that cannot be avoided if the proposal is implemented. Unavoidable adverse environmental impacts are those potential impacts of the NRC action and any future USACE action that cannot be avoided and for which no practical means of mitigation are available.

10.1.1.1 Unavoidable Adverse Impacts during Construction and Preconstruction

EIS Chapter 4 discusses in detail the potential impacts from construction and preconstruction of two or more SMRs at the CRN Site and presents mitigation and controls intended to lessen the adverse impacts. Table 10-1 presents the unavoidable adverse impacts associated with construction and preconstruction activities to each of the resource areas evaluated in this draft EIS and the mitigation measures that would reduce the impacts. Those impacts remaining after mitigation is applied (e.g., avoidance and minimization, but not compensatory mitigation) are identified in Table 10-1 as the unavoidable adverse impacts. Unavoidable adverse impacts are the result of both construction and preconstruction activities unless otherwise noted. The impact determinations in Table 10-1 are for the combined impacts of construction and preconstruction.

Table 10-1. Unavoidable Adverse Environmental Impacts during Construction and Preconstruction

Resource Area	Adverse Impacts	Actions to Mitigate Impacts	Unavoidable Adverse Impacts
Land Use	MODERATE	Return temporarily disturbed lands to former use upon completion of construction. Offset loss of wetland use and function impacts by mitigation expected to be required by Department of the Army Permit. Allow temporarily disturbed wetland areas to return to former use upon completion of construction. Limit ground disturbances to the smallest amount of area necessary to build the plant and ancillary facilities. Perform ground-disturbing activities in accordance with regulatory and permit requirements; use adequate best management practices (BMPs) erosion-control measures to minimize impacts. Restrict soil stockpiling and reuse to designated areas. Use BMPs and stormwater management plans to control erosion and runoff, vegetation clearing, and impacts on recreation and wildlife. Limit ground-disturbing activities such as vegetation removal to defined corridors.	327 ac of a total of 494 ac would be permanently converted from naturally vegetated land to industrial use. 30 ac of a total of 203 ac in the barge/traffic area (BTA) would be permanently affected by roadway improvements including conversion of naturally vegetated land to transportation use.
Water Use	SMALL	Comply with applicable regulations, permits, and plans. Grout fractures, cavities, and solution openings in the excavated rock face. Monitor effects of dewatering using groundwater wells.	Water use for building would increase the demand on the City of Oak Ridge water supply system, which obtains water from Melton Hill Reservoir. Temporary excavation dewatering is not expected to impact groundwater use.

Table 10-1. (contd)

Resource Area	Adverse Impacts	Actions to Mitigate Impacts	Unavoidable Adverse Impacts
Water Quality	SMALL	Comply with applicable regulations, permits, and plans. Establish and implement a stormwater pollution prevention plan. Apply BMPs as found in stormwater regulations and procedures. Revegetate construction areas in a timely manner. Install drainage controls to direct dewatering runoff. Invoke spill prevention procedures for construction activities. Use BMPs to maintain equipment and prevent spills and leaks. Train appropriate employees in methods for preventing and/or responding to spills. Establish and implement an Integrated Pollution Prevention Plan (IPPP) for construction practices.	Local and temporary increase in sediments in water from increased erosion and construction stormwater runoff; construction in the Clinch River arm of the Watts Bar Reservoir; and discharge of excavation dewatering product and spills. Underwater excavation would result in minor localized changes in flow patterns along the reservoir bottom due to differences in bottom contours at the edges of the excavation zone, as well as temporary suspension of sediments during excavation. Use of heavy equipment would introduce the possibility of petroleum and other chemical spills that could enter surface water.
Ecological Impacts			
Terrestrial and Wetland Resources	MODERATE	In temporarily disturbed areas, revegetate and allow natural succession, resulting in a reduction of long-term ecological impacts in these areas. To the extent feasible, plan facility construction to take place in previously disturbed areas. Use BMPs to minimize impacts on adjacent habitats, such as from erosion and runoff of sediment. To the extent feasible, plan facility locations and construction activities to avoid wetlands. Limit vegetation removal and ground-disturbing activities to the project footprint, underground transmission line right-of-way, and access roads.	Permanent loss of approximately 357 ac of habitat on the CRN Site and in the BTA. Temporary loss of 182 ac on the CRN Site and in the BTA. Total habitat disturbance on the CRN Site and in the BTA of 539 ac. Total of approximately 210 ac of right-of-way lands would be disturbed to install the offsite portion of the 69-kV underground transmission line. Filling of approximately 1.8 ac of wetland on the CRN Site and in the BTA. Mitigation could reduce impacts. Clearing of trees and other vegetation and grading could cause mortality or

Table 10-1. (contd)

Resource Area	Adverse Impacts	Actions to Mitigate Impacts	Unavoidable Adverse Impacts
			displacement of wildlife, including Federally listed bat species. Construction noise may cause some wildlife to avoid some habitats near the source. This impact may occur intermittently throughout the construction phase. Birds may occasionally collide with tall construction equipment and suffer mortality.
Aquatic Resources	SMALL	Install cofferdams or similar engineering protective measures around the intake and discharge sites while they are being built or installed. Employ BMPs to minimize erosion and sedimentation. Install stormwater drainage systems and stabilize disturbed soils. Attempt, to the extent feasible, to tunnel under streams when installing the buried 69-kV transmission line. Restore any disturbance to streams immediately after work is completed. Maintain streamside management zones appropriately. Extend new conductors across waterways within the existing right-of-ways without conducting in-water work or disturbing shorelines to the extent possible.	Removal of a perennial stream, an intermittent stream, two ponds, and 12 ephemeral streams. Minimal or no unavoidable adverse impacts to the Clinch River arm of the Watts Bar Reservoir from installing the intake at reservoir's edge and the discharge in the reservoir bottom. These actions may cause the loss of some benthic aquatic organisms and temporary degradation of habitat, as well as permanent loss of limited areas of habitat at the intake and discharge structures. Installation of underground transmission line would involve crossing streams and may cause temporary disturbance of aquatic habitats in short stream segments within the right-of-way.

Table 10-1. (contd)

Resource Area	Adverse Impacts	Actions to Mitigate Impacts	Unavoidable Adverse Impacts
Socioeconomic Impacts			
Physical	SMALL to MODERATE	Manage major high noise construction activities to limit and minimize noise impacts to residences in the vicinity. Use BMPs for controlling fugitive dust and proper maintenance of construction equipment for controlling emissions. Train and appropriately protect employees and construction workers to reduce the risk of potential exposure to noise, dust, and exhaust emissions. To the extent possible, recycle construction wastes with remaining waste disposed in approved landfills. Stabilize cleared areas, minimize disturbance and visual intrusion, and remove construction debris in timely manner. Install traffic controls and roadway modifications and additional turning capacity to mitigate traffic delays; construction workforce will work in up to three shifts to spread additional construction traffic volume over a 24-hour period. Provide onsite services for emergency first aid, and conduct regular health and safety monitoring.	Increased levels of temporary and localized noise, exhaust emissions, and fugitive dust associated with construction activities. Localized visual intrusion of building activities.
Demography	SMALL		No unavoidable adverse impacts.
Tax and Economic Impacts	SMALL (beneficial to the region)		No unavoidable adverse impacts.

Table 10-1. (contd)

Resource Area	Adverse Impacts	Actions to Mitigate Impacts	Unavoidable Adverse Impacts
Infrastructure and Community Services	SMALL (for all categories except traffic) to MODERATE to LARGE (for traffic)	Install traffic controls and roadway modifications and additional turning capacity to mitigate traffic delays in and around the CRN Site. Implement up to three shifts for construction workforce to spread additional construction traffic volume over a 24-hour period. Stagger shifts, encourage carpooling, and time deliveries to avoid shift change or commute times. Erect signs alerting drivers of construction and potential for increased construction traffic. Use procedures and employee training program to reduce potential for traffic accidents.	Substantially increased traffic on local roadways during the period of peak construction employment (Months 42-47). Increased demand for housing, infrastructure, public services, and education resources on a short-term basis from the influx of construction workers and families.
Environmental Justice	None[(a)]	No disproportionately high and adverse impacts on any minority or low-income populations. No mitigation is required.	No unavoidable adverse impacts.
Historic and Cultural	MODERATE to LARGE	TVA has executed a Programmatic Agreement describing its ongoing National Historic Preservation Act (NHPA) Section 106 compliance including commitments to avoid, minimize, mitigate, and resolve adverse effects to National Register of Historic Places (NRHP)-eligible resources that cannot be avoided and NHPA and Native American Graves Protection and Repatriation Act (NAGPRA) inadvertent discovery and notification provisions.	Preconstruction activities could result in unavoidable adverse impacts on 16 potentially NHRP-eligible archaeological resources, one NRHP-eligible archaeological resource (40RE233), deeply buried archaeological deposits, and one NRHP-eligible Melton Hill Dam District.
Air Quality	SMALL	Implement the Construction Air Permit, which includes controls such as watering, stabilizing disturbed areas, covering trucks, and minimizing idling times and the running of inactive construction equipment.	Temporary emissions from construction equipment firing fossil fuels, fugitive dust from soils disturbance and moving of soils, and workforce motor vehicles.

Table 10-1. (contd)

Resource Area	Adverse Impacts	Actions to Mitigate Impacts	Unavoidable Adverse Impacts
		Workforce emissions controls may include staggering shift hours and promoting car/van pooling.	
Nonradiological Health	SMALL to MODERATE (for noise)	Comply with Federal, State, and local regulations governing construction activities and construction vehicle emissions; comply with Federal, State, and local regulations governing noise from construction activities and increased traffic in the local area; comply with Federal and State occupational safety and health regulations; and implement traffic management plan.	Dust emissions, noise, occupational injuries, traffic accidents. Impacts from construction activities to worker health.
Radiological Health	SMALL	Train construction workers in radiation safety procedures; develop work plans that consider methods for reducing radioactive exposures to levels that are as low as is reasonably achievable (ALARA); monitor doses received by construction workers to ensure they are within regulatory limits.	Radiation exposures to construction workers that would be within regulatory limits and ALARA.
Nonradiological Wastes	SMALL	Manage hazardous and nonhazardous solid wastes according to county, State, and Federal handling and transportation regulations; implement recycling and BMPs to minimize waste generation; establish procedures for, and perform audits to verify, waste disposal according to applicable regulations such as the Resource Conservation and Recovery Act of 1976, as amended (42 U.S.C. § 6901 *et seq*.-TN1281); establish a waste-minimization program.	Minor decrease in available capacity of waste-treatment and disposal facilities. Minor stormwater, wastewater, and atmospheric discharges.

(a) The entry “None” for Environmental Justice does not mean there are no adverse impacts on minority or low-income populations from the proposed action. Rather, “None” means that, while adverse impacts may exist, they do not affect minority or low-income populations in any disproportionate manner, relative to the general population.

The unavoidable adverse environmental impacts identified in Table 10-1 are primarily attributable to preconstruction activities involving the initial land disturbance from clearing the site; excavation; filling areas of wetlands, intermittent streams, and waterways; excavating; adding impervious surfaces; and upgrading the offsite transportation access routes.

Construction and preconstruction activities would result in unavoidable adverse impacts on land use because they would disturb up to 494 ac on the 935-ac CRN Site, 45 ac in the nearby barge/traffic area (BTA), and 210 ac in the 500-kV transmission corridor between the CRN Site and Bethel Valley Substation. Of this 494-ac total on the CRN Site, 327 ac would be permanently disturbed and 167 ac would be temporarily disturbed, while in the BTA approximately 30 ac would be permanently disturbed and about 15 ac would be temporarily disturbed. Preconstruction activities would also minimally disturb up to 5,327 ac in offsite transmission corridors where transmission lines require uprating or other upgrades to support the addition of a new generating facility at the CRN Site. Land disturbance in the transmission corridors would be temporary except for 0.33 ac permanently disturbed to enlarge the Bethel Valley Substation.

Unavoidable adverse surface-water-use impacts during construction and preconstruction would result from the use of water supplied by the City of Oak Ridge. The increased water demand for building at the CRN Site (0.23 Mgd) would be about 3 percent of the current average excess capacity of the City of Oak Ridge water system and is about 0.1 percent of the minimum daily release from Melton Hill Reservoir. Minor amounts of water for dust suppression and other building purposes would be obtained directly from the Clinch River. No unavoidable groundwater-use impacts are expected to result from dewatering for power-block construction.

Unavoidable adverse impacts on surface-water quality during construction and preconstruction would result from clearing vegetation, disturbing the land surface, inadvertent release of contaminants associated with building materials and equipment, and excavation and building activities along the shoreline of the Clinch River arm of the Watts Bar Reservoir. Temporary and localized groundwater-quality impacts would result from dewatering for power-block construction and discharge of groundwater to adjacent bodies of surface water.

Unavoidable adverse impacts on terrestrial ecology during construction and preconstruction would result from the disturbance of about 494 ac on the CRN Site and 45 ac in the BTA, approximately 210 ac within the adjacent offsite existing 500-kV transmission line corridor where the new 69-kV transmission line would be buried, and about 5,327 ac within the corridors of existing offsite transmission lines that would be uprated, reconductored, or rebuilt. Of the 539 ac of total disturbance on the CRN Site and in the BTA, about 357 ac would be permanently disturbed and 182 ac would be temporarily disturbed. The 357 ac of permanent disturbance on the CRN Site and in the BTA would include about 171 ac of upland forest and 153 ac of herbaceous/grassland habitat. An additional 1.8 ac of wetland habitat (forested, emergent, and scrub-shrub) would be permanently disturbed on the CRN Site and in the BTA. The 182 ac of temporary disturbance on the CRN Site and BTA would include 140 ac of upland forest and 42 ac of herbaceous/grassland habitat.

Unavoidable adverse impacts on aquatic ecology would include some physical alteration of habitat (e.g., infilling, shoreline excavation, pile driving) including temporary or permanent removal of associated benthic organisms, sedimentation, and resulting changes in water quality. These impacts would result from shoreline excavation conducted to install the cooling-water intake structure, placement of the diffuser pipe for the discharge, and improvements to the barge-unloading facility. Aquatic habitats affected would include habitat near the shoreline for the intake, and habitat in the river for the discharge and the barge-unloading facility. The size and exact location of the disturbance is not known. Unavoidable adverse impacts include the elimination of a perennial stream, an intermittent stream, two ponds, and 12 ephemeral streams on the CRN site and in the BTA. Six streams would be affected by the burial of the 69-kV line within a 5-mi segment of the 500-kV right-of-way on the site and between the site and the Bethel Valley Substation. No impacts are anticipated on streams or ponds crossed by offsite transmission lines that are scheduled for uprating, reconductoring, and rebuilding activities.

For socioeconomic resources, unavoidable adverse physical impacts on workers and the local public would include increased noise, air pollution emissions, and roadway degradation. The addition of new cooling towers and the new visual intrusion of industrial facilities at the CRN Site would noticeably affect the aesthetic qualities from sensitive viewpoints in Roane County, Tennessee. This impact on visual resources would be moderate and not amenable to mitigation. During the period of peak construction employment (months 42–47), traffic impacts would be substantial. Level of Service (LOS) metrics would degrade from meeting current Tennessee standards (LOS A–C) under baseline conditions, to the lowest rating (LOS E–F) during key morning and afternoon commute times on principal access routes near the CRN Site.

Unavoidable adverse impacts on historic and cultural resources during construction and preconstruction include direct physical impacts on an unknown number of the 16 potentially National Register of Historic Places (NRHP)-eligible archaeological sites, one NHRP-eligible site, deeply buried archaeological deposits, and the Melton Hill Dam District. While impacts can be mitigated through implementation of TVA's Programmatic Agreement, impacts are expected to result in irretrievable damage if in situ stabilization of archaeological resources is not possible. Unavoidable impacts are possible on historic and cultural resources and include both direct and indirect impacts on historic properties from offsite transmission corridors where transmission lines require uprating or other upgrades to support the addition of a new generating facility at the CRN Site.

Unavoidable adverse impacts on air quality from construction and preconstruction would include fugitive dust, emissions of criteria pollutants, and greenhouse gases (GHGs) from land-disturbing and building activities, equipment, and from additional vehicle traffic.

Unavoidable nonradiological health impacts on the public and construction workers at the site would result from fugitive dust, occupational injuries, noise, and traffic impacts from the transport of materials and personnel to the site.

Unavoidable radiological doses to the public would be below annual exposure limits set by the NRC and the U.S. Environmental Protection Agency (EPA) to protect the general public. Radiological doses to construction workers at the CRN Site from both direct radiation exposure and inhalation of normal gaseous effluents would also be below the exposure limits.

Solid, liquid, and gaseous nonradiological wastes would be generated by construction and preconstruction activities at the CRN Site. These wastes would be managed by following the existing practices currently used at other TVA power plants. Solid waste would be recycled or disposed of in existing, permitted landfills. Sanitary wastes would discharged to and treated in the City of Oak Ridge municipal wastewater system.

The review team concludes that the unavoidable adverse impacts of construction and preconstruction activities at and near the CRN Site would range from SMALL to LARGE, depending on the affected resource. Similarly, the NRC staff concludes that the incremental contribution of the NRC-authorized construction activities to these unavoidable adverse impacts would also range from SMALL to LARGE.

10.1.2 Unavoidable Adverse Impacts during Operation

EIS Chapter 5 provides a detailed discussion of the potential impacts of operating two or more SMRs at the CRN Site. Table 10-2 lists the unavoidable adverse impacts associated with operating two or more SMRs on each of the resource areas evaluated in this draft EIS and the mitigation measures that would reduce the impacts. The impacts remaining after mitigation is applied (e.g., avoidance and minimization, but not compensatory mitigation) are identified in Table 10-2 as the unavoidable adverse impacts.

Operation of two or more SMRs would result in unavoidable adverse impacts on land use because the areas of permanent disturbance (327 ac on the site and 30 ac in the BTA) would be unavailable for other uses for the operational life of the new nuclear power plant.

Unavoidable adverse surface-water-use impacts during operations would result from withdrawal and consumptive use for plant cooling of water from the Clinch River arm of the Watts Bar Reservoir. The maximum consumptive use of 28.5 cfs is less than 1 percent of the average discharge from the Melton Hill Reservoir and is about 7 percent of the minimum daily release from the reservoir. Groundwater is not proposed to be used at the CRN Site during operations.

Unavoidable adverse impacts on surface-water quality in the Clinch River arm of the Watts Bar Reservoir during operations would result from thermal discharges and discharges of liquid effluents from the cooling-water and liquid radioactive waste systems. Impacts from the plant discharge would be mitigated by maintaining a minimum continuous release from Melton Hill Reservoir via a new bypass at the Melton Hill Dam. TVA does not plan routine discharges to groundwater for the new nuclear power plant, but impacts could result from chemical or radiological spills that could migrate to shallow groundwater.

Unavoidable adverse impacts on terrestrial ecological resources (including important species and habitats) during operations would include minor cooling-tower salt deposition impacts on early successional vegetation and noise impacts on wildlife near the towers. There would be a minor risk of avian and bat collisions with mechanical draft cooling towers and avian collision with and electrocution by new transmission lines. There would be a minor risk to wildlife from vegetation maintenance in new transmission line corridors, and a slightly elevated risk of wildlife mortality due to increased traffic.

Unavoidable adverse impacts on aquatic ecological resources during operations would include minor impacts on aquatic biota in the Clinch River arm of the Watts Bar Reservoir from impingement and entrainment in the cooling-water system intake, thermal discharges, and chemical discharges. Unavoidable adverse impacts on socioeconomic and environmental justice resources would include physical aesthetic impacts from the increased industrialization at the CRN Site. These aesthetic impacts would also contribute to the adverse impacts on recreational resources near the CRN Site and cannot be reduced by mitigation. No pathways exist by which adverse socioeconomic impacts would affect low-income or minority populations in close proximity to the CRN Site or offsite facilities.

Table 10-2. Unavoidable Adverse Environmental Impacts from Operations

Resource Area	Adverse Impact	Actions to Mitigate Impacts	Unavoidable Adverse Impacts
Land Use	SMALL	No mitigation is required.	Continued commitment of approximately 327 ac onsite and 30 ac offsite over the operational life of the CRN SMR Project. New transmission lines would use existing corridors.
Water Use	SMALL	No mitigation is required.	The maximum surface-water consumptive use would be less than 1 percent of the average flow rate in the Clinch River arm of the Watts Bar Reservoir adjacent to the CRN Site. Groundwater would not be used during operations.
Water Quality	SMALL	Ensure discharges comply with National Pollutant Discharge Elimination System (NPDES) permit and applicable water-quality standards. Prepare a stormwater pollution prevention plan to avoid/minimize releases of contaminated stormwater. Prepare and implement an Integrated Pollution Prevention Plan (IPPP) to avoid/minimize contamination from spills. Discharge radioactive effluents in compliance with applicable regulatory standards in 10 CFR Part 20, Appendix B (TN283). Comply with the IPPP when working on transmission lines and conducting facility maintenance activities. Operate the planned Melton Hill Dam bypass at 400 cfs. Install a diffuser designed to maximize thermal and chemical mixing while minimizing scour and hydrologic modifications.	Normal facility operations result in the discharge of small amounts of chemicals and radioactive effluents to the Clinch River arm of the Watts Bar Reservoir. Routine/maintenance activities at the CRN Site and along the transmission line right-of-ways may result in small episodic spills of petroleum or chemicals. Discharge of cooling water would result in a thermal plume to the Clinch River arm of the Watts Bar Reservoir. Thermal impacts would be within limits established in the NPDES permit.

Table 10-2. (contd)

Resource Area	Adverse Impact	Actions to Mitigate Impacts	Unavoidable Adverse Impacts
Ecological Impacts			
Terrestrial and Wetland Resources	SMALL	Best management practices (BMPs) would be implemented for vegetation maintenance in new transmission line corridors. No other mitigation is planned for other impacts of plant operations.	Potential cooling-tower salt deposition impacts on early successional vegetation near the towers. Potential noise impacts on wildlife near the towers. Minor risk of avian and bat collisions with mechanical draft cooling towers. Minor risk of avian collisions with or electrocutions by new transmission lines. Minor risk to wildlife from vegetation maintenance in new transmission line corridors. Minor risk of wildlife mortality due to increased traffic. Overall, only minor unavoidable adverse impacts are expected from the above sources.
Aquatic Resources	SMALL	Comply with NPDES permit limits to ensure discharges do not adversely affect aquatic organisms or habitats. Conduct reservoir operation improvements to ensure a continuous minimum release rate of 400 cfs from Melton Hill Dam to ensure mixing of the thermal plume. Compliance with EPA Section 316(b) guidelines for intake design minimizes impingement by limiting intake velocity.	Routine facility operations result in discharge of small amounts of chemical and thermal effluents to the Clinch River arm of the Watts Bar Reservoir that could affect aquatic life over the operational life of the CRN plant. Little or no unavoidable adverse impacts. Entrainment or impingement at the water intake results in mortality and injury to various life stages of fish and other aquatic organisms. A relatively small proportion of eggs, larvae, or adults of relatively common species of aquatic species would be impacted by entrainment or impingement.

Table 10-2. (contd)

Resource Area	Adverse Impact	Actions to Mitigate Impacts	Unavoidable Adverse Impacts
Socioeconomic Impacts			
Physical	SMALL to MODERATE (aesthetics)	None. Aesthetic impacts of new structures and cooling-tower plumes could not be reduced through mitigation.	The addition of new cooling towers and new reactor facilities at the CRN Site, and related operations causing cooling-tower steam plumes,
Demography	SMALL	None	No unavoidable adverse impacts.
Economic and Tax	SMALL (beneficial to the region)	None; all impacts would be beneficial.	No unavoidable adverse impacts.
Infrastructure and Community Services	SMALL to MODERATE (recreation)	None	Cooling-tower plumes would noticeably affect the aesthetic qualities from viewpoints in Anderson and Roane Counties. Recreational impacts would be adverse and not amenable to mitigation.
Environmental Justice	None[(a)]	No operations-related disproportionately high and adverse environmental or health effects on minority or low-income populations. No mitigation is required.	No unavoidable adverse impacts.
Historic and Cultural	SMALL	TVA would conduct operation and maintenance activities in compliance with National Historic Preservation Act (NHPA) Section 106 and would avoid, minimize, or mitigate potential operation-related impacts on historic and cultural resources. TVA would also comply with the Native American Graves Protection and Repatriation Act (NAGPRA), Archaeological Resources Protection Act, Archeological and Historic Preservation Act, NHPA, American Indian Religious Freedom Act, Executive Orders 13007 (Indian Sacred Sites), and 13175 (Consultation and Coordination with Indian Tribal Governments). TVA also maintains procedures and management plans that take into consideration impacts on historic	Unavoidable adverse impacts are possible during the life of the operating license if inadvertent discoveries result in adverse effects on places with human remains or on historic properties.

Table 10-2. (contd)

Resource Area	Adverse Impact	Actions to Mitigate Impacts	Unavoidable Adverse Impacts
		and cultural resources during operations. In the event that archaeological resources or human remains are encountered during operations, TVA has NHPA Section 106 and NAGPRA inadvertent discovery procedures requiring stop work and consulting party notifications.	
Air Quality	SMALL	Comply with permit limits and regulations for installing and operating air emission sources.	Diesel generators and other fossil fuel combustion equipment (during emergency and maintenance operations, and the auxiliary building) would contribute to air emissions. Cooling towers would emit plumes.
Nonradiological Health	SMALL to MODERATE	Comply with Occupational Safety and Health Administration standards and other Federal, State, and local safety regulations. Use sound attenuation measures for mechanical draft cooling towers.	Health risks to workers are expected to be dominated by occupational injuries and would be minor. Health impacts on the public from noise generated by plant operations would be noticeable.
Radiological Health	SMALL	Train workers in radiological procedures. Work plans address safety measures and the safety program includes radiological safety procedures. Maintain releases below regulatory limits. Treat effluents according to applicable regulatory standards before being discharged into the Clinch River arm of the Watts Bar Reservoir. Reduce the impacts of irradiated reactor fuel through specific plant design features and regulatory standards. Construction and licensing of an independent spent fuel storage installation (ISFSI).	Small radiation doses to members of the public below NRC and EPA standards. As low as is reasonably achievable (ALARA) doses to employees, adherence of the mitigation measures to applicable regulatory standards would reduce this exposure to ALARA. Non-human biota doses less than National Council on Radiation Protection and Measurements and International Atomic Energy Agency guidelines. The mitigation measures would reduce the risk of radiological impacts. However, there would be unavoidable long-term commitments of land for an ISFSI and geological repository. Long-term commitments of land for radwaste disposal.

Table 10-2. (contd)

Resource Area	Adverse Impact	Actions to Mitigate Impacts	Unavoidable Adverse Impacts
		Employee safety training programs and work procedures. Strict adherence to applicable regulations for storage, treatment, transportation, and ultimate disposal of spent fuel in a geological repository, which requires onsite and offsite long-term management. Implement waste-minimization program, employee training programs, and strict adherence to work procedures and applicable regulations, as well as regulatory licensing of disposal facilities.	
Nonradiological Wastes	SMALL	Maintain compliance with National Pollutant Discharge Elimination System permit requirements; adhere to local, State, and Federal permits and regulations regarding the classification and disposition of wastes	Increased consumption of landfill space for disposition of wastes; increased consumption of fuels for the transportation and disposition of wastes.
Fuel Cycle, Transportation, and Decommissioning	SMALL	Industrywide changes in technology are reducing fuel cycle impacts. Implement waste-minimization program. Comply with the NRC and U.S. Department of Transportation (DOT) regulations	Small impacts from fuel cycle as presented in Table S-3, 10 CFR Part 51 (TN250). Small impacts from radon and technetium-99 releases. Small radiological doses that are within the NRC and DOT regulations from transportation of fuel and radioactive waste. Small impacts from decommissioning as presented in NUREG–0586 (NRC 2002-TN665).

(a) The entry "None" for Environmental Justice does not mean there are no adverse impacts on minority or low-income populations from the proposed action. Rather, "None" means that, while adverse impacts may exist, they do not affect minority or low-income populations in any disproportionate manner, relative to the general population.

Unavoidable adverse direct impacts on historic and cultural resources are possible during the life of the operating license if inadvertent and post-review discoveries result in adverse effects on places with human remains or on historic properties. As a Federal agency, TVA must follow inadvertent discovery procedures in accordance with the Native American Graves Protection and Repatriation Act (NAGPRA) as well as post-review discoveries and include impacts on historic properties in their planning pursuant to National Historic Preservation Act (NHPA) Section 106. Unavoidable adverse indirect impacts are possible on historic properties from offsite transmission corridors where transmission lines result in significant visual intrusion such that impacts on historic and cultural resources are ongoing.

Unavoidable adverse impacts on air quality during operations would include emissions of criteria pollutants, GHG emissions, and cooling-system emissions. Operations would increase gaseous and particulate emissions by a small amount, primarily from equipment associated with auxiliary systems and the cooling towers. The primary sources of emissions from auxiliary systems would be the auxiliary boilers, standby power units such as diesel generators and/or gas turbines, and engine-driven emergency equipment. The cooling towers would be the primary source of particulate emissions.

Unavoidable nonradiological health impacts on the public and operations workers at the CRN Site would result from exposure to etiologic microorganisms through cooling systems, noise generated by unit operations, and transportation of operations and outage workers to and from the site. Health risks to workers would be dominated by occupational injuries.

Unavoidable radiological doses to the public would be below the NRC and EPA limits set to protect the general public. Radiological doses to operations workers at the CRN Site would also be below the NRC limits and would be maintained as low as reasonably achievable. The radiation protection measures designed to maintain doses to members of the public below the NRC and EPA standards would also ensure that doses to biota other than humans would be well below the guidelines of the National Council on Radiation Protection and Measurements and the International Atomic Energy Agency.

Solid, liquid, and gaseous nonradiological wastes would be generated by operations at the CRN Site. These wastes would be managed by following the existing practices currently used at other TVA power-generating facilities. Solid waste would be recycled or disposed of in existing, permitted landfills. Sanitary wastes would be discharged to and treated in the City of Oak Ridge municipal wastewater treatment system.

Operation of two or more SMRs at the CRN Site would also contribute to unavoidable adverse impacts related to the uranium fuel cycle, transportation of fuels and wastes, and decommissioning. Fuel cycle impacts would be small, as presented in Table S-3, 10 CFR Part 51 (TN250). There would be small impacts from radon and technetium-99 releases. There would be small radiological doses from transportation of fuel and radioactive waste that are within the NRC and U.S. Department of Transportation regulations. The impacts of decommissioning would be small, as presented in NUREG–0586 Supplement 1 (NRC 2002-TN665).

The NRC staff concludes that the unavoidable adverse impacts of operating two or more SMRs at the CRN Site would range from SMALL to MODERATE, depending on the affected resource.

10.2 Relationship between Short-Term Uses and Long-Term Productivity of the Human Environment

NEPA Section 102(2)(C)(iv) (42 U.S.C. § 4321 *et seq*. -TN661) requires that an EIS include information about the relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity.

The local use of the human environment by developing two or more SMRs at the CRN Site can be summarized as the unavoidable adverse environmental impacts of preconstruction, construction, and operations along with the irreversible and irretrievable commitments of resources. With the exception of the consumption of depletable resources as a result of preconstruction, construction, and operation, these uses may be categorized as short-term. The principal short-term benefit of building and operating two or more SMRs would be the production of electrical energy. The economic productivity of the CRN Site, when used for the production of electrical energy, would be extremely large when compared to the productivity from agriculture or other probable uses for the site.

The maximum long-term impact on productivity at the CRN Site would result if two or more SMRs were not immediately dismantled at the end of its period of operation, and consequently the land occupied by the plant structures would thus be unavailable for any other use. However, it is expected that the enhancement of regional productivity resulting from the electrical energy produced by two or more SMRs would lead to a correspondingly large increase in regional long-term productivity that would not be equaled by any other long-term use of the site. In addition, most long-term impacts resulting from land-use preemption by plant structures could be eliminated by removing these structures or by converting them to other productive uses at the end of operations. Once operations of the two or more SMRs cease and are shut down, plant structures would be decommissioned according to the NRC regulations. Once decommissioning was completed and the NRC license was terminated, the site would become available for other uses.

The NRC staff concludes that the negative impacts of plant construction and operation as they affect the human environment would be outweighed by the positive long-term enhancement of regional productivity through the generation of electrical energy.

10.3 Irreversible and Irretrievable Commitments of Resources

NEPA Section 102(2)(C)(v) (42 U.S.C. § 4321 *et seq*. -TN661) requires that an EIS include information about any irreversible and irretrievable commitments of resources that would occur if the proposed actions were implemented. The term “irreversible commitments of resources” refers to environmental resources that would be irreparably changed by the building or operation activities authorized by the NRC licensing decisions or the USACE permitting decisions and that could not be restored at some later time to the resource state before the relevant activity occurred. “Irretrievable commitments of resources” refers to materials that would be used for or consumed by two or more SMRs in such a way that they could not, by practical means, be recycled or restored for other uses. The commitment of resources summarized in this section are discussed in Chapters 4, 5, and 6 of this EIS.

10.3.1 Irreversible Commitments of Resources

The irreversible commitments of environmental resources resulting from preconstruction, construction, and operation of two or more SMRs at the CRN Site, in addition to the materials used for the nuclear fuel, are discussed below.

10.3.1.1 Land Use

Land committed to the disposal of radioactive and nonradioactive wastes is committed to that use and cannot be used for other purposes. The land used for two or more SMRs at the CRN Site, with the exception of any permanently filled wetlands, would not be irreversibly committed because the land supporting the facilities could be returned to other industrial or nonindustrial uses once the nuclear power plant ceased operations and was decommissioned in accordance with the NRC requirements.

10.3.1.2 Water Use and Quality

Surface water obtained from the City of Oak Ridge public supply would be used during building. The source of this water would be Melton Hill Reservoir on the Clinch River. Minor amounts of water obtained directly from the Clinch River arm of the Watts Bar Reservoir would be used for dust suppression and other purposes during building activities. Because the amount of surface water used for construction and preconstruction is expected to be negligible compared to the surface-water resource (about 0.1 percent of the minimum release from the Melton Hill Reservoir), the review team determined that there would be no irreversible commitments of surface-water resources during construction and preconstruction.

Construction and preconstruction activities at the CRN Site are not expected to result in any irreversible commitments of groundwater resources. Groundwater would not be withdrawn for use in building or for dust suppression. Because dewatering for power-block construction would be temporary and would have only localized effects on CRN Site groundwater, the impact would be minor.

The anticipated consumptive use of water withdrawn from the Clinch River arm of the Watts Bar Reservoir to support operation of two or more SMRs at the CRN Site is 12,808 gpm. The consumed water would be irreversibly lost from the Clinch River and would not be available to downstream users.

Groundwater is not proposed to be used during operation of the new nuclear power plant; therefore there would be no irreversible commitment of groundwater associated with operation.

10.3.1.3 Terrestrial and Aquatic Biota

Construction and preconstruction activities would permanently convert some portions of terrestrial and aquatic habitats on the CRN Site and in the BTA, which overall would permanently adversely affect the abundance and distribution of local terrestrial species. Irreversible commitments of aquatic resources would be minor, compared to similar habitat within the Clinch River arm of the Watts Bar Reservoir and on the site and in the vicinity. Irreversible commitments of terrestrial resources would be locally noticeable but not destabilizing.

10.3.1.4 Socioeconomic Resources

The review team expects that no irreversible commitments would be made to socioeconomic resources because they would be reallocated for other purposes once the plant was decommissioned.

10.3.1.5 Historic and Cultural Resources

Construction and preconstruction activities would permanently damage an unknown number of historic and cultural resources located at the CRN Site. Irreversible commitments of resources would include the potential permanent loss of an unknown number of 16 potentially NRHP-eligible archaeological resources, one NRHP-eligible archaeological resource, and deeply buried archaeological deposits, as well as a yet unknown number of historic and cultural resources impacted by offsite transmission line activities.

10.3.1.6 Air Quality

Air emission releases during preconstruction/construction activities and operations would conform to applicable Federal and State regulations, so the impact on public health and the environment would be limited. The review team expects no irreversible impacts on air quality because all releases would be made in accordance with duly issued permits.

10.3.2 Irretrievable Commitments of Resources

Irretrievable commitments of resources during the building of the proposed new nuclear power plant generally would be similar to those of any major construction project. The actual commitment of construction resources (e.g., concrete, steel, and other building materials) would depend on the reactor design selected by TVA at the construction permit/combined construction permit and operating license (combined license or COL) stage. Nevertheless, a study by the U.S. Department of Energy (DOE 2004-TN2240) on new reactor construction estimated that about 12,239 yd^3 of concrete, 3,107 tons of steel reinforcement (i.e., rebar), 13,000,000 ft of cable, and 275,000 ft of piping would be required for the reactor building of a typical new 1,300-MW(e) nuclear power plant. Historical records of operating reactors suggest a total of about 182,900 yd^3 of concrete and 20,512 tons of structural steel would be required to construct the reactor building, major auxiliary buildings, turbine generator building, and turbine generator pedestal (DOE 2005-TN2358).

The upper limit on the electrical generating capacity of the types of reactor units under consideration in this ESP review is 800 MW(e); hence, the quantities of construction materials required for such a nuclear power plant could be scaled to about 62 percent of the amounts discussed in the preceding paragraph.

The review team expects that the use of construction materials in the quantities associated with those expected for a new nuclear power plant, while irretrievable, would be of small consequence with respect to the availability of such resources.

The main resource that would be irretrievably committed during operation of two or more SMRs at the CRN Site would be uranium. The availability of uranium ore and existing stockpiles of highly enriched uranium in the United States and Russia that could be processed into fuel are sufficient (WNA 2012-TN1498) so that the irreversible and irretrievable commitment would be negligible.

10.4 Alternatives to the Proposed Action

Alternatives to the proposed actions are discussed in Chapter 9 of this draft EIS. The alternatives considered are the no-action alternative, system design alternatives, and alternative sites. If TVA submits a permit application to the USACE in the future, onsite alternatives will be addressed as part of the USACE least environmentally damaging practicable alternative determination.

The no-action alternative, as described in EIS Section 9.1, refers to a scenario in which the NRC would deny the TVA ESP request. If such an action were to occur, the construction and operation of a new nuclear plant at the CRN Site in accordance with the 10 CFR Part 52 (TN251) process referencing an approved ESP would not occur, and the environmental impacts predicted in this draft EIS would not occur. A comparison of the proposed action with the no-action alternative is presented in Section 9.1.

Alternative sites are discussed in EIS Section 9.3. The cumulative impacts of building and operating two or more SMRs at each of the three alternative sites are compared in Section 9.3.3 to the impacts of such facilities at the proposed CRN Site. Table 9-14 contains the review team characterization of cumulative impacts at the proposed CRN Site and the three alternative sites. Based on this review, the NRC staff concludes that while there are differences in cumulative impacts at the proposed and alternative sites, none of the alternative sites would be environmentally preferable or obviously superior to the proposed CRN Site.

In EIS Section 9.4, the NRC staff considered alternative system designs including alternative heat-dissipation systems and alternative intake, discharge, and water supply systems. The NRC staff did not identify any alternative that was environmentally preferable to the plant systems design currently under consideration for use at the CRN Site.

10.5 Benefit-Cost Balance

TVA did not address the balance of benefits and costs in its ESP application for the CRN Site, because such an assessment is not required for an ESP application per 10 CFR 51.50, Section (b)(2) (TN250). Should the NRC issue an ESP for the CRN Site, and a CP or COL application that references such an ESP is docketed, these matters will be considered in the EIS prepared in connection with the review of that CP or COL application.

At that time the COL (or CP/OL) review team would compare the relative magnitude of the expected social costs and benefits to be derived from approval of the proposed licensing action.

10.6 Staff Conclusions and Recommendations

The NRC staff preliminary recommendation to the Commission, after consideration of the environmental impacts described in this draft EIS, is that an ESP should be issued for the CRN Site in Roane County, Tennessee. The NRC staff evaluation of the safety and emergency preparedness aspects of the proposed action will be addressed in the NRC staff safety evaluation report.

The NRC staff recommendation is based on (1) the ESP application and supplemental information submitted by TVA; (2) consultation with Federal, State, Tribal, and local agencies; (3) the review team's independent review; (4) the NRC staff consideration of public scoping comments; and (5) the assessments summarized in this draft EIS, including the potential mitigation measures identified in the ER and in this draft EIS. In addition, in making its recommendation, the NRC staff has concluded that none of the alternative sites considered is obviously superior to the proposed CRN Site.

A comparative summary showing the environmental impacts of building and operating two or more SMRs at the proposed CRN Site or at any of the alternative sites is presented in EIS Section 9.3.3, Table 9-14. This table shows that the significance of the environmental impacts of the proposed action ranges from SMALL to LARGE at the CRN Site and at each of the alternative sites, depending on the resource category affected.

The range of impacts estimated by the NRC staff for resolved issues is predicated on certain assumptions that are identified in each section and summarized in Appendix J of this draft EIS. If the Commission issues an ESP for the CRN Site, and if that ESP is referenced in an application for a COL, the NRC staff will verify that the assumptions identified in the Final EIS for the ESP remain applicable. In addition, certain issues are not resolved because of a lack of information. An applicant for a COL (or CP/OL) referencing an ESP for the CRN Site would need to provide the necessary information to resolve these issues if the proposed licensing action ultimately would affect the resources associated with these issues.

11.0 REFERENCES

10 CFR Part 20. *Code of Federal Regulations*, Title 10, *Energy*, Part 20, "Standards for Protection Against Radiation." Washington, D.C. TN283.

10 CFR Part 50. *Code of Federal Regulations*, Title 10, *Energy*, Part 50, "Domestic Licensing of Production and Utilization Facilities." Washington, D.C. TN249.

10 CFR 50.67. *Code of Federal Regulations*, Title 10, *Energy*, Part 50, "Domestic Licensing of Production and Utilization Facilities," Section 67, *Accident Source Term*. Washington, D.C. TN5414.

10 CFR Part 51. *Code of Federal Regulations*, Title 10, *Energy*, Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions." Washington, D.C. TN250.

10 CFR Part 52. *Code of Federal Regulations*, Title 10, *Energy*, Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants." Washington, D.C. TN251.

10 CFR Part 71. *Code of Federal Regulations*, Title 10, *Energy*, Part 71, "Packaging and Transportation of Radioactive Material." Washington, D.C. TN301.

10 CFR Part 100. *Code of Federal Regulations*, Title 10, *Energy*, Part 100, "Reactor Site Criteria." Washington, D.C. TN282.

10 CFR Part 830. *Code of Federal Regulations*, Title 10, *Energy*, Part 830, "Nuclear Safety Management." Washington, D.C. TN5271.

10 CFR Part 961. *Code of Federal Regulations*, Title 10, *Energy*, Part 961, "Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste." Washington, D.C. TN300.

24 CFR Part 51. *Code of Federal Regulations*, Title 24, *Housing and Urban Development*, Part 51, "Environmental Criteria and Standards." Washington, D.C. TN1016.

29 CFR Part 1910. *Code of Federal Regulations*, Title 29, *Labor*, Part 1910, "Occupational Safety and Health Standards." Washington, D.C. TN654.

29 CFR Part 1926. *Code of Federal Regulations*, Title 29, *Labor*, Part 1926, "Safety and Health Requirements for Construction." Washington, D.C. TN4455.

33 CFR Part 230. *Code of Federal Regulations*, Title 33, *Navigation and Navigable Waters*, Part 230, "Procedures for Implementing NEPA." Washington, D.C. TN2273.

33 CFR Part 320. *Code of Federal Regulations*, Title 33, *Navigation and Navigable Waters*, Part 320, "General Regulatory Policies." Washington, D.C. TN424.

33 CFR Part 325. *Code of Federal Regulations*, Title 33, *Navigation and Navigable Waters*, Part 325, "Processing of Department of the Army Permits." Washington, D.C. TN425.

33 CFR Part 327. *Code of Federal Regulations*, Title 33, *Navigation and Navigable Waters*, Part 327, "Public Hearings." Washington, D.C. TN1788.

33 CFR Part 332. *Code of Federal Regulations*, Title 33, *Navigation and Navigable Waters*, Part 332, "Compensatory Mitigation for Losses of Aquatic Resources." Washington, D.C. TN1472.

36 CFR Part 60. *Code of Federal Regulations*, Title 36, *Parks, Forests, and Public Property*, Part 60, "National Register of Historic Places." Washington, D.C. TN1682.

36 CFR Part 79. *Code of Federal Regulations,* Title 36, *Parks, Forests, and Public Property*, Part 79, "Curation of Federally-Owned and Administered Archaeological Collections." Washington, D.C. TN5251.

36 CFR Part 800. *Code of Federal Regulations*, Title 36, *Parks, Forests, and Public Property*, Part 800, "Protection of Historic Properties." Washington, D.C. TN513.

40 CFR Part 9. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 9, "OMB Approvals Under the Paperwork Reduction Act." Washington, D.C. TN5322.

40 CFR Part 50. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 50, "National Primary and Secondary Ambient Air Quality Standards." Washington, D.C. TN1089.

40 CFR Part 52. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 52, "Approval and Promulgation of Implementation Plans." Washington, D.C. TN4498.

40 CFR 81.301. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 81, "Designation of Areas for Air Quality Planning Purposes," Section 301, *Alabama*. Washington, D.C. TN5011.

40 CFR 81.343. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 81, "Designation of Areas for Air Quality Planning Purposes," Section 343, *Tennessee*. Washington, D.C. TN5012.

40 CFR 81.428. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 81, "Designation of Areas for Air Quality Planning Purposes," Section 428, *Tennessee*. Washington, D.C. TN5047.

40 CFR Part 112. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 112, "Oil Pollution Prevention." Washington, D.C. TN1041.

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." Washington, D.C. TN254.

40 CFR Part 125 Subpart I. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 125, "Criteria and Standards for the National Pollutant Discharge Elimination System," Subpart I, *Requirements Applicable to Cooling Water Intake Structures for New Facilities Under Section 316(b) of the Act.* Washington, D.C. TN4818.

40 CFR Part 190. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations." Washington, D.C. TN739.

40 CFR Part 204. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 204, "Noise Emission Standards for Construction Equipment." Washington, D.C. TN653.

40 CFR Part 230. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 230, "Section 404(b)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material." Washington, D.C. TN427.

40 CFR Part 261. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 261, "Identification and Listing of Hazardous Waste." Washington, D.C. TN5092.

40 CFR Part 423. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 423, "Steam Electric Power Generating Point Source Category." Washington, D.C. TN253.

40 CFR Part 1508. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 1508, "Terminology and Index." Washington, D.C. TN428.

40 CFR Parts 50-99. *Code of Federal Regulations*, Title 40, *Protection of the Environment*, Subchapter C, Parts 50-99, "Air Programs." Washington, D.C. TN5264.

49 CFR Part 173. *Code of Federal Regulations*, Title 49, *Transportation*, Part 173, "Shippers—General Requirements for Shipments and Packagings." Washington, D.C. TN298.

50 CFR Part 17. *Code of Federal Regulations*, Title 50, *Wildlife and Fisheries*, Part 17, "Endangered and Threatened Wildlife and Plants." Washington, D.C. TN1648.

41 FR 24062. June 14, 1976. "Endangered Status for 159 Taxa of Animals." *Federal Register,* Department of the Interior, Washington, D.C. TN5173.

42 FR 45526. September 9, 1977. "Final Threatened Status and Critical Habitat for Five Species of Southeastern Fishes." *Federal Register*, Fish and Wildlife Service, Washington, D.C. TN5178.

43 FR 28932. July 3, 1978. "Determination that Seven Eastern U.S. Land Snails are Endangered or Threatened Species." *Federal Register*, Fish and Wildlife Service, Washington, D.C. TN5374.

49 FR 9351. March 12, 1984. "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions and Related Conforming Amendments; Final Rule." *Federal Register*, Nuclear Regulatory Commission, Washington, D.C. TN5279.

49 FR 10922. March 23, 1984. "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions and Related Conforming Amendments." *Federal Register*, Nuclear Regulatory Commission, Washington, D.C. TN5280.

51 FR 30028. August 21, 1986. "Safety Goals for the Operation of Nuclear Power Plants; Policy Statement; Republication." *Federal Register*, Nuclear Regulatory Commission, Washington, D.C. TN594.

59 FR 7629. February 16, 1994. "Executive Order 12898: Federal Actions To Address Environmental Justice in Minority Populations and Low-Income Populations." *Federal Register*, Office of the President, Washington, D.C. TN1450.

61 FR 65120. December 10, 1996. "Resolution of Dual Regulation of Airborne Effluents of Radioactive Materials; Clean Air Act." *Federal Register,* Nuclear Regulatory Commission, Washington, D.C. TN294.

64 FR 36454. July 6, 1999. "Endangered and Threatened Wildlife and Plants; Proposed Rule to Remove the Bald Eagle in the Lower 48 States from the List of Endangered and Threatened Wildlife." *Federal Register,* Department of the Interior, Washington, D.C. TN1848.

65 FR 794. January 6, 2000. "FirstEnergy Nuclear Operating Company, Davis-Besse Nuclear Power Station, Unit 1; Environmental Assessment and Finding of No Significant Impact." *Federal Register*, Nuclear Regulatory Commission, Washington, D.C. TN2657.

66 FR 65256. December 18, 2001. "National Pollutant Discharge Elimination System: Regulations Addressing Cooling Water Intake Structures for New Facilities." *Federal Register,* Environmental Protection Agency, Washington, D.C. TN243.

66 FR 76708. December 7, 2000. "National Primary Drinking Water Regulations; Radionuclides; Final Rule." *Federal Register*, Environmental Protection Agency, Washington, D.C. TN5061.

67 FR 77651. December 19, 2002. "Minor Errors in Regulatory Text; Correction." *Federal Register*, Nuclear Regulatory Commission, Washington, D.C. TN5278.

69 FR 52040. August 24, 2004. "Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions." *Federal Register*, Nuclear Regulatory Commission, Washington, D.C. TN1009.

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—Final Rule." *Federal Register*, Fish and Wildlife Service, Washington, D.C. TN918.

72 FR 49351. August 28, 2007. "Licenses, Certifications, and Approvals for Nuclear Power Plants; Final Rule." *Federal Register*, Nuclear Regulatory Commission, Washington, D.C. TN4796.

72 FR 57416. October 9, 2007. "Limited Work Authorizations for Nuclear Power Plants." *Federal Register,* Nuclear Regulatory Commission, Washington, D.C. TN260.

73 FR 19594. April 10, 2008. "Compensatory Mitigation for Losses of Aquatic Resources." *Federal Register*, U.S. Army Corps of Engineers, Washington, D.C. TN1789.

74 FR 66496. December 15, 2009. "Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act." *Federal Register*, Environmental Protection Agency, Washington, D.C. TN245.

76 FR 38095. June 29, 2011. "Endangered and Threatened Wildlife and Plants; 90-Day Finding on a Petition to List the Eastern Small-Footed Myotis and the Northern Long-Eared Bat as Threatened or Endangered." *Federal Register*, Fish and Wildlife Service, Washington, D.C. TN1798.

77 FR 14914. March 13, 2012. "Endangered and Threatened Wildlife and Plants; Determination of Endangered Status for the Sheepnose and Spectaclecase Mussels Throughout Their Range, Final Rule." *Federal Register,* Department of the Interior, Washington, D.C. TN5177.

77 FR 16082. March 19, 2012. "In the Matter of All Power Reactor Licensees and Holders of Construction Permits in Active or Deferred Status: Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation (Effective Immediately)." *Federal Register,* Nuclear Regulatory Commission, Washington, D.C. TN1424.

77 FR 16091. March 19, 2012. "Order Modifying Licenses With Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Effective Immediately)." *Federal Register,* Nuclear Regulatory Commission, Washington, D.C. TN2476.

77 FR 16098. March 19, 2012. "In the Matter of All Operating Boiling Water Reactor Licensees With Mark I and Mark II Containments; Order Modifying Licenses With Regard to Reliable Hardened Containment Vents (Effective Immediately)." *Federal Register,* Nuclear Regulatory Commission, Washington, D.C. TN2477.

78 FR 61046. October 2, 2013. "Endangered and Threatened Wildlife and Plants; 12–Month Finding on a Petition To List the Eastern Small-Footed Bat and the Northern Long-Eared Bat as Endangered or Threatened Species; Listing the Northern Long-Eared Bat as an Endangered Species." *Federal Register*, Fish and Wildlife Service, Washington, D.C. TN3207.

80 FR 17974. April 2, 2015. "Endangered and Threatened Wildlife and Plants; Threatened Species Status for the Northern Long-Eared Bat With 4(d) Rule—Final Rule and Interim Rule with Request for Comments." *Federal Register*, Fish and Wildlife Service, Washington, D.C. TN4216.

81 FR 62826. September 13, 2016. "Endangered and Threatened Wildlife and Plants; Threatened Species Status for *Platanthera integrilabia* (White Fringeless Orchid)." *Federal Register*, Fish and Wildlife Service, Washington, D.C. TN5378.

81 FR 85950. November 29, 2016. "Clean Air Act Operating Permit Program; Petition for Objection to State Operating Permit for Tennessee Valley Authority—Bull Run (Anderson County, Tennessee)." *Federal Register*, Environmental Protection Agency, Washington, D.C. TN4900.

82 FR 3812. January 12, 2017. "Tennessee Valley Authority; Clinch River Nuclear Site." *Federal Register*, Nuclear Regulatory Commission, Washington, D.C. TN5084.

82 FR 17885. April 13, 2017. "Tennessee Valley Authority; Clinch River Nuclear Site; Early Site Permit Application." *Federal Register.* U.S. Nuclear Regulatory Commission, Washington, D.C. TN4910.

82 FR 19430. April 27, 2017. "Bull Run Fossil Plant Landfill." *Federal Register*, Tennessee Valley Authority, Chattanooga, Tennessee. TN5077.

82 FR 40718. August 28, 2017. "Air Plan Approval and Air Quality Designation; TN; Redesignation of the Knoxville 2006 24-hour PM2.5 Nonattainment Area to Attainment." *Federal Register*, Environmental Protection Agency, Washington, D.C. TN5016.

82 FR 40953. August 29, 2017. "Air Plan Approval and Air Quality Designation; TN; Designation of the Knoxville 1997 Annual PM2.5 Nonattainment Area to Attainment." *Federal Register*, Environmental Protection Agency, Washington, D.C. TN5015.

7 U.S.C. § 4201 et seq. Farmland Protection Policy Act of 1981. TN708.

16 U.S.C. § 470aa et seq. Archaeological Resources Protection Act of 1979, as amended. TN1687.

16 U.S.C. § 668-668d et seq. Bald and Golden Eagle Protection Act. TN1447.

16 U.S.C. § 703 et seq. Migratory Bird Treaty Act of 1918. TN3331.

16 U.S.C. § 831 et seq. Tennessee Valley Authority Act, as amended. TN5024.

16 U.S.C. § 1451 et seq. Coastal Zone Management Act of 1972. TN1243.

16 U.S.C. § 1531 et seq. Endangered Species Act of 1973. TN1010.

22 U.S.C. § 3201 et seq. Nuclear Non-Proliferation Act of 1978. TN737.

25 U.S.C. § 3001 et seq. Native American Graves Protection and Repatriation Act. TN1686.

33 U.S.C. § 401 et seq. Rivers and Harbors Act of 1899. TN660.

33 U.S.C. § 1221 et seq. Ports and Waterways Safety Act of 1972. TN4314.

33 U.S.C. § 1251 et seq. Federal Water Pollution Control Act of 1972 [also referred to as Clean Water Act]. TN662.

33 U.S.C. § 1344. U.S. Code Title 33, *Navigation and Navigable Waters*, Chapter 26, "Water Pollution Prevention and Control," Subchapter IV, *Permits and Licenses*, Section 404 "Permits for Dredged or Fill Material." TN1019.

42 U.S.C. § 82 et seq. Solid Waste Disposal Act of 1965. TN1032.

42 U.S.C. § 1996 *et seq*. American Indian Religious Freedom Act, as amended. TN5281.

42 U.S.C. § 2011 et seq. Atomic Energy Act of 1954. TN663.

42 U.S.C. § 4321 et seq. National Environmental Policy Act of 1969 (NEPA), as amended. TN661.

42 U.S.C. § 6901 et seq. Resource Conservation and Recovery Act of 1976 (RCRA). TN1281.

42 U.S.C. § 6921 et seq. Hazardous and Solid Waste Amendments of 1984. TN1033.

42 U.S.C. § 7401 et seq. Clean Air Act. TN1141.

42 U.S.C. § 7401 et seq. Clean Air Act Amendments of 1977. Public Law 95-95, as amended. TN4540.

42 U.S.C. § 15801 et seq. Energy Policy Act of 2005. TN738.

54 U.S.C. § 300101 et seq. National Historic Preservation Act. TN4157.

54 U.S.C. § 306101. National Historic Preservation Act Section 110, "Assumption of Responsibility for Preservation of Historic Property." TN4840.

54 U.S.C. § 306108. National Historic Preservation Act Section 106, "Effect of Undertaking on Historic Property." TN4839.

54 U.S.C. § 312501 et seq. Archeological and Historic Preservation Act of 1974, as amended. TN4844.

ADEM (Alabama Department of Environmental Management). 2016. "2016 Alabama §303(d) List." Montgomery Alabama. Accession No. ML18019A931. TN5097.

ADEM (Alabama Department of Environmental Management). 2017. "Title V Air Permitting Licenses for Madison County, Alabama, 2012–2017." Montgomery, Alabama. Accession No. ML18019A933. TN5048.

ADPH (Alabama Department of Public Health). 2016. *Alabama Fish Consumption Advisories 2016*. Montgomery, Alabama. Accession No. ML18019A934. TN5098.

AEC (U.S. Atomic Energy Commission). 1972. *Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants*. WASH–1238, Washington, D.C. Accession No. ML14092A626. TN22.

AEC (U.S. Atomic Energy Commission). 1974. *Environmental Survey of the Uranium Fuel Cycle*. WASH–1248, Washington, D.C. Accession No. ML14092A628. TN23.

AECOM. 2014. *Final Clinch River Site Ambient Noise Assessment Technical Report.* Revision 1, Greenville, South Carolina. Accession No. ML17334A057. TN5004.

AECOM. 2015. *Clinch River Site Traffic Assessment.* Final Technical Report, Greenville, South Carolina. Accession No. ML17334A043. TN5000.

AFORR (Advocates for the Oak Ridge Reservation). 2011. "TDEC Division of Natural Heritage Proposal for an Oak Ridge Reservation Designated State Natural Area." Oak Ridge, Tennessee. Accession No. ML18019A936. TN5134.

AFT (American Farmland Trust). 2003. "Farming on the Edge: Alabama State Map." Washington, D.C. Accessed October 19, 2017, at http://162.242.222.244/resources/fote/states/map_alabama.asp. TN5132.

AGNIR (Advisory Group on Non-Ionising Radiation). 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. Accession No. ML093210326. TN3906.

AL Admin Code 220-2. *Alabama Administrative Code*, Chapter 220-2, Conservation, Game and Fish Division. TN5183.

Alapark (Alabama State Parks). 2016. "Bucks Pocket State Park." Montgomery, Alabama. Accessed June 6, 2016, at http://www.alapark.com/bucks-pocket-state-park. TN5110.

Alapark (Alabama State Parks). 2016. "Cathedral Caverns State Park." Montgomery, Alabama. Accessed June 6, 2016, at http://www.alapark.com/cathedral-caverns-state-park. TN5106.

Alapark (Alabama State Parks). 2016. "Joe Wheeler State Park." Montgomery, Alabama. Accessed June 6, 2016, at http://www.alapark.com/joe-wheeler-state-park. TN5109.

Alapark (Alabama State Parks). 2016. "Lake Guntersville State Park." Montgomery, Alabama. Accessed June 6, 2016, at http://www.alapark.com/lake-guntersville-state-park. TN5108.

Alapark (Alabama State Parks). 2016. "Monte Sano State Park." Montgomery, Alabama. Accessed June 6, 2016, at http://www.alapark.com/monte-sano-state-park. TN5107.

Alapark (Alabama State Parks). 2016. "Tims Ford State Park." Montgomery, Alabama. Accessed June 6, 2016, at http://tnstateparks.com/parks/about/tims-ford. TN5111.

ALDOT (Alabama Department of Transportation). 2016. *2015 Crash Facts*. Montgomery, Alabama. Accessed January 10, 2018, at http://drivesafealabama.org/uploads/files/ALDOT-2015-CrashFactsBook.pdf. TN5352.

Alexander, L.S. and C.P. Redwine. 2008. *The 2007 Phase I Archaeological Survey on Redstone Arsenal, Madison County, Alabama*. Alexander Archaeological Consultants, Wildwood, Georgia. Accession No. ML17234A011. TN5315.

Alexander, L.S., D.J. Minnich, J.M. Thomson, and E.J. Williams. 2000. *The 1999 Phase I Archaeological Survey of 189 Hectares (466 Acres) for Timber Management on Redstone Arsenal, Madison County, Alabama*. Final Report, Alexander Archaeological Consultants, Wildwood Georgia. Accession No. ML17234A009. TN5317.

Alexander, L.S., J.M. Thomson, and E.J. Williams. 2003. *The 1999-2000 Phase I Archaeological Survey of 2833 Hectares (7000 Acres) on Redstone Arsenal, Madison County, Alabama*. Alexander Archaeological Consultants, Wildwood, Georgia. Accession No. ML17234A010. TN5316.

ALRev (Alabama Department of Revenue). 2016. *2016 Annual Report*. Montgomery, Alabama. Accessed October 19, 2017, at https://revenue.alabama.gov/2016/12/31/2016-annual-report/. TN5139.

AMEC (AMEC Americas Limited). 2005. *Mackenzie Gas Project: Effects of Noise on Wildlife*. Imperial Oil Resources Ventures Limited, Calgary, Alberta, Canada. Accession No. ML14308A108. TN901.

Angst, M.G. and J.L. Kirkmeyer. 2007. *Phase I Archaeological Survey for the Proposed Rarity Ridge Water Line Project, Roane County, Tennessee*. Draft Version, Archaeological Research Laboratory, University of Tennessee, Knoxville, Tennessee. Accession No. ML18060A287. TN5336.

ANHP (Alabama Natural Heritage Program). 2017. Email from M. Barbour to J. Becker, PNNL, dated August 21, 2017, regarding "Map Package for AL NHP." Auburn University Museum of Natural History, Auburn University, Alabama. Accession No. ML18022A463. TN5398.

Baltimore Gas and Electric Co. v. Natural Resources Defense Council, Inc., et al. 462 U.S. 87 (1983). United States Supreme Court Decision June 6, 1983. *United States Reports* 462:87. Accession No. ML14091A199. TN1054.

Bander, T.J. 1982. *PAVAN: An Atmospheric-Dispersion Program for Evaluating Design-Basis Accidental Releases of Radioactive Materials from Nuclear Power Stations*. NUREG/CR–2858, Pacific Northwest Laboratory, Richland, Washington. Accession No. ML12045A149. TN538.

Baranski, M.J. 2009. *Natural Area Analysis and Evaluation, Oak Ridge Reservation*. ORNL/TM-2009-201, Oak Ridge National Laboratory, Oak Ridge, Tennessee. Accession No. ML18019A937. TN5133.

Baranski, M.J. 2011. *Aquatic Natural Areas Analysis and Evaluation Oak Ridge Reservation*. ORNL/TM-2011/13, Oak Ridge National Laboratory, Oak Ridge, Tennessee. Accession No. ML18019A939. TN5164.

Barrett, J., K. Hockersmith, T. Karpynec, and L. McKee. 2011. *Phase I Archaeological Survey of the Clinch River Small Modular Reactors Project (SMR), Roane County, Tennessee*. TRC Environmental Corporation, Nashville, Tennessee. Accession Nos. ML17284A318, ML17284A319. TN4975.

Barrett, J., K. Hockersmith, T. Karpynec, and L. McKee. 2011. *Phase I Archaeological Survey, TVA Clinch River Site Characterization Project, Roane County, Tennessee*. Draft Report, TRC Environmental Corporation, Nashville, Tennessee. Accession No. ML17284A317. TN4974.

BCI (Bat Conservation International). 2017. "Species Profiles." Washington, D.C. Accessed December 8, 2017, at http://www.batcon.org/resources/media-education/species-profiles. TN5294.

BEA (U.S. Bureau of Economic Analysis). 2017. "GDP and Personal Income, Regional Data, Tennessee." Washington, D.C. Accession No. ML18019A941. TN4941.

BEA (U.S. Bureau of Economic Analysis). 2017. "Implicit Price Deflators for Gross Domestic Product." Washington, D.C. Accession No. ML18019A942. TN4967.

Bechtel (Bechtel Corporation). 2016. "Uranium processing Facility, Oak Ridge, Tennessee." San Francisco, California. Accessed June 2, 2017, at http://www.bechtel.com/projects/uranium-processing-facility/. TN4919.

Bellrose, F.C. 1968. *Waterfowl Migration Corridors East of the Rocky Mountains in the United States*. Illinois Natural History Survey, Biological Notes No. 61, Urbana, Illinois. Accessed on September 14, 2017, at http://bhl-china.org/bhldatas/pdfs/w/waterfowlmigrati61bell.pdf. TN5150.

Bezdek, R.H. and R.M. Wendling. 2006. "The Impacts of Nuclear Facilities on Property Values and Other Factors in the Surrounding Communities." *International Journal of Nuclear Governance, Economy and Ecology* 1(1):122–144, Geneva, Switzerland. TN2748.

Blower, D. and A. Matteson. 2003. *Evaluation of the Motor Carrier Management Information System Crash File, Phase One.* UMTRI–2003–06, University of Michigan Transportation Research Institute, Ann Arbor, Michigan. Accession No. ML112650033. TN410.

BLS (U.S. Bureau of Labor Statistics). 2015. "National Rate of Fatal Work Injuries, 2008 through 2015." Census of Fatal Occupational Injury Charts, Washington, D.C. Accession No. ML18019A945. TN4903.

BLS (U.S. Bureau of Labor Statistics). 2016. "Incidence Rates of Nonfatal Occupational Injuries and Illnesses by Industry and Case Types, 2006 through 2015." Washington, D.C. Accession No. ML18019A946. TN4904.

BLS (U.S. Bureau of Labor Statistics). 2017. "Fatal Work Injuries for Tennessee, 2008 through 2015." Census of Fatal Occupational Injury Charts, Washington, D.C. Accession No. ML18019A948. TN4905.

BLS (U.S. Bureau of Labor Statistics). 2017. "Incidence Rates of Nonfatal Occupational Injuries and Illnesses by Industry and Case Types for Tennessee, 2006 through 2015." Washington, D.C. Accession No. ML18019A950. TN4906.

BLS (U.S. Bureau of Labor Statistics). 2017. "Local Area Unemployment Statistics January 2007–June 2017: Anderson, Knox, Loudon, and Roane Counties, Tennessee." Washington, D.C. Accession No. ML18019A951. TN4928.

BLS (U.S. Bureau of Labor Statistics). 2017. "May 2016 Metropolitan and Nonmetropolitan Area Occupational Employment and Wage Estimates, Knoxville, Tennessee." Washington, D.C. Accession No. ML18059A109. TN5389.

BLS (U.S. Bureau of Labor Statistics). 2017. "Unemployment Rate – Construction Industry, Private wage and Salary Workers, 2007 to 2017." Washington, D.C. Accession No. ML18019B169. TN4992.

Bohac, C.E. and A.K. Bowen. 2012. *Water Use in the Tennessee Valley for 2010 and Projected Use in 2035*. Tennessee Valley Authority, Knoxville, Tennessee. Accession No. ML18019A897. TN5026.

Bohac, C.E. and A.K. Bowen. 2015. *Clinch River Small Modular Reactor Site Regional Surface Water Use Study*. Revision 2, Tennessee Valley Authority, Knoxville, Tennessee. Accession No. ML17334A048. TN5157.

BRC (Breeder Reactor Corporation). 1985. *The Clinch River Breeder Reactor Plant Project*. Final Report, Oak Ridge, Tennessee. Accession No. ML18064A893. TN5245.

Brookfield (Brookfield Renewable Partners). 2017. "Smoky Mountain: Calderwood." Toronto, Ontario, Canada. Accessed November 13, 2017, at https://renewableops.brookfield.com/en/Presence/North-America/Recreation-and-Safety/Smoky-Mountain-Hydro/Recreation-and-Flow/Calderwood. TN5230.

Brookfield (Brookfield Renewable Partners). 2017. "Smoky Mountain: Cheoah." Toronto, Ontario, Canada. Accessed November 13, 2017, at https://renewableops.brookfield.com/en/Presence/North-America/Recreation-and-Safety/Smoky-Mountain-Hydro/Recreation-and-Flow/Cheoah. TN5228.

Brookfield (Brookfield Renewable Partners). 2017. "Smoky Mountain: Chilhowee." Toronto, Ontario, Canada. Accessed November 13, 2017, at https://renewableops.brookfield.com/en/Presence/North-America/Recreation-and-Safety/Smoky-Mountain-Hydro/Recreation-and-Flow/Chilhowee. TN5227.

Brookfield (Brookfield Renewable Partners). 2017. "Smoky Mountain: Santeetlah." Toronto, Ontario, Canada. Accessed November 13, 2017, at https://renewableops.brookfield.com/en/Presence/North-America/Recreation-and-Safety/Smoky-Mountain-Hydro/Recreation-and-Flow/Santeetlah. TN5229.

BTS (Bureau of Transportation Statistics). 2017. "Knoxville, TN: McGhee Tyson (TYS) Airport." Washington, D.C. Accession No. ML18019A898. TN4946.

Burger, J. and K.R. Campbell. 2004. "Species Differences in Contaminants in Fish on and Adjacent to the Oak Ridge Reservation, Tennessee." *Environmental Research* 96(2004):145-155, New York, New York. TN5059.

Caltrans (California Department of Transportation). 2016. *Technical Guidance for Assessment and Mitigation of the Effects of Highway and Road Construction Noise on Birds.* CTHWANP-RT-15-306.04.2, Sacramento, California. Accessed August 18, 2017, at http://www.dot.ca.gov/hq/env/noise/pub/caltransBirdReport_6_15_2016.pdf. TN5155.

CBD (Center for Biological Diversity) and DoW (Defenders of Wildlife). 2016. *Petition to list the Tricolored Bat* Perimyotis subflavus *as Threatened or Endangered under the Endangered Species Act*. Tucson, Arizona and Washington, D.C. Accession No. ML18019A110. TN5360.

CBER (Center for Business and Economic Research). 2017. "Estimates and Projections." University of Alabama, Tuscaloosa, Alabama. Accessed October 19, 2017, at https://cber.cba.ua.edu/edata/est_prj.html. TN5138.

CDC (Centers for Disease Control and Prevention). 2017. "Recreational Water Illnesses." Atlanta, Georgia. Accession No. ML18019A901. TN5146.

CDC (Centers for Disease Control and Prevention). 2017. "Surveillance for Waterborne-Disease Outbreaks—United States, 2003–2012." *Morbidity and Mortality* Weekly Reports from 2006 to 2015, Atlanta, Georgia. Accession No. ML18019B170. TN4902.

Chanin, D. and M.L. Young. 1998. *Code Manual for MACCS2: Volume 1*, *User's Guide*. NUREG/CR–6613, Sandia National Laboratories, Albuquerque, New Mexico. Accession No. ML110600923. TN66.

Chanin, D.I., J.L. Sprung, L.T. Ritchie, and H-N Jow. 1990. *MELCOR Accident Consequence Code System (MACCS) User's Guide.* NUREG/CR–4691, Volume 1, U.S. Nuclear Regulatory Commission, Washington, D.C. Accession No. ML063560409. TN2056.

Cherokee Nation. 2017. Letter from E. Toombs to NRC, dated May 12, 2017, regarding "Clinch River Nuclear Site Early Site Permit Application." Tahlequah, Oklahoma. Accession No. ML17145A580. TN5247.

Chickasaw Nation. 2018. Email from K. Brunso to J. Davis, NRC, dated January 22, 2018, regarding "Application for the Clinch River Nuclear Site in Roane County, Tennessee." Ada, Oklahoma. Accession No. ML18031A976. TN5428.

Choctaw Nation. 2017. Email from D. Ragle to NRC, dated June 5, 2017, regarding "Initiation of Section 106 and Scoping Process for the Environmental Review of the Early Site Permit Application for the Clinch River Nuclear Site in Roane County, Tennessee." Durant, Oklahoma. Accession No. ML17157B749. TN5248.

City of Oak Ridge. 1999. *Comprehensive Plan, Oak Ridge, Tennessee*. Oak Ridge, Tennessee. Accessed September 18, 2017, at http://www.oakridgetn.gov/images/uploads/Documents/Departments/CommDev/Pertinent%20Plan%20Docs/Comprehensive%20Plan.pdf. TN4995.

City of Oak Ridge. 2013. *Zoning Ordinance, Oak Ridge, Tennessee*. Oak Ridge, Tennessee. Accessed September 19, 2017, at http://www.oakridgetn.gov/images/uploads/Documents/Departments/CommDev/Planning%20files/Current%20Zoning%20Ordinance%20by%20Chapter/CompleteZoningOrdinance2-24-2016.pdf. TN4999.

Cole, P.E. 1974. "Investigation of Site 40RE124, A Late Woodland Burial Mound." Presented at the Thirty-First Annual Southeastern Archaeological Conference, Atlanta, Georgia, October 25-26, 1974. Accession No. ML17296A401. TN4970.

CollegeStats (CollegeStats.org). 2017. "Tennessee Colleges." Houston, Texas. Accessed August 28, 2017, at https://collegestats.org/colleges/tennessee/. TN4961.

Cook, M.R., S.P. Jennings, K.M. Smith, N.E. Moss, A. Rogers, and R. Norman. 2015. *Characterization of Hydrogeology and Regional Groundwater Movement in Madison County and Redstone Arsenal, Alabama*. Geological Survey of Alabama, Tuscaloosa, Alabama. Accession No. ML18019A903. TN5074.

Cornell (The Cornell Lab of Ornithology). 2015. "All About Birds." Ithaca, New York. Available at http://www.allaboutbirds.org/guide/search. TN4433.

Covanta. 2016. "Covanta Huntsville." Morristown, New Jersey. Accessed June 6, 2016, at https://www.covanta.com/Our-Facilities/Covanta-Huntsville. TN5105.

Cowan, J.P. 1994. *Handbook of Environmental Acoustics*. John Wiley & Sons, Inc., New York, New York. TN3905.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. *Classification of Wetlands and Deepwater Habitats of the United States*. FWS/OBS-79/31, Fish and Wildlife Service, Washington, D.C. Accession No. ML18019A904. TN5186.

Cox, P.B., A.J. Dattilo, and J.T. Baxter, Jr. 2015. *Clinch River Small Modular Reactor Site Terrestrial Plant Communities and Botanical Resources Survey Report*. Revision 5, Tennessee Valley Authority, Knoxville, Tennessee. Accession No. ML17334A049. TN5193.

CTAS (University of Tennessee County Technical Assistance Service). 2016. *Tennessee County Tax Statistics, FY 2016*. Nashville, Tennessee. Accession No. ML18019A906. TN4943.

Cullman Times. 2017. "City Utilities Files Suit Over Duck River Dam Leakage." Cullman, Alabama. Accessed October 19, 2017, at http://www.cullmantimes.com/news/city-utilities-files-suit-over-duck-river-dam-leakage/article_4b038c28-73d2-11e7-9897-331f0c06a5e3.html. TN5117.

Currie, R.R. 1993. *Recovery Plan for American Hart's-Tongue* (Asplenium scolopendrium *var*. americanum). Southeast Region, U.S. Fish and Wildlife Service, Atlanta, Georgia. Accession No. ML18019A907. TN5306.

DA (Department of the Army). 2016. "Redstone Arsenal, Ala. Home of Team Redstone." Huntsville, Alabama. Accession No. ML18019A908. TN5118.

Dattilo, A.J. 2015. *Clinch River Barge/Traffic Area Terrestrial Plant Communities and Botanical Resources Survey Report*. Tennessee Valley Authority, Knoxville, Tennessee. Accession No. ML18036A350. TN5283.

DOE (U.S. Department of Energy). 1984. *Clinch River Breeder Reactor Plant Project Site Redress Plan*. Washington, D.C. Accession No. ML18065A004. TN5282.

DOE (U.S. Department of Energy). 2002. *A Resource Handbook on DOE Transportation Risk Assessment*. DOE/EM/NTP/HB-01, Washington, D.C. Accession No. ML12192A286. TN418.

DOE (U.S. Department of Energy). 2002. *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada*. DOE/EIS-0250, Office of Civilian Radioactive Waste Management, Washington, D.C. Accession No. ML14024A327. TN1236.

DOE (U.S. Department of Energy). 2004. "Application of Advanced Construction Technologies to New Nuclear Power Plants." In *NP2010 Improved Construction Technologies, O&M Staffing and Cost, Decommissioning Costs, and Funding Requirements Study.* MPR-2610, Revision 2, Washington, D.C. Accession No. ML093160836. TN2240.

DOE (U.S. Department of Energy). 2005. *Cost Estimating Guidelines for Generation IV Nuclear Energy Systems.* Rev. 2.02 Final, Economic Modeling Working Group, Washington, D.C. Accession No. ML14087A250. TN2358.

DOE (U.S. Department of Energy). 2005. *DOE NP2010 Nuclear Power Plant Construction Infrastructure Assessment*. MPR-2776, Revision 0, Washington, D.C. Accession No. ML18019A910. TN5335.

DOE (U.S. Department of Energy). 2005. *DOE Standard Radiation Control.* DOE-STD-1098-99, Change Notice No. 1, Washington, D.C. Accession No. ML053330383. TN1235.

DOE (U.S. Department of Energy). 2008. *Final Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada*. DOE/EIS-0250F-S1, Washington, D.C. Accession No. ML14024A329. TN1237.

DOE (U.S. Department of Energy). 2011. *DOE Standard: Derived Concentration Technical Standard*. DOE-STD-1196-2011, Washington, D.C. Accession No. ML13323B598. TN5292.

DOE (U.S. Department of Energy). 2011. *Final Site-Wide Environmental Impact Statement for the Y-12 National Security Complex*. DOE/EIS-0387, Washington, D.C. Accession No. ML18019A920. TN5023.

DOE (U.S. Department of Energy). 2013. *Groundwater Strategy for the U.S. Department of Energy, Oak Ridge Reservation, Oak Ridge, Tennessee*. Volume 1, DOE/OR/01-2628/V1&D1, Oak Ridge, Tennessee. Accession No. ML18064A894. TN5075.

DOE (U.S. Department of Energy). 2014. *Preparation of Nonreactor Nuclear Facility Documented Safety Analysis.* DOE-STD-3009-2014, Washington, D.C. Accession No. ML18019A922. TN5272.

DOE (U.S. Department of Energy). 2015. *Department of Energy Oak Ridge Office of Environmental Management Economic Impact Analysis*. Oak Ridge, Tennessee. Accession No. ML18019A923. TN4964.

DOE (U.S. Department of Energy). 2016. *2015 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee. Data and Evaluations.* DOE/OR/01-2675&D2, Oak Ridge, Tennessee. Accession No. ML18019A928. TN5027.

DOE (U.S. Department of Energy). 2016. *2016 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation Oak Ridge, Tennessee, Data and Evaluations*. DOE/OR/01-2707&D1, Oak Ridge, Tennessee. Accession No. ML18019B166. TN5072.

DOE (U.S. Department of Energy). 2016. *Finding of No Significant Impact Property Transfer to Develop a General Aviation Airport at the East Tennessee Technology Park Heritage Center, Oak Ridge, Tennessee*. Oak Ridge, Tennessee. Accession No. ML18019A926. TN5022.

DOE (U.S. Department of Energy). 2016. *Oak Ridge Reservation Annual Site Environmental Report 2015*. DOE/ORO/2509, Oak Ridge, Tennessee. Accession No. ML18019A930. TN5031.

DOE (U.S. Department of Energy). 2016. "Oak Ridge Site." Office of Environmental Management, Washington, D.C. Accession No. ML18019A924. TN4634.

DOE (U.S. Department of Energy). 2017. "Manifest Information Management System Generator Data for Tennessee 2006 through 2016." Germantown, Maryland. Accession No. ML18019B165. TN5087.

DOE (U.S. Department of Energy). 2017. *Oak Ridge Reservation Annual Site Environmental Report 2016*. DOE/ORO/251, Oak Ridge, Tennessee. Accession No. ML18019B167. TN5081.

DOE (U.S. Department of Energy). 2017. *Waste Disposal Capacity for Oak Ridge Reservation Landfills*. Oak Ridge Tennessee. Accession No. ML18064A123. TN5064.

DOE (U.S. Department of Energy), TVA (Tennessee Valley Authority), and PMC (Project Management Corporation). 1984. *Clinch River Breeder Reactor Plant Site Redress Planning Task Force Report*. Washington, D.C., Knoxville Tennessee, and Oak Ridge, Tennessee. Accession No. ML17334A059. TN5221.

DOE Order 5400.5 Change 2. 1993. *Radiation Protection of the Public and the Environment*. U.S. Department of Energy, Washington, D.C. Accession No. ML110800239. TN5334.

DOE/EIA (U.S. Department of Energy/Energy Information Administration). 1995. *Electricity Generation and Environmental Externalities: Case Studies*. Washington, D.C. Accession No. ML14029A023. TN2996.

DOE/EIA (U.S. Department of Energy/Energy Information Administration). 2013. *Updated Capital Cost Estimates for Utility Scale Electricity Generating Plants*. Washington, D.C. Accession No. ML18019A915. TN4968.

DOE/EIA (U.S. Department of Energy/Energy Information Administration). 2017. *Electric Power Monthly with Data for December 2016*. Washington, D.C. Accession No. ML18019A917. TN5086.

DTN (DTN/The Progressive Farmer). 2016. "Tate & Lyle Grain, Inc. Loudon Facility Information." Accessed June 2, 2016, at http://www.tateandlylegrain.com/index.cfm?show=10&mid=23. TN4700.

Duckriver.org. 2017. "About Duck River, the Duck River Reservoir Project." Cullman, Alabama. Accession No. ML18019B162. TN5116.

Duvall, G.D. and P.A. Souza. 1996. *An Evaluation of Previously Recorded and Inventoried Archaeological Sites on the Oak Ridge Reservation, Anderson and Roane Counties, Tennessee*. ORNL/M-4946, Oak Ridge National Laboratory, Oak Ridge, Tennessee. Accession No. ML18064A385. TN5337.

EBR (Energy Business Review). 2017. "Tate& Lyle Commissions $60m Co-Generation Plant at its Tennessee Facility." London, United Kingdom. Accessed April 6, 2017, at http://fossilfuel.energy-business-review.com/news/siemens-commissions-60m-chp-system-for-tate-lyles-tennessee-plant-230217-5747857. TN4909.

Eckerman, K.F. and J.C. Ryman. 1993. *External Exposure to Radionuclides in Air, Water, and Soil*. U.S. Environmental Protection Agency, Federal Guidance Report No. 12, EPA-402-R-93-081, Washington, D.C. Accession No. ML111930454. TN3955.

Eckerman, K.F., R.W. Leggett, C.B. Nelson, J.S. Puskin, and A.C.B. Richardson. 1999. *Cancer Risk Coefficients for Environmental Exposure to Radionuclides*. Federal Guidance Report No. 13, EPA 402-R-99-001, U.S. Environmental Protection Agency, Washington, D.C. Accession No. ML18019B163. TN5020.

ECS (Education Commission of the States). 2014. "Teacher:Student Ratios." Denver, Colorado. Accessed January 17, 2018, at http://ecs.force.com/mbdata/mbquestRT?rep=Kq1411. TN5395.

EIA (U.S. Energy Information Administration). 2015. "Natural Gas Power Plant: University of Tennessee Steam Plant." Washington, D.C. Accession No. ML18019B168. TN4650.

EIA (U.S. Energy Information Administration). 2016. "Buffalo Mountain Wind Farm." Washington, D.C. Accession No. ML18019B164. TN4657.

EO 13007. May 24, 1996. *Executive Order 13007—Indian Sacred Sites*. Office of the President, Washington, D.C. TN5250.

EO 13175. November 6, 2000. *Executive Order 13175—Consultation and Coordination with Indian Tribal Governments*. Office of the President, Washington, D.C. TN4846.

EPA (U.S. Environmental Protection Agency). 1974. *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety*. Washington, D.C. Accession No. ML12241A393. TN3941.

EPA (U.S. Environmental Protection Agency). 1997. *EPA Superfund Record of Decision: Oak Ridge Reservation (USDOE), Clinch River & Poplar Creek Operable Units, Oak Ridge, TN*. EPA/541/R-97/075, Washington, D.C. Accession No. ML18023A335. TN5222.

EPA (U.S. Environmental Protection Agency). 2001. *Technical Development Document for the Final Regulations Addressing Cooling Water Intake Structures for New Facilities*. EPA Office of Science and Technology Engineering and Analysis Division, Washington, D.C. Accession No. ML14091A145. TN2384.

EPA (U.S. Environmental Protection Agency). 2002. *Clinch and Powell Valley Watershed Ecological Risk Assessment*. EPA/600/R-01/050, Washington, D.C. Accession No. ML18023A337. TN5038.

EPA (U.S. Environmental Protection Agency). 2004. "Level III and IV Ecoregions of EPA Region 4." Washington, D.C. Accession No. ML18023A339. TN5158.

EPA (U.S. Environmental Protection Agency). 2013. "Level III and IV Ecoregions of the Continental United States." Washington, D.C. Accession No. ML18023A341. TN5033.

EPA (U.S. Environmental Protection Agency). 2015. "2015 Greenhouse Gas Emissions from Large Facilities." EPA Facility Level Information on Greenhouse Gases Tool (FLIGHT), Washington, D.C. Accession No. ML18023A343. TN4925.

EPA (U.S. Environmental Protection Agency). 2016. *Clean Watersheds Needs Survey (CWNS) – 2012 Report and Data*. Washington, D.C. Accession No. ML18023A363. TN5037.

EPA (U.S. Environmental Protection Agency). 2016. "ECHO (Enforcement and Compliance History Online) Detailed Facility Report: Kohler Co." Washington, D.C. Accession No. ML18023A367. TN5122.

EPA (U.S. Environmental Protection Agency). 2016. "ECHO (Enforcement and Compliance History Online) Detailed Facility Report: National Copper & Smelting Co." Washington, D.C. Accession No. ML18023A371. TN5124.

EPA (U.S. Environmental Protection Agency). 2016. "ECHO (Enforcement and Compliance History Online) Detailed Facility Report: TDY Industries LLC." Washington, D.C. Accession No. ML18023A369. TN5123.

EPA (U.S. Environmental Protection Agency). 2016. "ECHO (Enforcement and Compliance History Online) Detailed Facility Report: Toyota Motor Manufacturing Alabama Inc." Washington, D.C. Accession No. ML18023A159. TN5125.

EPA (U.S. Environmental Protection Agency). 2016. "Energy Projects and Candidate Landfills." Washington, D.C. Accession No. ML18023A347. TN4653.

EPA (U.S. Environmental Protection Agency). 2016. "Envirofacts EPA-Regulated Facilities: Vulcan." Washington, D.C. Accession No. ML18023A353. TN4672.

EPA (U.S. Environmental Protection Agency). 2016. "Envirofacts Multisystem Search: Aggregates USA (Greenback) LLC." Washington, D.C. Accession No. ML18023A355. TN4673.

EPA (U.S. Environmental Protection Agency). 2016. "Envirofacts Multisystem Search: APAC Atlantic, Inc. Harrison Division Sand Mine 1." Washington, D.C. Accession No. ML18023A351. TN4671.

EPA (U.S. Environmental Protection Agency). 2016. "Envirofacts Multisystem Search: Lhoist North America." Washington, D.C. Accession No. ML18023A349. TN4670.

EPA (U.S. Environmental Protection Agency). 2016. "EPA Superfund Program: Oak Ridge Reservation (USDOE), Oak Ridge TN." Washington, D.C. Accession No. ML18023A345. TN4635.

EPA (U.S. Environmental Protection Agency). 2016. "EPA Superfund Program: Smokey Mountain Smelters, Knoxville, TN." Washington, D.C. Accession No. ML18023A359. TN4689.

EPA (U.S. Environmental Protection Agency). 2016. "EPA Superfund Program: USArmy/NASA Redstone Arsenal, Huntsville, AL." Washington, D.C. Accession No. ML18023A365. TN5119.

EPA (U.S. Environmental Protection Agency). 2016. "NAAQS Table." Washington, D.C. Accession No. ML18023A361. TN5013.

EPA (U.S. Environmental Protection Agency). 2016. "Superfund Site Information: Rockwood Iron and Metal." Washington, D.C. Accession No. ML18023A357. TN4688.

EPA (U.S. Environmental Protection Agency). 2017. "Ecoregion Download Files by State – Region 4, Alabama." Washington, D.C. Accession No. ML18023A162. TN5135.

EPA (U.S. Environmental Protection Agency). 2017. "Envirofacts Safe Drinking Water Search for the State of Tennessee, Anderson, Knox, Loudon, and Roane Counties." Washington, D.C. Accession No. ML18023A163. TN5147.

EPA (U.S. Environmental Protection Agency). 2017. "Greenhouse Gases Equivalencies Calculator – Calculations and References." Washington, D.C. Accession No. ML18023A164. TN5270.

EPA (U.S. Environmental Protection Agency). 2017. *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2015.* EPA 430-P-17-001, Washington, D.C. Accession No. ML18023A161. TN4924.

EPA (U.S. Environmental Protection Agency). 2017. "U.S. Army/NASA Redstone Arsenal Huntsville, Alabama Contaminant List." Washington, D.C. Accession No. ML18023A165. TN5277.

EPA (U.S. Environmental Protection Agency) and TVA (Tennessee Valley Authority). 2014. *U.S. Environmental Protection Agency and Tennessee Valley Authority Kingston Coal Ash Release Site Project Completion Fact Sheet*. Atlanta, Georgia. Accession No. ML18023A333. TN5057.

EPI (Energy Policy Institute). 2010. *Economic and Employment Impacts of Small Modular Nuclear Reactors*. Boise, Idaho. Accession No. ML18023A166. TN4966.

EPRI (Electric Power Research Institute). 1987. *User's Manual: Cooling-Tower Plume Prediction Code—A Computerized Methodology for Predicting Seasonal/Annual Impacts of Visible Plumes, Drift, Fogging, Icing, and Shadowing from Single and Multiple Sources*. Revision 1, Palo Alto, California. Accession No. ML14087A352. TN3335.

EPRI (Electric Power Research Institute, Inc.). 2004. *Comparison of Alternate Technologies for U.S. Power Plants, Economic, Environmental, and Other Tradeoffs.* 1005358, Palo Alto, California. Accessed September 18, 2017, at https://www.epri.com/#/pages/product/000000000001005358/. TN4990.

EPRI (Electric Power Research Institute, Inc.). 2012. *Economic Evaluation of Alternative Cooling Technologies.* 102805, Palo Alto, California. Accessed September 18, 2017, at https://www.epri.com/#/pages/product/1024805/. TN4991.

EPRI (Electric Power Research Institute). 2015. *Advanced Nuclear Technology: Site Selection and Evaluation Criteria for New Nuclear Power Generation Facilities (Siting Guide).* Palo Alto, California. TN5285.

ETEC (East Tennessee Economic Council). 2014. *Tennessee FY2013 Economic Impact Study of Department of Energy Spending.* YGG 14-0313, Oak Ridge, Tennessee. Accessed August 29, 2017, at https://eteconline.org/wp-content/uploads/2014/11/ETEC-2013-DOE-EIS-report-final.pdf. TN4963.

Etnier, D.A. and W.C. Starnes. 1993. *The Fishes of Tennessee*. University of Tennessee Press, Knoxville, Tennessee. Accessed October 11, 2017, at http://trace.tennessee.edu/utk_utpress/2/. TN5054.

Etnier, D.A., W.C. Starnes, and B.H. Bauer. 1979. "Whatever Happened to the Silvery Minnow (*Hybognathus nuchalis*) In the Tennessee River?" *Southeastern Fishes Council Proceedings* 2(3):1-4. Accession No. ML12173A457. TN5050.

FBI (Federal Bureau of Investigation). 2017. "2015 Crime in the United States." Washington, D.C. Accession No. ML18023A167. TN4958.

FD (FireDepartment.net). 2017. "Tennessee Fire Departments." Accessed August 29, 2017, at http://www.firedepartment.net/directory/Tennessee. TN4959.

Fielder, G.F. 1974. *Archaeological Survey with Emphasis on Prehistoric Sites of the Oak Ridge Reservation, Oak Ridge, Tennessee*. ORNL-TN-4694, Oak Ridge National Laboratory, Oak Ridge, Tennessee. Accession No. ML18054A475. TN5338.

Fielder, Jr., G.F. 1975. *Cultural Resource Survey of the Exxon Nuclear Facility Oak Ridge, Tennessee*. University of Tennessee, Knoxville, Tennessee. Accession No. ML17296A403. TN4978.

Fisher, A.B. 2015. *Clinch River Small Modular Reactor Site Groundwater Quality Monitoring Report*. Tennessee Valley Authority, Knoxville, Tennessee. Accession No. ML17334A044. TN5143.

Forman, R.T.T. and L.E. Alexander. 1998. "Roads and their Major Ecological Effects." *Annual Review of Ecology, Evolution and Systematics* 29:207–231, Palo Alto, California. TN2250.

Friedberg, W. and K. Copeland. 2003. *What Aircrews Should Know About Their Occupational Exposure to Ionizing Radiation*. DOT/FAA/AM-03/16, Federal Aviation Administration, Oklahoma City, Oklahoma. Accession No. ML12192A288. TN419.

FTA (Federal Transit Administration). 2017. "Monthly Module Adjusted Data Release." Washington, D.C. Accession No. ML18023A236. TN4955.

FWS (U.S. Fish and Wildlife Service). 1982. *Gray Bat Recovery Plan*. FWS Reference Service, Denver, Colorado. Accession No. ML18023A169. TN929.

FWS (U.S. Fish and Wildlife Service). 1997. "Threatened and Endangered Species, Gray Bat (*Myotis grisescens*)." Washington, D.C. Accession No. ML18023A170. TN5194.

FWS (U.S. Fish and Wildlife Service). 2005. *Biological Opinion on the Impacts of the Laxare East & Black Castle Contour Coal Mining Projects on the Indiana Bat.* West Virginia Field Office, Elkins, West Virginia. Accession No. ML18059A111. TN5382.

FWS (U.S. Fish and Wildlife Service). 2006. "Threatened and Endangered Species: Indiana Bat (*Myotis sodalis*)." Fort Snelling, Minnesota. Accession No. ML15043A589. TN4167.

FWS (U.S. Fish and Wildlife Service). 2007. *Indiana Bat (*Myotis sodalis*) Draft Recovery Plan: First Revision*. Great Lakes-Big Rivers Region, Fort Snelling, Minnesota. Accession No. ML14302A612. TN934.

FWS (U.S. Fish and Wildlife Service). 2007. *National Bald Eagle Management Guidelines*. Washington, D.C. Accession No. ML101960349. TN780.

FWS (U.S. Fish and Wildlife Service). 2009. "Sauta Cave National Wildlife Refuge, Southeast Region." Washington, D.C. Accession No. ML18023A171. TN5114.

FWS (U.S. Fish and Wildlife Service). 2014. "Fern Cave National Wildlife Refuge, Alabama." Washington, D.C. Accession No. ML18023A173. TN5113.

FWS (U.S. Fish and Wildlife Service). 2014. *Northern Long-Eared Bat Interim Conference and Planning Guidance, USFWS Regions 2, 3, 4, 5, & 6*. Bloomington, Minnesota. Accession No. ML15043A596. TN4162.

FWS (U.S. Fish and Wildlife Service). 2015. "Price's Potato-bean (*Apios priceana*). Midwest Region, Bloomington, Minnesota. Accession No. ML18059A113. TN5375.

FWS (U.S. Fish and Wildlife Service). 2015. *Zebra Mussel (*Dreissena polymorpha*) Ecological Risk Screening Summary*. Washington, D.C. Accession No. ML18023A174. TN5218.

FWS (U.S. Fish and Wildlife Service). 2016. "North American Bats Table of WNS [White-Nose Syndrome] and Protection Status (October 2016)." Washington, D.C. Accession No. ML18023A176. TN5030.

FWS (U.S. Fish and Wildlife Service). 2017. "Fact Sheet: Rusty Patched Bumble Bee." Midwest Region, Bloomington, Minnesota. Accession No. ML18059A119. TN5376.

FWS (U.S. Fish and Wildlife Service). 2017. "IPaC Information for Planning and Consultation." ECOS – Environmental Conservation Online System, Fort Collins, Colorado. Accession No. ML18023A181. TN5328.

FWS (U.S. Fish and Wildlife Service). 2017. Letter from M.E. Jennings to NRC, dated May 5, 2017, regarding "FWS# 2017-I-473. U.S. Nuclear Regulatory Commission – Requests for Participation in the Environmental Scoping Process and a List of Federally Protected Species Within the Area Under Evaluation for the Proposed Clinch River Nuclear Site Located in Oak Ridge, Roane County, Tennessee." Cookeville, Tennessee. Accession No. ML17205A341. TN5090.

FWS (U.S. Fish and Wildlife Service). 2017. Letter from M.E. Jennings to NRC, dated July 20, 2017, regarding "FWS# 2017-I-473. U.S. Nuclear Regulatory Commission (NRC) – Updated List of Federally Threatened and Endangered Species that Potentially Occur near the Proposed Clinch River Small Modular Nuclear Reactor Facility in Oak Ridge, Roane County, Tennessee." Cookeville, Tennessee. Accession No. ML17205A342. TN5091.

FWS (U.S. Fish and Wildlife Service). 2017. "National Wetlands Inventory." Falls Church, Virginia. Available at https://www.fws.gov/wetlands/data/Mapper.html. TN5300.

FWS (U.S. Fish and Wildlife Service). 2017. "Species Profile for Morefield's Leather Flower (*Clematis morefieldii*). ECOS–Environmental Conservation Online System, Fort Collins, Colorado. Accession No. ML18059A120. TN5411.

FWS (U.S. Fish and Wildlife Service). 2017. "Species Profile for Small Whorled Pogonia (*Isotria medeoloides*). ECOS–Environmental Conservation Online System, Fort Collins, Colorado. Accession No. ML18059A121. TN5412.

FWS (U.S. Fish and Wildlife Service). 2017. "Species Profile for Spotfin Chub (*Eriminax monachus*)." Washington, D.C. Accession No. ML18023A178. TN5219.

FWS (U.S. Fish and Wildlife Service). 2017. "Wheeler National Wildlife Refuge, Alabama." Washington, D.C. Accession No. ML18023A177. TN5112.

FWS (U.S. Fish and Wildlife Service). 2017. "White-Nose Syndrome: The Devastating Disease of Hibernating Bats in North America." Fact Sheet, October 2017, Washington, D.C. Accession No. ML18023A179. TN5309.

FWS (U.S. Fish and Wildlife Service). 2017. "White-Nose Syndrome Map." White-Nose Syndrome.org. Accession No. ML18023A180. TN5310.

GCR (GCR, Inc.). 2017. "Airport IQ 5010: Knoxville Downtown Island (DKX)." New Orleans, Louisiana. Accessed August 24, 2017, at http://www.gcr1.com/5010web/airport.cfm?Site=DKX&AptSecNum=2. TN4947.

GCRP (U.S. Global Change Research Program). 2014. *Climate Change Impacts in the United States: The Third National Climate Assessment*. J.M. Melillo, T.C. Richmond, and G.W. Yohe (eds.). U.S. Government Printing Office, Washington, D.C. Accession No. ML14129A233. TN3472.

GDNR (Georgia Department of Natural Resources). 2017. Email from A. Yellin to J. Becker, PNNL, dated September 24, 2017, regarding "Environmental Review for Georgia Portion of the Proposed Transmission Line." Atlanta, Georgia. Accession No. ML18012A441. TN5397.

Giffen, N.R. 2017. Email to J. Becker, PNNL, dated November 8, 2017, regarding "Question About a Former Area of 'Very High Biological Significance' on the Clinch River Site." Oak Ridge National Laboratory, Oak Ridge, Tennessee. Accession No. ML18022A742. TN5393.

Giffen, N.R. 2017. Email to J. Becker, PNNL, dated December 7, 2017, regarding "Question About a Former Area of 'Very High Biological Significance' on the Clinch River Site." Oak Ridge National Laboratory, Oak Ridge, Tennessee. Accession No. ML18010A883. TN5394.

Giffen, N.R., R.S. Reasor, B.L. Petersen, and C.A. Campbell. 2009. *Reptile and Amphibian Abundance and Distribution Survey, Oak Ridge National Environmental Research Park*. ORNL/TM-2009/296, Oak Ridge National Laboratory, Oak Ridge, Tennessee. Accession No. ML18023A184. TN5184.

Golden, J., R.P. Ouellette, S. Saari, and P.N. Cheremisinoff. 1979. *Environmental Impact Data Book*. Ann Arbor Science Publishers, Ann Arbor, Michigan. TN3873.

Griego, N.R., J.D. Smith, and K.S. Neuhauser. 1996. *Investigation of RADTRAN Stop Model Input Parameters for Truck Stops*. Sandia National Laboratories, Albuquerque, New Mexico. Accession No. ML14111A188. TN69.

Hamrick, E.B. 2015. *Clinch River – Addendum Barge/Traffic Area Terrestrial Animal Survey Report*. Tennessee Valley Authority, Knoxville, Tennessee. Accession No. ML17334A047. TN5187.

Hatcher, Jr., R.D., P.J. Lemiszki, R.B. Dreier, R.H. Ketelle, R.R. Lee, D.A. Lietzke, W.M. McMaster, J.L. Foreman, and S.Y. Lee. 1992. *Status Report on the Geology of the Oak Ridge Reservation*. ORNL/TM-12074, Oak Ridge National Laboratory, Oak Ridge, Tennessee. Accession No. ML17334A060. TN4989.

HDT (HDT Global). 2017. "A Global Technology Leader." Tanner, Alabama. Accessed October 19, 2017, at http://www.hdtglobal.com/. TN5131.

Henderson, A.R. and C.L. Phillips. 2015. *Clinch River Small Modular Reactor and Barge/Traffic Site Stream Survey Report*. Tennessee Valley Authority, Knoxville, Tennessee. Accession No. ML17334A051. TN5162.

Higgins, J.M. and W.G. Brock. 1999. "Overview of Reservoir Release Improvements at 20 TVA Dams." *Journal of Energy Engineering*, April 1999, American Society of Civil Engineers, Reston, Virginia. Accessed December 19, 2017, at http://cadswes2.colorado.edu/~zagona/CVEN5838/JournalArticles/Higgins%2099%20Res%20Release%20improvements%20TVA%20dams.pdf. TN5320.

Holzworth, G.C. 1972. *Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution throughout the Contiguous United States.* Office of Air Programs Publication No. AP-101, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. Accession No. ML14084A177. TN3024.

Howard, C.S., A.R. Henderson, and C.L. Phillips. 2015. *Clinch River Small Modular Reactor and Barge/Traffic Site, Evaluation of Aquatic Habitats and Protected Aquatic Animals Technical Report*. Revision 5, Tennessee Valley Authority, Knoxville, Tennessee. Accession No. ML17334A053. TN5049.

Hunter, J.A., D. Simpson, and S.T. Mocas. 2015. *Phase I Archaeological Survey TVA Clinch River SMR, Roane County, Tennessee*. Draft Report, Project No. 7361141061, Report of Cultural Resources Investigations 2015-002, AMEC Foster Wheeler, Lexington, Kentucky. Accession No. ML17296A405. TN4971.

IAEA (International Atomic Energy Agency). 1992. *Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards*. Technical Report Series 332, Vienna, Austria. TN712.

ICRP (International Commission on Radiological Protection). 1977. *Recommendations of the International Commission on Radiological Protection*. ICRP Publication 26, Pergamon Press, New York, New York. TN713.

ICRP (International Commission on Radiological Protection). 1990. *1990 Recommendations of the International Commission on Radiological Protection*. ICRP Publication 60, Pergamon Press, New York, New York. TN74.

ICRP (International Commission on Radiological Protection). 2007. *The 2007 Recommendations of the International Commission on Radiological Protection*. ICRP Publication 103, Elsevier, Maryland Heights, Missouri. Available at http://www.sciencedirect.com/science/journal/01466453/37/2-4. TN422.

IEEE (Institute of Electrical and Electronics Engineers, Inc.). 2007. *National Electrical Safety Code C2-2007*. New York, New York. TN1087.

IMS (Industrial Manufacturing Specialties). 2016. "Industrial Manufacturing Specialties." Decatur, Alabama. Accessed June 6, 2016, at http://www.imsprecisionmachining.com/. TN5129.

INEEL (Idaho National Engineering and Environmental Laboratory). 2003. *Early Site Permit Environmental Report Sections and Supporting Documentation*. EDF-3747, Idaho Falls, Idaho. Accession No. ML14098A017. TN71.

Jablon, S., Z. Hrubec, and J.D. Boice, Jr. 1991. "Cancer in Populations Living Near Nuclear Facilities." *IAEA Bulletin* 33(2):20-27, Vienna, Austria. TN77.

Jablon, S., Z. Hrubec, J.D. Boice, Jr., and B.J. Stone. 1990. *Cancer in Populations Living Near Nuclear Facilities, Volume 1—Report and Summary; Volume 2—Individual Facilities: Cancer Before and After Start-up; and Volume 3—Individual Facilities: Cancer by 5-Year Time Intervals*. NIH Publication No. 90-874, National Institutes of Health, Washington, D.C. TN1257.

Jacobs (Jacobs Environmental Restoration Team). 1995. *Archaeological Reconnaissance, K-25 Site, Oak Ridge Reservation, Oak Ridge, Tennessee*. Oak Ridge, Tennessee. Accession No. ML18054A441. TN5339.

JEC Group. 2016. "LeMond Composites Plans to Invest $125 Million to Build its First Carbon Fiber Production Line in Tennessee." Paris, France. Accessed June 2, 2017, at http://www.jeccomposites.com/knowledge/international-composites-news/lemond-composites-plans-invest-125-million-build-its-first. TN4917.

Johnson, H. 2015. "Cultural Resources Information, Small Modular Reactor (SMR) Alternate Sites Project Covering the Tennessee Valley Authority (TVA) Oak Ridge Reservation (ORR) Sites 2, 5, and 8, in Roane County, Tennessee and Redstone Site 12 in Madison County, Alabama." Tennessee Valley Archaeological Research, Huntsville, Alabama. Accession No. ML17296A406. TN5220.

Johnson, J.B., J.W. Edwards, and W.M. Ford. 2011. "Nocturnal Activity Patterns of Northern Myotis (*Myotis septentrionalis*) During the Maternity Season in West Virginia (USA)." *Acta Chiropterologica* 13(2):391–397, Warsaw, Poland. TN1852.

Jolley, R.L. 1982. *Archaeological Investigations in the Clinch River Breeder Reactor Project Area, 1981–1982*. Building Conservation Technology, Inc., Nashville, Tennessee. Accession No. ML17296A407. TN4977.

Jones, J., S. Ahlstedt, B. Ostby, B. Beaty, M. Pinder, N. Eckert, R. Butler, D. Hubbs, C.Walker, S. Hanlon, J. Schmerfeld, and R. Neves. 2014. "Clinch River Freshwater Mussels Upstream of Norris Reservoir, Tennessee and Virginia: A Quantitative Assessment from 2004 to 2009." *Journal of the American Water Resources Association* 1-17, Middleburg, Virginia. TN5324.

Jow, H.N., J.L. Sprung, J.A. Rollstin, L.T. Ritchie, and D.I. Chanin. 1990. *MELCOR Accident Consequence Code System (MACCS), Model Description*. NUREG/CR–4691, Volume 2, Sandia National Laboratories, Albuquerque, New Mexico. Accession No. ML063560409. TN526.

Karpynec, T. 2011. Letter to TVA Cultural Resources Office, dated August 18, 2011, regarding "Phase I Architectural Survey, TVA Clinch River Site Characterization Project, Roane County, Tennessee." Nashville, Tennessee. Accession No. ML17298A063. TN4976.

KCMPC (Knox County Metropolitan Planning Commission, Tennessee). 2017. *2016 Development Activity*. Knoxville, Tennessee. Accession No. ML18023A273. TN4942.

Kerlinger, P. 2004. "Wind Turbines and Avian Risk: Lessons from Communication Towers." In S.S. Schwartz (ed.), *Proceedings of the Wind Energy and Birds/Bats Workshop: Understanding and Resolving Bird and Bat Impacts.* May 18–19, 2004, Washington, D.C. American Wind Energy Association (AWEA), Washington, D.C. Available at http://www.ewashtenaw.org/government/departments/planning_environment/planning/wind_power/Wind%20Energy%20Birds%20and%20Bats%20Workshop. TN3871.

Keurig (Keurig Green Mountain, Inc.). 2016. "Our Locations, Tennessee." Waterbury, Vermont. Accessed June 2, 2016, at http://www.keuriggreenmountain.com/en/OurCompany/OurLocations/Tennessee.aspx. TN4712.

Kimble Chase (Kimble Chase Life Science and Research Products LLC). 2016. "About Us." Rockwood, Tennessee. Accessed June 2, 2016, at http://www.kimble-chase.com/advancedwebpage.aspx?p=About_us. TN4703.

Knox County (Knox County, Tennessee). 2016. *Knox County, Tennessee Comprehensive Annual Financial Report for the Fiscal Year Ended June 30, 2016*. Knoxville, Tennessee. Accession No. ML18023A275. TN4929.

KSNPC (Kentucky State Nature Preserves Commission). 2014. "Kentucky Rare Plant Database: Rock Harlequin." Frankfort, Kentucky. Accession No. ML18023A277. TN5297.

KSNPC (Kentucky State Nature Preserves Commission). 2015. *Endangered, Threatened, and Special Concern Plants, Animals, and Natural Communities of Kentucky with Habitat Description*. Frankfort, Kentucky. Accession No. ML18023A190. TN5296.

KSNPC (Kentucky State Nature Preserves Commission). 2017. Email from I. Horn to J. Becker, PNNL, dated October 2, 2017, regarding "KY HNP Review of Transmission Line Segment for Clinch River SMR ESP Project in Tennessee." Frankfort, Kentucky. Accession No. ML18012A656. TN5400.

Kunz, T.D. and J.D. Reichard. 2010. *Status Review of the Little Brown Myotis (Myotis lucifugus) and Determination that Immediate Listing under the Endangered Species Act is Scientifically and Legally Warranted*. Boston University's Center for Ecology and Conservation Biology, Boston, Massachusetts. Accessed January 12, 2018, at https://www.bu.edu/cecb/files/2010/12/Final-Status-Review.pdf. TN5373.

La Sorte, F.A., D. Fink, W.M. Hochachka, A. Farnsworth, A.D. Rodewald, K.V. Rosenberg, B.L. Sullivan, D.W. Winkler, C. Wood, and S. Kelling. 2014. "The Role of Atmospheric Conditions in the Seasonal Dynamics of North American Migration Flyways." *Journal of Biogeography* 41:1685-1696, Medford, Massachusetts. TN5152.

LandScope America. 2017. "LandScope Virginia: Clinch River Valley." Richmond, Virginia. Accessed October 9, 2017, at http://www.landscope.org/virginia/places/clinch/. TN5039.

Larkin, R.P. 1996. *Effects of Military Noise on Wildlife: A Literature Review*. USACERL Technical Report 96/21, U.S. Army Corps of Engineers Research Laboratory, Champaign, Illinois. Accession No. ML051150109. TN772.

LeGrand, H.G., E.B. Hamrick, and J.T. Baxter, Jr. 2015. *Clinch River Small Modular Reactor Site Terrestrial Animal Survey Report.* Revision 7, Tennessee Valley Authority, Knoxville, Tennessee. Accession No. ML17334A052. TN5188.

Leigh, D.S. 1999. *Geomorphology and Site Burial Potential for TVA Property Along Clinch River Miles 14.6 to 18.9*. Watkinsville, Georgia. Accession No. ML17296A408. TN4980.

LIHI (Low Impact Hydropower Institute). 2017. "LIHI Certificate #18 – Smoky Mountain Project, North Carolina." Lexington, Massachusetts. Accessed December 4, 2017, at http://lowimpacthydro.org/lihi-certificate-18-smoky-mountain-project-north-carolina-ferc-2169/. TN5269.

Liu, C., A. Myers, and S. Peterson. 2016. "WebTRAGIS (Transportation Routing Analysis GIS), Version 6." Oak Ridge National Laboratory, Oak Ridge, Tennessee. TN4885.

Lloyd, O.B. and W.L. Lyke. 1995. *Ground Water Atlas of the United States: Illinois, Indiana, Kentucky, Ohio, Tennessee*. HA 730-K, U.S. Geological Survey, Reston, Virginia. Accession No. ML18023A191. TN4988.

Loar, J.M., J.S. Griffith, and K.D. Kumar. 1978. *An Analysis of Factors Influencing the Impingement of Threadfin Shad* (Dorosoma pretenense) *at Power Plants in the Southeastern United States*. Oak Ridge National Laboratory, Oak Ridge, Tennessee. Accession No. ML18023A192. TN5056.

Mack, J.J. 2001. *Ohio Rapid Assessment Method for Wetlands, Manual for Using Version 5.0, Ohio EPA Technical Bulletin Wetland/2001-1-1*. Ohio Environmental Protection Agency, Columbus, Ohio. Accession No. ML18023A193. TN5289.

Macknick, J., R. Newmark, G. Heath, and K.C. Hallett. 2012. "Operational Water Consumption and Withdrawal Factors for Electricity Generating Technologies: A Review of Existing Literature." *Environmental Research Letters* 7 045802, Philadelphia, Pennsylvania. TN4993.

Manville, A.M., II. 2005. "Bird Strikes and Electrocutions at Power Lines, Communication Towers, and Wind Turbines: State of the Art and State of the Science–Next Steps Toward Mitigation." In *Proceedings 3rd International Partners in Flight Conference 2002*, U.S. Forest Service General Technical Report PSW–GTR–191, Albany, California. Available at http://www.fs.fed.us/psw/publications/documents/psw_gtr191/psw_gtr191_1051-1064_manville.pdf. TN893.

Martens, A.K. and P. Thomason. 2015. "National Register of Historic Places Registration Form for Melton Hill Hydroelectric Project." Thomason and Associates, Nashville, Tennessee. Accession No. ML18023A194. TN5260.

Martens, A., C. Collett, P. Thomason, and R. Hightower. 2015. "National Register of Public Places Multiple Property Documentation Form for Historic Resources of the Tennessee Valley Authority Hydroelectric System, 1933-1979." Thomason and Associates, Nashville, Tennessee. Accession No. ML18023A195. TN5262.

Mayasich, J., D. Grandmaison, and C. Philips. 2003. *Eastern Hellbender Status Assessment Report*. NRR/TR-2003/09, Natural Resources Research Institute, Duluth, Minnesota. Accession No. ML12171A230. TN5179.

McCracken, M.K., N.R. Giffen, A.M. Haines, B.J. Guge, and J.W. Evans. 2015. *Bat Species Distribution on the Oak Ridge Reservation*. ORNL/TN-2015/248, Oak Ridge National Laboratory, Oak Ridge, Tennessee. Accession No. ML18023A196. TN5287.

McKee, L. and T. Karpynec. 2006. *Phase I Cultural Resources Survey of the Kingston-Oak Ridge National Laboratory 161-KV Transmission Line Project, Anderson and Roane Counties, Tennessee*. Revised Draft Report, TRC, Nashville, Tennessee. Accession No. ML18054A393. TN5340.

McKerrow, A. 1996. *Recovery Plan for Cumberland Sandwort* (Arenaria cumberlandensis). Southeast Region, U.S. Fish and Wildlife Service, Atlanta, Georgia. Accession No. ML18023A197. TN5302.

McKerrow, A. 1996. *Recovery Plan for Large-flowered Skullcap* (Scutellaria Montana). Southeast Region, U.S. Fish and Wildlife Service, Atlanta, Georgia. Accession No. ML18023A198. TN5304.

Menzel, J.M., M.A. Menzel, W.M. Ford, J.W. Edwards, S.R. Sheffield, J.C. Kilgo, and M.S. Bunch. 2003. "The Distribution of the Bats of South Carolina." *Southeastern Naturalist* 2(1):121-152, Steuben, Maine. TN5293.

Mettee, M.F., P.E. O'Neil, and J.M. Pierson. 1996. *Fishes of Alabama and the Mobile Basin*. Oxmoor House, Inc., Birmingham, Alabama. TN5169.

Micor (Micor Industries, Inc.). 2016. "Micor Industries, Inc., Energy." Decatur, Alabama. Accessed June 6, 2016, at https://www.micorind.com/. TN5130.

Miller, J.A. 1990. *Ground Water Atlas of the United States: Alabama, Florida, Georgia, and South Carolina.* HA 730-G, U.S. Geological Survey, Reston, Virginia. Accession No. ML101930591. TN550.

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. TN5174.

MKAA (Metropolitan Knoxville Airport Authority). 2017. "Oak Ridge Airport Initiative." Knoxville, Tennessee. Accessed August 24, 2017, at http://oakridgeairport.org/About_The_Airport.html. TN4948.

MKAA (Metropolitan Knoxville Airport Authority). 2017. "Oak Ridge Airport Initiative Proposed Site Layout." Knoxville, Tennessee. Accessed October 6, 2017, at http://www.oakridgeairport.org/Proposed_Site_Layout.html. TN5021.

Moss, N.E. and M.R. Cook. 2008. *Potential for Impacts of Regional Ground-Water Movement and Quality on Redstone Arsenal*. Open-File Report 1307, Geological Survey of Alabama, Tuscaloosa, Alabama. Accession No. ML18023A199. TN5073.

Murdock, N.A. 1993. *Recovery Plan for Spreading Avens* (Guem radiatum). U.S. Fish and Wildlife Service Southeast Region, Atlanta Georgia. Accession No. ML18059A123. TN5377.

Murdock, N.A. and K. Langdon. 1997. *Recovery Plan for Rock Gnome Lichen* (Gymnoderma lineare) *(Evans) Yoshimura and Sharp*. U.S. Fish and Wildlife Service Southeast Region, Atlanta, Georgia. Accession No. ML18059A122. TN5380.

Najjar, K.F., J.J. Shaw, E.E. Adams, G.H. Jirka, and D.R.F. Harleman. 1979. *An Environmental and Economic Comparison of Cooling System Designs for Steam-Electric Power Plants*. MIT-EL 79-037, Massachusetts Institute of Technology, Cambridge, Massachusetts. TN4994.

NASS (National Agricultural Statistics Service). 2017. "CropScape – Cropland Data Layer, 2016." Washington, D.C. Accessed July 20, 2017, at https://nassgeodata.gmu.edu/CropScape/. TN5144.

National Research Council. 1980. *The Effects on Populations of Exposure to Low Levels of Ionizing Radiation, 1980*. National Academy Press, Washington, D.C. TN5291.

National Research Council. 2006. *Health Risks from Exposure to Low Levels of Ionizing Radiation BEIR VII Phase 2*. National Academies Press, Washington, D.C. Available at http://www.nap.edu/openbook.php?record_id=11340&page=1. TN296.

NatureServe. 2017. "NatureServe Explorer: An Online Encyclopedia of Life—Species Quick Search." Arlington, Virginia. Available at http://explorer.natureserve.org/index.htm. TN5216.

NCES (National Center for Education Statistics). 2017. "Tennessee Public School Districts." Washington, D.C. Accession No. ML18023A200. TN4960.

NCRP (National Council on Radiation Protection and Measurements). 1991. *Effects of Ionizing Radiation on Aquatic Organisms.* NCRP Report No. 109, Bethesda, Maryland. TN729.

NCRP (National Council on Radiation Protection and Measurements). 1995. *Principles and Applications of Collective Dose in Radiation Protection*. NCRP Report No. 121, Bethesda, Maryland. TN728.

NCRP (National Council on Radiation Protection and Measurements). 2009. *Ionizing Radiation Exposure of the Population of the United States*. NCRP Report No. 160, Bethesda, Maryland. Available at http://app.knovel.com/web/toc.v/cid:kpIREPUS05. TN420.

NECNP v. NRC (New England Coalition on Nuclear Pollution v. U.S. Nuclear Regulatory Commission). 582 F.2d 87 (1st Circuit 1978). U.S. Court of Appeals First Circuit Decision, August 22, 1978. TN2632.

NEI (Nuclear Energy Institute). 2012. *Industry Guideline for Developing a Plant Parameter Envelope in Support of an Early Site Permit*. NEI 10-01, Revision 1, Washington, D.C. Accession No. ML12144A429. TN5237.

NEI (Nuclear Energy Institute). 2015. *Diverse and Flexible Coping Strategies (FLEX) Implementation Guide*. NEI 12-06, Revision 2, Washington, D.C. Accession No. ML16005A625. TN5062.

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(Issue Supplement):45–52, Medford, Massachusetts. TN5053.

Neves, R.J., A.E. Bogan, J.D. Williams, S.A. Ahlstedt, and P.W. Hartfield. 1997. "Status of Aquatic Mollusks in the Southeastern United States: A Downward Spiral of Diversity." In *Aquatic Fauna in Peril: The Southeastern Perspective*. G.W. Bense and D.E. Collins (eds.). Special Publication 1, Southeast Aquatic Research Institute, Lenz Design and Communications, Decatur, Georgia. Accessed October 10, 2017, at http://www.sherpaguides.com/southeast/aquatic_fauna/chapter_3/index.html. TN5051.

New York v. NRC (*State of New York et al. v. U.S. Nuclear Regulatory Commission)*. 681 F.3d 471 (D.C. Cir. 2012). Accession No. ML14094A018. TN2397.

NIEHS (National Institute of Environmental Health Sciences). 1999. *NIEHS Report on Health Effects from Exposure to Power-Line Frequency Electric and Magnetic Fields*. NIH Publication No 99–4493, National Institutes of Health, Research Triangle Park, North Carolina. Accession No. ML093240277. TN78.

Norquist, C. 1994. *Morefield's Leather Flower* Clematis morefleidii *Recovery Plan*. U.S. Fish and Wildlife Service, Jackson, Mississippi. Accession No. ML18059A124. TN939.

NPS (National Park Service). 2016. "Big South Fork National River and Recreation Area." Washington, D.C. Accession No. ML18023A202. TN4676.

NPS (National Park Service). 2016. "Great Smoky Mountains National Park." Washington, D.C. Accession No. ML18023A203. TN4677.

NPS (National Park Service). 2016. "Manhattan Project National Historical Park NM, WA, TN." Washington, D.C. Accession No. ML18023A201. TN4675.

NRC (U.S. Nuclear Regulatory Commission). 1975. *Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants, Supplement 1.* NUREG–75/038, Washington, D.C. Accession No. ML14091A176. TN216.

NRC (U.S. Nuclear Regulatory Commission). 1976. *Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle*. W.P. Bishop and F.J. Miraglia, Jr. (eds.). NUREG–0116 (Supplement 1 to WASH–1248), Washington, D.C. Accession No. ML14098A013. TN292.

NRC (U.S. Nuclear Regulatory Commission). 1976. *Preparation of Environmental Reports for Nuclear Power Stations*. Regulatory Guide 4.2, Revision 2, Washington, D.C. Accession No. ML003739519. TN89.

NRC (U.S. Nuclear Regulatory Commission). 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, Revision 1, Washington, D.C. Accession No. ML003740384. TN90.

NRC (U.S. Nuclear Regulatory Commission). 1977. *Final Environmental Impact Statement Related to the Construction and Operation of Clinch River Breeder Reactor Plant*. NUREG-0139, Washington, D.C. Accession No. ML082610503. TN5083.

NRC (U.S. Nuclear Regulatory Commission). 1977. *Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes.* NUREG–0170, Volume 1, Washington, D.C. Accession No. ML12192A283. TN417.

NRC (U.S. Nuclear Regulatory Commission). 1977. *Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors.* Regulatory Guide 1.111, Revision 1, Washington, D.C. Accession No. ML003740354. TN91.

NRC (U.S. Nuclear Regulatory Commission). 1977. *Public Comments and Task Force Responses Regarding the Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle.* NUREG–0216 (Supplement 2 to WASH–1248), Washington, D.C. Accession No. ML14091A203. TN1255.

NRC (U.S. Nuclear Regulatory Commission). 1978. "Atomic Safety and Licensing Appeal Board Order In the Matter of Rochester Gas and Electric Corporation, et al." ALAB–502, Washington, D.C. Accession No. ML13274A004. TN2636.

NRC (U.S. Nuclear Regulatory Commission). 1980. *Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants*. NUREG–0654/FEMA–REP–1, Revision 1, Washington, D.C. Accession No. ML040420012. TN512.

NRC (U.S. Nuclear Regulatory Commission). 1981. *Final Environmental Statement Related to the Operation of Enrico Fermi Atomic Power Plant, Unit No. 2.* NUREG–0769, Washington, D.C. Accession No. ML12209A107. TN675.

NRC (U.S. Nuclear Regulatory Commission). 1983. *Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants.* Regulatory Guide 1.145, Revision 1, Washington, D.C. Accession No. ML003740205. TN279.

NRC (U.S. Nuclear Regulatory Commission). 1989. *Storage of Spent Nuclear Fuel in NRC-Approved Storage Casks at Nuclear Power Reactor Sites, Environmental Assessment and Finding of No Significant Impact*. Washington, D.C. Accession No. ML083190229. TN3714.

NRC (U.S. Nuclear Regulatory Commission). 1990. *Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants*. NUREG–1150, Washington, D.C. Accession No. ML040140729. TN525.

NRC (U.S. Nuclear Regulatory Commission). 1996. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. Volumes 1 and 2, NUREG–1437, Washington, D.C. Accession Nos. ML040690705, ML040690738. TN288.

NRC (U.S. Nuclear Regulatory Commission). 1999. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants Addendum to Main Report*. NUREG–1437, Volume 1, Addendum 1, Washington, D.C. Accession No. ML040690720. TN289.

NRC (U.S. Nuclear Regulatory Commission). 2000. *Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors.* Regulatory Guide 1.183, Washington, D.C. Accession No. ML003716792. TN517.

NRC (U.S. Nuclear Regulatory Commission). 2000. *Environmental* Standard *Review* Plan—Standard *Review Plans for Environmental Reviews for Nuclear Power Plants*. NUREG–1555, Main Report and 2007 Revisions, Washington, D.C. Available at http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1555/toc/. TN614.

NRC (U.S. Nuclear Regulatory Commission). 2001. *Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants*. NUREG-1738, Washington, D.C. Accession No. ML010430066. TN5235.

NRC (U.S. Nuclear Regulatory Commission). 2002. *Final Generic Environmental Impact Statement of Decommissioning of Nuclear Facilities: Regarding the Decommissioning of Nuclear Power Reactors*. NUREG–0586, Supplement 1, Volumes 1 and 2, Washington, D.C. Accession Nos. ML023470327, ML023500228. TN665.

NRC (U.S. Nuclear Regulatory Commission). 2003. Letters to Simard, Kray, and Hughey, regarding USNRC Responses—Comments on Draft RS-002, "Processing Applications for Early Site Permits." Washington, D.C. Accession No. ML031710698. TN2064.

NRC (U.S. Nuclear Regulatory Commission). 2004. *Processing Applications for Early Site Permits*. RS-002, Washington, D.C. Accession No. ML040700094. TN2219.

NRC (U.S. Nuclear Regulatory Commission). 2005. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants Supplement 21 Regarding Browns Ferry Nuclear Plant, Units 1,2, and 3*. NUREG–1437, Final Report, Washington, D.C. Accession No. ML051730443. TN5192.

NRC (U.S. Nuclear Regulatory Commission). 2007. *Combined License Applications for Nuclear Power Plants (LWR Edition)*. Regulatory Guide 1.206, Washington, D.C. Accession No. ML070720184. TN3035.

NRC (U.S. Nuclear Regulatory Commission). 2007. *Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants.* Regulatory Guide 1.76, Revision 1, Washington, D.C. Accession No. ML070360253. TN3294.

NRC (U.S. Nuclear Regulatory Commission). 2007. *Environmental Standard Review Plan—Standard Review Plans for Environmental Reviews for Nuclear Power Plants*. NUREG–1555, Draft Revision 1, Washington, D.C. Accession No. ML18023A205. TN5141.

NRC (U.S. Nuclear Regulatory Commission). 2007. "Memorandum and Order in the Matter of Dominion Nuclear North Anna, LLC (Early Site Permit for North Anna ESP Site)." CLI-07-27, Rockville, Maryland. Accession No. ML082521051. TN2487.

NRC (U.S. Nuclear Regulatory Commission). 2007. *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, LWR Edition.* NUREG–0800, Washington, D.C. Accession No. ML070660036. TN613.

NRC (U.S. Nuclear Regulatory Commission). 2008. *Clinch River Breeder Reactor Project Preliminary Safety Analysis Report*. Washington, D.C. Accession No. ML082960468. TN5142.

NRC (U.S. Nuclear Regulatory Commission). 2009. *Radiological Environmental Monitoring for Nuclear Power Plants.* Regulatory Guide 4.1, Revision 2, Washington, D.C. Accession No. ML091310141. TN3802.

NRC (U.S. Nuclear Regulatory Commission). 2011. *Recommendations for Enhancing Reactor Safety in the 21st Century: The Near-Term Task Force Review of Insights from the Fukushima Dai-Ichi Accident.* SECY–11–0093, NRC Task Force, Washington, D.C. Accession No. ML111861807. TN684.

NRC (U.S. Nuclear Regulatory Commission). 2012. *Central and Eastern United States Seismic Source Characterization for Nuclear Facilities*. NUREG–2115, Washington, D.C. Accession No. ML12048A776. TN3810.

NRC (U.S. Nuclear Regulatory Commission). 2012. Letter from E. Leeds and M. Johnson to All Power Reactor Licensees and Holders of Construction Permits in Active or Deferred Status, dated March 12, 2012, regarding "Issuance of Order to Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation." Washington, D.C. Accession No. ML12054A679. TN3236.

NRC (U.S. Nuclear Regulatory Commission). 2012. Letter from E. Leeds and M. Johnson to All Power Reactor Licensees and Holders of Construction Permits in Active or Deferred Status, dated March 12, 2012, regarding "Issuance of Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events." Washington, D.C. Accession No. ML12054A735. TN3237.

NRC (U.S. Nuclear Regulatory Commission). 2012. *Spent Fuel Transportation Risk Assessment, Draft Report for Comment*. NUREG-2125, Washington, D.C. Accession No. ML12125A218. TN2658.

NRC (U.S. Nuclear Regulatory Commission). 2012. *State-of-the-Art Reactor Consequence Analyses (SOARCA) Report.* NUREG–1935, Washington, D.C. Accession No. ML12332A057. TN3092.

NRC (U.S. Nuclear Regulatory Agency). 2013. *Final Environmental Impact Statement Related to the Operation of Watts Bar Nuclear Plant Units Nos. 1 and 2*. NUREG-0498, Supplement No. 2, Washington, D.C. Accession Nos. ML13144A092, ML13144A093. TN5165.

NRC (U.S. Nuclear Regulatory Commission). 2013. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* [GEIS]. NUREG–1437, Revision 1, Washington, D.C. Accession No. ML13107A023. TN2654.

NRC (U.S. Nuclear Regulatory Commission). 2013. "mPower Design-Specific Review Standard Scope and Safety Review Matrix." Revision 0, Washington, D.C. Accession No. ML13088A252. TN5231.

NRC (U.S. Nuclear Regulatory Commission). 2014. *Attachment 1: Staff Guidance for Greenhouse Gas and Climate Change Impacts for New Reactor Environmental Impact Statements, COL/ESP-ISG-026*. Washington, D.C. Accession No. ML14100A157. TN3768.

NRC (U.S. Nuclear Regulatory Commission). 2014. *Consequence Study of a Beyond-Design-Basis Earthquake Affecting the Spent Fuel Pool for a U.S. Mark I Boiling Water Reactor*. NUREG-2161, Washington, D.C. Accession No. ML14255A365. TN5236.

NRC (U.S. Nuclear Regulatory Commission). 2014. *Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel.* Final Report, NUREG–2157, Washington, D.C. Accession No. ML14198A440. TN4117.

NRC (U.S. Nuclear Regulatory Commission). 2014. *Interim Staff Guidance on Environmental Issues Associated with New Reactors, COL/ESP–ISG–026.* Washington, D.C. Accession No. ML14092A402. TN3767.

NRC (U.S. Nuclear Regulatory Commission). 2014. "Memorandum and Order in the Matter of Calvert Cliffs 3 Nuclear Project, LLC, and UniStar Nuclear Operating Services; DTE Electric Co,; Duke Energy Carolinas, LLC; et al. (Lifting the Suspension on Final Licensing Decisions Imposed in CLI-12-16)" CLI-14-08, Rockville, Maryland. Accession No. ML14238A212. TN4303.

NRC (U.S Nuclear Regulatory Commission). 2014. *Specific Environmental Guidance for Light Water Small Modular Reactors Reviews.* Interim Staff Guidance, COL/ESP-ISG-027, Washington, D.C. Accession No. ML14100A648. TN3774.

NRC (U.S. Nuclear Regulatory Commission). 2015. Letter from T. Dozier to NRC, dated October 26, 2015, regarding "Observations from the Environmental Readiness Assessment Activities for a Future Early Site Permit Application for the Clinch River Nuclear Site." Washington, D.C. Accession No. ML15251A697. TN5275.

NRC (U.S. Nuclear Regulatory Commission). 2015. *Summary of Observations and Issues Identified During Environmental Readiness Assessment Visits (March 30-31, 2015 Site Visit, July 7-8 Alternative Site Visit and August 4-6 Readiness Assessment at TVA Headquarters*. Washington, D.C. Accession No. ML15251A399. TN5408.

NRC (U.S. Nuclear Regulatory Commission). 2016. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. NUREG–1437, Main Report, Appendices, Revision 1, and Supplements 1 through 57, Washington, D.C. Available at https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1437/. TN5385.

NRC (U.S. Nuclear Regulatory Commission). 2016. "Sequoyah Nuclear Plant, Unit 1." Washington, D.C. Accession No. ML18023A207. TN4641.

NRC (U.S. Nuclear Regulatory Commission). 2016. "Sequoyah Nuclear Plant, Unit 2." Washington, D.C. Accession No. ML18023A206. TN4640.

NRC (U.S. Nuclear Regulatory Commission). 2016. "Watts Bar Nuclear Plant, Unit 1." Washington, D.C. Accession No. ML18023A208. TN4643.

NRC (U.S. Nuclear Regulatory Commission). 2016. "Watts Bar Nuclear Plant, Unit 2." Washington, D.C. Accession No. ML18023A209. TN4644.

NRC (U.S. Nuclear Regulatory Commission). 2017. *Environmental Impact Statement Scoping Process Summary Report, Clinch River Nuclear Site Early Site Permit Application, Oak Ridge, Tennessee.* Rockville, Maryland. Accession No. ML17242A069. TN5343.

NRC (U.S. Nuclear Regulatory Commission). 2017. Letter from A.H. Fetter to the Absentee Shawnee Tribe, dated April 20, 2017, regarding "Invitation of Section 106 and Scoping Process for the Environmental Review of the Early Site Permit Application for the Clinch River Nuclear Site in Roane County, Tennessee." Washington, D.C. Accession No. ML17041A081. TN5215.

NRC (U.S. Nuclear Regulatory Commission). 2017. Letter from A.H. Fetter to the Alabama-Coushatta Tribe of Texas, dated April 20, 2017, regarding "Invitation of Section 106 and Scoping Process for the Environmental Review of the Early Site Permit Application for the Clinch River Nuclear Site in Roane County, Tennessee." Washington, D.C. Accession No. ML17041A082. TN5196.

NRC (U.S. Nuclear Regulatory Commission). 2017. Letter from A.H. Fetter to the Alabama-Coushatta Tribal Town, dated April 20, 2017, regarding "Invitation of Section 106 and Scoping Process for the Environmental Review of the Early Site Permit Application for the Clinch River Nuclear Site in Roane County, Tennessee." Washington, D.C. Accession No. ML17041A084. TN5197.

NRC (U.S. Nuclear Regulatory Commission). 2017. Letter from A.H. Fetter to the Cherokee Nation of Oklahoma, dated April 20, 2017, regarding "Invitation of Section 106 and Scoping Process for the Environmental Review of the Early Site Permit Application for the Clinch River Nuclear Site in Roane County, Tennessee." Washington, D.C. Accession No. ML17041A085. TN5198.

NRC (U.S. Nuclear Regulatory Commission). 2017. Letter from A.H. Fetter to the Chickasaw Nation, dated April 20, 2017, regarding "Invitation of Section 106 and Scoping Process for the Environmental Review of the Early Site Permit Application for the Clinch River Nuclear Site in Roane County, Tennessee." Washington, D.C. Accession No. ML17041A081. TN5199.

NRC (U.S. Nuclear Regulatory Commission). 2017. Letter from A.H. Fetter to the Choctaw Nation of Oklahoma, dated April 20, 2017, regarding "Invitation of Section 106 and Scoping Process for the Environmental Review of the Early Site Permit Application for the Clinch River Nuclear Site in Roane County, Tennessee." Washington, D.C. Accession No. ML17041A086. TN5200.

NRC (U.S. Nuclear Regulatory Commission). 2017. Letter from A.H. Fetter to the Coushatta Tribe of Louisiana, dated April 20, 2017, regarding "Invitation of Section 106 and Scoping Process for the Environmental Review of the Early Site Permit Application for the Clinch River Nuclear Site in Roane County, Tennessee." Washington, D.C. Accession No. ML17041A405. TN5201.

NRC (U.S. Nuclear Regulatory Commission). 2017. Letter from A.H. Fetter to the Eastern Band of Cherokee Indians of North Carolina, dated April 20, 2017, regarding "Invitation of Section 106 and Scoping Process for the Environmental Review of the Early Site Permit Application for the Clinch River Nuclear Site in Roane County, Tennessee." Washington, D.C. Accession No. ML17017A123. TN5202.

NRC (U.S. Nuclear Regulatory Commission). 2017. Letter from A.H. Fetter to the Eastern Shawnee Tribe of Oklahoma, dated April 20, 2017, regarding "Invitation of Section 106 and Scoping Process for the Environmental Review of the Early Site Permit Application for the Clinch River Nuclear Site in Roane County, Tennessee." Washington, D.C. Accession No. ML17047A406. TN5203.

NRC (U.S. Nuclear Regulatory Commission). 2017. Letter from A.H. Fetter to the Jena Band of the Choctaw Indians, dated April 20, 2017, regarding "Invitation of Section 106 and Scoping Process for the Environmental Review of the Early Site Permit Application for the Clinch River Nuclear Site in Roane County, Tennessee." Washington, D.C. Accession No. ML17047A407. TN5204.

NRC (U.S. Nuclear Regulatory Commission). 2017. Letter from A.H. Fetter to the Kialegee Tribal Town, dated April 20, 2017, regarding "Invitation of Section 106 and Scoping Process for the Environmental Review of the Early Site Permit Application for the Clinch River Nuclear Site in Roane County, Tennessee." Washington, D.C. Accession No. ML17047A408. TN5205.

NRC (U.S. Nuclear Regulatory Commission). 2017. Letter from A.H. Fetter to the Mississippi Band of Choctaw Indians, dated April 20, 2017, regarding "Invitation of Section 106 and Scoping Process for the Environmental Review of the Early Site Permit Application for the Clinch River Nuclear Site in Roane County, Tennessee." Washington, D.C. Accession No. ML17047A409. TN5206.

NRC (U.S. Nuclear Regulatory Commission). 2017. Letter from A.H. Fetter to the Muscogee (Creek) Nation of Oklahoma, dated April 20, 2017, regarding "Invitation of Section 106 and Scoping Process for the Environmental Review of the Early Site Permit Application for the Clinch River Nuclear Site in Roane County, Tennessee." Washington, D.C. Accession No. ML17047A675. TN5207.

NRC (U.S. Nuclear Regulatory Commission). 2017. Letter from A.H. Fetter to the Poarch Band of Creek Indians, dated April 20, 2017, regarding "Invitation of Section 106 and Scoping Process for the Environmental Review of the Early Site Permit Application for the Clinch River Nuclear Site in Roane County, Tennessee." Washington, D.C. Accession No. ML17047A676. TN5208.

NRC (U.S. Nuclear Regulatory Commission). 2017. Letter from A.H. Fetter to the Quapaw Tribe of Oklahoma, dated April 20, 2017, regarding "Invitation of Section 106 and Scoping Process for the Environmental Review of the Early Site Permit Application for the Clinch River Nuclear Site in Roane County, Tennessee." Washington, D.C. Accession No. ML17047A677. TN5209.

NRC (U.S. Nuclear Regulatory Commission). 2017. Letter from A.H. Fetter to the Seminole Nation of Oklahoma, dated April 20, 2017, regarding "Invitation of Section 106 and Scoping Process for the Environmental Review of the Early Site Permit Application for the Clinch River Nuclear Site in Roane County, Tennessee." Washington, D.C. Accession No. ML17047A678. TN5210.

NRC (U.S. Nuclear Regulatory Commission). 2017. Letter from A.H. Fetter to the Seminole Tribe of Florida, dated April 20, 2017, regarding "Invitation of Section 106 and Scoping Process for the Environmental Review of the Early Site Permit Application for the Clinch River Nuclear Site in Roane County, Tennessee." Washington, D.C. Accession No. ML17047A679. TN5211.

NRC (U.S. Nuclear Regulatory Commission). 2017. Letter from A.H. Fetter to the Shawnee Tribe of Oklahoma, dated April 20, 2017, regarding "Invitation of Section 106 and Scoping Process for the Environmental Review of the Early Site Permit Application for the Clinch River Nuclear Site in Roane County, Tennessee." Washington, D.C. Accession No. ML17047A680. TN5212.

NRC (U.S. Nuclear Regulatory Commission). 2017. Letter from A.H. Fetter to the Thlopthlocco Tribal Town, dated April 20, 2017, regarding "Invitation of Section 106 and Scoping Process for the Environmental Review of the Early Site Permit Application for the Clinch River Nuclear Site in Roane County, Tennessee." Washington, D.C. Accession No. ML17047A682. TN5213.

NRC (U.S. Nuclear Regulatory Commission). 2017. Letter from A.H. Fetter to the United Keetoowah Band of Cherokee Indians, dated April 20, 2017, regarding "Invitation of Section 106 and Scoping Process for the Environmental Review of the Early Site Permit Application for the Clinch River Nuclear Site in Roane County, Tennessee." Washington, D.C. Accession No. ML17047A683. TN5214.

NRC (U.S. Nuclear Regulatory Commission). 2017. Letter from A.H. Fetter to U.S. Fish and Wildlife Service, dated April 20, 2017, regarding "Request for Participation in the Environmental Scoping Process and a List of Protected Species Within the Area Under Evaluation for the Proposed Clinch River Nuclear Site Early Site Permit Application Review." Washington, D.C. Accession No. ML17069A249. TN5089.

NRC (U.S. Nuclear Regulatory Commission). 2017. *Revision to JLD-ISG-2012-01, Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events*. JLD-ISG-2012-01, Revision 2, Washington, D.C. Accession No. ML17005A182. TN5063.

NRC (U.S. Nuclear Regulatory Commission). 2017. Summary of Meeting between the NRC and TVA to Discuss Topics Associated with TVA's Early Site Permit Application for the Clinch River Nuclear Site [Cultural Resources and Transportation]. Washington, D.C. Accession No. ML17352A028. TN5413.

NRC (U.S. Nuclear Regulatory Commission). 2018. *Clinch River Nuclear Site Early Site Permit Application Environmental Audit Summary Report*. Washington, D.C. Accession No. ML17226A020. TN5386.

NRC (U.S. Nuclear Regulatory Commission). 2018. Email from J.A. Davis to Poarch Band of Creek Indians, dated February 16, 2018, regarding "Early Site Permit Application for the Clinch River Nuclear Site in Roane County, Tennessee." Washington, D.C. Accession No. ML18051A743. TN5425.

NRC (U.S. Nuclear Regulatory Commission). 2018. Email from J. Davis to Seminole Nation of Oklahoma , dated January 19, 2018, regarding "Early Site Permit Application for the Clinch River Nuclear Site n Roane County, Tennessee, including April 20, 2017 letter regarding Initiation of Section 106 Scoping Process." Washington, D.C. Accession No. ML18031A950. TN5431.

NRC (U.S. Nuclear Regulatory Commission). 2018. Email from J. Davis to T. Clouthier, Thlopthlocco Tribal Town, dated January 29, 2018, regarding "Early Site Permit Application for the Clinch River Nuclear Site in Roane County, Tennessee." Washington, D.C. Accession No. ML18040A438. TN5429.

NRC (U.S. Nuclear Regulatory Commission). 2018. Email from J. Davis to the Alabama Coushatta Tribe of Texas, dated January 19, 2018, regarding "Early Site Permit Application for the Clinch River Nuclear Site in Roane County, Tennessee, including April 20, 2017 letter regarding Initiation of Section 106 Scoping Process." Washington, D.C. Accession No. ML18058B560. TN5432.

NRC (U.S. Nuclear Regulatory Commission). 2018. Email from J. Davis to the Alabama-Quassarte Tribal Town, dated January 19, 2018, regarding "Early Site Permit for the Clinch River Nuclear Site in Roane County, Tennessee." Washington, D.C. Accession No. ML18046A410. TN5430.

NRC (U.S. Nuclear Regulatory Commission). 2018. Email from J. Davis to the Seminole Nation of Oklahoma, dated March 5, 2018, regarding "Early Site Permit for the Clinch River Nuclear Site in Roane County, Tennessee." Washington, D.C. Accession No. ML18064A222. TN5434.

NRC (U.S. Nuclear Regulatory Commission). 2018. Note to File dated March 5, 2018, regarding "Summary of Follow-Up Communications with Federally-Recognized Tribes Regarding the Clinch River Early Site Permit Review." Washington, D.C. Accession No. ML18046B439. TN5435.

NRCS (Natural Resources Conservation Service). 2012. *Prime and Unique Farmlands*. U.S. Department of Agriculture, Washington, D.C. Accession No. ML18023A212. TN5238.

NSC (National Safety Council). 2010. "Summary from *Injury Facts, 2010 Edition*." Washington, D.C. Accession No. ML14085A444. TN3240.

NSCORP (Norfolk Southern Corporation). 2011. "Norfolk Southern Railway System Map." Norfolk, Virginia. Accessed August 24, 2017, at http://www.nscorp.com/nscorphtml/pdf/system-map.pdf. TN4945.

NuScale (NuScale Power LLC). 2016. "Auxiliary Systems, Part 2 – Tier 2." Chapter 9 in *NuScale Standard Plant Design Certification Application.* Revision 0, Corvallis, Oregon. Accession No. ML17013A280. TN5233.

Oak Ridge Today. 2018. "Search Results for Oak Ridge Airport." Oak Ridge, Tennessee. Accessed January 30, 2018, at http://oakridgetoday.com/?s=OAk+Ridge+Airport. TN5409.

Ogle, D.W. 1992. *Virginia Spiraea* (Spiraea virginiana Britton) *Recovery Plan*. U.S. Fish and Wildlife Service Region Five, Newton Corner, Massachusetts. Accession No. ML18059A125. TN5379.

OREIS (Oak Ridge Environmental Information System). 2017. "OREIS Database Query for Sediment Associated with Surface Water in the Vicinity of the Clinch River Site (CRM 14-15)." Oak Ridge, Tennessee. Accession No. ML18023A325. TN5225.

ORNL (Oak Ridge National Laboratory). 2017. Email from K. McCracken to J. Becker, PNNL, dated September 18, 2017, regarding "Fish Population Data for Ish Creek." Oak Ridge, Tennessee. Accession No. ML18016A334. TN5358.

ORR (Oak Ridge Reservation). 2017. "Oak Ridge Reservation Annual Site Environmental Report (ASER) [webpage with links to past reports]." DOE Office of Science, Oak Ridge Tennessee. Accession No. ML18023A327. TN5080.

Ortega, C.P. 2012. "Effects of Noise Pollution on Birds: A Brief Review of Our Knowledge." *Ornithological Monographs* 74:6–22, Chicago, Illinois. TN5153.

Outdoor Alabama. 2017. "Wheeler Reservoir." Montgomery, Alabama. Accessed October 7, 2017, at http://www.outdooralabama.com/wheeler-reservoir. TN5191.

Pace, R.A. 1995. *Archaeological Survey of Proposed State Route 58/95 Modifications, Roane County, Tennessee*. Accession No. ML17296A409. TN4969.

Parmalee, P.W. and A.E. Bogan. 1998. *Freshwater Mussels of Tennessee*. University of Tennessee Press, Knoxville, Tennessee. Accession No. ML042800060. TN5166.

Parr, P.D. and J.F. Hughes. 2006. *Oak Ridge Reservation Physical Characteristics and Natural Resources*. ORNL-2006-G01046/lmh, Oak Ridge National Laboratory, Oak Ridge, Tennessee. Accession No. ML17334A061. TN5058.

Parr, P.D., G.S. Byrd, J.W. Johnson, Jr., and N.R. Giffen. 2015. *Forest Management Plan for the DOE Oak Ridge Reservation: An Interdisciplinary Approach for Managing a Heritage Resource*. ORNL/TM-2015/98, Oak Ridge National Laboratory, Oak Ridge, Tennessee. Accession No. ML18023A329. TN5151.

PGC (Pennsylvania Game Commission). 2013. "Threatened and Endangered Species." Harrisburg, Pennsylvania. Accessed September 17, 2014, at https://www.portal.state.pa.us/portal/server.pt?open=514&objID=621014&mode=2. TN3845.

Pilarski-Hall, K. 2015. *Clinch River Small Modular Reactor Site: Technical Report Natural Areas (Managed Areas & Sites).* Revision 2, Tennessee Valley Authority, Knoxville, Tennessee. Accession No. ML17334A050. TN5185.

Pilarski-Hall, K. and R.A. Kennon. 2015. *Clinch River Small Modular Reactor Site Supplemental Wetland Survey Report Barge/Traffic Area*. Revision 1, Tennessee Valley Authority, Knoxville, Tennessee. Accession No. ML18036A351. TN5290.

Pilarski-Hall, K. and B.P. Lees. 2015. *Clinch River Small Modular Reactor Site Wetland Survey Report.* Revision 4, Tennessee Valley Authority, Knoxville, Tennessee. Accession No. ML18036A352. TN5299.

PLTA (Pennsylvania Land Trust Association). 2014. "Important Bird Areas." Harrisburg, Pennsylvania. Available at http://conservationtools.org/guides/show/32-Important-Bird-Areas. TN3977.

PNNL (Pacific Northwest National Laboratory). 2017. Email from J. Becker, to Georgia Natural Heritage Program, dated September 6, 2017, regarding "GA NHP Review of Transmission Line Segment for Clinch River SMR Project in Tennessee." Richland, Washington. Accession No. ML18059A128. TN5401.

PNNL (Pacific Northwest National Laboratory). 2017. Emails from J. Becker to Kentucky State Nature Preserves Commission, dated September 13 and 27, 2017, regarding "KY NHP Review of Transmission Line Segment for Clinch River SMR ESP Project in Tennessee." Richland, Washington. Accession No. ML18059A130. TN5403.

PNNL (Pacific Northwest National Laboratory). 2017. Phone/Conference Call Record form P. Meyer to T. Storey, Huntsville Utilities, dated October 18, 2017, regarding "Williams Well Information." Richland, Washington. Accession No. ML18073A182. TN5460.

PNNL (Pacific Northwest National Laboratory). 2017. Summary of Notes from Telephone Conference Call with U.S. Fish and Wildlife Service on October 24, 2017 with Additional Notes from Dustin Boles, FWS, Telephone Call to Jim Becker, PNNL, on October 23, 2017. Richland, Washington. Accession No. ML18040A429. TN5384.

PSCO v. NRC (1st Circuit 1978) (Public Service Company of New Hampshire v. U.S. Nuclear Regulatory Commission). 582 F.2d 77 (1st Circuit 1978). U.S. Court of Appeals First Circuit Decision June 21, 1978. TN2633.

Raikow, D.F. 2004. "Food Web Interactions between Larval Bluegill (*Lepomis macrochirus*) and Exotic Zebra Mussels (*Dreissena polymorpha*)." *Canadian Journal of Fisheries and Aquatic Science* 61:497-504, Ottawa, Canada. TN5182.

Reed, E. 2007. *Preventing and Controlling Cancer, The Nation's Second Leading Cause of Death.* Center for Disease Control and Prevention, Atlanta, Georgia. Accession No. ML14282A749. TN523.

Reisman, J. and G. Frisbie. 2002. "Calculating Realistic PM10 Emissions from Cooling Towers." *Environmental Progress* 21(2):127–130, Medford, Massachusetts. TN5258.

Renewco. 2017. "Projects: Meadow Branch Landfill Methane Recovery Project." Atlanta, Georgia. Accessed October 10, 2017, at http://www.renewcogas.com/projects.shtml. TN5044.

Ridge (Ridge Instruments Co.). 2016. "About Ridge." Decatur, Alabama. Accession No. ML18023A331. TN5127.

Ropak (Ropak Manufacturing Company, Inc.). 2016. "Ropak – A Leader in Flexible Packaging Technology." Decatur, Alabama. Accessed June 6, 2016, at http://www.ropak.com/. TN5128.

Roy, W.K., N.R. Giffen, M.C. Wade, A.M. Haines, J.W. Evans, and R.T. Jet. 2014. *Oak Ridge Reservation Bird Records and Population Trends*. ORNL/TM-2014/109, Oak Ridge National Laboratory, Oak Ridge, Tennessee. Accession No. ML18023A334. TN5154.

Sagendorf, J.F., J.T. Goll, and W.F. Sandusky. 1982. *XOQDOQ: Computer Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations.* NUREG/CR–2919, Pacific Northwest Laboratory, Richland, Washington. Accession No. ML081360412. TN280.

Saidak, C.G. 2015. *Determination of Dispersal Patterns and Characterization of Important Habitats for Lake Sturgeon Restoration in the Upper Tennessee River System*. Master of Science Thesis, University of Tennessee, Knoxville, Tennessee. TN5181.

Saricks, C.L. and M.M. Tompkins. 1999. *State-Level Accident Rates of Surface Freight Transportation: A Reexamination*. ANL/ESD/TM-150, Argonne National Laboratory, Argonne, Illinois. Accession No. ML091060020. TN81.

Schroedl, G.F. 1972. *Archaeological Reconnaissance and Test Excavations in the Clinch River Liquid Metal Fast Breeder Reactor Plant Site Area.* University of Tennessee, Knoxville, Tennessee. Accession No. ML17296A410. TN4983.

Schroedl, G.F. 1974. *Historic Sites Reconnaissance in the Clinch River Breeder Reactor Plant Area*. University of Tennessee, Knoxville, Tennessee. Accession No. ML17296A411. TN4985.

Schroedl, G.F. 1974. *Salvage Archaeology in the Clinch River Breeder Reactor Plant Area*. Progress Report for January and February 1974, University of Tennessee, Knoxville, Tennessee. Accession No. ML17298A065. TN4986.

Schroedl, G.F. 1974. *Test Excavations at Site 40RE129 in the Clinch River Breeder Reactor Plant Area*. University of Tennessee, Knoxville, Tennessee. Accession No. ML17298A066. TN4984.

Schroedl, G.F. 1990. *Archaeological Research at 40RE107, 4RE108, and 40RE124 in the Clinch River Breeder Reactor Plant Area, Tennessee*. Report of Investigations No. 49, Department of Anthropology, University of Tennessee, Knoxville, Tennessee. Accession No. ML18057B029. TN5341.

Seminole Nation of Oklahoma. 2018. Email from T. Isham, to NRC, dated January 20, 2018, regarding "Early Site Permit Application for the Clinch River Nuclear Site in Roane County, Tennessee." Seminole, Oklahoma. Accession No. ML18046A412. TN5419.

SERTP (Southeastern Regional Transmission Planning). 2016. "Order 1000 Biennial Regional Transmission Plan Review Meeting." Presentation, PJM-SERTP Meeting April 26, 2016, Georgia Power Headquarters, Atlanta, Georgia. Available at http://www.pjm.com/~/media/committees-groups/committees/teac/20160714/20160714-order-1000-biennial-regional-transmission-plan-review-meeting.ashx. TN4896.

SERTP (Southeastern Regional Transmission Planning). 2017. *Preliminary 10 Year Transmission Expansion Plans*. Atlanta, Georgia. Accessed October 10, 2017, at http://www.southeasternrtp.com/docs/general/2017/2017-Preliminary-10-Year-Expansion-Plans.pdf. TN5046.

Shea, A.B. and T.H. Roulston. 1996. *Recovery Plan for Cumberland Rosemary* (Conradina verticillata). Southeast Region, U.S. Fish and Wildlife Service, Atlanta, Georgia. Accession No. ML18023A336. TN5303.

SMR (SMR, LLC). 2017. "Economical and Efficient: SMR-160 Delivers High Performance with a Smaller Footprint." Jupiter, Florida. Accessed November 20, 2017, at https://smrllc.com/features/economical-and-efficient/. TN5232.

Soldat, J.K., N.M. Robinson, and D.A. Baker. 1974. *Models and Computer Codes for Evaluating Environmental Radiation Doses*. BNWL-1754, Battelle, Pacific Northwest Laboratories, Richland, Washington. Accession No. ML12223A187. TN710.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreler, and W.M. McMaster. 1992. *Status Report, A Hydrologic Framework for the Oak Ridge Reservation*. ORNL/TN-12026, Environmental Sciences Division Publication No. 3815, Oak Ridge National Laboratory, Oak Ridge, Tennessee. Accession No. ML17334A062. TN5148.

Sprung, J.L., D.J. Ammerman, N.L. Breivik, R.J. Dukart, F.L. Kanipe, J.A. Koski, G.S. Mills, K.S. Neuhauser, H.D. Radloff, R.F. Weiner, and H.R. Yoshimura. 2000. *Reexamination of Spent Fuel Shipment Risk Estimates*. NUREG/CR–6672, Sandia National Laboratories, Albuquerque, New Mexico. Accession No. ML003698324. TN222.

Stanyard, W.F., S.C. Sherwood, J.L. Holland, M.J. Wild, and T. Karpynec. 2003. *Cultural Resource Survey of a Proposed Storage/Disposal and Borrow Area on the Clinch River Breeder Reactor Site in Roane County, Tennessee*. Project #01621, TRC, Atlanta, Georgia. Accession No. ML17296A412. TN4979.

Strenge, D.L., R.A. Peloquin, and G. Whelan. 1986. *LADTAP II—Technical Reference and User Guide*. NUREG/CR–4013, Pacific Northwest Laboratory, Richland, Washington. Accession No. ML14098A069. TN82.

Strenge, D.L., T.J. Bander, and J.K. Soldat. 1987. *GASPAR II—Technical Reference and User Guide*. NUREG/CR–4653, Pacific Northwest Laboratory, Richland, Washington. Accession No. ML14098A066. TN83.

T.C.A. § 11-14-101 et seq. *Tennessee Code Annotated*, Title 11, *Natural Resources and Recreation*, Chapter 14, "Natural Areas Preservation." TN5163.

T.C.A. § 69-3-101 et seq. Water Quality Control Act. TN4914.

T.C.A. § 69-7-301 et seq. Water Resources Information Act. TN4915.

T.C.A. Title 46. *Tennessee Code Annotated*, Title 46, "Cemeteries." TN5088.

T.C.A. Title 67. *Tennessee Code Annotated*, Title 67, "Taxes and Licenses." TN4962.

TACIR (Tennessee Advisory Commission on Intergovernmental Regulations). 2017. *Tennessee Valley Authority's Payments in Lieu of Taxes: Annual Report to the Tennessee General Assembly*. Nashville, Tennessee. Accession No. ML18023A340. TN4927.

TANSTF (Tennessee Aquatic Nuisance Species Task Force). 2008. *Tennessee Aquatic Nuisance Species Management Plan*. Tennessee Wildlife Resources Agency, Nashville, Tennessee. Accession No. ML12170A038. TN5244.

TDA (Tennessee Department of Agriculture). 2003. *Guide to Forestry Best Management Practices in Tennessee*. Nashville, Tennessee. Accession No. ML18023A342. TN5161.

TDEC (Tennessee Department of Environment & Conservation). 2005. *Lower Clinch River Watershed Water Quality Management Plan.* Nashville, Tennessee. Accession No. ML18023A231. TN5007.

TDEC (Tennessee Department of Environment & Conservation). 2010. "Tennessee Division of Air Pollution Control, Permit ID 8829: Shawmut Advanced Mtl. Solutions." Nashville, Tennessee. Accession No. ML18023A348. TN4706.

TDEC (Tennessee Department of Environment & Conservation). 2012. "APC Permit Information: National Nuclear Security Administration Y-12 US DOE Title V Renewal." Tennessee Division of Air Pollution Control, Nashville, Tennessee. Accession No. ML18023A235. TN4636.

TDEC (Tennessee Department of Environment & Conservation). 2012. *Tennessee Erosion & Sediment Control Handbook*. Fourth Edition, Nashville, Tennessee. Accession No. ML18023A352. TN4889.

TDEC (Tennessee Department of Environment & Conservation). 2014. *2014 305(b) Report, The Status of Water Quality in Tennessee*. Division of Water Resources, Nashville, Tennessee. Accession No. ML18023A239. TN4893.

TDEC (Tennessee Department of Environment & Conservation). 2014. *Environmental Monitoring Report, January through December 2013*. Nashville, Tennessee. Accession No. ML18023A358. TN5288.

TDEC (Tennessee Department of Environment & Conservation). 2015. "APC Permit Information: TVA – Bull Run Fossil Plant Title V Renewal." Tennessee Division of Air Pollution Control, Nashville, Tennessee. Accession No. ML18023A360. TN4648.

TDEC (Tennessee Department of Environment & Conservation). 2015. "Tennessee Division of Air Pollution Control, Permit ID 63277: 3M Company dba 3M Clinton." Nashville, Tennessee. Accession No. ML18023A248. TN4707.

TDEC (Tennessee Department of Environment & Conservation). 2015. "Tennessee Division of Air Pollution Control, Permit ID 64009: Doral Steel of Tennessee." Nashville, Tennessee. Accession No. ML18023A366. TN4710.

TDEC (Tennessee Department of Environment & Conservation). 2015. "Tennessee Division of Air Pollution Control, Site ID 63668: Manufacturing Sciences Corporation." Nashville, Tennessee. Accession No. ML18023A362. TN4697.

TDEC (Tennessee Department of Environment & Conservation). 2016. "APC Permit Information: Carlisle Tire, Title V Renewal." Tennessee Division of Air Pollution Control, Nashville, Tennessee. Accession No. ML18023A270. TN4693.

TDEC (Tennessee Department of Environment & Conservation). 2016. "APC Permit Information: Chestnut Ridge Landfill/Recycling Center Title V Renewal." Tennessee Division of Air Pollution Control, Nashville, Tennessee. Accession No. ML18023A372. TN4652.

TDEC (Tennessee Department of Environment & Conservation). 2016. "APC Permit Information: East Tennessee Materials and Energy Corporation." Tennessee Division of Air Pollution Control, Nashville, Tennessee. Accession No. ML18023A268. TN4692.

TDEC (Tennessee Department of Environment & Conservation). 2016. "Contaminants in Fish." Knoxville, Tennessee. Accession No. ML18023A307. TN5172.

TDEC (Tennessee Department of Environment & Conservation). 2016. *Design Criteria for Sewage Works*. Nashville, Tennessee. Accession No. ML18023A301. TN5041.

TDEC (Tennessee Department of Environment & Conservation). 2016. "Heritage WPC Permits in Tennessee Database [Active Coal Mines]." Nashville, Tennessee. Accession No. ML18023A374. TN4668.

TDEC (Tennessee Department of Environment & Conservation). 2016. "Tennessee Division of Air Pollution Control, Permit ID 64566: MHF Packaging Solutions, LLC." Nashville, Tennessee. Accession No. ML18023A289. TN4708.

TDEC (Tennessee Department of Environment & Conservation). 2016. "Tennessee Division of Air Pollution Control, Site ID 2010: ArcelorMittal Laplace, LLC." Nashville, Tennessee. Accession No. ML18023A282. TN4701.

TDEC (Tennessee Department of Environment & Conservation). 2016. "Tennessee Division of Air Pollution Control, Site ID 2117: Tennessee Valley Authority (TVA) – Kingston Fossil Plant." Nashville, Tennessee. Accession No. ML18023A370. TN4646.

TDEC (Tennessee Department of Environment & Conservation). 2016. "Tennessee Division of Air Pollution Control, Site ID 3003: Canberra." Nashville, Tennessee. Accession No. ML18023A278. TN4698.

TDEC (Tennessee Department of Environment & Conservation). 2016. "Tennessee Division of Air Pollution Control, Site ID 3566: Nuclear Lead Co. Inc." Nashville, Tennessee. Accession No. ML18023A276. TN4696.

TDEC (Tennessee Department of Environment & Conservation). 2016. "Tennessee Division of Air Pollution Control, Site ID 4883: U.S Department of Energy, Oak Ridge National Laboratory (Office of Science)." Nashville, Tennessee. Accession No. ML18023A253. TN4633.

TDEC (Tennessee Department of Environment & Conservation). 2016. "Tennessee Division of Water Resources, Site ID 5823: Kimberly Clark Corporation—Loudon Mill." Nashville, Tennessee. Accession No. ML18023A284. TN4702.

TDEC (Tennessee Department of Environment & Conservation). 2016. "Tennessee Division of Air Pollution Control, Site ID 5946: Horsehead Corporation." Nashville, Tennessee. Accession No. ML18023A286. TN4704.

TDEC (Tennessee Department of Environment & Conservation). 2016. "Tennessee Division of Air Pollution Control, Site ID 7235: PolyOne Corporation." Nashville, Tennessee. Accession No. ML18023A291. TN4709.

TDEC (Tennessee Department of Environment & Conservation). 2016. "Tennessee Division of Air Pollution Control, Site ID 7255: Diversified Scientific Services, Inc." Nashville, Tennessee. Accession No. ML18023A267. TN4691.

TDEC (Tennessee Department of Environment & Conservation). 2016. "Tennessee Division of Air Pollution Control, Site ID 7844: Diversified Toho Tenax America, Inc." Nashville, Tennessee. Accession No. ML18023A272. TN4694.

TDEC (Tennessee Department of Environment & Conservation). 2016. "Tennessee Division of Air Pollution Control, Site ID 8220: Energy Solutions, LLC Bear Creek Facility; TSDF." Nashville, Tennessee. Accession No. ML18023A265. TN4690.

TDEC (Tennessee Department of Environment & Conservation). 2016. "Tennessee Division of Air Pollution Control, Site ID 8829: Clinton Pallet Co." Nashville, Tennessee. Accession No. ML18023A288. TN4705.

TDEC (Tennessee Department of Environment & Conservation). 2016. "Tennessee Division of Air Pollution Control, Site ID 19331: Aisin Automotive Casting Tennessee, Inc." Nashville, Tennessee. Accession No. ML18023A293. TN4711.

TDEC (Tennessee Department of Environment & Conservation). 2016. "Tennessee Division of Air Pollution Control, Site ID 38035: Advanced Measurement Technology." Nashville, Tennessee. Accession No. ML18023A280. TN4699.

TDEC (Tennessee Department of Environment & Conservation). 2016. "Tennessee Division of Air Pollution Control, Site ID 73350: Proton Power Inc." Nashville, Tennessee. Accession No. ML18023A274. TN4695.

TDEC (Tennessee Department of Environment & Conservation). 2016. "Tennessee Division of Air Pollution Control Site Information: Goodman Company, L.P." Nashville, Tennessee. Accession No. ML18023A303. TN5120.

TDEC (Tennessee Department of Environment & Conservation). 2016. "Tennessee Division of Air Pollution Control Site Information: Latham Pool Products, Inc." Nashville, Tennessee. Accession No. ML18023A305. TN5121.

TDEC (Tennessee Department of Environment & Conservation). 2016. "Tennessee Division of Water Resources: Oil and Gas Well Permits." Nashville, Tennessee. Accession No. ML18023A263. TN4674.

TDEC (Tennessee Department of Environment & Conservation). 2016. "Tennessee Marble Company Endsley Quarry." Nashville, Tennessee. Accession No. ML18023A261. TN4669.

TDEC (Tennessee Department of Environment & Conservation). 2016. *Year 2016 303(d) List (Draft Version)*. Division of Water Resources, Nashville, Tennessee. Accession No. ML18023A299. TN5006.

TDEC (Tennessee Department of Environment & Conservation). 2017. Email from V. Leray to L. Aston, PNNL, dated October 16, 2017, regarding Data Pertinent to Roane County Waste. Nashville, Tennessee. Accession No. ML18059A133. TN5399.

TDEC (Tennessee Department of Environment & Conservation). 2017. Email from W. Muirhead to P. Meyer, PNNL, dated October 6, 2017, regarding "Request for Public Drinking Water Pumpage Data for 2015 or 2016." Nashville, Tennessee. Accession No. ML18023A311. TN5032.

TDEC (Tennessee Department of Environment & Conservation). 2017. Letter from K. Abkowitz to NRC, dated June 12, 2017, regarding "Comments on the Nuclear Regulatory Commission (NRC) Notice of Intent (NOI) to prepare an Environmental Impact Statement (EIS) related to the *Tennessee Valley Authority (TVA) Early Site Permit (ESP) for the Clinch River Nuclear (CRN) Site* near Oak Ridge, Tennessee." Nashville, Tennessee. Accession No. ML17170A310. TN5261.

TDEC (Tennessee Department of Environment & Conservation). 2017. *Proposed Final Year 2016 303(d) List*. Nashville, Tennessee. Accession No. ML18023A313. TN5060.

TDEC (Tennessee Department of Environment & Conservation). 2017. "Rare Species by County, Roane County." Nashville, Tennessee. Accession No. ML18023A318. TN5217.

TDEC (Tennessee Department of Environment & Conservation). 2017. "Tennessee Department of Air Pollution Control Permit Information, Title V Permits, Roane County, Tennessee." Nashville, Tennessee. Accession No. ML18023A309. TN5017.

TDHS (Tennessee Department of Human Services). 2017. "Program Descriptions." Nashville, Tennessee. Accession No. ML18023A322. TN4932.

TDOL (Tennessee Department of Labor and Workforce Development). 2017. "Quarterly Census of Employment and Wages (QCEW) for Multiple Industries in Multiple Areas in 2016." Nashville, Tennessee. Accession No. ML18023A324. TN4931.

TDOSHS (Tennessee Department of Safety and Homeland Security). 2017. *Tennessee Traffic Crash Data, County Rankings and Statistics by Emphasis Area 2012–2016*. TITAN Business Unit, Nashville, Tennessee. Accession No. ML18059A134. TN5351.

TDOT (Tennessee Department of Transportation). 2015. *TDOT 25-Year Long-Range Transportation Policy Plan*. Nashville, Tennessee. Accession No. ML18023A326. TN4944.

TDOT (Tennessee Department of Transportation). 2016. "Transportation Projects." Nashville, Tennessee. Accession No. ML18023A328. TN4687.

TDOT (Tennessee Department of Transportation). 2017. "Tennessee Department of Transportation Project Status." Nashville, Tennessee. Accession No. ML18023A330. TN4930.

Tennessee Air Agencies (Chattanooga/Hamilton County Air Pollution Control Bureau; Knox County Health Department, Department of Air Quality Management; Memphis/Shelby County Health Department, Air Pollution Control Program; Metropolitan Health Department, Division of Air Pollution; and Tennessee Department of Environment and Conservation, Air Pollution Control Division). 2010. *Ambient Air Monitoring Plan 2010*. Accession No.ML18026A601. TN4956.

Tennessee Comptroller (Tennessee Comptroller of the Treasury). 2017. "Transparency and Accountability for Government in Tennessee (TAG), FY 2016 Revenue Control Accounts for Anderson, Knox, Loudon, and Roane Counties." Nashville, Tennessee. Accessed August 8, 2017, at http://www.comptroller.tn.gov/TAG/CountyCompare.aspx. TN5001.

Tex. Admin Code 31-675.23. "Importation of Waste from a Non-Compact Generator for Disposal." *Texas Administrative Code.* TN731.

THC (Tennessee Historical Commission). 2003. Letter from H.L. Harper to TVA, dated July 25, 2003, regarding "TVA, Archaeological Assessment, Breeder Reactor Site/120 Acres, Unincorporated, Roane County." Nashville, Tennessee. Accession No. ML18003A389. TN5252.

THC (Tennessee Historical Commission). 2011. Letter from E.P. McIntyre, Jr., to TVA, dated February 28, 2011, regarding "TVA, Archaeological Assessment Management Summary, Clinch River Site Geophysical Test, Unincorporated, Roane County, TN." Nashville, Tennessee. Accession No. ML18003A389. TN5391.

THC (Tennessee Historical Commission). 2011. Letter from E.P. McIntyre, Jr., to TVA, dated March 21, 2011, regarding "TVA, Archaeological Assessment, Clinch River Site Geophysical Test, Unincorporated, Roane County, TN." Nashville, Tennessee. Accession No. ML18026A603. TN5266.

THC (Tennessee Historical Commission). 2011. Letter from E.P. McIntyre to TVA, dated September 12, 2011, regarding "TVA, Phase I Archaeological Assessment, Clinch Small Modular Reactors Proj, Unincorporated, Roane County." Nashville, Tennessee. Accession No. ML17298A064. TN4982.

THC (Tennessee Historical Commission). 2015. Letter from E.P. McIntyre, Jr., to TVA, dated April 7, 2015, regarding "TVA, Archaeological Assessment, Clinch R. Small Modular Reactors, Unincorporated, Roane County, TN." Nashville, Tennessee. Accession No. ML18026A604. TN5263.

THC (Tennessee Historical Commission). 2015. Letter from E.P. McIntyre to TVA, dated May 27, 2015, regarding "TVA, Architectural Survey Report, Clinch River SMR Phase I, Unincorporated, Roane County." Nashville, Tennessee. Accession No. ML18059A135. TN5392.

THC (Tennessee Historical Commission). 2016. Letter from E.P. McIntyre, Jr., to TVA, dated August 23, 2016, regarding "TVA, Revised Area of Potential Effect, Clinch River SMR APE Expansion, Unincorporated, Roane County, TN." Nashville, Tennessee. Accession No. ML18026A605. TN4950.

Thlopthlocco Tribal Town. 2018. Letter from T. Clouthier to NRC, dated February 19, 2018, regarding "Early Site Permit Application for the Clinch River Nuclear Site in Roane County, Tennessee." Tribal Historic Preservation Office, THPO File Number 2018-67, Okemah, Oklahoma. Accession No. ML18051A732. TN5424.

Thomas, Jr., P.M. 1973. *A Map of Two Historic Sites in the Clinch River Liquid Metal Fast Breeder Reactor Plant Area Roane County, Tennessee*. Accession No. ML17298A067. TN4973.

Thomason and Associates. 1991. "National Register of Historic Places Registration Form for George Jones Memorial Baptist Church." Nashville, Tennessee. Accession No. ML18059A136. TN5354.

TIPC (Tennessee Invasive Plant Council). 2009. "Invasive Plants." Nashville, Tennessee. Accessed December 14, 2017, at http://www.tnipc.org/invasive-plants/. TN5308.

Tipler, P.A. and G. Mosca. 2008. *Physics for Scientists and Engineers.* Sixth Edition, W.H. Freeman and Company, New York, New York. TN1467.

TN Aquarium (Tennessee Aquarium). 2017. "Lake Sturgeon." Chattanooga, Tennessee. Accessed October 19, 2017, at http://www.tnaqua.org/our-animals/fish/lake-sturgeon. TN5180.

TNBWG (Tennessee Bat Working Group). 2017. "Tri-Colored Bat." Nashville, Tennessee. Accession No. ML18059A137. TN5359.

TNBWG (Tennessee Bat Working Group). 2017. "White-nose Syndrome in Tennessee." Nashville, Tennessee. Accession No. ML18026A606. TN5043.

TNC (The Nature Conservancy). 2003. *The Cumberlands and Southern Ridge & Valley Ecoregion: A Plan for Biodiversity Conservation.* Arlington, Virginia. Available at https://www.conservationgateway.org/ConservationPlanning/SettingPriorities/EcoregionalReports/Documents/CSRVPlan.pdf. TN5036.

TNDOS (Tennessee Department of State). 2017. "Notice of Rulemaking Hearing., Tennessee Wildlife Resources Agency." Sequence Number 10-9-2017, Nashville, Tennessee. Accession No. ML18026A608. TN5323.

TNHP (Tennessee Natural Heritage Program). 2016. *A Guide to the Rare Animals of Tennessee*. Tennessee Department of Environment & Conservation, Nashville, Tennessee. Accession No. ML18026A609. TN5295.

TNHP (Tennessee Natural Heritage Program). 2017. Email from S. Williams to J. Becker, PNNL, dated September 11, 2017, regarding "Map Package for TN NHP." Nashville, Tennessee. Accession No. ML18026A552. TN5361.

TNSOS (Tennessee Secretary of State). 2017. "Effective Rules and Regulations of the State of Tennessee: 0400 Rules of the Tennessee Department of Environment and Conservation, Division of Water Resources Water Pollution Control." Nashville, Tennessee. Accessed January 23, 2017, at http://share.tn.gov/sos/rules/0400/0400-40/0400-40.htm. TN5071.

TOSHA (Tennessee Occupational Safety and Health Administration). 2017. "Field Operations Manual." Part V of the *Tennessee Occupational Safety and Health Plan.* Nashville, Tennessee. Accession No. ML18059A138. TN5388.

TRC (ThirdRock Consultants, LLC). 2010. *Mollusk Survey of the Tennessee River Near Watts Bar Nuclear Plant (Rhea County, Tennessee).* Lexington, Kentucky, Accession No. ML18026A610. TN5175.

TRC (ThirdRock Consultants, LLC). 2011. *Evaluation of Freshwater Mollusk and Habitat, Clinch River, CRM 15.0 – 19.0, Roane County, Tennessee.* Lexington, Kentucky. Accession No. ML17334A055. TN5168.

TRDA (Tellico Reservoir Development Agency). 2017. "Choose Premier Industrial Sites in Tellico." Vonore, Tennessee. Accessed June 2, 2017, at https://www.tellico.com/. TN4918.

TSP (Tennessee State Parks). 2016. "Big Ridge State Park." Tennessee Department of Environment & Conservation, Nashville, Tennessee. Accessed June 2, 2016, at http://tnstateparks.com/parks/about/big-ridge. TN4683.

TSP (Tennessee State Parks). 2016. "Cove Lake State Park." Tennessee Department of Environment & Conservation, Nashville, Tennessee. Accessed July 8, 2016, at http://tnstateparks.com/parks/about/cove-lake. TN4682.

TSP (Tennessee State Parks). 2016. "Cumberland Mountain State Park." Tennessee Department of Environment & Conservation, Nashville, Tennessee. Accessed June 2, 2016, at http://tnstateparks.com/parks/about/cumberland-mountain. TN4684.

TSP (Tennessee State Parks). 2016. "Fort Loudon State Park." Tennessee Department of Environment & Conservation, Nashville, Tennessee. Accessed June 2, 2016, at http://tnstateparks.com/parks/about/fort-loudoun. TN4680.

TSP (Tennessee State Parks). 2016. "Frozen Head State Park." Tennessee Department of Environment & Conservation, Nashville, Tennessee. Accessed June 2, 2016, at http://tnstateparks.com/parks/about/frozen-head. TN4679.

TSP (Tennessee State Parks). 2016. "Hiwassee/Ocoee State Park." Tennessee Department of Environment & Conservation, Nashville, Tennessee. Accessed June 2, 2016, at http://tnstateparks.com/parks/about/hiwassee-ocoee. TN4686.

TSP (Tennessee State Parks). 2016. "Norris Dam State Park." Tennessee Department of Environment & Conservation, Nashville, Tennessee. Accessed June 2, 2016, at http://tnstateparks.com/parks/about/norris-dam. TN4681.

TSP (Tennessee State Parks). 2016. "Seven Islands State Birding Park." Tennessee Department of Environment & Conservation, Nashville, Tennessee. Accessed June 2, 2016, at http://tnstateparks.com/parks/about/seven-islands. TN4685.

Tucci, P. 1992. *Hydrology of Melton Valley at Oak Ridge National Laboratory, Tennessee*. Water-Resources Investigations Report 92-4131, U.S. Geological Survey, Nashville, Tennessee. Accession No. ML18026A611. TN5034.

TVA (Tennessee Valley Authority). 2003. Letter from J.B. Graham to the Tennessee Division of Archaeology, dated May 28, 2003, regarding "Tennessee Valley Authority, Section 110 Compliance Surveys, Roane County, Tennessee." Knoxville, Tennessee. Accession No. ML18036A919. TN4953.

TVA (Tennessee Valley Authority). 2004. *Programmatic Environmental Impact Statement, Tennessee Valley Authority Reservoir Operations Study Record of Decision.* Knoxville, Tennessee. Accession No. ML17334A041. TN4913.

TVA (Tennessee Valley Authority). 2007. *Kingston Fossil Plant NPDES Permit No. TN0005452 316(b) Monitoring Program, Fish Impingement at Kingston Fossil Plant During 2004 through 2006*. TVA-00025391, Knoxville, Tennessee. Accession No. ML18036A921. TN5055.

TVA (Tennessee Valley Authority). 2009. *Watts Bar Reservoir Land Management Plan, Loudon, Meigs, Rhea, and Roane Counties, Tennessee*. Knoxville, Tennessee. Accession Nos. ML12170A325, ML12170A350. TN4997.

TVA (Tennessee Valley Authority). 2010. Letter from M. Bajestani to NRC, dated April 9, 2010, regarding "Watts Bar Nuclear Plant (WBN) Unit 2 – Response to U.S. Nuclear Regulatory Commission (NRC) Request fro Additional Information Regarding Environmental Review (TAC No. MD8203)." Spring City, Tennessee. Accession No. ML101130393. TN5273.

TVA (Tennessee Valley Authority). 2011. Letter from A.E. Howard to Tennessee Historical Commission, dated February 17, 2011, regarding "Tennessee Valley Authority (TVA), Clinch River Site Characterization Project, Roane County, Tennessee." Knoxville, Tennessee. Accession No. ML18003A389. TN5390.

TVA (Tennessee Valley Authority). 2011. Letter from A.E. Howard to Tennessee Historical Commission, dated March 11, 2011, regarding "Tennessee Valley Authority (TVA), Clinch River Site Characterization Project, Roane County, Tennessee." Knoxville, Tennessee. Accession No. ML18036A926. TN5265.

TVA (Tennessee Valley Authority). 2011. Letter from P.B. Ezzell to Multiple Recipients, dated August 26, 2011, regarding "Tennessee Valley Authority (TVA), Clinch River Small Modular Reactors Project, Phase I Archaeological Survey, Roane County, Tennessee." Knoxville, Tennessee. Accession No. ML18036A924. TN5254.

TVA (Tennessee Valley Authority). 2011. Letter from S.J. Kelly to Tennessee Historical Commission, dated August 26, 2011, regarding "Tennessee Valley Authority (TVA), Clinch River Small Modular Reactors Project, Phase I Archaeological Survey, Roane County, Tennessee." Chattanooga, Tennessee. Accession No. ML18036A928. TN5267.

TVA (Tennessee Valley Authority). 2011. *Natural Resource Plan Alabama, Georgia, Kentucky, Mississippi, North Carolina, Tennessee, and Virginia Final Environmental Impact Statement*. Knoxville, Tennessee. Accession No. ML18036A925. TN5257.

TVA (Tennessee Valley Authority). 2011. *Tennessee Valley Authority Natural Resource Plan*. Chattanooga, Tennessee. Accession No. ML18036A922. TN4998.

TVA (Tennessee Valley Authority). 2012. *A Guide for Environmental Protection and Best Management Practices for Tennessee Valley Authority Transmission Construction and Maintenance Activities*. Revision 2.1-2012, Chattanooga, Tennessee. Accession No. ML18036A929. TN4911.

TVA (Tennessee Valley Authority). 2013. *Biological Monitoring to Characterize the Aquatic Community near the Site of the Proposed Clinch River Small Modular Reactor 2011*. Chattanooga, Tennessee. Accession No. ML17334A058. TN5167.

TVA (Tennessee Valley Authority). 2013. *Energy Delivery Environmental Protection Procedures Right-Of-Way Vegetation Management Guidelines*. Revision 3, Knoxville, Tennessee. Accession No. ML17334A045. TN4996.

TVA (Tennessee Valley Authority). 2014. *Tennessee Valley Authority Strategic Plan Fiscal Years 2014–2018*. Knoxville, Tennessee. Accession No. ML18036A932. TN4957.

TVA (Tennessee Valley Authority). 2015. *Integrated Resource Plan 2015 Final Report*. Knoxville, Tennessee. Accession No. ML18036A937. TN5025.

TVA (Tennessee Valley Authority). 2015. *Kingston Ash Recovery Project Completion Report TVA Kingston Fossil Fuel Plant Release Site, Roane County, Tennessee*. EPA-AO-064, Harriman, Tennessee. Accession No. ML18036A939. TN5274.

TVA (Tennessee Valley Authority). 2015. Letter from C.E. Jones to the Tennessee Historical Commission, dated May 20, 2015, regarding "Tennessee Valley Authority (TVA), Clinch River Small Modular Reactors (SMR) Project, Phase I Architectural Assessment, Roane County, Tennessee 35°55.01' N / 84°23.29' W." Knoxville, Tennessee. Accession No. ML18036A936. TN4981.

TVA (Tennessee Valley Authority). 2015. Letter from C.E. Jones to Tennessee Historical Commission, dated June 22, 2015, regarding "Tennessee Valley Authority (TVA), Draft Programmatic Agreement, Clinch River Small Modular Reactors Project, Roane County, Tennessee." Knoxville, Tennessee. Accession No. ML18036A934. TN4851.

TVA (Tennessee Valley Authority). 2015. Letter from C.E. Jones to Tennessee Historical Commission, dated August 24, 2015, regarding "Programmatic Agreement (PA) Between the Tennessee Valley Authority (TVA) and the Tennessee State Historic Preservation Officer (SHPO) Regarding the Management of Historic Properties Affected by the Clinch River SMR Project." Knoxville, Tennessee. Accession No. ML18036A935. TN4952.

TVA (Tennessee Valley Authority). 2015. Letter from C.E. Jones to the Tennessee Historical Commission, Eastern Band of Cherokee Indians, and United Keetoowah Band of Cherokee Indians in Oklahoma, dated October 9, 2015, regarding "Tennessee Valley Authority (TVA), Programmatic Agreement, the Clinch River SMR Project." Knoxville, Tennessee. Accession No. ML18036A918. TN4954.

TVA (Tennessee Valley Authority). 2015. Letter from P.B. Ezzell to Multiple Recipients, dated April 2, 2015, regarding "Tennessee Valley Authority (TVA), Clinch River Small Modular Reactors Project, Phase I Archaeological Survey, Roane County, Tennessee (Latitude 35.916944, Longitude -84.391389)." Knoxville, Tennessee. Accession No. ML18036A938. TN5256.

TVA (Tennessee Valley Authority). 2015. "Transmission System Projects: Rugby-Sunbright Areas, Tennessee." Knoxville, Tennessee. Accession No. ML18036A933. TN4894.

TVA (Tennessee Valley Authority). 2015. *TVA Clinch River SMR Project Application of Plant Parameter Envelope*. Knoxville, Tennessee. Accession No. ML15119A062. TN5085.

TVA (Tennessee Valley Authority). 2016. "Browns Ferry Nuclear Plant." Knoxville, Tennessee. Accession No. ML18036A953. TN5100.

TVA (Tennessee valley Authority). 2016. "Bull Run Fossil Plant." Knoxville, Tennessee. Accession No. ML18036A943. TN4649.

TVA (Tennessee Valley Authority). 2016. "Clinch River Nuclear Site Early Site Permit Application, Part 02—Site Safety Analysis Report (Revision 0)." Chattanooga, Tennessee. Accession No. ML16144A074. TN5018.

TVA (Tennessee Valley Authority). 2016. "Clinch River Nuclear Site Early Site Permit Application, Part 03—Environmental Report (Revision 0)." Chattanooga, Tennessee. Accession No. ML16144A145. TN4637.

TVA (Tennessee Valley Authority). 2016. "Douglas." Knoxville, Tennessee. Accession No. ML18036A949. TN4666.

TVA (Tennessee Valley Authority). 2016. "Fontana." Knoxville, Tennessee. Accession No. ML18036A948. TN4665.

TVA (Tennessee Valley Authority). 2016. "Fort Loudon." Knoxville, Tennessee. Accession No. ML18036A945. TN4659.

TVA (Tennessee Valley Authority). 2016. "Guntersville." Knoxville, Tennessee. Accession No. ML18036A955. TN5102.

TVA (Tennessee Valley Authority). 2016. "Kingston Fossil Plant." Knoxville, Tennessee. Accession No. ML18036A942. TN4647.

TVA (Tennessee Valley Authority). 2016. Letter from C.E. Jones to Tennessee Historical Commission, dated August 18, 2016, regarding "Tennessee Valley Authority (TVA), Clinch River Small Modular Reactors Project, APE Expansion to Include Melton Hill Dam, Roane County, Tennessee 35° 55.01' N/84° 23.29' W and 35° 53.18'N/84° 18.01'W." Knoxville, Tennessee. Accession No. ML18036A959. TN5259.

TVA (Tennessee Valley Authority). 2016. Letter from J.W. Shea to NRC, dated May 12, 2016, regarding "Application for Early Site Permit for Clinch River Nuclear Site." CNL-16-081, Oak Ridge, Tennessee. Accession No. ML16139A752. TN5002.

TVA (Tennessee Valley Authority). 2016. Letter from J.W. Shea to NRC, dated June 10, 2016, regarding "Submittal of Meteorological Data in Support of Early Site Permit Application for Clinch River Nuclear Site." CNL-16-097, Chattanooga, Tennessee. Accession No. ML16168A212. TN5014.

TVA (Tennessee Valley Authority). 2016. Letter from J.W. Shea to NRC, dated June 23, 2016, regarding "Submittal of Calculation Input and Output Files in Support of Early Site Permit Application for Clinch River Nuclear Site." CNL-16-103, Chattanooga, Tennessee. Accession No. ML16180A307. TN5284.

TVA (Tennessee Valley Authority). 2016. Letter from J.W. Shea to NRC, dated December 2, 2016, regarding "Submittal of Supplemental Information Regarding Radiation Protection and Accident Consequences in Support of Early Site Permit Application for Clinch River Nuclear Site." CNL-16-191, Chattanooga, Tennessee. Accession No. ML16340A258. TN5019.

TVA (Tennessee Valley Authority). 2016. Letter from J.W. Shea to NRC, dated December 8, 2016, regarding "Submittal of Supplemental Information Alternate Cooling Water Systems in Support of Early Site Permit Application for Clinch River Nuclear Site." CNL-16-198, Chattanooga, Tennessee. Accession No. ML16344A061. TN5243.

TVA (Tennessee Valley Authority). 2016. Letter from J.W. Shea to NRC, dated December 12, 2016, regarding "Submittal of Cultural Reports and Programmatic Agreement in Support of Early Site Permit Application for Clinch River Nuclear Site; Enclosure 2, *Supplemental Historic and Cultural Resource Information*." CNL-16-154, Chattanooga, Tennessee. Accession No. ML17284A315. TN5318.

TVA (Tennessee Valley Authority). 2016. Letter from J.W. Shea to NRC, dated December 12, 2016, regarding "Submittal of Cultural Reports and Programmatic Agreement in Support of Early Site Permit Application for Clinch River Nuclear Site; Enclosure 3, *Correspondence with Native American Tribes Regarding the Cultural Resources Consultation Associated with the Proposed Clinch River SMR Project*." CNL-16-154, Chattanooga, Tennessee. Accession No. ML17284A316. TN5319.

TVA (Tennessee Valley Authority). 2016. Letter from J.W. Shea to NRC, dated December 13, 2016, regarding "Submittal of Supplemental Information Regarding Terrestrial Ecology in Support of Early Site Permit Application for Clinch River Nuclear Site." CNL-16-200, Chattanooga, Tennessee. Accession No. ML16348A552. TN5145.

TVA (Tennessee Valley Authority). 2016. Letter from J.W. Shea to NRC, dated December 15, 2016, regarding "Submittal of Supplemental Information Related to Site Selection in Support of the Early Site Permit Application for Clinch River Nuclear Site." CNL-16-190, Chattanooga, Tennessee. Accession No. ML6350A429. TN5040.

TVA (Tennessee Valley Authority). 2016. Letter from J.W. Shea to NRC, dated December 16, 2016, regarding "Submittal of Supplemental Information Regarding Aquatic Ecology in Support of Early Site Permit Application for Clinch River Nuclear Site." CNL-16-201. Chattanooga, Tennessee. Accession No. ML16356A485. TN5008.

TVA (Tennessee Valley Authority). 2016. "Melton Hill." Knoxville, Tennessee. Accession No. ML18036A944. TN4658.

TVA (Tennessee Valley Authority). 2016. "Norris." Knoxville, Tennessee. Accession No. ML18036A946. TN4660.

TVA (Tennessee Valley Authority). 2016. "Sequoyah Nuclear Plant." Knoxville, Tennessee. Accession No. ML18036A940. TN4639.

TVA (Tennessee Valley Authority). 2016. "Tellico." Knoxville, Tennessee. Accession No. ML18036A952. TN5010.

TVA (Tennessee Valley Authority). 2016. "Tims Ford." Knoxville, Tennessee. Accession No. ML18036A957. TN5104.

TVA (Tennessee Valley Authority). 2016. "TVA Completes Bellefonte Sale." Knoxville, Tennessee. Accession No. ML18036A954. TN5101.

TVA (Tennessee Valley Authority). 2016. "Watts Bar." Knoxville, Tennessee. Accession No. ML18036A947. TN4664.

TVA (Tennessee Valley Authority). 2016. "Watts Bar Nuclear Plant." Knoxville, Tennessee. Accession No. ML18036A941. TN4642.

TVA (Tennessee Valley Authority). 2016. "Watts Bar Unit 2 Complete and Commercial." Knoxville, Tennessee. Accession No. ML18036A951. TN4895.

TVA (Tennessee Valley Authority). 2016. "Wheeler." Knoxville, Tennessee. Accession No. ML18036A956. TN5103.

TVA (Tennessee Valley Authority). 2017. *A Guide for Environmental Protection and Best Management Practices for Tennessee Valley Authority Construction and Maintenance Activities, Revision 3*. G. Behel, S. Benefield, R. Brannon, C. Buttram, G. Dalton, C. Ellis, C. Henley, T. Korth, T. Giles, A. Masters, J. Melton, R. Smith, J.Turk, T. White, and R. Wilson (eds.). Chattanooga, Tennessee. Accession No. ML18036A963. TN5176.

TVA (Tennessee Valley Authority). 2017. *Annual Radiological Environmental Operating Report, Watts Bar Nuclear Plant 2016*. Spring City, Tennessee. Accession No. ML17135A145. TN5082.

TVA (Tennessee Valley Authority). 2017. *Bull Run Fossil Plant Landfill Final Environmental Impact Statement, Anderson County, Tennessee*. Chattanooga, Tennessee. Accession No. ML18036A961. TN5076.

TVA (Tennessee Valley Authority). 2017. "Clinch River Nuclear Site Early Site Permit Application, Part 02—Site Safety Analysis Report (Revision 1)." Chattanooga, Tennessee. Accession No. ML18003A374. TN5387.

TVA (Tennessee Valley Authority). 2017. "Clinch River Nuclear Site Early Site Permit Application, Part 03—Environmental Report (Revision 1)." Chattanooga, Tennessee. Accession No. ML18003A471. TN4921.

TVA (Tennessee Valley Authority). 2017. "Clinch River Nuclear Site Early Site Permit Application, Part 5A—Emergency Plan (Site Boundary EPZ) (Revision 1)." Chattanooga, Tennessee. Accession No. ML18003A475. TN5443.

TVA (Tennessee Valley Authority). 2017. "Clinch River Nuclear Site Early Site Permit Application, Part 5B—Emergency Plan (2-Mile EPZ) (Revision 1)." Chattanooga, Tennessee. Accession No. ML18003A480. TN5442.

TVA (Tennessee Valley Authority). 2017. "Clinch River Nuclear Site Early Site Permit Application, Part 06—Exemptions and Departures (Revision 1)." Chattanooga, Tennessee. Accession No. ML18003A487. TN5444.

TVA (Tennessee Valley Authority). 2017. *Finding of No Significant Impact, Tennessee Valley Authority Rugby-Sunbright Power Supply Improvements*. Chattanooga, Tennessee. Accession No. ML18036A960. TN5045.

TVA (Tennessee Valley Authority). 2017. "Hydroelectric." Knoxville, Tennessee. Accession No. ML18036A967. TN5241.

TVA (Tennessee Valley Authority). 2017. "Lake Levels." Knoxville, Tennessee. Accession No. ML18036A968. TN5242.

TVA (Tennessee Valley Authority). 2017. Letter from J.W. Shea to NRC, dated March 1, 2017, regarding "Submittal of Calculation Input and Output Files in Support of Early Site Permit Application for Clinch River Nuclear Site." CNL-17-032, Chattanooga, Tennessee. Accession No. ML17065A269. TN5093.

TVA (Tennessee Valley Authority). 2017. Letter from J.W. Shea to NRC, dated March 10, 2017, regarding "Submittal of Tribal Consultation Letter in Support of Early Site Permit Application for Clinch River Nuclear Site." CNL-17-040, Chattanooga, Tennessee. Accession No. ML17072A224. TN5246.

TVA (Tennessee Valley Authority). 2017. Letter from J.W. Shea to NRC, dated July 7, 2017, regarding "Submittal of Supplemental Information Related to the Environmental Audit in Support of Early Site Permit Application for Clinch River Nuclear Site." CNL-17-088, Chattanooga, Tennessee. Accession No. ML17206A091. TN4920.

TVA (Tennessee Valley Authority). 2017. Letter from J.W. Shea to NRC, dated August 1, 2017, regarding "Submittal of Supplemental Information Related to the Environmental Audit in Support of Early Site Permit Application for Clinch River Nuclear Site." CNL-17-097, Chattanooga, Tennessee. Accession No. ML17234A003. TN4922.

TVA (Tennessee Valley Authority). 2017. Letter from J.W. Shea to NRC, dated August 21, 2017, regarding "Submittal of Supplemental Information Related to the Environmental Audit in Support of Early Site Permit Application for Clinch River Nuclear Site." CNL-17-113, Chattanooga, Tennessee. Accession No. ML17233A298. TN5028.

TVA (Tennessee Valley Authority). 2017. Letter from J.W. Shea to NRC, dated August 25, 2017, regarding "Supplemental Information Related to Groundwater Hydrology in Support of Early Site Permit Application for Clinch River Nuclear Site." CNL-17-115, Chattanooga, Tennessee. Accession No. ML17237C084. TN4987.

TVA (Tennessee Valley Authority). 2017. Letter from J.W. Shea to NRC, dated September 5, 2017, regarding "Supplemental Information Related to Environmental Report Figures in Support of Early Site Permit Application for Clinch River Nuclear Site." CNL-17-118, Chattanooga, Tennessee. Accession No. ML17346B286. TN5226.

TVA (Tennessee Valley Authority). 2017. "Melton Hill." Knoxville, Tennessee. Accession No. ML18036A966. TN5240.

TVA (Tennessee Valley Authority). 2017. "Norris." Knoxville, Tennessee. Accession No. ML18036A965. TN5239.

TVA (Tennessee Valley Authority). 2017. "Wheeler Reservoir: Ecological Health Indicators at Wheeler Reservoir – 2011." Knoxville, Tennessee. Accession No. ML18036A962. TN5099.

TVA (Tennessee Valley Authority). 2017. "Wheeler Spring Sport Fish Survey Results." Knoxville, Tennessee. Accession No. ML18036A964. TN5190.

TVA (Tennessee Valley Authority). 2018. Letter from J.W. Shea to NRC, dated January 22, 2018, regarding "Response to Request for Additional Information Related to Emergency Planning Exemption Requests in Support of Early Site Permit Application for Clinch River Nuclear Site." CNL-18-009, Chattanooga, Tennessee. Accession No. ML18022A917. TN5407.

TVA (Tennessee Valley Authority). 2018. Letter from J.W. Shea to NRC, dated February 20, 2018, regarding "Replacement Pages for Response to Request for Additional Information Related to Emergency Planning Exemption Requests in Support of Early Site Permit Application for Clinch River Nuclear Site." CNL-18-019, Chattanooga, Tennessee. Accession No. ML18052A085. TN5427.

TVA (Tennessee Valley Authority) and TSHPO (Tennessee State Historic Preservation Office). 2016. "Programmatic Agreement Between the Tennessee Valley Authority and Tennessee State Historic Preservation Office Regarding the Management of Historic Properties Affected by the Clinch River SMR Project." TVA, Knoxville Tennessee and TSHPO, Nashville, Tennessee. Accession No. ML17296A399. TN5298.

TVA (Tennessee Valley Authority), U.S. Army Corps of Engineers, U.S. Department of Energy, U.S. Environmental Protection Agency, and Tennessee Department of Health and Environment. 1991. *Interagency Agreement, Watts Bar Reservoir Permit Coordination*. Nashville, Tennessee. Accession No. ML18059A139. TN5345.

TWRA (Tennessee Wildlife Resources Agency). Undated. "Asian Carp in Tennessee." Nashville, Tennessee. Accession No. ML18026B227. TN5276.

TWRA (Tennessee Wildlife Resources Agency). 2006. "IBA: Oak Ridge Reservation." Nashville, Tennessee. Accession No. ML18026B228. TN5301.

TWRA (Tennessee Wildlife Resources Agency). 2015. *Tennessee State Wildlife Action Plan 2015*. Nashville, Tennessee. Accessed February 1, 2018, at http://www.tnswap.com/pdf/2015swap.pdf. TN5042.

TWRA (Tennessee Wildlife Resources Agency). 2016. "Tennessee Fish and Wildlife Commission Proclamation 16-21 Statewide Proclamation on the Commercial Taking of Fish and Turtles." Nashville, Tennessee. Accession No. ML18026B229. TN5171.

TWRA (Tennessee Wildlife Resources Agency). 2017. Email from B. Flock to J. Becker, PNNL, dated November 3, 2017, regarding "Clinch River Small Modular Nuclear Reactor Project." Nashville, Tennessee. Accession No. ML18064A895. TN5362.

TWRA (Tennessee Wildlife Resources Agency). 2017. Emails from P. Black to J. Becker, Pacific Northwest National Laboratory, dated August 16-September 6, 2017, regarding "Watts Bar Creel Survey Report." Nashville, Tennessee. Accession No. ML18022A346. TN5410.

TWRA (Tennessee Wildlife Resources Agency). 2017. "Warmwater Stocking, 10/12/2017." Nashville, Tennessee. Accession No. ML18026B231. TN5170.

UKB (United Keetoowah Band of Cherokee Indians in Oklahoma). 2011. Email from L. Larue to TVA, dated August 29, 2011, regarding "Corrections RE: TVA, Clinch River small Modular Reactors Project, Phase I Archaeological Survey, Roane County, Tennessee." Tahlequah, Oklahoma. Accession No. ML18026B232. TN5255.

UKB (United Keetoowah Band of Cherokee Indians in Oklahoma). 2017. Email from K. Pritchett to NRC, dated June 28, 2017, regarding "Clinch River Nuclear Site, Roane County, Tennessee." Tahlequah, Oklahoma. Accession No. ML17206A450. TN5249.

University of Chicago. 2012. *The Economic Impact of Redstone Arsenal*. Chicago, Illinois. Accessed October 19, 2017, at http://hsvchamber.org/images/CommunityData/economicreports/redstone_economic_impact_analysis_may.pdf. TN5136.

USACE (U.S. Army Corps of Engineers). 1987. *Corps of Engineers Wetlands Delineation Manual*. Wetlands Research Program Technical Report Y-87-1, Environmental Laboratory, Vicksburg, Mississippi. Accession No. ML042790476. TN2066.

USACE (U.S. Army Corps of Engineers). 2010. *Interim Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Eastern Mountains and Piedmont Region*. ERDC/EL TR-10-9, Engineer Research and Development Center, Vicksburg, Mississippi. Accession No. ML18026B233. TN5325.

USACE (U.S. Army Corps of Engineers). 2016. "Chickamauga Lock Replacement Project Work Restarts." *District Digest*, Nashville District Public Affairs Office, Nashville, Tennessee. Accession No. ML18026B237. TN5079.

USACE (U.S. Army Corps of Engineers). 2016. Letter from T. Turley to NRC, dated May 2, 2017, regarding "Invitation to Participate as a Cooperating Agency in Preparation of an Environmental Impact Statement for the Tennessee Valley Authority Early Site Permit Application at the Clinch River Nuclear Site, Roane County, Tennessee." Nashville, Tennessee. Accession No. ML17205A413. TN5003.

USACE (U.S. Army Corps of Engineers). 2016. *Waterborne Commerce of the United States Calendar Year 2015. Part 2: Waterways and Harbors Gulf Coast, Mississippi River System, and Antilles*. IWR-WCUS-15-2, Institute for Water Resources, Washington, D.C. Accession No. ML18026B236. TN4949.

USACE (U.S. Army Corps of Engineers) and NRC (U.S. Nuclear Regulatory Commission). 2008. "Memorandum of Understanding Between U.S. Army Corps of Engineers and U.S. Nuclear Regulatory Commission on Environmental Reviews Related to the Issuance of Authorizations to Construct and Operate Nuclear Power Plants." Washington, D.C. Accession No. ML082540354. TN637.

USCB (U.S. Census Bureau). 2000. "Overview of Race and Hispanic Origin 2000." Washington, D.C. Accession No. ML100890583. TN2488.

USCB (U.S. Census Bureau). 2016. "ACS Demographic and Housing Estimates; 2010–2014 American Community Survey 5–Year Estimates; Tennessee, Kentucky, North Carolina, Census Block Group data for Table B17021 and Table B03002." Washington, D.C. Accession No. ML18026B240. TN5149.

USCB (U.S. Census Bureau). 2016. "American Fact Finder: Race, Universe Total Population 2011–2015, American Community Survey 5-Year Estimates." B02001, Washington, D.C. Accession No. ML18026B241. TN5333.

USCB (U.S. Census Bureau). 2016. *Income and Poverty in the United States: 2015.* P60-256, U.S. Government Printing Office, Washington, D.C. Available at https://www.census.gov/library/publications/2016/demo/p60-256.html. TN5458.

USCB (U.S. Census Bureau). 2016. "Quick Facts: Population by Geography for the Cities of Lenoir, Harriman, Kingston, and Oak Ridge and the State of Tennessee." Washington, D.C. Accession No. ML18026B238. TN4933.

USCB (U.S. Census Bureau). 2016. "Quick Facts: Tennessee Population Estimates, July 1, 2016." Washington, D.C. Accession No. ML18026B239. TN4965.

USCB (U.S. Census Bureau). 2017. "2009–2013 5-Year American Community Survey Commuting Flows." Washington, D.C. Accession No. ML18026B244. TN4938.

USCB (U.S. Census Bureau). 2017. "American Fact Finder: Age and Sex, 2011–2015 American Community Survey 5-Year Estimates, Anderson, Knox, Loudon, and Roane Counties, Tennessee." Washington, D.C. Accession No. ML18065A005. TN4934.

USCB (U.S. Census Bureau). 2017. "American Fact Finder: Hispanic or Latino Origin by Race, 2011–2015 American Community Survey 5-Year Estimates, Anderson, Knox, Loudon, and Roane Counties, Tennessee." Washington, D.C. Accession No. ML18026B243. TN4937.

USCB (U.S. Census Bureau). 2017. "American Fact Finder: Selected Economic Characteristics, 2011–2015 American Community Survey 5-Year Estimates, Anderson, Knox, Loudon, and Roane Counties, Tennessee." Washington, D.C. Accession No. ML18026B242. TN4936.

USCB (U.S. Census Bureau). 2017. "American Fact Finder: Selected Housing Characteristics, 2011–2015 American Community Survey 5-Year Estimates, Anderson, Knox, Loudon, and Roane Counties, Tennessee." Washington, D.C. Accession No. ML18026B246. TN4939.

USCB (U.S. Census Bureau). 2017. "American Fact Finder: Selected Housing Characteristics, 2011–2015 American Community Survey 5-Year Estimates, Limestone, Madison, Marshall, and Morgan Counties, Alabama." Washington, D.C. Accession No. ML18026B248. TN5140.

USCB (U.S. Census Bureau). 2017. "Quick Facts: Alabama." Washington, D.C. Accession No. ML18026B247. TN5137.

USDA (U.S. Department of Agriculture). 2014. "2012 Census of Agriculture, Tennessee State and County Data." National Agricultural Statistic Service, Washington, D.C. Accession No. ML18026B249. TN4940.

USDA (U.S. Department of Agriculture). 2016. "Daniel Boone National Forest." Forest Service, Washington, D.C. Accession No. ML18026B250. TN4678.

USDA (U.S Department of Agriculture). 2017. "Bankhead National Forest." Washington, D.C. Accession No. ML18026B251. TN5115.

USDOT (U.S. Department of Transportation). 2004. *Synthesis of Noise Effects on Wildlife Populations*. Publication No. FHWA-HEP-06-016, Washington, D.C. Accession No. ML18026B252. TN5156.

USEC (U.S. Enrichment Corporation). 2013. Letter from S. Toelle to NRC, dated June 3, 2013, regarding "Paducah Gaseous Diffusion Plant, Docket No. 70-7001, Certificate No. GDP-1, Notification of Termination of Uranium Enrichment." Bethesda, Maryland. Accession No. ML13176A151. TN2765.

USGS (U.S. Geological Survey). 1998. "Ecoregions of Tennessee." Washington, D.C. Accession No. ML18026B253. TN5159.

USGS (U.S. Geological Survey). 2016. "Land Cover Trends Project: Ridge and Valley." Denver, Colorado. Accession No. ML18026B254. TN5035.

USGS (U.S. Geological Survey). 2017. "National Water Information System: USGS Surface-Water Annual Statistics for Tennessee, Site 03528000 Clinch River above Tazewell, TN and Site 03533000 Clinch River below Norris Dam, TN." Washington, D.C. Accession No. ML18026B257. TN5286.

USGS (U.S. Geological Survey). 2017. "Nonindigenous Aquatic Species Database Query–Major Drainage Area Hydrologic Unit Code 60102 for Upper Tennessee." Gainesville, Florida. Accession No. ML18026B256. TN5066.

USGS (U.S. Geological Survey). 2017. "Nonindigenous Aquatic Species Database Query–Major Drainage Area Hydrologic Unit Code 60300 for Middle Tennessee." Gainesville, Florida. Accession No. ML18026B255. TN5065.

UTK (University of Tennessee Knoxville). 2015. "Boyd Center Population Projections." Knoxville, Tennessee. Accession No. ML18026B258. TN4935.

Valk, D., D. Price, and J.W. Joseph. 2011. *Archaeological Survey and Testing of the Happy Valley Worker Camp, Roane County, Tennessee*. New South Associates Technical Report 1908, Nashville, Tennessee. Accession No. ML17296A404. TN4972.

Vishay. 2016. "Vishay – Manufacturer of Discrete Semiconductors and Passive Components." Malvern, Pennsylvania. Accession No. ML18026B259. TN5126.

Vissolis (Vissolis Inc.). 2016. "Oak Ridge Solar Park, TN." Franklin, Tennessee. Accessed June 2, 2016, at http://vissolis.us/projects-reader/oak-ridge-solar-park-vissolis.html. TN4654.

Visvesvara, G.S., H. Moura, and F.L. Schuster. 2007. "Pathogenic and Opportunistic Free-Living Amoebae: *Acanthamoeba* spp., *Balamuthia mandrillaris*, *Naegleria fowleri*, and *Sappinia diploidea*." *FEMS Immunology and Medical Microbiology* 50:1–26, Malden, Massachusetts. TN4907.

Weiner, R.F., D. Hinojosa, T.J. Heames, C. Ottinger Farnum, and E.A. Kalinina. 2013. *RADTRAN 6/RadCat 6 User Guide.* SAND2013–8095, Sandia National Laboratories, Albuquerque, New Mexico. Accession No. ML14286A092. TN3390.

Weiner, R.F., K.S. Neuhauser, T.J. Heames, B.M. O'Donnell, and M.L. Dennis. 2014. *RADTRAN 6 Technical Manual*. SAND2013-0780, Sandia National Laboratories, Albuquerque, New Mexico. Accession No. ML14286A085. TN3389.

Wells, J.V., D.K. Niven, and J. Cecil. 2005. "The Important Bird Areas Program in the United States: Building a Network of Sites for Conservation, State by State." In *Bird Conservation Implementation and Integration in the Americas: Proceedings of the Third International Partners in Flight Conference, March 20–24, 2002, Asilomar, California*. USDA Forest Service, PSW-GTR-191, Albany, California. Accession No. ML14265A511. TN133.

Westinghouse (Westinghouse Electric Company LLC). 2013. "Westinghouse Small Modular Reactor Overview." Presented to Nuclear Regulatory Commission Open Forum, April 2, 2013. Accession No. ML13095A190. TN5234.

White, D., K. Johnson, and M. Miller. 2005. "Ohio River Basin." Chapter 9 in *Rivers of North America*. A.C. Benke and C.E. Cushing (eds.). Elsevier Academic Press, New York, New York. TN5052.

WHO (World Health Organization). 2007. *Extremely Low Frequency Fields*. Environmental Health Criteria 238, Geneva, Switzerland. Available at http://www.who.int/peh-emf/publications/elf_ehc/en/. TN1272.

Wiken, E., F. Jiménez Nava, and G. Griffith. 2011. *North American Terrestrial Ecoregions-Level III.* Commission for Environmental Cooperation, Montreal, Canada. Available at http://www3.cec.org/islandora/en/item/10415-north-american-terrestrial-ecoregionslevel-iii-en.pdf. TN2744.

WIMS (Waste Information Management System). 2017. "Waste Stream Report for Oak Ridge, Tennessee, 2017." Florida Applied Research Center, Miami, Florida. Accessed June 29, 2017, at http://www.emwims.org. TN5070.

WNA (World Nuclear Association). 2012. "Supply of Uranium." London, United Kingdom. Available at http://www.world-nuclear.org/info/Nuclear-Fuel-Cycle/Uranium-Resources/Supply-of-Uranium/. TN1498.

Woods, A.J., J.M. Omernik, and D.D. Brown. 1999. *Level III and Level IV Ecoregions of Delaware, Maryland, Pennsylvania, Virginia, and West Virginia*. U.S. Environmental Protection Agency, Corvallis, Oregon. Accession No. ML083220457. TN1805.

Woods, A.J., J.M. Omernik, and D.D. Brown. 2003. "Map of Level III and Level IV Ecoregions of EPA Region 3." U.S. Environmental Protection Agency, Corvallis, Oregon. Accession No. ML14252A897. TN1806.

WSDOT (Washington State Department of Transportation). 2017. "Construction Noise Impact Assessment." Chapter 7 in *Biological Assessment Preparation for Transportation Projects – Advanced Training Manual*. Olympia, Washington. Accessed December 15, 2017, at https://www.wsdot.wa.gov/Environment/Biology/BA/BAguidance.htm. TN5313.

Yoder, J., B. Eddy, G. Visvesvara, L. Capewell, and M. Beach. 2010. "The Epidemiology of Primary Amoebic Meningoencephalitis in the USA, 1962–2008." *Epidemiology and Infection* 138(7), 968–975, Cambridge, England. TN5009.

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Docket 52-047

11. ABSTRACT (200 words or less)

This environmental impact statement (EIS) has been prepared in response to an application to the U.S. Nuclear Regulatory Commission (NRC) by Tennessee Valley Authority (TVA) for an early site permit (ESP). The U.S. Army Corps of Engineers (USACE) is a cooperating agency on this EIS. This EIS includes the analysis by the NRC and USACE staff, which considers and weighs the environmental impacts of building, operating and decommissioning two or more SMRs at the CRN Site.

After considering the environmental impacts of the proposed NRC action, the NRC staff's preliminary recommendation to the Commission is that the ESP be issued as requested. The recommendation is based on (1) the application and supplemental information submitted by TVA, including Revision 1 of the Environmental Report (ER); (2) consultation with Federal, State, Tribal and local agencies; (3) the staff's independent review; (4) the staff's consideration of comments related to the environmental review that were received during the public scoping process; and (5) the assessments summarized in the EIS, including the potential mitigation measures identified in the ER and this EIS.

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