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NUREG-1437
Supplement 53

Generic Environmental Impact Statement for License Renewal of Nuclear Plants

Supplement 53

Regarding Sequoyah Nuclear Plant, Units 1 and 2

Draft Report for Comment

Office of Nuclear Reactor Regulation

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Regarding Sequoyah Nuclear Plant, Units 1 and 2

Draft Report for Comment

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Title: *Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 53, Regarding Sequoyah Nuclear Plant, Units 1 and 2, Draft Report for Comment* (NUREG-1437). Sequoyah Nuclear Plant (SQN), Units 1 and 2, are located in Hamilton County, Tennessee.

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ABSTRACT

This supplemental environmental impact statement (SEIS) has been prepared in response to an application submitted by Tennessee Valley Authority (TVA) to renew the operating license for Sequoyah Nuclear Plant, Units 1 and 2 (SQN), for an additional 20 years.

This SEIS includes the preliminary analysis that evaluates the environmental impacts of the proposed action and alternatives to the proposed action. Alternatives considered include: natural gas combined-cycle generation, supercritical pulverized coal generation, new nuclear generation, combination wind and solar generation, and no renewal of the license (the no-action alternative).

The U.S. Nuclear Regulatory Commission's (NRC's) preliminary recommendation is that the adverse environmental impacts of license renewal for SQN are not great enough to deny the option of license renewal for energy-planning decisionmakers. This recommendation is based on the following:

- the analysis and findings in NUREG–1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*;
- the Environmental Report submitted by TVA;
- consultation with Federal, State, local, and Tribal government agencies;
- the NRC's environmental review; and
- consideration of public comments received during the scoping process.

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EXECUTIVE SUMMARY

BACKGROUND

By letter dated January 7, 2013, Tennessee Valley Authority (TVA), submitted an application to the U.S. Nuclear Regulatory Commission (NRC) to issue renewed operating licenses for Sequoyah Nuclear Plant, Units 1 and 2 (SQN) for an additional 20-year period.

Pursuant to Title 10 of the *Code of Federal Regulations* 51.20(b)(2) (10 CFR 51.20(b)(2)), the renewal of a power reactor operating license requires preparation of an environmental impact statement (EIS) or a supplement to an existing EIS. In addition, 10 CFR 51.95(c) states that, in connection with the renewal of an operating license, the NRC shall prepare an EIS, which is a supplement to the Commission's NUREG-1437, *Generic Environmental Impact Statement (GEIS) for License Renewal of Nuclear Plants*.

Upon acceptance of TVA's application, the NRC staff began the environmental review process described in 10 CFR Part 51 by publishing a Notice of Intent to prepare a supplemental EIS (SEIS) and conduct scoping. In preparation of this SEIS for SQN, the NRC staff performed the following:

- conducted public scoping meetings on April 3, 2013, in Soddy-Daisy, Tennessee;
- conducted a site audit at SQN on April 7–11, 2013;
- reviewed TVA's Environmental Report and compared it to the GEIS;
- consulted with Federal, state, and local agencies;
- conducted a review of the issues following the guidance set forth in NUREG-1555, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants, Supplement 1, Revision 1: Operating License Renewal*; and
- considered public comments received during the scoping process.

PROPOSED FEDERAL ACTION

TVA initiated the proposed Federal action—issuing renewed power reactor operating licenses—by submitting an application for license renewal of SQN, for which the existing licenses (DPR-77 and DPR-79) expire on September 17, 2020, and September 15, 2021, respectively. The NRC's Federal action is the decision whether or not to renew the licenses for an additional 20 years. In accordance with 10 CFR 2.109, if a licensee of a nuclear power plant files an application to renew an operating license at least 5 years before the expiration date of that license, the existing license will not be deemed to have expired until the safety and environmental reviews are completed and the NRC has made a final decision to either deny the application or issue a renewed license for the additional 20 years.

PURPOSE AND NEED FOR THE PROPOSED FEDERAL ACTION

The purpose and need for the proposed action (issuance of renewed licenses) is to provide an option that allows for power generation capability beyond the term of the current nuclear power plant operating license to meet future system generating needs. Such needs may be determined by other energy-planning decisionmakers, such as state, utility, and, where authorized, Federal agencies (other than NRC). This definition of purpose and need reflects the NRC's recognition that, unless there are findings in the safety review required by the Atomic Energy Act or findings in the National Environmental Policy Act (NEPA) environmental analysis that would lead the NRC to reject a license renewal application, the NRC does not have a role in the energy-planning decisions as to whether a particular nuclear power plant should continue to operate.

ENVIRONMENTAL IMPACTS OF LICENSE RENEWAL

The SEIS evaluates the potential environmental impacts of the proposed action. The environmental impacts from the proposed action are designated as SMALL, MODERATE, or LARGE. As set forth in the GEIS, Category 1 issues are those that meet all of the following criteria:

- The environmental impacts associated with the issue are determined to apply either to all plants or, for some issues, to plants having a specific type of cooling system or other specified plant or site characteristics.
- A single significance level (i.e., SMALL, MODERATE, or LARGE) has been assigned to the impacts, except for collective offsite radiological impacts from the fuel cycle and from high-level waste and spent fuel disposal.
- Mitigation of adverse impacts associated with the issue is considered in the analysis, and it has been determined that additional plant-specific mitigation measures are likely not to be sufficiently beneficial to warrant implementation.

> **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.

For Category 1 issues, no additional site-specific analysis is required in this SEIS unless new and significant information is identified. Chapter 4 of this SEIS presents the process for identifying new and significant information. Site-specific issues (Category 2) are those that do not meet one or more of the criteria for Category 1 issues; therefore, an additional site-specific review for these non-generic issues is required, and the results are documented in the SEIS.

Neither TVA nor NRC identified information that is both new and significant related to Category 1 issues that would call into question the conclusions in the GEIS. This conclusion is supported by the NRC's review of the applicant's ER and other documentation relevant to the applicant's activities, the public scoping process and substantive comments raised, and the findings from the environmental site audit conducted by the NRC staff. The NRC staff, therefore, relies upon the conclusions of the GEIS for all Category 1 issues applicable to SQN.

Table ES-1 summarizes the Category 2 issues relevant to SQN as well as the NRC staff's findings related to those issues. If the NRC staff determined that there were no Category 2 issues applicable for a particular resource area, the findings of the GEIS, as documented in Appendix B to Subpart A of 10 CFR Part 51, are incorporated for that resource area.

Table ES–1. Summary of NRC Conclusions Relating to Site-Specific Impacts of License Renewal

Resource Area	Relevant Category 2 Issues	Impacts
Surface Water Resources	Surface water use conflicts	SMALL
Groundwater Resources	Radionuclides released to groundwater	SMALL
Terrestrial Resources	Effects on terrestrial resources (non-cooling system impacts)	SMALL
	Water use conflicts with terrestrial resources (plants with cooling ponds or cooling towers using makeup water from a river)	SMALL
Aquatic Resources	Impingement and entrainment of aquatic organisms	SMALL
	Thermal impacts on aquatic organisms	SMALL
	Water use conflicts with aquatic resources	SMALL
Special Status Species	Threatened or endangered species	No effect[a]
Historic and Cultural	Historic and cultural resources	No adverse effect[b]
Human Health	Microbiological hazards to the public health Electric shock hazards	SMALL
Environmental Justice	Minority and low-income populations	See note below[c]
Cumulative Impacts	Surface Water	SMALL-MODERATE
	Terrestrial resources	MODERATE
	Aquatic resources	LARGE
	Environmental Justice	See note below[c]
	Global Climate Change	MODERATE
	All other resource areas	SMALL

[a] For Federally protected species, the NRC reports the effects from continued operation of SQN during the license renewal period in terms of its Endangered Species Act (ESA) findings of “no effect,” “may effect, but not likely to adversely effect,” or “may affect, and is likely to adversely affect.”

[b] The National Historic Preservation Act of 1966, as amended (NHPA) requires Federal agencies to consider the effects of their undertakings on historic properties.

[c] There would be no disproportionately high and adverse impacts to minority and low-income populations and subsistence consumption from continued operation of SQN during the license renewal period and from cumulative impacts.

SEVERE ACCIDENT MITIGATION ALTERNATIVES

Since TVA had not previously considered alternatives to reduce the likelihood or potential consequences of a variety of highly uncommon but potentially serious accidents at SQN, 10 CFR 51.53(c)(3)(ii)(L) requires that TVA evaluate severe accident mitigation alternatives (SAMAs) in the course of the license renewal review. SAMAs are potential ways to reduce the risk or potential impacts of uncommon, but potentially severe accidents, and they may include changes to plant components, systems, procedures, and training.

The NRC staff reviewed the ER's evaluation of potential SAMAs. Based on the staff's review, the NRC staff concluded that none of the potentially cost beneficial SAMAs relate to adequately managing the effects of aging during the period of extended operation. Therefore, they need not be implemented as part of the license renewal, pursuant to 10 CFR Part 54.

ALTERNATIVES

The NRC staff considered the environmental impacts associated with alternatives to license renewal. These alternatives include other methods of power generation and not renewing the SQN operating license (the no-action alternative). The feasible and commercially viable replacement power alternatives considered were:

- natural gas combined-cycle (NGCC),
- supercritical pulverized coal (SCPC),
- new nuclear, and
- a combination of wind and solar power.

The NRC staff initially considered a number of additional alternatives for analysis as alternatives to the license renewal of SQN; these were later dismissed because of technical, resource availability, or commercial limitations that currently exist and that the NRC staff believes are likely to continue to exist when the existing SQN licenses expire. The no action alternative and the effects it would have were also considered by the NRC staff.

Where possible, the NRC staff evaluated potential environmental impacts for these alternatives located both at the SQN site and at some other unspecified alternate location. Alternatives considered, but dismissed, were:

- wind power,
- solar power,
- conventional hydroelectric power,
- geothermal power,
- biomass energy,
- municipal solid waste,
- wood waste,
- ocean wave and current energy,
- oil-fired power,
- conventional hydroelectric power,
- fuel cells,
- coal-fired integrated gasification combined-cycle (IGCC),
- delayed retirement,
- demand-side management (DSM), and
- purchased power.

The NRC staff evaluated each alternative using the same resource areas that were used in evaluating impacts from license renewal.

PRELIMINARY RECOMMENDATION

The NRC's preliminary recommendation is that the adverse environmental impacts of license renewal for SQN are not great enough to deny the option of license renewal for energy-planning decisionmakers. This recommendation is based on the following:

- the analyses and findings in the GEIS;
- the ER submitted by TVA;
- the NRC staff's consultation with Federal, state, and local agencies;
- the NRC staff's independent environmental review; and
- the NRC staff's consideration of public comments received during the scoping process.

ABBREVIATIONS AND ACRONYMS

°C	degree(s) Celsius
°F	degree(s) Fahrenheit
μm	micrometer(s)
AADT	average annual daily traffic
ac	acre(s)
AC	alternating current
ACHP	Advisory Council on Historic Preservation
ACRS	Advisory Committee on Reactor Safeguards
ACS	American Community Survey
ADAMS	Agencywide Documents Access and Management System
AEA	Atomic Energy Act of 1954
AFW	auxiliary feedwater
ALARA	as low as is reasonably achievable
ANS	American Nuclear Society
ANSI	American National Standards Institute
AP	Associated Press
APE	area of potential effect
AQCR	air quality control region
ASLBP	Atomic Safety and Licensing Board Panel
ASME	American Society of Mechanical Engineers
ATSDR	Agency for Toxic Substances and Disease Registry
ATWS	anticipated transient(s) without scram
BEA	Bureau of Economic Analysis
BLEU	blended low-enriched uranium
BLS	Bureau of Labor Statistics
BMP	best management practice
BREDL	Blue Ridge Environmental Defense League
BWR	boiling water reactor
CAA	Clean Air Act, as amended through 1990
CACC	Chattanooga Area Chamber of Commerce
CAFTA	cutset and fault tree analysis/analyses
CAIR	Clean Air Interstate Rule
CAPS	Circular Area Profiles

CCDP	conditional core damage probability
CCS	carbon capture and sequestration/storage
CCS	component cooling system
CCW	component cooling water
CCW	condenser circulating water
CDC	Centers for Disease Control and Prevention
CDF	core damage frequency
CDL	Cropland Data Layer
CEQ	Council on Environmental Quality
C_{eq}/kWh	carbon equivalent per kilowatt-hour
CET	containment event tree
CFR	*Code of Federal Regulations*
cfs	cubic foot/feet per second
CH^4	methane
CHCAPCB	Chattanooga–Hamilton County Air Pollution Control Bureau
CHCRPA	Chattanooga–Hamilton County Regional Planning Agency
Ci	curie(s)
CLB	current licensing basis/bases
cm	centimeter(s)
CNWRA	Center for Nuclear Waste Regulatory Analyses
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent(s)
COL	combined license
CPC	Center for Plant Conservation
CS	candidate species
CSAPR	Cross-State Air Pollution Rule
CSP	concentrated solar power
CT	combustion turbine
CWA	Clean Water Act of 1972
dBA	decibels adjusted
DBA	design-basis accident
DC	direct current
DOE	U.S. Department of Energy
DOI	digital object identifier

DSEIS	draft supplemental environmental impact statement
DSM	demand-side management
DT104	definitive phage type 104
DWS	drinking water standard
E.O.	Executive Order
EA	environmental assessment
EA	equivalent adult
EAB	exclusion area boundary
EAC	Early Action Compact
EDG	emergency diesel generator
EEDR	energy efficiency and demand response
EF4	Enhanced Fujita Scale of tornado strength (166–200 mph)
EFH	essential fish habitat
EIA	Energy Information Administration (of DOE)
EIS	environmental impact statement
ELF	extremely low frequency
EMF	electromagnetic field
EnerNOC	EnerNOC Utility Solutions Consulting
EPA	U.S. Environmental Protection Agency
EPRI	Electric Power Research Institute
ER	Environmental Report
ERC	Energy Recovery Council
ERCW	emergency/essential raw cooling water
ERDC	Engineer Research and Development Center
ESA	Endangered Species Act of 1973, as amended
FAQ	frequently asked question
FDCT	floor drain collector tank
FEMA	Federal Emergency Management Agency
FES	final environmental statement
FHWA	Federal Highway Administration
FIVE	fire-induced vulnerability evaluation
fps	foot/feet per second
FR	*Federal Register*
ft	foot/feet
ft^2	square foot/feet

ft^3	cubic foot/feet
FW	feedwater
FWPCA	Federal Water Pollution Control Act
FWS	U.S. Fish and Wildlife Service
g	gram(s)
g Ceq/kWh	gram(s) of carbon equivalent per kilowatt-hour
gal	gallon(s)
GEA	Geothermal Energy Association
GEIS	*Generic Environmental Impact Statement for License Renewal of Nuclear Plants*, NUREG–1437
GEP	Global Energy Partners
GHG	greenhouse gas
GI	generic issue
GIS	geographic information system
GISS	Goddard Institute for Space Studies
GL	generic letter
gpd	gallons per day
gpm	gallons per minute
Gt	gigatonne(s)
GW	gigawatt(s)
GW	groundwater
GWh	gigawatt hour(s)
GWP	global warming potential
GWPS	gaseous waste processing system
H_2O	water vapor
ha	hectare(s)
HAP	hazardous air pollutant
HCFC	hydrochlorofluorocarbon
HCLPF	high confidence in low probability of failure
HEP	human error probability
HEU	highly enriched uranium
HFC	hydrofluorocarbon
Hg	mercury
HPA	habitat protection area
HSDT	hot shower drain tank

HUD	Housing and Urban Development
HVAC	heating, ventilation, and air conditioning
HWSF	hazardous waste storage facility
Hz	hertz
IAEA	International Atomic Energy Agency
IEA	International Energy Agency
IEEE	Institute of Electrical and Electronics Engineers
IGCC	integrated gasification combined cycle
in.	inch(es)
INEEL	Idaho National Engineering and Environmental Laboratory
IPCC	Intergovernmental Panel on Climate Change
IPE	individual plant examination
IPEEE	individual plant examination(s) of external events
IPPNW	International Physicians for the Prevention of Nuclear War
IPS	Intake Pumping Station
IRP	Integrated Resource Plan
ISFSI	independent spent fuel storage installation
ISLOCA	interfacing-systems loss-of-coolant accident
ISSG	Invasive Species Specialist Group
ITIS	Integrated Taxonomic Information System
ISO	International Organization for Standardization
kg	kilogram(s)
km	kilometer(s)
km^2	square kilometer(s)
kV	kilovolt(s)
kW	kilowatt(s)
kWh	kilowatt-hour(s)
$kWh/m^2/day$	kilowatt hour(s) per square meter per day
L	litre(s)
L/min	liter(s) per minute
lb	pound(s)
LEFM	Leading Edge Flow Meter
LERF	large early release frequency
LIDAR	light detection and ranging
LLMW	low-level mixed waste

LLRW	low-level radioactive waste
LNB	low NO_x burner
LNT	linear, no-threshold
LOCA	loss-of-coolant accident
LOOP	loss(es) of offsite power
Lpd	litre(s) per day
LRA	license renewal application
LUB	Loudon Utilities Board
LWPS	liquid waste processing system
m	meter(s)
m/s	meter(s) per second
m^2	square meter(s)
m^3	cubic meter(s)
m^3/s	cubic meters per second
m^3/y	cubic meters per year
mA	milliampere(s)
MAAP	Modular Accident Analysis Program
MACCS2	MELCOR Accident Consequence Code System 2
MACR	maximum averted cost-risk
MAIS	macroinvertebrate aggregated index for streams
MATS	Mercury and Air Toxics Standards
MBq	megabecquerel(s)
MBTA	Migratory Bird Treaty Act
MDAFWP	motor-driven auxiliary feedwater pump
MF	migratory fishes
mg/L	milligrams per liter
mgd	million gallons per day
mgy	million gallons per year
mGy	milligray
mi	mile(s)
mi^2	square mile(s)
min	minute(s)
mm	millimeter(s)
MMACR	modified maximum averted cost-risk
MMI	Modified Mercalli Intensity

MMS	Minerals Management Service
MMSHT	Michigan Mine Safety & Health Training
MMT	million metric ton(s)
MOXF	mixed-oxide fuel
mph	mile(s) per hour
mrad	milliradiation absorbed dose
mrem	milliroentgen equivalent man
MSA	Magnuson–Stevens Fishery Conservation and Management Act
MSL	mean sea level
mSv	millisievert
MSW	municipal solid waste
MT	metric ton(s)
MUR	measurement uncertainty recapture
MW	megawatt(s)
MWd	megawatt-day(s)
MWd/MTU	megawatt-day(s) per metric ton of uranium
MWe	megawatt(s) electrical
MWh	megawatt hour(s)
MWt	megawatt(s) thermal
N/A	not applicable
N_2O	nitrous oxide
NAAQS	National Ambient Air Quality Standards
NAICS	North American Industry Classification System
NARUC	National Association of Regulatory Utility Commissioners
NAS	National Academy of Sciences
NASA	National Aeronautics and Space Administration
NASS	National Agricultural Statistics Service
NBII	National Biological Information Infrastructure
NCADAC	National Climate Assessment Development Advisory Committee
NCDC	National Climatic Data Center
NCES	National Center for Education Statistics
NEI	Nuclear Energy Institute
NEPA	National Environmental Policy Act of 1969
NERC	North American Electric Reliability Corporation
NESC	National Electrical Safety Code

NETL	National Energy Technology Laboratory
NGCC	natural gas combined-cycle
NHPA	National Historic Preservation Act of 1966, as amended
NIEHS	National Institute of Environmental Health Sciences
NMFS	National Marine Fisheries Service (of NOAA)
NNSA	National Nuclear Security Administration
NO_2	nitrogen dioxide
NOAA	National Oceanic and Atmospheric Administration
NO_x	nitrogen oxide(s)
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRC	U.S. Nuclear Regulatory Commission
NREL	National Renewable Energy Laboratory
NRHP	National Register of Historic Places
NRR	Office of Nuclear Reactor Regulation
NSR	New Source Review
NUREG	NRC technical report designation (Nuclear Regulatory Commission)
NWS	National Weather Service
O_3	ozone
OCA	Owner-Controlled Area
ODCM	Offsite Dose Calculation Manual
OECD	Organisation for Economic Co-operation and Development
OECR	offsite economic cost risk
OSHA	Occupational Safety and Health Administration
OTM	OSHA Technical Manual
P.L.	Public Law
PAH	polycyclic aromatic hydrocarbon
Pb	lead
PCB	polychlorinated biphenyl
pCi/L	picocuries per liter
PDS	plant damage state
PF	production foregone
PFC	perfluorocarbon
PGA	peak ground acceleration

pH	potential of hydrogen
PHAC	Public Health Agency of Canada
PM	particulate matter
PM_{10}	particulate matter >2.5 microns and ≤10 microns in diameter
$PM_{2.5}$	particulate matter ≤2.5 microns in diameter
PNNL	Pacific Northwest National Laboratory
PORV	power-operated relief valve
PPA	power purchase agreement
PRA	probabilistic risk assessment
PSD	Prevention of Significant Deterioration
psia	pounds per square inch absolute
Pu	plutonium
PV	photovoltaic
PWR	pressurized water reactor
RAI	request for additional information
RCA	radiological control area
RCP	reactor coolant pump
RCRA	Resource Conservation and Recovery Act of 1976, as amended
RCS	reactor coolant system
RCW	raw cooling water
REIRS	Radiation Exposure Information and Reporting System
rem	roentgen equivalent(s) man
REMP	radiological environmental monitoring program
RG	Regulatory Guide
RGPP	Radiological Groundwater Protection Program
RHR	Regional Haze Rule
RHR	residual heat removal
RKm	river kilometer
RLE	review-level earthquake
RM	river mile
ROI	region of influence
ROW(s)	right(s)-of-way
RPS	renewable portfolio standard
RRW	risk reduction worth
RSP	radwaste storage pad

RV	recreational vehicle
RWCU	reactor water cleanup
SAMA	severe accident mitigation alternative
SAMDA	Severe Accident Mitigation Design Alternative
SAMGs	Severe Accident Mitigation Guidelines
SAR	safety analysis report
SBO	station blackout
SCCW	supplemental condenser cooling water
SCPC	supercritical pulverized coal
SCR	selective catalytic reduction
SDWA	Safe Drinking Water Act
SE	state endangered
SEIDA	Southeast Industrial Development Association
SEIS	supplemental environmental impact statement
SER	safety evaluation report
SERC	SERC Reliability Corporation
SF_6	sulfur hexafluoride
SFU	Simon Fraser University
SGTS	standby gas treatment system
SHPO	State Historic Preservation Officer
SIP	State Implementation Plan
SMA	Seismic Margin Assessment
SMR	small modular reactor
SNF	spent nuclear fuel
SO_2	sulfur dioxide
SO_x	sulfur oxide(s)
SPCC	Spill Prevention Control and Countermeasure
SQN	Sequoyah Nuclear Plant, Units 1 and 2
SR	state rare
SREL	Savannah River Ecology Laboratory
SRP	Standard Review Plan
SRST	spent resin storage tank
SSC	species of special concern
SSCs	structures, systems, and components
SSE	safe-shutdown earthquake

SSEL	Safe Shutdown Equipment List
ST	state threatened
STG	steam turbine generator
Sv	sievert
SW	surface water
SWPPP	Stormwater Pollution Prevention Plan
TAC	technical assignment control
TAW	Tennessee American Water
TCA	Tennessee Code Annotated
TDAFWP	turbine-driven auxiliary feedwater pump
TDCT	tritium drain collector tank
TDEC	Tennessee Department of Environment and Conservation
TDH	Tennessee Department of Health
TDLWD	Tennessee Department of Labor and Workforce Development
TDOT	Tennessee Department of Transportation
TLD	thermoluminescent dosimeters
TMDL	total maximum daily upload
TNR	Tennessee Rule
TPBAR	tritium-producing burnable absorber rod
tpy	ton(s) per year
TRM	Tennessee River Mile
TRU	transuranic
TS	technical specification
TSP	Tennessee State Parks
TSP	total suspended particles
TVA	Tennessee Valley Authority
TWh	terawatt-hour(s)
TWRA	Tennessee Wildlife Resources Agency
U	uranium
U.S.	United States
U.S.C.	United States Code
UFSAR	updated final safety analysis report
UO	uranium oxide
USACE	U.S. Army Corps of Engineers
USCB	U.S. Census Bureau

USDA	U.S. Department of Agriculture
USEC	U.S. Enrichment Corporation
USGCRP	United States Global Change Research Program [or GCRP]
USGS	U.S. Geological Survey
USST	unit station service transformer
UT	The University of Tennessee
VDGIF	Virginia Department of Game and Inland Fisheries
VOC	volatile organic compound
WAW	wet active waste
WBN	Watts Bar Nuclear Power Plant
WBN 2	Watts Bar Unit 2
WBUD	Watts Bar Utility District
WCAP	Westinghouse Commercial Atomic Power

1.0 INTRODUCTION

Under the U.S. Nuclear Regulatory Commission's (NRC's) environmental protection regulations in Title 10, Part 51, of the *Code of Federal Regulations* (10 CFR 51)—which implement the National Environmental Policy Act (NEPA)—issuance of a new nuclear power plant operating license requires the preparation of an environmental impact statement (EIS).

The Atomic Energy Act of 1954 (AEA) specifies that licenses for commercial power reactors can be granted for up to 40 years. NRC regulations (10 CFR 54.31) allow for an option to renew a license for up to an additional 20 years. The initial 40-year licensing period was based on economic and antitrust considerations rather than on technical limitations of the nuclear facility.

The decision to seek a license renewal rests entirely with nuclear power facility owners and, typically, is based on the facility's economic viability and the investment necessary to continue to meet NRC safety and environmental requirements. The NRC makes the decision to grant or deny license renewal based on whether the applicant has demonstrated that the environmental and safety requirements in the agency's regulations can be met during the period of extended operation.

1.1 Proposed Federal Action

Tennessee Valley Authority (TVA) initiated the proposed Federal action by submitting an application for license renewal of Sequoyah Nuclear Plant, Units 1 and 2 (SQN), for which the existing licenses (DPR-77 and DPR-79) expire on September 17, 2020, and September 15, 2021, respectively. The NRC's proposed Federal action is the decision whether to renew the licenses for an additional 20 years.

1.2 Purpose and Need for the Proposed Federal Action

The purpose and need for the proposed action (issuance of a renewed license) is to provide an option that allows for power generation capability beyond the term of a current nuclear power plant operating license to meet future system generating needs, as such needs may be determined by other energy-planning decisionmakers. This definition of purpose and need reflects the NRC's recognition that, unless there are findings in the safety review required by the AEA or findings in the NEPA environmental analysis that would lead the NRC to reject a license renewal application (LRA), the NRC does not have a role in the energy-planning decisions of State regulators and utility officials as to whether a particular nuclear power plant should continue to operate.

1.3 Major Environmental Review Milestones

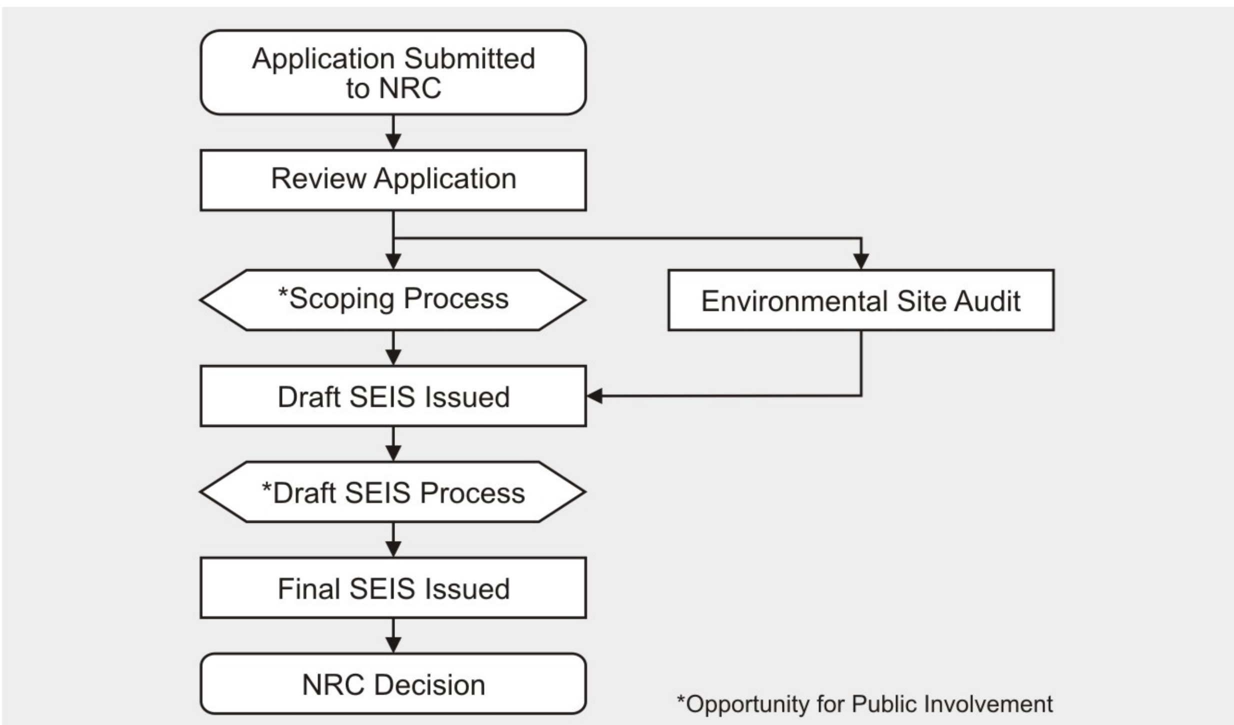
TVA submitted an Environmental Report (ER) (TVA 2013b) as part of its LRA (TVA 2013a) on January 15, 2013. After reviewing the LRA and ER for sufficiency, the NRC staff published a *Federal Register* Notice of Acceptability and Opportunity for Hearing (78 FR 14362) on March 5, 2013. Then, on March 8, 2013, the NRC published another notice in the *Federal Register* (78 FR 15055) on the intent to conduct scoping, thereby beginning the 60-day scoping period.

The NRC staff held two public scoping meetings on April 3, 2013, in Soddy-Daisy, Tennessee. The comments received during the scoping process are presented in their entirety in "Environmental Impact Statement Scoping Process, Summary Report, Sequoyah Nuclear Plant, Units 1 and 2," published in April 2014 (NRC 2014). The staff presents comments considered to be within the scope of the environmental license renewal review and the NRC responses in Appendix A of this supplemental environmental impact statement (SEIS).

In order to independently verify information provided in the ER, the NRC staff conducted a site audit at SQN, in April 2013. During the site audit, the staff met with plant personnel, reviewed specific documentation, toured the facility, and met with interested Federal, State, and local agencies. A summary of that site audit and the attendees is contained in the audit summary report (NRC 2013b).

Upon completion of the scoping period and site audit, the NRC staff compiled its findings in the draft SEIS. This document is made available for public comment for 45 days. During this time, the staff hosts public meetings and collects public comments. Based on the information gathered, it amends the draft SEIS findings, as necessary, and publishes the final SEIS for license renewal. Figure 1–1 shows the major milestones of the NRC's license renewal application environmental review.

Figure 1–1. Environmental Review Process



The NRC has established a license renewal review process that can be completed in a reasonable period with clear requirements to assure safe plant operation for up to an additional 20 years of plant life. The NRC staff conducts the safety review simultaneously with the environmental review. The staff documents the findings of the safety review in a safety evaluation report (SER). The findings in the SEIS and the SER are both factors in the NRC's decision to either grant or deny the issuance of a renewed license.

1.4 Generic Environmental Impact Statement

The NRC staff performed a generic assessment of the environmental impacts associated with license renewal to improve the efficiency of its license renewal review. The *Generic*

Environmental Impact Statement for License Renewal of Nuclear Power Plants (GEIS), NUREG-1437, Revision 1 (NRC 1996, 1999, 2013a), documented the results of the staff's systematic approach to evaluate the environmental consequences of renewing the licenses of individual nuclear power plants and operating them for an additional 20 years. The staff analyzed in detail and resolved those environmental issues that could be resolved generically in the GEIS. The GEIS was originally issued in 1996 (NRC 1996), Addendum 1 to the GEIS was issued in 1999 (NRC 1999), and Revision 1 to the GEIS was issued in 2013 (NRC 2013b). Unless otherwise noted, all references to the GEIS include the GEIS, Addendum 1 and Revision 1.

The GEIS establishes separate environmental impact issues for the NRC staff to independently verify. Of these issues, the NRC staff determined that some issues are generic to all plants (Category 1). Other issues do not lend themselves to generic consideration (Category 2 or uncategorized). The staff evaluated these issues on a site-specific basis in the SEIS. Appendix B to Subpart A of 10 CFR 51 provides a summary of the staff findings in the GEIS.

For each potential environmental issue, in the GEIS, the NRC staff performs the following:

- describes the activity that affects the environment,
- identifies the population or resource that is affected,
- assesses the nature and magnitude of the impact on the affected population or resource,
- characterizes the significance of the effect for both beneficial and adverse effects,
- determines whether the results of the analysis apply to all plants, and
- considers whether additional mitigation measures would be warranted for impacts that would have the same significance level for all plants.

The NRC's standard of significance for impacts was established using the Council on Environmental Quality (CEQ) terminology for "significant." The NRC established three levels of significance for potential impacts: SMALL, MODERATE, and LARGE, as defined below.

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.

Significance indicates the importance of likely environmental impacts and is determined by considering two variables: **context** and **intensity**.

Context is the geographic, biophysical, and social context in which the effects will occur.

Intensity refers to the severity of the impact, in whatever context it occurs.

LARGE: Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

The GEIS includes a determination of whether the analysis of the environmental issue could be applied to all plants and whether additional mitigation measures would be warranted. Issues are assigned a Category 1 or a Category 2 designation. As set forth in the GEIS, Category 1 issues are those that meet the following criteria:

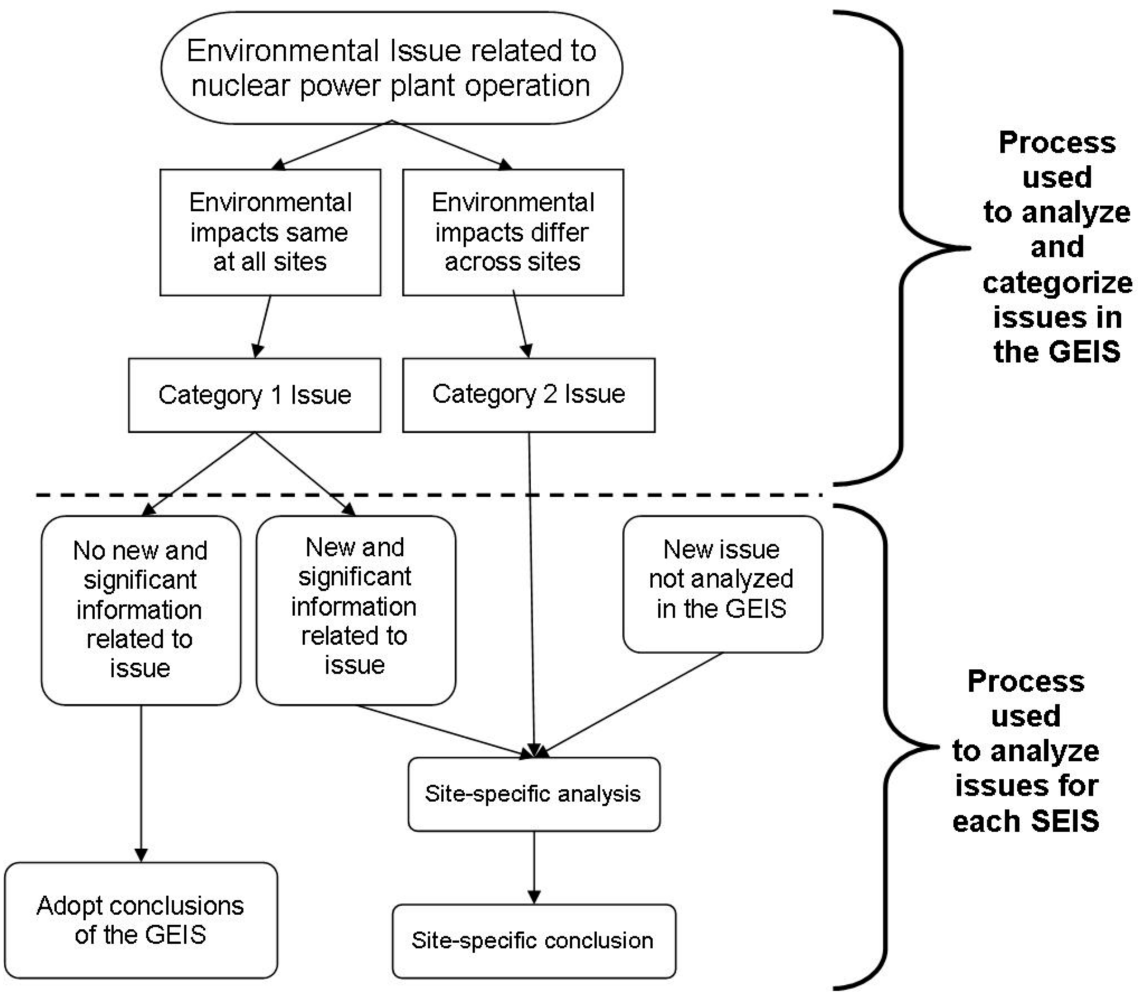
- The environmental impacts associated with the issue have been determined to apply either to all plants or, for some issues, to plants having a specific type of cooling system or other specified plant or site characteristics.

- A single significance level (i.e., SMALL, MODERATE, or LARGE) has been assigned to the impacts (except for offsite radiological impacts—collective impacts from other than the disposal of spent fuel and high-level waste).
- Mitigation of adverse impacts associated with the issue has been considered in the analysis, and it has been determined that additional plant-specific mitigation measures are likely not to be sufficiently beneficial to warrant implementation.

Figure 1–2 illustrates the process used to analyze and categorize issues in the GEIS and in each SEIS.

Figure 1–2. Environmental Issues Evaluated For License Renewal

In the GEIS, 78 issues were evaluated.
A site-specific analysis is required for 17 of those 78 issues



For generic issues (Category 1), no additional site-specific analysis is required in the SEIS unless new and significant information is identified. The process for identifying new and significant information is presented in Chapter 4. Site-specific issues (Category 2) are those that do not meet one or more of the criteria of Category 1 issues; therefore, additional site-specific review for these issues is required. The results of that site-specific review are documented in the SEIS.

1.5 Supplemental Environmental Impact Statement

The SEIS presents an analysis that considers the environmental effects of the continued operation of SQN, alternatives to license renewal, and mitigation measures for minimizing adverse environmental impacts. Chapter 4 contains analysis and comparison of the potential environmental impacts from alternatives while Chapter 5 presents the recommendation of the NRC on whether or not the environmental impacts of license renewal are so great that preserving the option of license renewal would be unreasonable. The final recommendation will be made after consideration of comments received on the draft SEIS during the public comment period.

In the preparation of the SEIS for SQN, the NRC staff carried out the following activities:

- reviewed the information provided in the TVA's ER;
- consulted with other Federal, State, local agencies, and tribal nations;
- conducted an independent review of the issues during site audit; and
- considered the public comments received (during the scoping process and, subsequently, on the draft SEIS).

New information can be identified from many sources, including the applicant, the NRC, other agencies, or public comments. If a new issue is revealed, it is first analyzed to determine whether it is within the scope of the license renewal environmental evaluation. If the new issue is not addressed in the GEIS, the NRC staff would determine the significance of the issue and document the analysis in the SEIS.

> **New and significant information** must be both new and bear on the proposed action or its impacts, presenting a seriously different picture of the impacts from those envisioned in the GEIS (i.e., impacts of greater severity than impacts considered in the GEIS, considering their intensity and context).

1.6 Decision To Be Supported by the SEIS

The decision to be supported by the SEIS is whether or not to renew the operating licenses for SQN for an additional 20 years. The NRC decision standard is specified in 10 CFR 51.103:

> In making a final decision on a license renewal action pursuant to Part 54 of this chapter, the Commission shall determine whether or not the adverse environmental impacts of license renewal are so great that preserving the option of license renewal for energy planning decisionmakers would be unreasonable.

There are many factors that the NRC takes into consideration when deciding whether to renew the operating license of a nuclear power plant. The analyses of environmental impacts evaluated in this GEIS will provide the NRC's decisionmaker (in this case, the Commission) with important environmental information for use in the overall decisionmaking process. There are also decisions outside the regulatory scope of license renewal that cannot be made on the basis of the final GEIS analysis. These decisions concern the following issues: changes to plant cooling systems, disposition of spent nuclear fuel, emergency preparedness, safeguards and security, need for power, and seismicity and flooding. (NRC 2013a)

1.7 Cooperating Agencies

During the scoping process, no Federal, State, or local agencies were identified as cooperating agencies in the preparation of this SEIS.

1.8 Consultations

The Endangered Species Act of 1973, as amended (ESA); the Magnuson–Stevens Fishery Conservation and Management Act of 1996, as amended (MSA); and the National Historic Preservation Act of 1966 (NHPA) require that Federal agencies consult with applicable state and Federal agencies and groups prior to taking action that may affect endangered species, fisheries, or historic and archaeological resources, respectively. The NRC consulted with the following agencies and groups:

- State Historic Preservation Office,
- Advisory Council on Historic Preservation,
- U.S. Fish and Wildlife Service (FWS),
- Cherokee Nation,
- The Chickasaw Nation,
- Alabama Quassarte Tribal Town,
- Muscogee (Creek) Nation,
- Alabama-Coushatta Tribe of Texas,
- Thlopthlocco Tribal Town,
- Eastern Shawnee Tribe of Oklahoma,
- Kialegee Tribal Town,
- Eastern Band of the Cherokee Indians,
- Absentee Shawnee Tribe of Oklahoma,
- United Keetoowah Band of Cherokee Indians in Oklahoma,
- Seminole Tribe of Florida, and
- Seminole Nation of Oklahoma.

Appendix C contains a discussion of consultation related documents sent and received during the environmental review.

1.9 Correspondence

The NRC staff corresponded with Federal, State, regional, local, and tribal agencies during the environmental review. Appendix D contains a chronological list of documents sent and received during the environmental review.

1.10 Status of Compliance

TVA is responsible for complying with all NRC regulations and other applicable Federal, state, and local requirements. Appendix F of the GEIS describes some of the major applicable

Federal statutes. There are numerous permits and licenses issued by Federal, State, and local authorities for activities at SQN. Appendix B contains further discussion about SQN status of compliance.

1.11 Related Federal and State Activities

The NRC reviewed the possibility that activities of other Federal agencies might impact the renewal of the operating license for SQN. There are no Federal projects that would make it necessary for another Federal agency to become a cooperating agency in the preparation of this supplemental EIS. There are no known Native American reservations or controlled lands within 50 mi of SQN (TVA 2013b). There are approximately 37 Federal and 88 State-managed lands within 50 mi of SQN. There are four Federal lands and one State-managed land within 6 mi of SQN. These Federal lands are TVA-managed habitat protection areas. Harrison Bay State Recreation Park is the only state-managed area within 6 mi of SQN (TVA 2013b).

The NRC is required under Section 102(2)(C) of NEPA to consult with and obtain comments from any Federal agency that has jurisdiction by law or has special expertise with respect to any environmental impact involved in the subject matter of the EIS. For example, during the course of preparing the SEIS, the NRC consulted with the FWS. A complete list of key consultation correspondences is listed in Appendix C.

1.12 References

10 CFR Part 51. *Code of Federal Regulations*, Title 10, *Energy*, Part 51, "Environmental protection regulations for domestic licensing and related regulatory functions."

10 CFR Part 54. *Code of Federal Regulations*, Title 10, *Energy*, Part 54, "Requirements for renewal of operating licenses for nuclear power plants."

61 FR 28467. U.S. Nuclear Regulatory Commission. "Environmental review for renewal of nuclear power plant operating licenses." *Federal Register* 61(109):28467–28497. June 5, 1996.

78 FR 14362. U.S. Nuclear Regulatory Commission. "Tennessee Valley Authority; notice of acceptance for docketing of application and notice of opportunity for hearing regarding renewal of Sequoyah Nuclear Plant, Units 1 and 2 facility operating license nos. DPR–77, DPR–79 for an additional 20-year period." *Federal Register* 78(43):14362–14365. March 5, 2013.

78 FR 15055. U.S. Nuclear Regulatory Commission. "License renewal application for Sequoyah Nuclear Plant, Units 1 and 2, Tennessee Valley Authority." *Federal Register* 78(46):15055–15056. March 8, 2013.

[AEA] Atomic Energy Act of 1954, as amended. 42 U.S.C. §2011 et seq.

[ESA] Endangered Species Act of 1973, as amended. 16 U.S.C. §1531 et seq.

[MSA] Magnuson–Stevens Fishery Conservation and Management Act, as amended. 16 U.S.C. §1801 et seq.

[NEPA] National Environmental Policy Act of 1969, as amended. 42 U.S.C. §4321 et seq.

[NHPA] National Historic Preservation Act of 1966. 16 U.S.C. §470 et seq.

[NRC] U.S. Nuclear Regulatory Commission. 2013a. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. Revision 1. Washington, DC: NRC. NUREG-1437, Volumes 1, 2, and 3. June 2013. 1,535 p. Agencywide Documents Access and Management System (ADAMS) No. ML13107A023.

[NRC] U.S. Nuclear Regulatory Commission. 2013b. Memorandum from D. Drucker, Sr. Project Manager, to Tennessee Valley Authority. Subject: Summary of the site audit related to the review of the license renewal application for Sequoyah Nuclear Plant, Units 1 and 2. August 7, 2013. 6 p. ADAMS No. ML13120A198.

[NRC] U.S. Nuclear Regulatory Commission. 2014. *Environmental Impact Statement Scoping Process, Summary Report, Sequoyah Nuclear Plant, Units 1 and 2, Hamilton County, TN*. Washington, DC: NRC. 2014. ADAMS No. ML14041A118.

[TVA] Tennessee Valley Authority. 2013a. *License Renewal Application*, *Sequoyah Nuclear Plant, Units 1 and 2.* January 7, 2013. 1,544 p. ADAMS No. ML13024A011.

[TVA] Tennessee Valley Authority. 2013b. *Sequoyah Nuclear Plant, Units 1 and 2, License Renewal Application, Appendix E, Applicant's Environmental Report, Operating License Renewal Stage*. Chattanooga, TN: TVA. January 7, 2013. 783 p. ADAMS No. ML130240007, Parts 2 through 8 of 8.

2.0 ALTERNATIVES INCLUDING THE PROPOSED ACTION

Although the U.S. Nuclear Regulatory Commission's (NRC's) decisionmaking authority in the case of license renewal is limited to deciding whether or not to renew a nuclear power plant's operating license, the NRC's implementation of the National Environmental Policy Act (NEPA) requires consideration of the environmental impacts of potential alternatives to renewing a plant's operating license. While the ultimate decision about which alternative (or the proposed action) to carry out falls to utility, state, or other Federal officials (non-NRC), comparing the impacts of renewing the operating license to the environmental impacts of alternatives allows the NRC to determine whether the environmental impacts of license renewal are so great that preserving the option of license renewal for energy-planning decisionmakers would be unreasonable (10 CFR 51.95(c)(4)).

Energy-planning decisionmakers and owners of the nuclear power plant ultimately decide whether the plant will continue to operate, and economic and environmental considerations play important roles in this decision. In general, the NRC's responsibility is to ensure the safe operation of nuclear power facilities and not to formulate energy policy or encourage or discourage the development of alternative power generation. The NRC does not engage in energy-planning decisions and makes no judgment as to which energy alternatives evaluated would be the most likely alternative in any given case.

The remainder of this chapter provides: (1) a description of the proposed action, (2) a description of alternatives to the proposed action (including the no-action alternative), and (3) alternatives to Sequoyah Nuclear Plant, Units 1 and 2 (SQN), license renewal that were considered and eliminated from detailed study. Chapter 4 of this plant-specific supplemental environmental impact statement (SEIS) compares the impacts of renewing the operating licenses of SQN and continued plant operations to the environmental impacts of alternatives.

2.1 Proposed Action

As stated in Section 1.1 of this document, the NRC's proposed Federal action is the decision whether to renew the SQN operating licenses for an additional 20 years. For the NRC to determine the impacts from continued operation of SQN an understanding of that operation is needed. A description of normal power plant operations during the license renewal term is provided in Section 2.1.1. SQN is a two-unit, nuclear-powered steam-electric generating facility that began commercial operation in July 1981 (Unit 1) and June 1982 (Unit 2). The nuclear reactor for each unit is a Westinghouse pressurized-water reactor (PWR), producing a reactor core rated thermal power of 3,455 megawatts thermal.

2.1.1 Plant Operation During the License Renewal Term

Most plant operation activities during license renewal would be the same as or similar to those occurring during the current license term (NRC 2013 new GEIS). Section 2.1.1 of the *Generic Environmental Impact Statement for License Renewal of Nuclear Power Plants* (GEIS), NUREG-1437, Revision 1 (NRC 2013 new GEIS) describes the general types of activities that are carried out during the operation of a nuclear power plant such as SQN, as follows:

- reactor operation;
- waste management;
- security;

- office and clerical work;
- surveillance, monitoring, and maintenance; and
- refueling and other outages.

As stated in the Tennessee Valley Authority (TVA) Environmental Report (ER), SQN will continue to operate during the license renewal term in the same manner as during the current license term except for, as appropriate, additional aging management programs to address structure and component aging, in accordance with Title 10, Part 54, of the *Code of Federal Regulations* (10 CFR Part 54).

2.1.2 Refurbishment and Other Activities Associated With License Renewal

Refurbishment activities include replacement and repair of major systems, structures, and components. Replacement activities include replacement of steam generators for PWRs and recirculation piping systems for boiling water reactors (BWRs).

SQN Units 1 and 2 are PWRs. All original SQN steam generators have been replaced. The last steam generator replacement took place in 2012. The TVA ER states that no plant refurbishment activities were identified as necessary to support the continued operation of SQN beyond the end of the existing operating license terms.

2.1.3 Termination of Nuclear Power Plant Operation and Decommissioning After the License Renewal Term

The impacts of decommissioning are described in the *Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities: Regarding the Decommissioning of Nuclear Power Reactors*, NUREG-0586 (NRC 2002a). The majority of the activities associated with plant operations would cease with reactor shutdown. Some activities (e.g., security and oversight of spent nuclear fuel) would remain unchanged, while others (waste management, office and clerical work, laboratory analysis, and surveillance, monitoring, and maintenance) would continue at reduced or altered levels. Systems dedicated to reactor operations would cease operations; however, impacts from their physical presence may continue if not removed after reactor shutdown. For sites such as SQN, with more than one unit, shared systems may operate at reduced capacities. Impacts associated with dedicated systems that remain in place or shared systems that continue to operate at normal capacities would remain unchanged.

Decommissioning would occur whether SQN was shut down at the end of its current operating licenses or at the end of the period of extended operation. There are no site-specific issues related to decommissioning. The GEIS concludes SMALL (Category 1) impacts of terminating operation and decommissioning on all resources for nuclear power plants.

2.2 Alternatives

As stated at the beginning of this chapter, the NRC has the obligation to consider reasonable alternatives to the proposed action of renewing the license for a nuclear reactor. The 2013 GEIS update incorporated the latest information on replacement power alternatives; however, rapidly evolving technologies are likely to outpace the information presented in the GEIS. As such, a site-specific analysis of alternatives must be performed for each SEIS, taking into account changes in technology and science since the preparation of the GEIS.

Sections 2.2.1 below describes the no-action alternative, i.e., the NRC takes no action and does not issue renewed licenses for SQN. Sections 2.2.2.1–2.2.2.4 describe the characteristics of replacement power alternatives for SQN.

2.2.1 No-Action Alternative

At some point, operating nuclear power plants will terminate operations and undergo decommissioning. The no-action alternative represents a decision by the NRC not to renew the operating license of a nuclear power plant beyond the current operating license term. Under the no-action alternative, the NRC denies the renewed operating licenses, and the SQN plant will shut down at or before the end of the current licenses, in 2020 and 2021. After shutdown, plant operators will initiate decommissioning in accordance with 10 CFR 50.82.

Only those impacts that arise directly as a result of plant shutdown will be addressed in this SEIS. The environmental impacts from decommissioning and related activities are addressed in several other documents, including the *Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities*, NUREG-0586, Supplement 1 (NRC 2002); the license renewal GEIS, Chapter 4 (NRC 2013 new GEIS); and Chapter 4 of this SEIS. These analyses either directly address or bound the environmental impacts of decommissioning whenever TVA ceases to operate SQN.

Even with renewed operating licenses, SQN will eventually shut down, and the environmental impacts addressed later in Chapter 4 of this SEIS will occur at that time. As with decommissioning impacts, shutdown impacts are expected to be similar whether they occur at the end of the current license or at the end of a renewed license.

Termination of operations at SQN would result in the total cessation of electrical power production. Unlike the alternatives described below in Section 2.2.2, no-action does not expressly meet the purpose and need of the proposed action as described in Section 2.2, as it does not provide a means of delivering baseload power to meet future electric system needs. Assuming that a need currently exists for the power generated by SQN, the no-action alternative would likely create a need for a replacement power alternative. A full range of replacement power alternatives (including fossil fuels, new nuclear, and renewable energy sources) are described in the following section, and their potential impacts are assessed in Chapter 4. Although the NRC's authority only extends to the decision of whether to grant or deny the renewed SQN operating licenses, the replacement power alternatives described in the following sections represent possible options for energy-planning decisionmakers should NRC choose to deny the SQN operating licenses.

2.2.2 Replacement Power Alternatives

In evaluating alternatives to license renewal, the NRC considered energy technologies or options currently in commercial operation, as well as technologies not currently in commercial operation but likely to be commercially available by the time the current SQN operating licenses expire. The current operating licenses for the SQN reactors expire on September 17, 2020, and September 15, 2021. Alternatives that cannot be constructed, permitted, and connected to the grid by the time the SQN licenses expire were eliminated from detailed consideration.

Alternatives that cannot provide the equivalent of SQN's current generating capacity and, in some cases, those alternatives whose costs or benefits do not justify inclusion in the range of reasonable alternatives, were eliminated from detailed consideration. Each alternative eliminated from detailed study is briefly discussed, and a basis for its removal is provided at the end of this section. In total, 18 alternatives to the proposed action were considered (see text box) and then narrowed to the 4 alternatives considered in Sections 2.2.2.1–2.2.2.4. The NRC staff evaluated the environmental impacts of these four alternatives and the no-action alternative and discusses them in depth in Chapter 4 of this SEIS.

Alternatives Evaluated in Depth:

- natural gas combined-cycle (NGCC)
- supercritical pulverized coal (SCPC)
- new nuclear
- combination of wind and solar

Other Alternatives Considered:

- wind power
- solar power
- conventional hydroelectric power
- geothermal power
- biomass energy
- municipal solid waste (MSW)
- wood waste
- ocean wave and current energy
- oil-fired power
- fuel cells
- coal-fired integrated gasification combined cycle (IGCC)
- delayed retirement
- demand-side management (DSM)
- purchased power

The GEIS presents an overview of some energy technologies but does not reach any conclusions about which alternatives are most appropriate. Because many energy technologies are continually evolving in capability and cost, and because regulatory structures have changed to either promote or impede development of particular alternatives, the analyses in this chapter may include updated information from the following sources:

- Energy Information Administration (EIA),
- other offices within the U.S. Department of Energy (DOE),
- U.S. Environmental Protection Agency (EPA),
- industry sources and publications, and
- information submitted by TVA in its ER.

The evaluation of each alternative in Chapter 4 of this SEIS considers the environmental impacts across several impact categories: land use and visual resources, air quality and noise, geologic environment, water resources, ecological resources, historic and cultural resources, socioeconomics, human health, environmental justice, and waste management. Most site-specific issues (Category 2) have been assigned a significance level of SMALL, MODERATE, or LARGE. For ecological and historic and archaeological resources the impact significance determination language is specific to the authorizing legislation (e.g., Endangered Species Act and National Historic Preservation Act). The order of presentation of the alternatives is not meant to imply increasing or decreasing level of impact. Nor does it imply that an energy-planning decisionmaker would be more likely to select any given alternative.

In some cases, the NRC considers the environmental effects of locating a replacement power alternative at the existing nuclear plant site. Selecting the existing plant site allows for the maximum use of existing transmission and cooling system infrastructure and minimizes the overall environmental impact. However, based on information gathered from TVA, SQN does not have a sufficient amount of land available for all the replacement power alternatives because TVA would want to continue operating while the replacement alternative is being built to prevent a gap in energy generation during the period of construction—which would likely take several years (TVA 2013). As a result, the NRC evaluated the impacts of locating replacement power facilities at other existing power plant sites within the TVA region of interest, which includes most of Tennessee and parts of Alabama, Georgia, Kentucky, Mississippi, North Carolina, and Virginia (TVA 2013). TVA also stated that replacement power alternatives could reasonably be located outside of the TVA region, specifically elsewhere within the Southeast Electric Reliability Corporation (SERC) transmission grid because electricity generated within SERC region could be efficiently routed back to the TVA region. Installing replacement power facilities at existing power plants and connecting to existing transmission and cooling system infrastructure would reduce the overall environmental impact.

To ensure that the alternatives analysis is consistent with State or regional energy policies, the NRC reviewed energy-related statutes, regulations, and policies within the TVA Region. As a result, the staff considers alternatives that include wind power or solar photovoltaic (PV) power, as well as a combination that includes both of them.

The NRC considered the current generation capacity and electricity production within the State of Tennessee, as well as, where pertinent, the TVA region in the alternatives analysis. Tennessee relies on coal, natural gas, and nuclear power as its primary electric generation fuels (EIA 2012b). While the staff generally considers alternatives located within Tennessee, it acknowledges that alternatives could also be located elsewhere in the TVA region, or elsewhere in the SERC region.

At this time, the State of Tennessee has no regulations to encourage the increased production of energy from renewable resources such as wind, solar, biomass, and other alternatives to fossil and nuclear generation. TVA's current renewable energy portfolio includes 3,889 megawatts (MW) from hydroelectric, wind, solar, and methane gas sources within the TVA region. TVA also recently announced the addition of 1,625 MW of wind energy through the acquisition of eight additional purchased power contracts with Iowa, Kansas, North Dakota, South Dakota, and Illinois (TVA 2011b). An analysis of clean energy policy in the SERC region concluded that Tennessee has a variety of available renewable resources, including solar PV and a small hydroelectric potential (McLaren 2011).

The remainder of this section describes the alternatives to license renewal that are evaluated in depth in Chapter 4 for potential environmental impacts. These include an NGCC alternative in Section 2.2.2.1, an SCPC alternative in Section 2.2.2.2, a new nuclear alternative in Section 2.2.2.3, and a combination wind and solar power alternative in Section 2.2.2.4. Table 2–1 summarizes key design characteristics of the alternative technologies evaluated in depth.

Table 2–1. Summary of Replacement Power Alternatives and Key Characteristics Considered in Depth

	NGCC Alternative	SCPC Alternative	New Nuclear Alternative	Combination Alternative
Summary of Alternative	Six 400-MWe units, for a total of 2,400 MWe	Four SCPC units, for a total of 2,400 MWe	Two-unit nuclear plant, for a total of 2,400 MWe	2,350–3,150 2-MWe wind turbines, for a total of 4,700–6,300 MWe (DOE 2008); 2,000–2,900 MWe installed solar PV
Location	An existing power plant site (other than SQN) or brownfield site with available infrastructure in the TVA region; some infrastructure upgrades may be required; would require construction of a new or upgraded supply pipeline.	An existing power plant site (other than SQN) or brownfield site with available infrastructure in the TVA region; some infrastructure upgrades may be required.	An existing nuclear power plant site (other than SQN); some infrastructure upgrades may be required.	Spread across multiple sites throughout TVA region; solar PV installed at developed sites and existing buildings
Cooling System	Closed-cycle with mechanical draft cooling towers; cooling water withdrawal 14.9 mgd; consumptive water use 11.4 mgd (NETL 2010a, 2010b)	Closed-cycle with natural draft cooling towers; cooling water withdrawal 33.5 mgd; consumptive water use 26.6 mgd (NETL 2010a, 2010c)	Closed-cycle with natural draft cooling towers; cooling water withdrawal 48–62 mgd; consumptive water use 45–48 mgd (NRC 2013)	N/A
Land Require-ments	48 ac for the plant (NETL 2010b); 8,640 ac for wells, collection site, pipeline (NRC 1996)	131 ac for the plant (NETL 2010a); 7,440–52,800 ac for coal mining and waste disposal (NRC 1996)	1,000 ac (TVA 2013); 2,400 ac for uranium mining and processing (TVA 2013)	Wind farms would require 1,410–1,890 ac (NRC 2013); standalone solar PV installations would require 12,400–17,980 ac (Renné et al. 2008).
Work Force	2,880 during peak construction; 120–180 during operations	2,880–6,000 during peak construction; 360–480 during operations	5,000 during peak construction; 540–720 during operations	200 during peak construction; 50 during operations

Sources: Cited values derived or scaled from NETL 2010a, 2010b, 2010c; NRC 1996, 2013; Renné et al. 2008; TVA 2013

2.2.2.1 NGCC Alternative

Natural gas combined-cycle (NGCC) systems represent the largest majority of the total number of plants currently under construction or planned in the United States. The EIA projects that natural gas-fired generation will account for the largest single share of new generating capacity in the United States (37 percent) through 2040 (EIA 2013a). Factors that contribute to the current popularity of NGCC facilities include high capacity factors (ratio of actual output to potential output at full capacity, over a given period of time), low relative construction costs, low gas prices, and relatively low air emissions. Development of new NGCC plants may be affected by uncertainties about the continued availability and price of natural gas (though less so than in the recent past) and future regulations that may limit greenhouse gas (GHG) emissions. A gas-fired power plant, however, produces markedly fewer GHGs per unit of electrical output than a coal-fired plant of the same electrical output.

Combined-cycle power plants differ significantly from most coal-fired and all existing nuclear power plants. Combined-cycle plants derive the majority of their electrical output from a gas turbine and then generate additional power—without burning any additional fuel—through a second steam-turbine cycle. The exhaust gas from the gas turbine is still hot enough to boil water to steam. Ducts carry the hot exhaust to a heat recovery steam generator, which produces steam to drive a steam turbine and produce additional electrical power. The combined-cycle approach is significantly more efficient than any one cycle on its own; thermal efficiency (ratio of electrical power output to electrical power input) can exceed 50 percent versus 39 percent for conventional single-cycle facilities (NETL 2010a; Siemens 2007). In addition, because the natural gas-fired alternative derives much of its power from a gas-turbine cycle, and because it wastes less heat than the existing SQN units, it requires significantly less cooling water.

While nuclear reactors, on average, operate with capacity factors above 90 percent (SQN Units 1 and 2 operated at a 96 percent average capacity factor from 2008 to 2010 (TVA 2013)), the staff expects that an NGCC alternative would operate with roughly an 85 percent capacity factor. Nonetheless, the staff assumes that a similar-sized NGCC facility would be capable of providing adequate replacement power for the purposes of this NEPA analysis.

Typical power trains for large-scale NGCC power generation would involve one, two, or three combined-cycle units, available in a variety of standard sizes, mated to a heat-recovery steam generator. To complete the assessment of an NGCC alternative, the NRC assumes that appropriately sized units could be assembled to annually produce electrical power in amounts equivalent to SQN. For purposes of this review, the staff evaluated an alternative that consists of six parallel Advanced F Class units, 400 megawatts electric (MWe) each, equipped with dry-low-nitrogen-oxide combustors to suppress nitrogen oxide formation and selective catalytic reduction of the exhaust with ammonia for post combustion control of nitrogen oxide emissions. This alternative provides 2,400 MWe of capacity, replacing the full 2,400 MWe produced by SQN.

In its ER, TVA scaled from estimates in the 1996 GEIS of 0.11 ac/MW (110 acres per 1,000 MW for an NGCC plant) to calculate a land requirement for the NGCC alternative of approximately 264 ac (107 ha) (TVA 2013). For the purposes of this analysis, NRC staff will use a scaling factor of 0.02 ac/MW, based on updated information from DOE sources (NETL 2010b). Using this updated scaling factor, a 2,400-MWe NGCC alternative would require approximately 48 ac (19 ha) of land. Depending on the site location and availability of existing natural gas pipelines, a 100-ft wide (30.5-m wide) right-of-way may be needed for a new supply pipeline. The NGCC alternative may also require up to 8,640 ac (3,497 ha) of land for wells, collection stations, and pipelines to bring the gas to the plant (NRC 1996). Most of this land requirement would occur on land where gas extraction already occurs.

The NRC staff assumes that an NGCC alternative would utilize a closed-cycle cooling system and be equipped with mechanical-draft cooling towers. The NGCC alternative would require approximately 14.9 mgd (0.65 m^3/s, 23 cubic feet per second (cfs)) of water for cooling and related processes (NETL 2010a, 2010b). Consumptive water use by the plant would be approximately 77 percent of the amount withdrawn, or about 11.4 mgd (0.5 m^3/s, 17.6 cfs) (NETL 2010a, 2010b).

While siting an alternative on the SQN site would allow for the fullest use of existing ancillary infrastructure, such as transmission and support buildings, and minimize the use of undisturbed land, space constraints on the SQN site preclude that option (TVA 2013). In its ER, TVA assumed that the NGCC alternative could be located outside the Tennessee Valley if the electricity could be efficiently routed to the SQN region (TVA 2013). The NRC determined that this assumption is valid, and for the purposes of this analysis also assumes that the NGCC alternative could be constructed at another existing nuclear power plant site or brownfield[1] site with available infrastructure elsewhere in the TVA region or SERC region, which would mitigate construction impacts in a similar way to building the alternative at the SQN site. It is possible that an NGCC alternative constructed at an existing power plant site would require some infrastructure upgrades, such as improved transmission lines or modifications to existing intake or cooling systems, but the NRC staff expects that these impacts would be smaller than those necessary to support an NGCC alternative constructed on an undeveloped site.

Wherever the NGCC alternative is constructed, it is likely to require a new or upgraded pipeline to supply natural gas to the facility. Some of the natural gas supplied to this alternative is likely to come from Tennessee or from neighboring states, but the NGCC alternative is unlikely to directly trigger new natural gas development in Tennessee or the TVA region.

NGCC power plants are feasible, commercially available options for providing electric generating capacity beyond the current SQN license expiration dates. The overall environmental impacts of an NGCC alternative, as well as the environmental impacts of proposed SQN license renewal, are discussed in Chapter 4.

2.2.2.2 SCPC Alternative

Coal-fired generation historically has been the largest source of electricity in the United States; however, due to cost uncertainties associated with anticipated future environmental regulations (such as cap-and-trade and greenhouse emission regulations), projections for future coal-fired generation vary (EIA 2013a; NRC 2013). In its 2013 Annual Energy Outlook, the EIA projects that coal's generation share could fall from 48 percent in 2008 to 35 percent in 2040, or as low as 27 percent in some projections (EIA 2013a). In Tennessee, 41 percent of electricity was generated using coal-fired power plants in 2010 (EIA 2012b). Baseload coal units have proven their reliability and can routinely sustain capacity factors of 85 percent or greater. Among the various boiler designs available, pulverized coal boilers producing supercritical steam (SCPC boilers) are the most likely variant for a coal-fired alternative given their generally high thermal efficiencies and overall reliability.

While nuclear reactors, on average, operate with capacity factors above 90 percent, the new SCPC coal-fired power plant would operate with roughly an 85 percent capacity factor. Despite the slightly lower capacity factor, an SCPC plant would be capable of providing adequate replacement power for a nuclear plant for the purposes of this NEPA analysis.

A myriad of sizes of pulverized coal boilers and steam turbine generators (STGs) are available; however, the NRC staff assumes that four equal-sized boiler/STG powertrains, operating independently and simultaneously, would likely be used to match the power output of SQN. To

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[1] A brownfield site is an abandoned, idled, or under-used industrial and commercial facilities in which expansion or redevelopment is sometimes complicated by real or perceived environmental contamination (EPA 2011, NRC 2013).

complete this analysis, the NRC staff assumes that all powertrains would have the same features, operate at generally the same conditions, have similar impacts on the environment, and be equipped with the same pollution-control devices, such that once all parasitic loads (electric power consumed that does not contribute to the net electric yield) are overcome, the net power available would be equal to 2,400 MWe. The NRC staff assumes that 6 percent of an SCPC boiler's gross capacity is needed to supply typical parasitic loads (plant operation plus control devices for criteria pollutants to meet New Source Performance Standards). Introducing controls for GHG emissions (i.e., carbon capture and sequestration (CCS)) would cause the parasitic load to increase to 27.6 percent of the boiler's gross rated capacity (NETL 2010a). However, because of uncertainty regarding future GHG regulations and the limited real-world experience in CCS at utility-scale power plants, parasitic loads associated with CCS are not considered. Various bituminous coal sources are available to coal-fired power plants in Tennessee. EIA reports that, in 2009, Tennessee produced electricity from coal with heating values of 12,650 British thermal units per pound, sulfur content of 1.25 percent, and ash of 8.87 percent (EIA 2010b). For the purpose of this evaluation, the staff assumes that coal burned in 2009 will be representative of coal that would be burned in a coal-fired alternative regardless of where it was located. Approximately 0.7 percent of the coal burned in Tennessee in 2009 came from mines in Tennessee. Wyoming, Illinois, and Kentucky supplied most of the remaining coal (EIA 2010b). Bituminous coals from Tennessee and Georgia mines have average carbon dioxide emission factors of 204.8 to 206.1 lb per million British thermal units of heat input, respectively (Hong and Slatick 1994).

In its ER, TVA determined that the current SQN site was not viable to accommodate a coal-fired alternative with net generating capacity sufficient to meet the power production of SQN because of limited space on the SQN site (TVA 2013). The staff considers this assessment valid and the analysis of the impacts, in this SEIS, of the coal-fired alternative assumes that the SCPC coal-fired power plant would be sited at an existing power plant site or brownfield site with available infrastructure to take advantage of existing infrastructure. The site could be located in Tennessee or elsewhere in the TVA or SERC regions.

Supercritical Steam

"Supercritical" refers to the thermodynamic properties of the steam being produced. Steam whose temperature and pressure is below water's "critical point" (3,200 pounds per square inch absolute (psia) (221 bar] and 705 °F (374 °C)) is subcritical. Subcritical steam forms as water boils and both liquid and gas phases are observable in the steam. The majority of coal boilers currently operating in the United States produce subcritical steam with pressures around 2,400 psia (165 bar) and temperatures as high as 1,050 °F (566 °C). Above the critical point pressure, water expands rather than boils, and the liquid and gaseous phases of water are indistinguishable in the supercritical steam that results. More than 150 coal boilers currently operating in the United States produce supercritical steam with pressures between 3,300 and 3,500 psia (228 to 241 bar) and temperatures between 1,000 and 1,100 °F (538 to 593 °C). Ultrasupercritical boilers produce steam at pressures above 3,600 psia (248 bar) and temperatures exceeding 1,100 °F (593 °C). There are only a few of these boilers in operation worldwide, none of which are in the United States.

It is reasonable to assume that a coal-fired alternative would use supercritical steam (see text box). Supercritical steam technologies are increasingly common in new coal-fired plants. They are commercially available and feasible. Supercritical plants operate at higher temperatures and pressures than older subcritical coal-fired plants and, therefore, can attain higher thermal efficiencies. While supercritical facilities are more expensive to construct than subcritical facilities, they consume less fuel for a given output, reducing environmental impacts throughout the fuel life cycle. The NRC staff expects that a new supercritical coal-fired plant would operate at a heat rate of 8,721 British thermal units per kilowatt hour (EIA 2010a), or approximately 39 percent thermal efficiency. However, heat inputs could be less, depending on the coal source and whether fuel blending is practiced in order to remain compliant with emission limitations.

In its ER, TVA scaled from estimates in the 1996 GEIS of 1.7 ac per MW to calculate a land requirement for the SCPC alternative of approximately 4,080 ac (1,651 ha) (TVA 2013). For the purposes of this analysis, NRC staff will use an updated scaling factor of 0.05 ac per MW, based on updated information from DOE sources (NETL 2010a, 2010b). Using this updated scaling factor, a 2,400-MWe SCPC alternative would require approximately 131 ac (53 ha) of land. The 1996 GEIS estimates that up to 22,000 ac (8,900 ha) of land would be necessary for coal mining and processing for a 1,000-MWe coal-fired plant (22 ac per MW) (NRC 1996). A 2010 NETL study, however, estimated a much smaller scaling factor of 3.1 ac per MW (NETL 2010c). Because the NETL study was based on only one operating coal mine (Galatia Mine, Illinois), NRC staff will use a range of 7,440 ac (3,011 ha) to 52,800 ac (21,400 ha) of land for coal mining and processing for the SCPC alternative.

The NRC staff assumes that an SCPC alternative would utilize a closed-cycle cooling system and be equipped with natural-draft cooling towers. The SCPC alternative would require approximately 34 mgd (1.5 m^3/s, 53 cfs) of water for cooling and related processes (NETL 2010a, 2010c). Consumptive water use by the plant would be approximately 80 percent of the amount withdrawn, or about 27 mgd (1.2 m^3/s, 42 cfs) (NETL 2010a, 2010c).

SCPC coal-fired power plants are currently commercially available and currently are feasible alternatives to SQN license renewal. The overall environmental impacts of a coal-fired alternative, as well as the environmental impacts of proposed SQN license renewal, are discussed in Chapter 4.

2.2.2.3 New Nuclear Alternative

In Tennessee, 15.9 percent of electricity was generated using nuclear power plants in 2010 (EIA 2012b). As noted by EIA in its Annual Energy Outlook (EIA 2013a), nuclear generation is expected to grow by 14.3 percent from 2011 through 2040. The EIA projects that nuclear capacity will increase by 19 gigawatts (GW) (1 GW equals 1,000 MW) through 2040, including 8.0 GW of expansions at existing plants and 11.0 GW of new capacity (EIA 2013a). A new nuclear power plant is likely to be similar to SQN in terms of capacity factor.

Several designs are possible for a new nuclear facility. However, a two-unit nuclear power plant similar to the existing SQN in output is most likely. Currently, four nuclear reactor designs have been certified, including the 1,300-MWe U.S. Advanced BWR, the 1,300-MWe System 80+ Design, the 600-MWe AP600 Design, and the 1,100-MWe AP1000 Design (NRC 2013). The new nuclear alternative would rely on a closed-cycle cooling system with natural-draft cooling towers, similar to the cooling system currently in place at SQN.

In its ER, TVA determined that the current SQN site was not viable to accommodate a new nuclear alternative with net generating capacity sufficient to meet the power production of SQN because of insufficient space at the SQN site (TVA 2013). The NRC staff supports this assumption, and for the purposes of this analysis also assumes that the new nuclear alternative would most likely be constructed on a site that already hosts a nuclear power plant elsewhere in the TVA region or SERC region. This placement would allow the new nuclear alternative to take advantage of existing site infrastructure, including transmission lines and some support facilities. In February 2012, the NRC issued two combined licenses (COLs) for the construction and operation of two AP1000 reactors at the Alvin W. Vogtle Electric Generating Plant site in Waynesboro, Georgia (77 FR 12332; NRC 2013). In March 2012, NRC issued two COLs for the construction and operation of two new AP1000 reactors at the Virgil C. Summer Nuclear Station site in Jenkinsville, South Carolina (77 FR 21593; NRC 2013).

In its ER, TVA calculated a land requirement for the new nuclear alternative of approximately 1,000 ac (405 ha) based on the sizes of TVA's existing nuclear plant sites (Bellefonte, Sequoyah, and Watts Bar, which range from 600 to 1,500 ac (243 to 607 ha)) (TVA 2013). This estimate is consistent with the 2013 GEIS, which estimates a land requirement of 500 to 1,000 ac (202 to 405 ha) for a new nuclear plant (NRC 2013). For the purposes of this analysis, NRC staff will use TVA's estimate of 1,000 ac (405 ha). TVA also estimated that up to 2,400 ac (971 ha) of land would be affected by the uranium mining and processing during the life of the nuclear plant (TVA 2013).

The NRC staff assumes that a new nuclear alternative would utilize a closed-cycle cooling system and be equipped with natural-draft cooling towers. Because SQN only operates in open-cycle and helper cooling modes, water consumption for the new nuclear alternative would be considerably greater than SQN (see Section 4.5.5.1). The new nuclear alternative would require approximately 62 mgd (2.7 m^3/s, 96 cfs) of water for cooling and related processes (NETL 2010a, 2010c). Consumptive water use by the plant would be approximately 80 percent of the amount withdrawn, or about 48 mgd (2.1 m^3/s, 74 cfs) (NETL 2010a, 2010c).

New nuclear power plants are commercially available and feasible alternatives to SQN license renewal. The overall environmental impacts of a new nuclear alternative, as well as the environmental impacts of proposed SQN license renewal, are discussed in Chapter 4.

2.2.2.4 Combination Wind and Solar Alternative

The combination alternative consists of 4,700 to 6,300 MWe of total installed wind capacity and 2,000 to 2,900 MWe of total installed solar PV capacity to provide the balance needed to replace SQN. The staff applied a capacity-factor-based approach to determining the relative amount of wind and solar power in this alternative.

The overall environmental impacts of a combination wind and solar (PV) alternative, as well as the environmental impacts of proposed SQN license renewal, are discussed in Chapter 4.

Wind Power Portion

The feasibility of wind as a baseload power source depends on the availability, accessibility, and constancy of the wind resource within the region of interest. Wind power, in general, cannot be stored without first being converted to electrical energy. Wind power installations, which may consist of several hundred turbines, produce variable amounts of electricity. SQN, however, produces electricity almost constantly. Because wind power installations deliver variable output when wind conditions change, wind power cannot substitute for existing baseload generation on a one-to-one basis.

The energy potential in wind is expressed by wind generation classes, which range from 1 (least energetic) to 7 (most energetic). Wind resources with wind speeds of at least 15.7 miles per hour (mph) (7.0 meters per second (m/s)), that is, Class 3 or better, are most desirable for utility-scale amounts of electricity. Utility-scale wind potential in the State of Tennessee and the surrounding TVA region is relatively low compared to other parts of the country, with the majority of the region rated at Class 1 or 2 (DOE 2012). A 2010 NREL report estimated a wind potential of 1,247 MWe in the TVA region, while DOE estimated approximately 3,219 MW in the seven states that comprise the TVA region (NREL 2011). TVA owns one small windfarm with three 660-kilowatt (kW) turbines on Buffalo Mountain near Oak Ridge, Tennessee, and purchases 27 MW of wind generated electricity from another windfarm on Buffalo Mountain (TVA 2011a). Due to lack of available resources, TVA has taken the approach of procuring wind power through power purchase agreements (PPAs) with other States that do have the available wind energy potential (TVA 2011b). TVA has entered into PPAs with seven windfarms for a total of 1,625 MW (TVA 2011b).

Wind power is a commercially available and feasible means of generating electricity. Although the TVA region has relatively low wind energy potential, other areas in the SERC region have higher potential wind resources (DOE 2012). A study by Archer and Jacobson (2007) indicates that an array of interconnected wind sites (19 in the study) spread across significant distances (with approximately 850 km (530 mi) distance from north to south and east to west) could provide 21 percent of installed capacity 79 percent of the time. While the sites in Archer and Jacobson's study, in most cases, accessed higher power-class wind resources than are readily available onshore in the TVA region, the approach suggests that approximately 20 percent of the installed capacity in a series of interconnected wind installations could provide baseload power. Therefore, this study indicates that interconnecting windfarms, as assumed in this alternative, may provide a source of consistent baseload power. In this alternative, the staff considers a wind alternative that relies on numerous, interconnected wind installations scattered across the TVA or SERC region. This arrangement ensures that generators are sufficiently dispersed so that low-wind or no-wind conditions are unlikely to occur at all or most locations at any given time.

Wind farms currently operate at much lower capacity factors than nuclear power. For example, SQN operated at a 96-percent average capacity factor from 2008 to 2010 (TVA 2013). Currently, DOE estimates that wind turbine installations operate at 39 percent or lower capacity factors because of the variability of wind resources (DOE 2008). NREL uses a capacity factor range of 30 to 37 percent (NREL 2013; Tegen et al. 2013). Capacity factors are likely to increase as wind turbine technology advances and as operators become more experienced in maximizing output. According to a DOE report, capacity factors improved by 11 percent from 2005 to 2006 (DOE 2008). The DOE report states that most common large turbines have a rated capacity of between 1 MW and 3 MW, with rotor diameters between 60 m and 90 m (197 and 295 ft), tower heights between 60 m and 100 m (197 and 328 ft), and capacity factors between 30 and 40 percent (DOE 2008). For the purposes of this analysis, the staff will assume a capacity factor range of 30 to 40 percent. In the wind portion of this alternative, the staff considers a wind alternative that relies on numerous interconnected wind installations scattered across the TVA or SERC region, with an installed capacity between 4,700 MWe and 6,300 MWe. Relying on commonly available 2-MWe turbines, 2,350 to 3,150 turbines would be required to replace SQN generation in conjunction with the solar portion of this alternative described below.

Since wind turbines require ample spacing between one another to avoid air turbulence, the footprint of a utility scale wind farm could be quite large. Wind energy facilities require approximately 0.3 ac (0.12 ha) of land per MW (NRC 2013). Most of the wind farms would likely be located on open agricultural cropland, which would remain largely unaffected by the wind turbines. Once the installation of the turbines and the construction of support facilities are completed, land areas between the turbines can be used for other beneficial (nonintrusive) uses. During operations, only 5–10 percent of the total acreage within the wind farm is actually occupied by turbines, access roads, support buildings, and associated infrastructure while the remaining land area can be returned to its original condition or some other compatible use, such as farming or grazing.

This alternative assumes all wind power would be generated onshore because it is currently commercially available and a feasible means of generating electricity. While some offshore wind development is possible by 2024, no commercial offshore wind installations currently operate in the United States, despite more than a decade of development efforts. In the Atlantic

Ocean, several commercial wind-power projects have been proposed, but none have yet received final approvals or begun construction.

Solar Photovoltaic Portion

Solar energy potential is a function of average daily solar insolation and is reported either as direct normal radiation (without diffuse light) or total radiation (direct and diffuse light) (TVA 2011a). In PV systems, sunlight incident on special PV materials produces direct current (DC) electricity. An advantage of PV is that it is suitable for locations with low direct-sun irradiation. The potential for solar technologies to serve as reliable baseload power alternative depends on the value, constancy, and accessibility of the solar resource. Solar resources across the United States are good to excellent, with solar insolation levels ranging from about 2.7 to 6.8 kilowatt hours per square meter per day ($kWh/m^2/day$) (NREL 2012). Tennessee receives approximately 4.5 to 5.0 kilowatt hours per square meter per day ($kWh/m^2/day$) of global radiation, compared to roughly 6.0 to 8.0 $kWh/m^2/day$ in areas of the Southwest and West, such as California (NREL 2012). Other states within the TVA region receive 5.0 to 5.5 $kWh/m^2/day$ of global radiation (NREL 2012). A 2007 study which calculated the net PV energy density for each state concluded that solar resources in the TVA region are plentiful, with TVA region states ranking between 14th and 29th in PV energy density (Denholm and Margolis 2007; TVA 2011a).

Currently, TVA owns 14 PV installations, with a combined capacity of about 280 kW (TVA 2011b). TVA has taken a similar approach of procuring solar power as it has with wind power, through PPAs with other States that have available solar energy potential (TVA 2011b). TVA projects the acquisition of an additional 365 MW of solar capacity through PPAs by 2020 (TVA 2011b). In TVA's renewable portfolio projections, solar accounts for approximately 7 to 10 percent net renewable capacity, approximately 185 to 365 MW, by the year 2029 (TVA 2011b).

The PV technologies would generally be installed on building roofs at existing residential, commercial, or industrial sites; however, some solar installations may also be built at standalone solar sites. Land use impacts may vary depending on the amount of additional land required and the actual allocation of solar installations. The footprint of a utility scale standalone PV solar installation would be quite large, with approximately 12,400 to 17,980 ac (5,018 to 7,276 ha) of land needed to support a 2,000- to 2,900-MW solar PV alternative (Renné et al. 2008). Installing PV solar technologies on building rooftops would reduce the amount of land required for standalone solar. A 2008 study found the PV rooftop potential solar capacity in the TVA region to be approximately 23,000 MW (Paidipati et al. 2008; TVA 2011a). Based on this, NRC staff assumes that sufficient rooftop space exists throughout the TVA or SERC regions to support installation of the solar PV portion of this alternative solely on existing structures, thus minimizing potential for land-use and terrestrial ecology impacts from solar PV installations.

2.3 Alternatives Considered but Dismissed

Alternatives to SQN license renewal that were considered and eliminated from detailed study are presented in this section. These alternatives were eliminated because of technical, resource availability, or current commercial limitations. Many of these limitations would continue to exist when the current SQN licenses expire.

2.3.1 Wind Power

The feasibility of wind power relies on the availability of the wind resource within the region of interest and access to transmission infrastructure. In recent years, wind power has increased in scale significantly, and the largest operating plant in the United States is a 1,020-MW facility located in Tehachapi Pass in Kern County, California. The advantages of wind power are the use of a renewable natural resource and no direct airborne emissions. Disadvantages are a large total land commitment (although much of the land surrounding individual wind turbines could be used for other purposes such as agriculture), a relatively low capacity factor, aesthetic intrusion, and bird and bat casualties.

The energy potential in wind is expressed by wind generation classes, which range from 1 (least energetic) to 7 (most energetic). Wind resources with wind speeds of at least 15.7 mph (7.0 m/s), that is, Class 3 or better, are most desirable for utility-scale amounts of electricity. However, advances in wind energy technology development, specifically blade diameter, make areas previously considered “low” wind resources, such as areas with wind speeds of 13.4 mph (6 m/s), suitable for development (NREL 2011).

The majority of Tennessee and the TVA region is classified as a Class 1 or Class 2 region (NREL 2009). Approximately 29 MW of wind capacity is operating in the TVA region as of 2011, all of which is located within the State of Tennessee (DOE 2012). Based on the amount of available windy land area, the NREL estimates 309 MW of potential installed wind capacity for Tennessee, and 3,219 MW for the entire TVA region, with a gross capacity factor of 30 percent at 80-m (260-ft) heights above ground (NREL 2011). Although this does not address current cost and turbine design limitations, as stated previously, turbine technology improvements are leading to industry expectations to serve sites with lower wind speeds (NREL 2012).

The potential for energy storage could address the variable aspect of wind power, which is now one of the primary drivers behind renewed interest in energy storage. Storage provides one solution to provide firm capacity and energy, allowing intermittent generation to effectively replace baseload generation. As of 2009, only four energy storage technologies (sodium-sulfur batteries, pumped hydro, compressed air energy storage, and thermal storage) have a worldwide installed capacity that exceeds 100 MW (NREL 2012).

As a result, the NRC staff does not consider new wind generation to be a reasonable standalone alternative to SQN license renewal. However, when combined with other renewable technologies, wind energy can contribute to a viable alternative. The NRC staff evaluated such a possible combination in Section 2.2.2.4.

2.3.2 Solar Power

Solar technologies, including PV and solar thermal (also known as concentrated solar power (CSP)), use the sun’s energy to produce electricity at a utility scale. In PV systems, special PV materials convert the energy contained in photons of sunlight to DC electricity that can be aggregated, converted to alternating current, and connected to the high-voltage transmission grid. Some PV installations, especially those located on existing buildings, provide power directly to consumers without first going onto the grid. The CSP technologies produce electricity by capturing the sun’s heat energy. The CSP facilities are typically grid connected, and owing to size and operational characteristics, are not located atop existing structures. Although some aspects of solar generation result in few environmental impacts, solar technology requires substantial land areas, and CSP technologies require roughly the same amount of water for cooling of the steam cycle as most other thermoelectric technologies.

The potential for solar technologies to serve as reliable baseload power alternative to SQN depends on the value, constancy, and accessibility of the solar resource. Both PV and CSP are enjoying explosive growth worldwide, especially for various off-grid applications or to augment grid-provided power at the point of consumption; however, discrete baseload applications still have technological limitations. Solar power generation typically requires backup generation or other means of balancing its variable output. Further, PV installations have no ability to provide power at night, and they provide reduced levels of power on overcast days, during fog events, and when snow accumulates. While their generation during summer months is high when electricity consumption is high, their capacity to generate electricity in winter declines before the evening electricity demand peaks.

EIA reports the total solar generating capacity (CSP and solar PV) in the United States in 2011 was 1,524 MW, 0.01 percent of the total nationwide generating capacity. Solar power produced 1.818 million megawatt hours (MWh) of power in 2011, 0.04 percent of the nationwide production (EIA 2013b). The NRC staff is not aware of any CSP facilities in the United States that are not located in the Southwest, while many PV installations occur throughout the country. As a result, the NRC staff determined that a solar-powered alternative in the TVA region would rely on solar PV technology rather than CSP technology.

Because PV does not produce electricity at night and produces diminished amounts of power during particular weather conditions, the staff does not consider solar PV to provide a viable standalone alternative to license renewal. Load balancing or firming methods (using storage to remove the variability of available solar resources) would be necessary for solar to serve as a standalone alternative to SQN. Technology to achieve load balancing or firming methods is not yet feasible or commercially available, which is part of the reason why the NRC staff determined that this alternative is not reasonable. However, when combined with other renewable technologies, solar power can contribute to a viable alternative. The NRC staff evaluated such a possible combination in Section 2.2.2.4.

2.3.3 Conventional Hydroelectric Power

Currently, there are approximately 2,000 operating hydroelectric facilities in the United States. Hydroelectric technology captures flowing water and directs it to a turbine and generator to produce electricity (NRC 2013). There are three variants of hydroelectric power: run-of-the-river (diversion) facilities redirect the natural flow of a river, stream, or canal through a hydroelectric facility; store-and-release facilities block the flow of the river by using dams that cause water to accumulate in an upstream reservoir; and pumped storage facilities use electricity from other power sources to pump water to higher elevations during off-peak load periods to be released during peak load periods through the turbines to generate additional electricity. Store-and-release facilities affect large amounts of land behind the dam to create reservoirs, but can provide substantial amounts of power at capacity factors greater than 90 percent. Power generating capacities of run-of-the-river facilities fluctuate with the flow of water in the river, and operation is typically constrained (and suspended entirely during certain periods) so as not to create undue stress on an aquatic ecosystem. Capacities of pumped storage facilities are dependent on the configuration and capacity of the elevated storage facility.

The EIA projects that hydropower will remain the leading source of renewable generation through 2040; however, there is little expected growth in hydropower capacity (EIA 2013). The potential for future construction of large hydropower facilities has diminished due to increased public concerns over flooding, habitat alteration and loss, and destruction of natural river courses (NRC 2013).

A comprehensive survey of hydropower resources in Tennessee was completed in 1997 by DOE's Idaho National Engineering and Environmental Laboratory (INEEL) (now known as the Idaho National Laboratory). In the study, generating potential was defined by a model that considered the existing hydroelectric technology at developed sites, or applied the most appropriate technology to undeveloped sites, and introduced site-specific environmental considerations and limitations. Tennessee had limited hydroelectric potential, with a total generating potential of 138 MWe (INEEL 1997a). This potential was spread across 22 sites, one of which had the potential for 90 MWe of generation, or 65 percent of the total undeveloped hydropower potential of the Tennessee river basins. Most other states in the TVA region have similarly limited undeveloped potential (Conner et al. 1998), with the largest potential in Virginia, which has 617 MWe spread across 88 sites (INEEL 1997b).

More recently, EIA reported that, in 2010, conventional hydroelectric power (excluding pumped storage) was the principal electricity generation source among renewable sources in Tennessee (EIA 2012c). Approximately 2,624 MWe of hydroelectric capacity was installed in Tennessee as of 2010. Those installations provided 8,138 gigawatt hours (GWh) of electricity (EIA 2012c). Although hydroelectric facilities can demonstrate relatively high capacity factors, the small potential capacities and actual recent power generation of hydroelectric facilities in Tennessee, combined with the diminishing public support for large hydroelectric facilities because of their potential for adverse environmental impacts, supports the NRC staff's conclusion that hydroelectric is not a feasible alternative to SQN.

2.3.4 Geothermal Energy

Geothermal technologies extract the heat contained in geologic formations to produce steam to drive a conventional steam-turbine generator. Geothermal energy facilities have demonstrated capacity factors of 90 to 98 percent, making geothermal energy clearly eligible as a source of baseload electric power (NRC 2013). However, as with other renewable energy technologies, the ultimate feasibility of geothermal energy serving as a baseload power replacement for SQN depends on the quality and accessibility of geothermal resources within or proximate to the region of interest—in this case, the TVA or SERC region. Most domestic geothermal resources exist in the western United States, with the greatest contribution of geothermal energy to electricity production occurring in California. As of October 2009, the United States had a total installed geothermal electricity production capacity of 3,153 MWe originating from geothermal facilities in eight states—Alaska, California, Hawaii, Idaho, Nevada, New Mexico, Utah, and Wyoming. Additional geothermal projects are being considered in 14 other states. Neither Tennessee nor the TVA region has adequate geothermal resources to support utility-scale electricity production (GEA 2010). NRC staff concludes, therefore, that geothermal energy does not represent a feasible alternative to SQN.

2.3.5 Biomass Energy

When used here, "biomass energy" includes crop residues, switchgrass grown specifically for electricity production, forest residues, methane from landfills, methane from animal manure management, primary wood mill residues, secondary wood mill residues, urban wood wastes, and methane from domestic wastewater treatment. The feasibility of using biomass fuels for baseload power depends on its geographic distribution, available quantities, constancy of supply, and energy content. Biomass energy conversion is accomplished using a wide variety of technologies, including direct burning, conversion to liquid biofuels, and biomass gasification. In a study completed in December 2005, Milbrandt of NREL documented the geographic distribution of biomass fuels within the United States, reporting the results in metric tons (MT) available (dry basis) per year. Most counties in Tennessee have limited potential for biomass fuels, with the exception of Shelby County. Use of biomass fuels in Tennessee is also limited. Beyond the wood and wood waste considered in Section 2.3.7, generators in the State used biomass fuels to produce merely 2,000 MWh of electricity in 2010 (EIA 2012).

TVA has a cofiring methane facility at the Allen Fossil Plant and also purchases about 21 MW of non-wood waste biomass-fueled generation, including 9.6 MW of landfill gas generation and 11 MW of corn milling residue generation (TVA 2011b). TVA's Integrated Resource Plan (IRP) also includes up to 490 MW of biomass generation and landfill generation, some of which includes the conversion of existing coal-fired units to biomass-fired units and cofiring biomass with coal at existing coal plants (TVA 2011b). TVA is currently assessing the feasibility of converting coal-fired units to biomass fuel.

In the GEIS (NRC 2013), the NRC indicated that technologies relying on a variety of biomass fuels had not progressed to the point of being competitive on a large scale or of being reliable enough to replace a baseload plant such as SQN. After reevaluating current technologies, and after reviewing existing Statewide capacities and the extent to which biomass is currently being used to produce electricity, the NRC staff finds biomass-fueled alternatives are still unable to replace the SQN capacity and are not considered feasible alternatives to SQN license renewal.

2.3.6 Municipal Solid Waste

Municipal solid waste (MSW) combustors use three types of technologies—mass burn, modular, and refuse-derived fuel. Mass burning is currently the method used most frequently in the United States and involves no (or little) sorting, shredding, or separation. Consequently, toxic or hazardous components present in the waste stream are combusted, and toxic constituents are exhausted to the air or become part of the resulting solid wastes. Currently, approximately 87 waste-to-energy plants operate in 25 states, processing 97,000 tons (88,000 MT) of MSW per day. Approximately 26 million tons (24 million MT) of trash were processed in 2008 by waste-to-energy facilities. With a reliable supply of waste fuel, waste-to-energy plants have a nationwide aggregate capacity of 2,720 MWe (compared to a 2,400 MWe capacity at SQN) and can operate at capacity factors greater than 90 percent (ERC 2010).

The decision to burn municipal waste to generate energy is usually driven by the need for an alternative to landfills, rather than energy considerations. Regulatory structures that once supported MSW incineration no longer exist. For example, the Tax Reform Act of 1986 made capital-intensive projects, such as municipal waste combustion facilities, more expensive relative to less capital-intensive waste disposal alternatives, such as landfills. Additionally, the 1994 Supreme Court decision *C & A Carbone, Inc., et al. v. Town of Clarkstown, New York*, struck down local flow control ordinances that required waste to be delivered to specific municipal waste combustion facilities rather than landfills that may have had lower fees. In addition, environmental regulations have increased the capital cost necessary to construct and maintain municipal waste combustion facilities.

Given the limited nationwide implementation of MSW-based generation to date (only 7 percent greater than the capacity of SQN), the small average installed size of MSW plants, the likelihood that additional stable streams of MSW are not likely to be available to support numerous new facilities, and the increasingly unfavorable regulatory environment, the NRC staff does not consider MSW combustion to be a reasonable alternative to SQN license renewal.

2.3.7 Wood Waste

The use of wood waste to generate utility-scale baseload power is limited to those locations where wood waste is plentiful (NRC 1996). Wastes from pulp, paper, and paperboard industries and from forest management activities can be expected to provide sufficient, reliable supplies of wood waste as feedstocks to external combustion sources for energy generation. Beside the fuel source, the technological aspects of a wood-fired generation facility are virtually identical to those of a coal-fired alternative—combustion in an external combustion unit such as a boiler to produce steam to drive a conventional STG. Given constancy of the fuel source, wood waste facilities can be expected to operate at equivalent efficiencies and reliabilities. Costs of operation would depend significantly on processing and delivery costs. Wood waste combustors would be sources of criteria pollutants and GHGs, and pollution control requirements would be similar to those for coal plants. Unlike coal plants, there is no potential for the release of hazardous air pollutants (HAPs) such as mercury. Cofiring of wood waste with coal is also technically feasible. Processing the wood waste into pellets can improve the overall efficiency of such cofired units.

Although cofired units can have capacity factors similar to baseload coal-fired units, such levels of performance are dependent on the continuous availability of the wood fuel. In Tennessee, 2010 electricity generating capacity from wood waste was 185 MWe and produced 914,000 MWh (EIA 2012). TVA has a cofiring wood waste facility at Colbert Fossil Plant and currently purchases about 70 MW of wood waste generation through PPAs (TVA 2011b). Given the limited capacity and modest actual electricity production, the NRC staff has determined that production of electricity from wood waste would not be a feasible alternative to SQN license renewal.

2.3.8 Ocean Wave and Current Energy

Ocean waves, currents, and tides represent kinetic and potential energies. Waves, currents, and tides are often predictable and reliable; ocean currents flow consistently, while tides can be predicted months and years in advance with well-known behavior in most coastal areas. The total annual average wave energy off the U.S. coastlines at a water depth of 60 m (197 ft) is estimated at 2,100 terawatt-hours (TWh) (2,100,000,000 MWh) (MMS 2006). In general, technologies that harness ocean wave energy are in their infancy and have not been used at a utility scale, though these technologies may become commercially available in the near future as more feasibility studies and prototype tests are conducted.

Ocean current energy technology is similarly in its infancy. In relatively constant currents, ocean turbines can produce sufficient capacity factors for baseload demand (MMS 2006). Only a small number of prototypes and demonstration units have been deployed to date.

The NRC staff is not currently aware of any plans to develop or deploy ocean wave and ocean current generation technologies on a scale similar to that of SQN. Consequently, due to relatively high costs and limited planned implementation the NRC staff concludes that ocean energy technologies are not feasible substitutes for SQN.

2.3.9 Oil-Fired Power

EIA projects that oil-fired plants will account for very little of the new generation capacity constructed in the United States during the 2008 to 2030 time period (EIA 2013a). In 2010, Tennessee generated 0.3 percent of its total electricity from oil (EIA 2012).

The variable costs of oil-fired generation tend to be greater than those of nuclear or coal -fired sources, and oil-fired generation tends to have greater environmental impacts than natural gas-fired generation. In addition, future increases in oil prices are expected to make oil-fired generation increasingly expensive (EIA 2013a). The high cost of oil has prompted a steady decline in its use for electricity generation. Thus, the NRC staff does not consider oil-fired generation as a reasonable alternative to SQN license renewal.

2.3.10 Fuel Cells

Fuel cells oxidize fuels without combustion and its environmental side effects. Power is produced electrochemically by passing a hydrogen-rich fuel over an anode and air (or oxygen) over a cathode and separating the two by an electrolyte. The only byproducts (depending on fuel characteristics) are heat, water, and carbon dioxide. Hydrogen fuel can come from a variety of hydrocarbon resources by subjecting them to steam reforming under pressure. Natural gas is typically used as the source of hydrogen.

Currently, fuel cells are not economically or technologically competitive with other alternatives for electricity generation (EIA 2012). Fuel cell units are likely to be small in size (the EIA reference plant is 10 MWe). While it may be possible to use a distributed array of fuel cells to provide an alternative to SQN, it would be extremely costly to do so and would require many units and wholesale modifications to the existing transmission system. Accordingly, the NRC staff does not consider fuel cell technology to be a reasonable alternative to SQN license renewal.

2.3.11 Coal-Fired Integrated Gasification Combined Cycle

Integrated gasification combined cycle (IGCC) is an emerging technology for generating electricity with coal that combines modern coal gasification technology with both gas turbine and steam turbine power generation. Gasifiers, similar to those used in oil refineries, use heat pressure and steam to pyrolyze (thermally reform complex organic molecules without oxidation) coal to produce synthesis gases (generically referred to as syngas) typically composed of carbon monoxide, hydrogen, and other flammable constituents. After processing to remove contaminants and produce various liquid chemicals, the syngas is combusted in a combustion turbine (CT) to produce electric power. Separating the carbon dioxide from the syngas before combustion is also possible. Latent heat is recovered both from the syngas as it exits the gasifier and from the combustion gases exiting the CT and directed to a heat recovery steam generator feeding a conventional Rankine cycle STG to produce additional amounts of electricity. Emissions of criteria pollutants would likely be slightly higher than those from an NGCC alternative but significantly lower than those from the supercritical coal-fired alternative. Depending on the gasification technology employed, IGCC would use less water than SCPC units but slightly more than NGCC (NETL 2010a). Long-term maintenance costs of this relatively complex technology would likely be greater than those for a similarly sized SCPC or NGCC plant.

Only a few IGCC plants are operating at utility scale. Operating at higher thermal efficiencies than supercritical coal-fired boilers, IGCC plants can produce electrical power with fewer air pollutants and solid wastes than coal-fired boilers. To date, however, IGCC technologies have had limited application and have been plagued with operational problems such that their effective, long-term capacity factors are often not high enough for them to reliably serve as baseload units. Although IGCC technology may become more commonplace in the future, current operational problems that compromise reliability result in the dismissal of this technology as a viable alternative to SQN license renewal.

2.3.12 Delayed Retirement

The retirement of a power plant ends that power plant's ability to supply electricity. Delaying the retirement of a power plant enables that power plant to continue supplying electricity. TVA's IRP, issued in March 2011, outlines TVA's plan to retire 18 of its 59 coal-fired units by the end of 2017 (TVA 2011b). Delayed retirement of these units would provide approximately 2,400 to 4,700 MWe of capacity, or about 16 percent of its coal-fired generation. TVA's decision to retire these coal plants was based on the age of the fleet, increasingly stringent air quality regulations, and the anticipation of new generating capacity from Watts Bar Nuclear Plant Unit 2 and a new combined-cycle plant at the John Sevier Fossil Plant (TVA 2011b).

Most retired units are dirtier and less efficient than new units. Often, units are retired because operation is no longer economical. In some cases, the cost of environmental compliance or necessary repairs and upgrades are too high to justify continued operation. As a result, the NRC staff does not consider delayed retirement a reasonable alternative to license renewal.

2.3.13 Energy Efficiency and Demand Side Management

In its ER, TVA indicates that its energy efficiency and demand response (EEDR) program by itself would not be a reasonable alternative to license renewal (TVA 2013). While the NRC staff finds this position reasonable for purposes of this analysis, it notes that demand-side management (DSM) is an option for energy planners and decisionmakers—and it may be a potential consequence of a no action alternative—and so it is discussed in this section.

As addressed in the GEIS, DSM measures are efforts designed to either reduce electricity demand at the retail level or alter the shape of the electricity load (NRC 2013). DSM programs can include incentives for equipment upgrades, improved codes and standards, rebates or rate reductions in exchange for allowing a utility to control or curtail the use of high-consumption appliances or equipment, training in efficient operation of building heating and lighting systems, direct payments in consideration for avoided consumption, or use of price signals to shift consumption away from peak times (NRC 2013).

In terms of overall ability to offset or replace an existing baseload power plant, DSM measures that reduce energy consumption, typically referred to as energy conservation and energy efficiency, are the most useful. Though often used interchangeably, energy conservation and energy efficiency are different concepts. Energy efficiency typically means deriving a similar level of service by using less energy, while energy conservation simply indicates a reduction in energy consumption. Conservation measures may include incentives to reduce overall energy consumption, while efficiency measures may include incentives to replace older, less efficient appliances, lighting, or heating and cooling systems. A variety of conservation or energy efficiency measures would likely be necessary to replace the capacity currently provided by SQN.

TVA currently has an EEDR program, which outlines a variety of residential, commercial, and industrial programs, as well as education and outreach (TVA 2011a). TVA's current power planning approach, outlined in its IRP, shows an increase in focus on the EEDR program. The IRP strategy reduces required energy and capacity needs by approximately 14,000 GWh and 4,700 MW, respectively, by the year 2029, using a variety of power planning scenarios (TVA 2011b). In 2011, TVA commissioned a study from Global Energy Partners (GEP) to determine the potential for EEDR as a resource to help meet the TVA region's future energy needs (EnerNOC 2011a). The 2012 update to the 2011 study projected potential cumulative annual energy savings of approximately 2.1 to 4.7 percent (3,061 to 6,993 GWh) of the region's baseline energy forecast in 2015, and approximately 9.6 to 17.9 percent (17,343 to

32,474 GWh) of the baseline forecast in 2030 (EnerNOC 2012). GEP's study notes that TVA's energy efficiency and DSM programs are "off to a strong start," and provides general recommendations to TVA to reach the projected potentials (EnerNOC 2011b). GEP's energy efficiency recommendations include coordinating the distributor layer between TVA and energy end-users, maintaining a transparent stakeholder process, creating internal energy efficiency targets, pursuing light savings, creating targeted marketing messages, and expanding TVA's knowledge of its customer base (EnerNOC 2011b). GEP's DSM recommendations include expanding DSM programs to include smaller customers, focusing efforts on programs with the largest potential, providing incentives for voltage regulation programs, customers, and technologies (EnerNOC 2011b).

Because it is unlikely that demand reductions in the TVA region could be sufficiently increased to replace the SQN baseload capacity, the NRC staff did not consider DSM to be a reasonable alternative to license renewal.

2.3.14 Purchased Power

It is possible that replacement power may be imported from outside the SQN region of interest, which would have little or no measurable environmental impact in the vicinity of SQN; however, impacts could occur where the power is generated or anywhere along the transmission route, depending on the generation technologies used to supply the purchased power (NRC 2013).

As described in earlier sections, TVA is currently a party to numerous short-term and long-term PPAs, totaling 4,495 MW of generating capacity (TVA 2011b). For the PPAs that TVA has contracted, it is assumed that the supplier will either interconnect with the TVA transmission grid, or obtain a transmission path to the grid. Based on the PPAs TVA currently has in place with various transmission companies in other states, impacts from operation of other generators could occur within the TVA region, the SERC region, or outside both regions. TVA dismissed purchased power as a reasonable alternative for meeting load obligations if the SQN licenses are not renewed (TVA 2013). TVA acknowledged in its ER that PPAs have an inherent risk of power not being delivered and, based on its IRP, TVA must plan for the possibility of undelivered purchased capacity (TVA 2011b, 2013).

Purchased power would likely come from one or more of the other types of alternatives considered in this chapter. As a result, operational impacts would be similar to the operational impacts of the alternatives considered in this chapter. Unlike the alternatives considered in this chapter, however, facilities from which power would be purchased would not likely be constructed solely to replace SQN. Purchased power may, however, require new transmission lines (which may require new construction), and may also rely on slightly older and less efficient power plants that operate at higher capacities than they currently operate.

2.4 Comparison of Alternatives

In this SEIS, the NRC considers both the proposed action (license renewal of the SQN operating licenses); alternatives to the proposed action, including the no-action alternative (denial of renewed SQN licenses); and, alternatives to SQN license renewal that were considered and eliminated from detailed study, as described in the preceding sections. Table 2–1 in this chapter summarizes key design characteristics of the alternatives evaluated in depth.

The environmental impacts of the proposed action are evaluated in Chapter 4 of this SEIS, along with the environmental impacts of the no-action alternative and each of the replacement power alternatives considered in depth above (the NGCC alternative, the

SCPC alternative, the new nuclear alternative, and the combination wind and solar alternative). Table 2–2 presents a summary comparison of the environmental impacts of the proposed action and alternatives that were evaluated in detail with respect to common resource areas. The NRC staff concluded that the environmental impacts of renewal of the operating licenses for SQN would be smaller than those of feasible and commercially viable alternatives. The no-action alternative, the act of shutting down SQN on or before its licenses expires, would have SMALL environmental impacts in most areas with the exception of socioeconomic impacts which would have SMALL to LARGE environmental impacts. Continued operations of SQN would have SMALL environmental impacts in all areas. The staff concluded that continued operation of the existing SQN is the environmentally preferred alternative.

Table 2–2. Summary of Environmental Impacts of Proposed Action and Alternatives

Impact Area (Resource)	SQN License Renewal (Propose d Action)	Natural Gas Combined Cycle (NGCC)	Super-critical Pulverized Coal (SCPC)	New Nuclear	Combination (Wind and Solar)	No-Action
Land Use	SMALL	SMALL	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE	SMALL
Visual Resources	SMALL	SMALL	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE	SMALL
Air Quality	SMALL	SMALL to MODERATE	MODERATE	SMALL	SMALL	SMALL
Noise	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL
Geologic Environment	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL
Surface Water	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL
Groundwater	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL
Terrestrial	SMALL	SMALL	SMALL to MODERATE	SMALL	SMALL to MODERATE	SMALL
Aquatic	SMALL	SMALL	SMALL to MODERATE	SMALL to MODERATE	SMALL	SMALL
Special Status Species	NO EFFECT	SEE NOTE[1]	SEE NOTE[1]	SEE NOTE[1]	SEE NOTE[1]	NO EFFECT
Historic and Cultural	SEE NOTE[2]	SMALL to MODERATE	SMALL	SMALL	SMALL to LARGE	SMALL
Socioeconomics	SMALL	SMALL to LARGE	SMALL to LARGE	SMALL to LARGE	SMALL to MODERATE	SMALL to LARGE
Human Health	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL
Environmental Justice	SMALL	SEE NOTE[3]	SEE NOTE[3]	SEE NOTE[3]	SEE NOTE[3]	SEE NOTE[4]
Waste Management	SMALL	SMALL	MODERATE	SMALL	SMALL	SMALL

Notes:
[1] The magnitude of impacts could vary widely based on site selection and the presence or absence of special status species and habitats when the alternative is implemented; thus, the NRC staff cannot forecast a level of impact for this alternative.
[2] The NRC staff concludes that license renewal would cause no adverse effect on historic properties.
[3] This alternative would not have disproportionately high and adverse human health and environmental effects on minority and low-income populations in the vicinity of the SQN.
[4] The No-Action alternative could disproportionately affect minority and low-income populations that may have become dependent on the public services in Hamilton County, Tennessee.

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3.0 AFFECTED ENVIRONMENT

In this supplemental environmental impact statement (SEIS), the “affected environment” is the environment that currently exists at and around Sequoyah Nuclear Plant, Units 1 and 2 (SQN). Because existing conditions are at least partially the result of past construction and operation at the plant, the impacts of these past and ongoing actions and how they have shaped the environment are presented here. The facility and its operation are described in Section 3.1. The affected environment is presented in Sections 3.2 to 3.13.

3.1 Description of Nuclear Power Plant Facilities and Operation

SQN is a two-unit nuclear power plant located in Hamilton County, Tennessee. It began commercial operation in July 1981 (Unit 1) and June 1982 (Unit 2). Generally , the Nuclear Regulatory Commission (NRC) staff drew information about SQN’s facilities and operation from Tennessee Valley Authority’s (TVA) Environmental Report (ER) (TVA 2013n).

3.1.1 External Appearance and Setting

The SQN site is approximately 18 miles (mi) (29 kilometers (km)) northeast of Chattanooga, Tennessee, and approximately 31 mi (50 km) south-southwest of the Tennessee Valley Authority (TVA) Watts Bar Nuclear Plant (WBN) site. The SQN site is approximately 630 acres (ac) (250 hectares (ha)). The power production portion of SQN is located on 525 ac (212 ha). SQN’s training center is located on the remaining 105 ac (42.5 ha) (TVA 2013n).

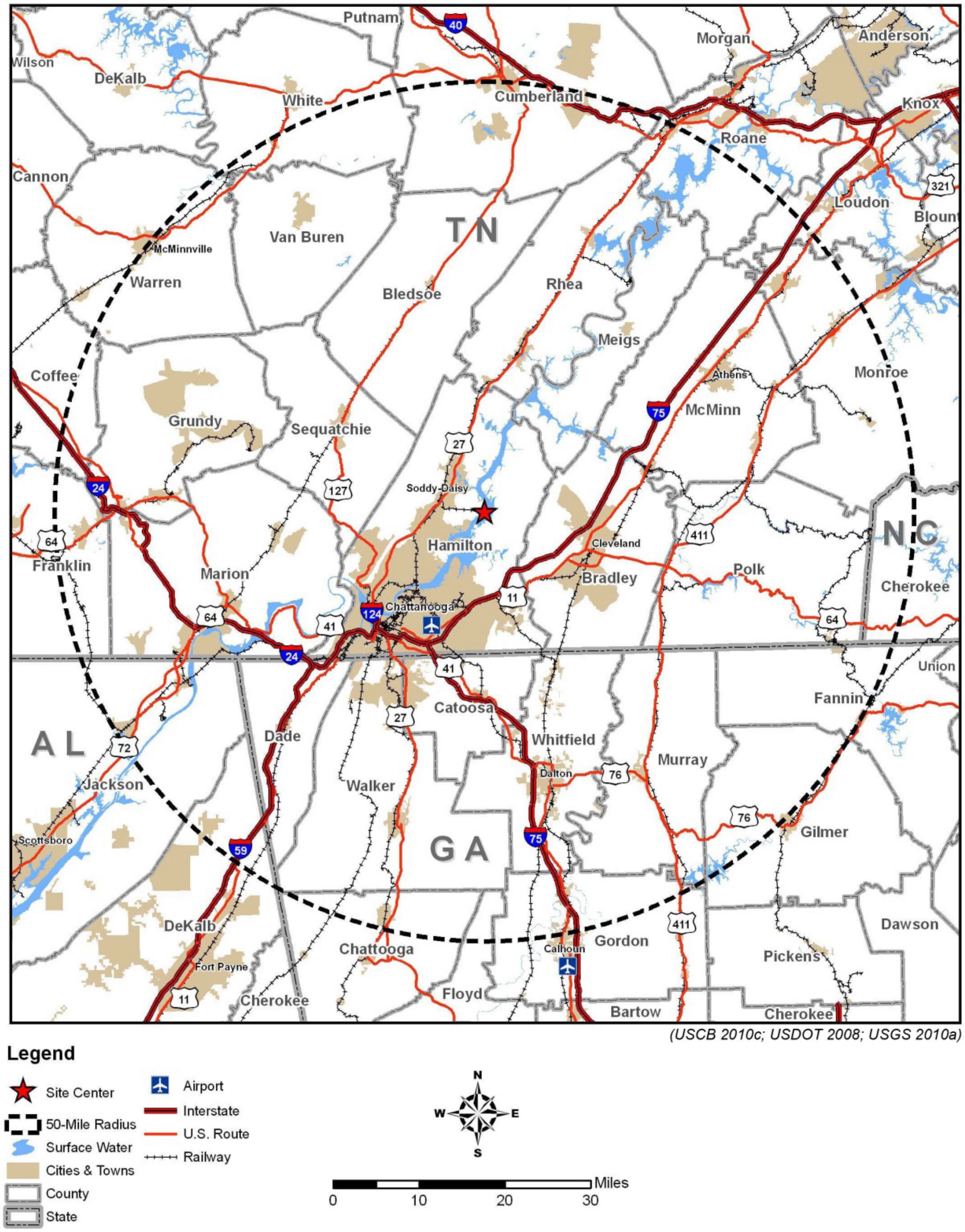
The SQN site is located on a peninsula on the western shore of Chickamauga Reservoir at Tennessee River Mile (TRM) 484.5. The town of Soddy-Daisy, Tennessee, is located 6 mi (10 km) west of site. Figure 3–1 and Figure 3–2 present 50-mi (80-km) and 6-mi (10-km) vicinity maps, respectively.

The SQN site’s main structures include two reactor buildings, a turbine building, an auxiliary building, a control building, a service and office building, a diesel generator building, an intake pumping station, an essential raw cooling water (ERCW) pumping station, two natural draft cooling towers, 161-kilovolt (kV) and 500-kV switchyards, a condensing water discharge and diffuser system, and an independent spent fuel storage installation (ISFSI). The site’s tallest structures are the two 459-ft cooling towers (TVA 2013n).

The area of the SQN site completely enclosed by a security fence with access to the area controlled at a security gate is called the protected area. A plant security system monitors the protected area, as well as buildings within the protected area. Principal roadways near the SQN site are US 27 and Tennessee Route 319 (Hixson Pike). Sequoyah Access Road leads directly to the SQN site. The nearest occupied residence is 0.5 mi (0.8 km) north-northwest of the site boundary (TVA 2013n).

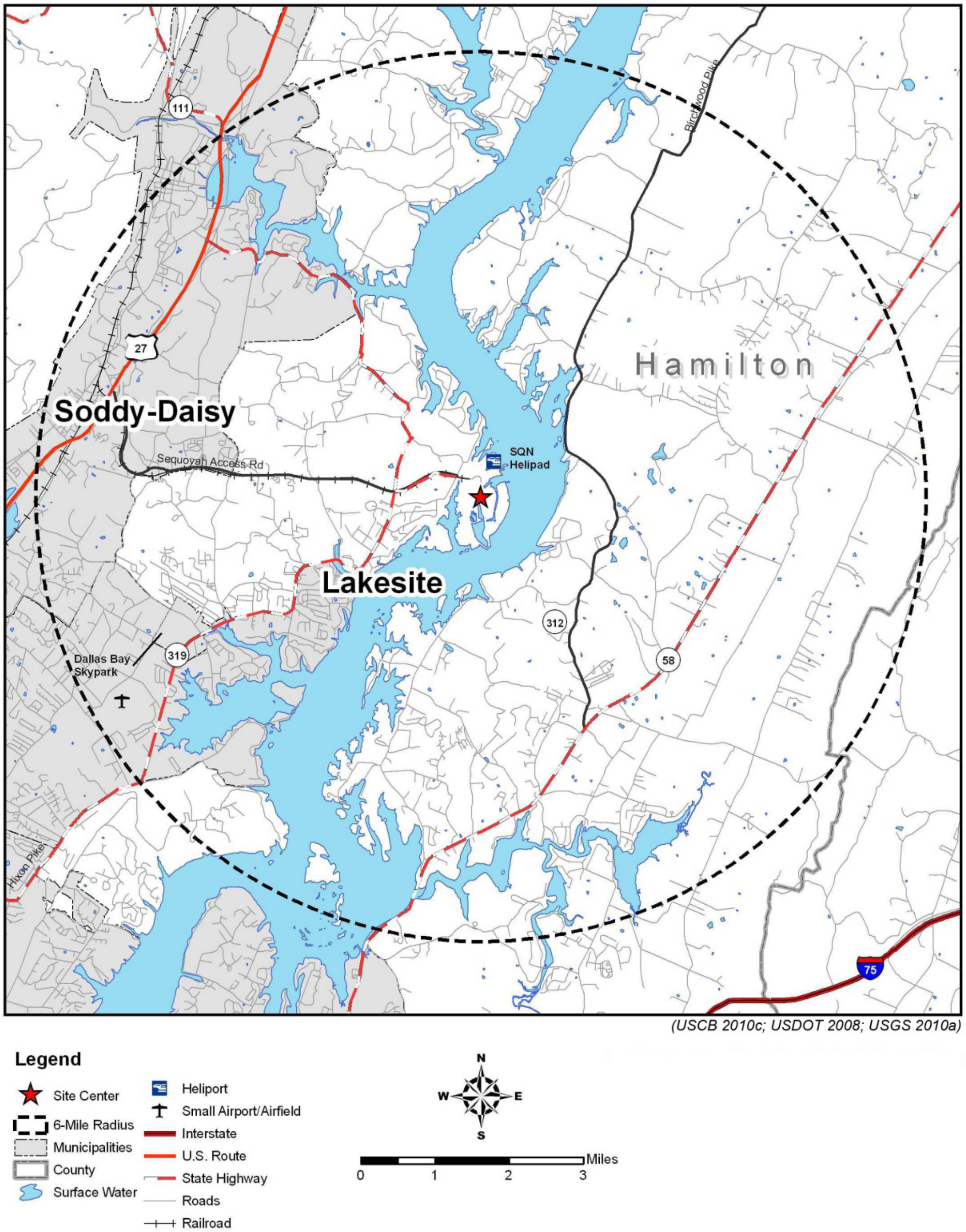
The SQN exclusion area boundary (EAB) defines the area around the reactors where TVA has the authority to determine all activities, including exclusion or removal of personnel and property (NRC 2014). Figure 3–3 shows the general features of the facility, the protected area, and the EAB.

Figure 3–1. SQN 50-mi (80-km) Radius Map



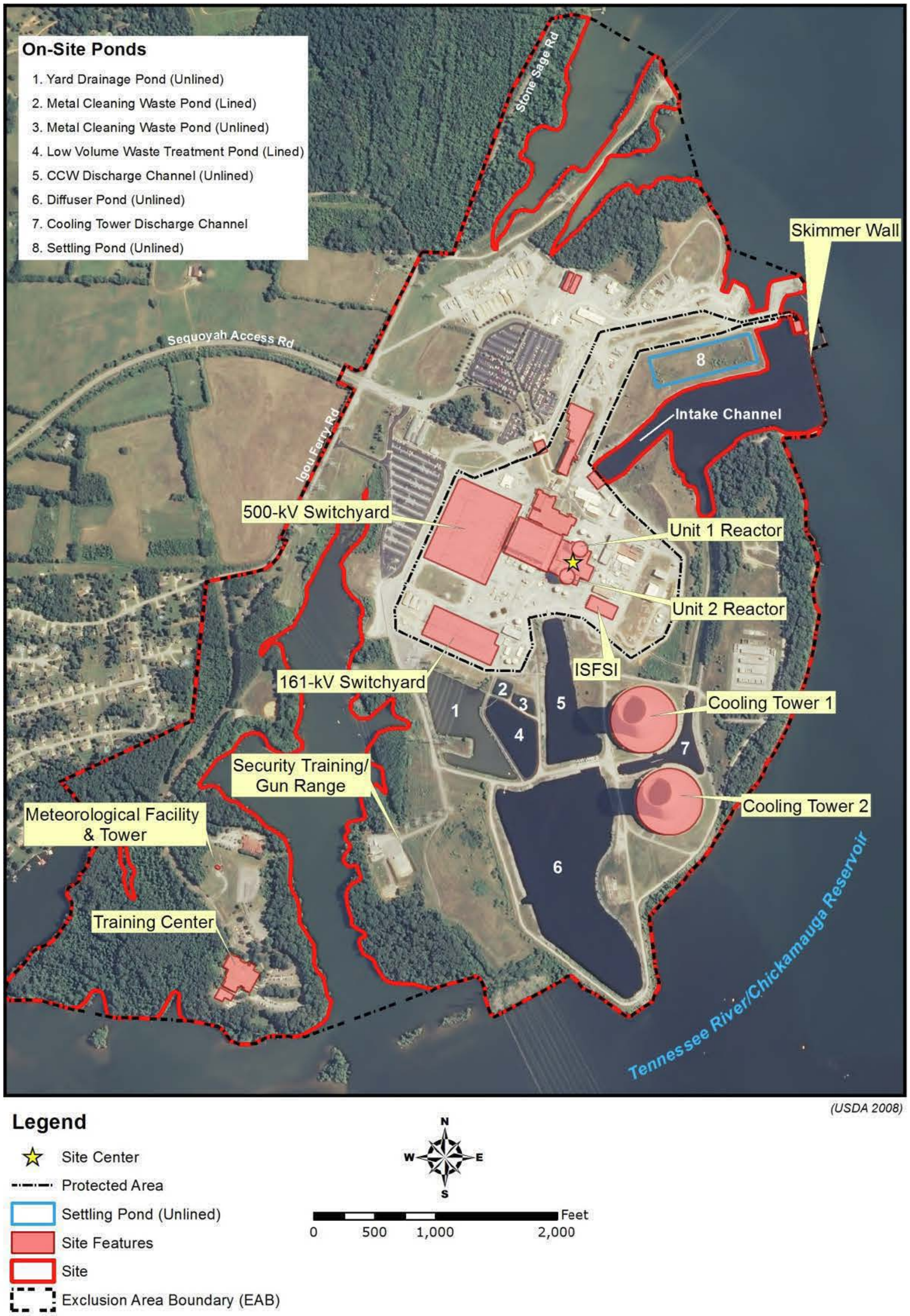
Source: TVA 2013n

Figure 3–2. SQN 6-mi (10-km) Radius Map



Source: TVA 2013n

Figure 3–3. SQN General Site Layout



Source: TVA 2013n

3.1.2 Nuclear Reactor Systems

The nuclear reactor for each of the two SQN units is a Westinghouse pressurized-water reactor (PWR), producing a reactor core rated thermal power of 3,586 megawatts thermal (MWt). The nominal net electrical capacity for SQN is 2,400 megawatts electric (MWe). SQN uses a once-through cooling system, aided by periodic operation of cooling towers. The system withdraws cooling water from and discharges to Chickamauga Reservoir (TVA 2013n).

The nuclear fuel is low-enriched (less than 5 percent by weight) uranium dioxide, with a maximum average burnup level of less than 62,000 megawatt-days/metric ton of uranium. Refueling and maintenance outages for SQN Units 1 and 2 are on a staggered 18-month schedule (TVA 2013n).

The containment for each reactor consists of a steel containment vessel with an ice condenser and a shield building. The steel containment vessel is a freestanding carbon steel structure composed of a cylindrical wall, a hemispherical dome, and a bottom liner plate encased in concrete. The ice condenser system, located inside the steel containment vessel, provides containment energy removal and pressure suppression for certain accident events. The system contains about two million pounds of ice located in 1,944 baskets. The shield building encloses the steel containment vessel. It is a reinforced concrete cylinder supported by a circular base concrete foundation resting on bedrock and covered with a spherical dome (TVA 2013n).

3.1.3 Cooling and Auxiliary Water Systems

As discussed previously, SQN uses pressurized-water reactors in the nuclear steam supply system. At SQN, water is withdrawn from the Chickamauga Reservoir portion of the Tennessee River to cool plant components and to condense the steam exiting the turbines to liquid water. Normally, the vast majority of withdrawn water is discharged back through SQN's diffuser pond system and into the reservoir at a point 1.1 mi (1.8 km) downstream from the intake. The waste heat in the thermal discharge is dissipated to the atmosphere mainly by evaporation from the water body and, to a much smaller extent, by conduction, convection, and thermal radiation loss.

The SQN cooling system functions to remove heat from the steam and transfers that heat to the environment. Excess heat is removed using a combination cooling system: a once-through condenser circulating water (CCW) system that may be assisted by two natural-draft cooling towers (i.e., helper mode operation) (TVA 2013n). Helper mode operation is typically implemented when the mixing zone river temperature downstream of SQN's discharge diffuser climbs to within about 1 °F (0.6 °C) of SQN's National Pollutant Discharge Elimination System (NPDES) permit limits. SQN also uses helper mode during low flow conditions to limit the upstream propagation of heat from the SQN discharge diffusers (NPDES-permitted Outfall 101) to the plant intake 1.1 mi (1.8 km) upstream. The number of cooling tower lift pumps (CTLPs) in operation controls the degree of cooling that can be achieved from helper mode (TVA 2013j). From an operations standpoint, helper mode is defined as full operation of one cooling tower and at least three CTLPs in service for each operating unit (TVA 2013n).

For each of the two turbine generator units, SQN's CCW system can supply a theoretical maximum of 561,000 gallons per minute (gpm) (1,250 cubic feet per second (cfs) or 35.3 m^3/s) of water for the main condensers and water for the raw cooling water (RCW) system that supplies auxiliary systems. The CCW system is comprised of a total of six pumps housed in SQN's CCW intake pump station located at the end of the intake channel, as depicted in Figure 3–3 (TVA 2013j, 2013n).

The ERCW system is designed to continuously supply cooling water to SQN systems and components necessary for plant safety. The eight supply and four associated screen-wash pumps of the ERCW system are housed in the ERCW intake pump station located at the top of the plant's skimmer wall structure (see Figure 3–3).

The SQN maximum surface water withdrawal rate from Chickamauga Reservoir is approximately 1,166,000 gpm (2,600 cfs (73.5 m^3/s)), or 1,680 mgd (TVA 2011c, 2011d). The plant's consumptive use of water withdrawn is essentially zero when operated in open mode and could be as much as 31,250 gpm (70 cfs (1.98 m^3/s)) or 45 mgd in full helper mode (TVA 2013n).

Generally, the NRC staff drew information about SQN's cooling and auxiliary water systems from the TVA's ER (TVA 2013n) and responses to the NRC's request for additional information (TVA 2013d-f, 2013j). Individual SQN systems that interact with the environment are further summarized below with a focus on facilities owned and operated by TVA.

3.1.3.1 Cooling Water Intake System

Both the CCW and ERCW systems are supplied from Chickamauga Reservoir using intake structures on the upstream end of the SQN site. An intake skimmer wall, situated approximately 400 ft (122 m) into the reservoir, spans the entrance to the embayment leading to SQN's CCW intake. The intake channel extends approximately 1,800 ft (550 m) from the skimmer wall to the CCW intake pump station (see Figure 3–4). The skimmer wall has a clear opening length of 550 ft (167 m) and an opening height of 9.7 ft (3 m). The top of the opening is 641 ft (195 m) above mean sea level (MSL), which is approximately 34 ft (10 m) below minimum pool elevation of Chickamauga Reservoir (TVA 2013j, 2013n). Based on the design CCW flow rate, the staff determined that the average velocity through the skimmer wall opening is approximately 0.47 foot per second (fps) (0.14 meters per second (m/s)). This is consistent with the original design velocity (i.e., 0.5 fps (0.15 m/s)), which TVA confirmed remains valid (TVA 2013j).

The skimmer wall is designed to allow withdrawal of cooler water from the lower depths of Chickamauga Reservoir (TVA 2013n). River water temperature stratification with depth is typical from late spring through early fall. In this case, the river stage (water elevation) can influence the location of the river thermocline (thin layer of water in which temperature changes more rapidly with depth than it does in the layers above or below) relative to the location of the withdrawal zone for SQN's cooling water intake. In contrast, the vertical river temperature distribution is more uniform in the late fall, winter, and early spring. Under these conditions, river stage has little effect on the plant intake water temperature (TVA 2013j).

Dam hydropeaking operations (the practice of abruptly increasing dam discharge and river flow for added power generation during periods of high demand) temporarily increase river discharges and produce higher levels of turbulence that result in deeper mixing of warm surface water. This produces higher water temperatures in SQN's cooling water withdrawal zone. When hydropeaking is deemed detrimental to SQN's intake water temperature, TVA reduces or suspends hydropeaking operations to provide calmer, steadier flows in Chickamauga Reservoir, which tends to stabilize intake water temperature for SQN. Dam hydropeaking operations have less effect on plant intake water temperature in late fall through early spring when the vertical river temperature is more uniform than in late spring through early fall (TVA 2013j).

1 **Figure 3–4. Location of SQN Cooling Water Supply Facilities and Surface Water Features**

2

3 Source: TVA 2013f

Another engineered feature that affects cooling water intake temperatures is the presence of a submerged dam across the main river channel. This dam is situated approximately 1 mi (1.6 km) downstream from the intake skimmer wall (about 250 ft (80 m) upstream from the discharge diffusers). The dam is about 90 ft (27 m) thick and 900 ft (274 m) long, with its crest at 654 ft (199 m) above MSL or 13 ft (4 m) above the top of the skimmer wall opening (TVA 2013j, 2013n). The dam is designed to provide a subpool of cooling water for the CCW intake pumps in the event of a sudden drop in the Chickamauga Reservoir level (e.g., catastrophic water release from the downriver Chickamauga Dam). The submerged dam also serves to impound cooler water in the lower layer of Chickamauga Reservoir, making it available for SQN withdrawals. This has the effect of decreasing the potential for any water wedge buildup of discharge water emanating from the discharge diffusers extending upstream to the plant intake (TVA 2011c, 2013n).

Condenser Circulating Water System. The CCW system is designed to condense steam that has passed through each turbine generator and to dissipate all rejected heat. Efficient operation of the turbine generators will limit the maximum temperature rise for water circulating through the steam condensers to about 29.5 °F (16.4 °C). Depending on the thermal conditions in Chickamauga Reservoir, there are three operational modes for controlling the temperature of SQN's thermal discharge to the reservoir: open, helper, and closed. In open mode, the system operates as a once-through cooling system, and water exiting the CCW system is discharged directly to the reservoir after passing through SQN's pond system. In helper mode, water exiting the CCW system is pumped to the cooling towers so that some of the heat can be transferred to the atmosphere before the water is returned to Chickamauga Reservoir. In closed mode, plant hydraulics return flow from the cooling tower(s) to the intake forebay by way of the cooling tower discharge (return) channel (see Figure 3–4). However, closed mode testing after plant startup determined that cooling tower performance is not sufficient for sustaining this mode without significant power derates (TVA 2013n).

The CCW system consists of six circulating water pumps, a water intake structure and discharge lines, traveling screens, screen wash pumps, and associated piping, valves, and instrumentation. Each pump has a capacity of 187,000 gpm (417 cfs or 11.8 m^3/s). The nominal (design) CCW flow through the condensers with both SQN units in operation is about 1,070,000 gpm (2,384 cfs (67.3 m^3/s) or about 1,541 mgd) (TVA 2013j, 2013n).

The circulating water pumps are mounted vertically in the intake structure and discharge into six separate lines and then to two separate conduits, with one conduit supplying each unit's main condenser. From the intake channel, water flows into the intake structure through racks designed to remove larger trash items, such as driftwood, plastic containers, etc. The flow then passes through six traveling screens (i.e., one for each pump) with a velocity of approximately 2.08 fps (0.63 m/s). The traveling screens were replaced in February 2013 (TVA 2013d-f, 2013j, 2013n). The traveling screens have 3/8-in. (0.95-cm) square openings and are designed to trap smaller trash and any larger-sized trash that may have passed through the trash racks. There are currently no fish return systems or any plans for structural or operational measures to reduce entrainment and impingement of fish and shellfish associated with the CCW intake structure (TVA 2013n).

Upon discharge to the CCW discharge channel (see no. 5 in Figure 3.4) and ultimately through the diffuser pond system as further discussed below, the CCW flow can provide for dilution and dispersion of routine low-level radioactive liquid wastes. As discussed in Section 3.1.4, such low-level radioactive effluents are released only in small quantities and in accordance with applicable NRC and other Federal regulations (TVA 2011c, 2013n).

Raw Cooling Water (RCW) System. In addition to condenser cooling, the CCW system supplies water to the plant RCW system for use by auxiliary equipment. This includes pumps, which, in turn, supply cooling water to nonessential systems (i.e., systems not necessary for the safe shutdown of the reactor). Raw cooling water can also be supplied by gravity directly from the river by way of the condenser intake tunnels without the CCW pumps (TVA 2013n).

Cooling Tower Operation. In helper mode, control gates are lowered at the end of the CCW discharge channel (see no. 5 in Figure 3–4) and condenser discharge water is pumped into the cooling towers by the CTLPs, where part of the waste heat is rejected to the atmosphere. Four CTLPs are designed to deliver approximately 560,000 gpm (1,248 cfs or 35.2 m^3/s) of water to each cooling tower (TVA 2013j, 2013n). The original cooling tower pumping station included eight CTLPs. However, following operational damage, one of the CTLPs was abandoned, with the plant's current design basis reflecting use of seven CTLPs. Control valves allow any of the lift pumps to supply flow to either one or both of the cooling towers. As a consequence, if five or more CTLPs are placed in service, the headers must be aligned through the control valves to supply flow to both cooling towers. After exiting the cooling towers, the treated flow enters the diffuser pond through a gate structure (TVA 2013j).

From 2006 through 2009, cooling towers were in service an average of 112.7 days per year (TVA 2011c). For the period 2007–2011, helper-mode use averaged about 120 days a year. Between 2007 and 2013, SQN operated cooling towers an average of 125 equivalent days per year, with a minimum of 34 equivalent days in 2009 and a maximum of 197 equivalent days in 2008. TVA calculates equivalent days of cooling tower operation based on a summation of the number of hours where at least one CTLP is in service (TVA 2013j).

The cooling towers are designed to reject waste heat to the atmosphere, thereby cooling the CCW and controlling the temperature of the thermal discharge at the edge of the mixing zone established for SQN's diffusers (NPDES Outfall 101) (TVA 2013n). Cooling tower operation is used by TVA to comply with the conditions of the plant's current NPDES permit (No. TN0026450) issued to TVA by the Tennessee Department of Environment and Conservation (TDEC), Division of Water Pollution Control. The permit imposes the following limitations at the edge of SQN's diffuser mixing zone:

- the 24-hour downstream temperature must not exceed 30.5 °C (86.9 °F), except in cases when the 24-hour ambient river temperature exceeds 29.4 °C (84.9 °F). In these cases, the 24-hour downstream temperature can exceed 30.5 °C (86.9 °F) when SQN is operated in helper mode (defined as full operation of one cooling tower and at least three CTLPs in service for each operating unit), but, in such situations, the hourly average downstream temperature must not exceed 33.9 °C (93.0 °F) without the consent of TDEC;

- the maximum 24-hour average temperature rise is limited to 3.0 °C (5.4 °F) for April through October and 5.0 °C (9.0 °F) for November through March; the maximum hourly average temperature change is limited to 2.0 °C (3.6 °F) per hour.

SQN's NPDES permit delineates the maximum extent of the mixing zone as an area 750 ft (230 m) wide and extending 1,500 ft (457 m) downstream and 275 ft (85 m) upstream of the plant's twin diffusers. The depth of the mixing zone varies linearly from the water surface 275 ft (85 m) upstream of the diffusers to the top of the diffuser pipes and then extends to the bottom downstream of the diffusers. For closed-mode operation, the mixing zone also includes the area of the forebay to the CCW intake pump station.

The amount of cooling water loss caused by evaporation and drift from the cooling towers depends on such factors as flow volume, the temperature of the water delivered to the cooling towers, and local weather conditions. When operated in helper mode under design conditions (which TVA identifies as a “conservative upper-bounding scenario”), water losses to the atmosphere from evaporation and drift resulting from cooling tower operation can consume up to 31,250 gpm (70 cfs (1.98 m^3/s, or 45 mgd)) of water (TVA 2013n).

Diffuser Pond and Discharge to River. Heated water is discharged either from the CCW discharge channel (when in open mode) or from the cooling towers (when in helper mode) directly into the diffuser pond (see no. 6 in Figure 3–4). From the diffuser pond, the wastewater (including cooling tower blowdown during helper mode operations) and other permitted effluent sources are conveyed to the Chickamauga Reservoir through two corrugated metal diffuser pipes that extend under the pond’s diked embankment into the river channel. The upstream and downstream diffuser pipes are 17 ft (5.2 m) and 16 ft (4.9 m) in diameter, respectively, and the diffuser sections of the discharge pipes are installed in the 900-ft (274-m) wide navigation channel of the Chickamauga Reservoir. Each diffuser section is 350 ft (107 m) long and contains seventeen 2-in. (5.1-cm) diameter ports per foot of pipe length. The downstream diffuser pipe discharges across a section 0 to 350 ft (0 to 107 m) from the SQN side of the deeper main navigation channel. The diffuser section of the longer upstream diffuser pipe discharges across a section 350 to 700 ft (107 to 214 m) from the SQN side of the main channel (TVA 2011c, 2013n). Flow rate through SQN’s diffusers is controlled by the elevation difference between the water levels in the diffuser pond and in the Chickamauga Reservoir. At peak plant operation, each diffuser discharges about 1,250 cfs (35.3 m^3/s) of effluent to the river. When the discharges to the diffuser pond are reduced and the elevation difference between the pond and the reservoir is less than 4 ft (1.2 m), a gate automatically closes the downstream diffuser, permitting discharge only through the upstream diffuser. The diffuser pond will discharge to the river through the upstream diffuser whenever the pond level is greater than the reservoir level (TVA 2013n).

3.1.3.2 Essential Raw Cooling Water System

The ERCW system is a safety-related system (seismic Category 1 structure) used to supply cooling water to various heat loads in both the primary (radiological) and secondary (nonradiological) portions of each SQN unit. It is operated to provide a continuous flow of cooling water to those systems and components necessary for plant safety during normal operations, or under accident conditions.

The ERCW intake pump station is located near the north end of the intake skimmer wall (see Figure 3–4). It is designed to be operable for all Chickamauga Reservoir levels, including the probable maximum flood and loss of the Chickamauga Dam. The estimated minimum river flow for the ERCW system to operate is only 45 cfs (1.27 m^3/s). To protect the intake from floating debris, a floating trash boom (shown in Figure 3–4) extends from a spit on the upstream end of the SQN site, around the ERCW intake pump station, to the skimmer wall to the south. The station houses eight ERCW pumps, four traveling water screens, four screen wash pumps, four strainers, and associated piping and valves. These components are divided between each of the plant’s two units. Each of the eight ERCW pumps are rated at 11,000 gpm (24.5 cfs (0.69 m^3/s)), and the screen wash pumps are each rated at 270 gpm (0.6 cfs (0.017 m^3/s)) (TVA 2011c, 2013n). While the ERCW system has a total of eight pumps, minimum combined safety requirements are met by only two pumps in operation per each of the plant’s two ERCW cooling trains.

Water withdrawn from the reservoir enters the pumping station through the ¼-in. (0.64-cm) mesh traveling water screens at a velocity of <0.50 fps (<0.15 m/s) and into a corresponding

ERCW pump pit, each served by two ERCW pumps. The screens are designed to remove 3/8-in. (0.95-cm) diameter and larger objects. A routine manual backwash of the traveling screens is performed four times per week, but may be performed on an unscheduled basis as needed. The ERCW pumping station supplies water to the SQN auxiliary building systems through four independent sectionalized supply headers. The return discharge from the various heat exchangers served by the ERCW system goes to a seismically qualified open basin with overflow capability, then flows by gravity to the cooling tower discharge channel (see no. 7 in Figure 3–4), and ultimately to the diffuser pond, where it provides a continuous source of return water for effluent dilution, including low-level radioactive liquid effluents (TVA 2013n).

3.1.4 Radioactive Effluent, Waste, and Environmental Monitoring Programs

As part of their normal operations and as a result of equipment repairs and replacements caused by normal maintenance activities, nuclear power plants routinely generate both radioactive and nonradioactive wastes. Nonradioactive wastes include hazardous and nonhazardous wastes. There is also a class of waste, called mixed waste, which is both radioactive and hazardous. The systems used to manage (i.e., treat, store, and dispose of) these wastes are described in this section. Waste minimization and pollution prevention measures commonly employed at nuclear power plants are also discussed in this section.

All nuclear plants were licensed with the expectation that they would release radioactive material to both the air and water during normal operation. However, NRC regulations require that radioactive gaseous and liquid releases from nuclear power plants must meet radiation dose-based limits specified in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 20, "Standards for protection against radiation," and the as low as is reasonably achievable (ALARA) criteria in Appendix I to 10 CFR Part 50. Regulatory limits are placed on the radiation dose that members of the public can receive from radioactive effluents released by a nuclear power plant. All nuclear power plants use radioactive waste management systems to control and monitor radioactive wastes.

The liquid, gaseous, and solid waste processing systems used by SQN collect and process, as needed, radioactive materials produced as a byproduct of plant operations. The radioactive liquid and gaseous effluents are processed to reduce the levels of radioactive material before discharge to the environment. This is to ensure that the dose to members of the public from radioactive effluents is reduced to levels that are ALARA in accordance with NRC regulations. The radioactive material removed from the effluents is converted into a solid form for eventual disposal at a licensed radioactive disposal facility.

SQN's radiological environmental monitoring program (REMP) assesses the radiological impact, if any, to the public and the environment from radioactive effluents released during operations at SQN. The REMP measures the aquatic, terrestrial, and atmospheric environment for radioactivity, as well as the ambient radiation. In addition, the REMP measures background radiation (i.e., cosmic sources, global fallout, and naturally occurring radioactive material, including radon).

SQN's Offsite Dose Calculation Manual (ODCM) contains the methods and parameters used to calculate offsite doses resulting from radioactive liquid and gaseous effluents. These methods are used to ensure that radioactive material discharges meet NRC and U.S. Environmental Protection Agency (EPA) regulatory dose standards. The ODCM also contains the requirements for the REMP (TVA 2013b).

3.1.4.1 Liquid Waste Processing Systems and Effluent Controls

Radioactive liquids are processed as necessary by the liquid waste processing system (LWPS) for release to the environment into the Tennessee River/Chickamauga Reservoir. The layout of the LWPS consists of two main subsystems designed for collecting and processing the liquid waste. Provisions are made to sample and analyze the liquids to ensure the radiation levels are within NRC and EPA regulatory standards and are ALARA before being released. Based on the laboratory analysis, these wastes are either released under controlled conditions via the cooling water system or retained for further processing. The data from the analysis are used to ensure that the release conforms to the controls specified in the ODCM. The ODCM's controls are based on the concentration of radioactive material in the liquid effluent and the projected dose from the release.

The liquid waste is processed through a demineralizer system that removes soluble and suspended radioactive material using ion exchange and filtration processes before being released into the environment. Once the resin and filter media are expended, it is processed for disposal. The system has controls to prevent an inadvertent release. For example, at least two valves must be manually opened to permit the liquid waste to be released from the plant, and one of these valves is normally locked closed. In addition, an automatic control valve will stop the release if there is a high effluent radioactivity level signal.

Parts of the LWPS are shared by the two units. The following shared equipment is inside the auxiliary building:

- one sump tank and two pumps;
- one tritium drain collector tank (TDCT) with two pumps and one filter;
- one floor drain collector tank (FDCT) with two pumps and one strainer, monitor tank and two pumps;
- a chemical drain tank and pump;
- two hot shower drain tanks (HSDT) and pump;
- a spent resin storage tank (SRST);
- a cask decontamination tank with two pumps and two filters;
- auxiliary building floor and equipment drain sump and two pumps;
- a passive sump;
- a radwaste demineralizer system; and
- associated piping, valves, and instrumentation.

Waste liquids high in tritium content are routed to the TDCT, while liquids low in tritium content are routed to the FDCT. All liquid wastes are processed before being released into the environment.

Waste water enters the liquid waste disposal system from equipment leaks and drains, valve leakoffs, pump seal leakoffs, tank overflows, and other sources, including draindown of the chemical and volume control system holdup tanks. The waste is processed through the radwaste demineralizer and then prepared for release through one of two release tanks.

The liquid collected in the TDCT contains boric acid and fission product activity. The liquid is processed as necessary to remove fission products so the water may be reused in the reactor coolant system or discharged to the environment.

Nontritiated water is sampled and processed as necessary for discharge to the Tennessee River/Chickamauga Reservoir. Sources include floor drains, equipment drains containing nontritiated water, certain sample room and radiochemical laboratory drains, hot-shower drains, and other nontritiated sources. If the activity is below regulatory release limits, the tank contents may be discharged without further treatment other than filtration. Otherwise, the tank contents are processed through the radwaste demineralizer system.

The SRST stores the used demineralizer resins. The resin is held in this tank for a period of time to allow for the decay of short-lived isotopes. The resin is periodically removed for disposal.

The use of these radioactive waste systems and the procedural requirements in the ODCM ensure that the dose from radioactive liquid effluents complies with NRC and EPA regulatory dose standards.

Dose estimates for members of the public are calculated based on radioactive liquid effluent release data and aquatic transport models. TVA's annual radioactive material release report contains a detailed presentation of the radioactive liquid effluents released from SQN, Units 1 and 2, and the resultant calculated doses. The NRC staff reviewed 5 years of radioactive effluent release data: 2008 through 2012 (TVA 2009a, 2010a, 2011b, 2012a, 2013a). A 5-year period provides a data set that covers a broad range of activities that occur at a nuclear power plant, such as refueling outages, routine operation, and maintenance activities that can affect the generation of radioactive effluents. The NRC staff compared the data against NRC dose limits and looked for indication of adverse trends (e.g., increasing dose levels) over the period from 2008 through 2012.

The following summarizes the calculated doses from radioactive liquid effluents released during 2012:

- The total-body dose to an offsite member of the public from SQN's radioactive liquid effluents was 1.27×10^{-2} millirem (mrem) (1.27×10^{-4} millisievert (mSv)), which is well below the 6 mrem (0.06 mSv) dose criterion in Appendix I to 10 CFR Part 50 for a site having two reactor units.

- The organ (child liver) dose to an offsite member of the public from SQN's radioactive liquid effluents was 1.28×10^{-2} mrem (1.28×10^{-4} mSv), which is well below the 20 mrem (0.2 mSv) dose criterion in Appendix I to 10 CFR Part 50 for a site having two reactor units.

The NRC staff's review of SQN's radioactive liquid effluent control program showed that radiation doses to members of the public were controlled within the NRC's and EPA's radiation protection standards contained in Appendix I to 10 CFR Part 50, 10 CFR Part 20, and 40 CFR Part 190. No adverse trends were observed in the dose levels.

Routine plant refueling and maintenance activities currently performed will continue during the license renewal term. Based on the past performance of the radioactive waste system to maintain doses from radioactive liquid effluents within NRC and EPA radiation protection standards, similar performance is expected during the license renewal term.

3.1.4.2 Gaseous Waste Processing System and Effluent Controls

The gaseous waste processing system (GWPS) is designed to remove fission product gases from the reactor coolant and minimize the amount of radioactivity released into the environment. The GWPS is a shared system serving both units. It consists of two waste-gas compressor packages, nine gas decay tanks, and the associated piping, valves, and instrumentation.

Gaseous wastes are generated from the following: gases removed from the reactor coolant and purging of the volume control tank before a cold shutdown of the reactor, displacing of cover gases caused by the accumulation of liquids in storage tanks, purging of some equipment, sampling and gas analyzer operation. The reduction of the levels of radioactivity is accomplished by internal recirculation of the gases within piping systems and temporary storage in gas decay tanks. The recirculation of the gases and the temporary storage (at least 60 days) in tanks allows time for radioactive decay to reduce the level of radioactivity.

Periodically, small quantities of radioactive gases are released into the atmosphere, in a controlled and monitored manner, through plant vents on the shield building, auxiliary building, turbine building, and service building. The radioactive gaseous waste sampling and analysis program specifications supplied in the ODCM address the gaseous release type, sampling frequency, minimum analysis frequency, type of activity analysis, and lower limit of detection (i.e., sensitivity) for the radiation monitor.

The use of these radioactive waste systems and the procedural requirements in the ODCM ensure that the dose from radioactive gaseous effluents complies with NRC and EPA regulatory dose standards.

Dose estimates for members of the public are calculated based on radioactive gaseous effluent release data and atmospheric transport models. TVA's annual radioactive material release report contains a detailed presentation of the radioactive gaseous effluents released from SQN and the resultant calculated doses. The NRC staff reviewed 5 years of radioactive effluent release data: 2008 through 2012 (TVA 2009a, 2010a, 2011b, 2012a, 2013a). A 5-year period provides a data set that covers a broad range of activities that occur at a nuclear power plant, such as refueling outages, routine operation, and maintenance activities that can affect the generation of radioactive effluents. The NRC staff compared the data against NRC dose limits and looked for indication of adverse trends (e.g., increasing dose levels) over the period of 2008 through 2012. The following summarizes the calculated doses from radioactive gaseous effluents released during 2012:

- The air dose at the site boundary from gamma radiation in gaseous effluents from SQN was 3.91×10^{-3} millirad (mrad) (3.91×10^{-5} milligray (mGy)), which is well below the 20 mrad (0.2 mGy) dose criterion in Appendix I to 10 CFR Part 50 for a site having two reactor units.

- The air dose at the site boundary from beta radiation in gaseous effluents from SQN was 1.52×10^{-3} mrad (1.52×10^{-5} mGy), which is well below the 40 mrad (0.4 mGy) dose criterion in Appendix I to 10 CFR Part 50 for a site having two reactor units.

- The dose to an organ (child bone) from radioactive iodine, radioactive particulates, and carbon-14 from SQN was 3.35×10^{-1} mrem (3.35×10^{-3} mSv), which is well below the 30 mrem (0.3 mSv) dose criterion in Appendix I to 10 CFR Part 50 for a site having two reactors.

The NRC staff's review of the SQN's radioactive gaseous effluent control program showed that radiation doses to members of the public were controlled within the NRC's and EPA's radiation protection standards contained in Appendix I to 10 CFR Part 50, 10 CFR Part 20, and 40 CFR Part 190. No adverse trends were observed in the dose levels.

Routine plant refueling and maintenance activities currently performed will continue during the license renewal term. Based on the NRC's review of past performance of the radioactive waste system to maintain doses from radioactive gaseous effluents within NRC and EPA radiation protection standards, similar performance is expected during the license renewal term.

3.1.4.3 Solid Waste Processing

Solid low-level radioactive waste (LLRW) is generated by the removal of radioactive material from liquid waste streams, filtration of gaseous effluents, and removal of contaminated material from various reactor areas. Solid wastes are processed by the solid waste system. The waste is divided into two categories: dry active waste (DAW) and wet active waste (WAW). The DAW and WAW inputs are products of plant operation and maintenance. The DAW is further subdivided into compactible and noncompactible wastes. Solid compactible wastes include paper, clothing, rags, mop heads, rubber boots, and plastic. Noncompactible wastes include tools, mop handles, lumber, glassware, pumps, motors, valves, and piping. The WAW is primarily composed of spent resins. Sources for spent resins are the SRST and the radwaste demineralizer system.

A waste packaging area is provided for receiving, sorting, and compacting DAW. Dry active waste is collected from throughout the plant and brought to the waste processing area for final packaging. The waste may also be sent to a contracted broker or processor for any or all of the stages involving processing, packaging, and subsequent disposal.

Wet waste that is suitable for disposal is transferred from a shielded storage tank to a large container called a liner. The wet waste is pushed through a piping system using a combination of reactor system water and pressurized nitrogen. When the liner is filled, the water is removed and the waste is stabilized to eliminate freestanding water, as required by licensed disposal facilities. The disposable liner is placed in a reusable shielded cask mounted on a truck or trailer bed for transport to a temporary onsite storage facility or to a licensed disposal facility.

Transportation and disposal of solid radioactive wastes are performed in accordance with the applicable requirements of 10 CFR Part 71 and Part 61, respectively. In 2012, 10 waste shipments were made from SQN to treatment facilities for processing and disposal. The total volume and activity of DAW shipped off site in 2012 was 60.4 cubic meters (m^3) (2,133 cubic feet (ft^3)) and 0.26 curies (Ci) (9,620 megabecquerel (MBq)), respectively (TVA 2013a). Routine plant operation, refueling outages, and maintenance activities that generate solid radioactive waste will continue during the license renewal term. Similar levels of solid radioactive waste are expected to be generated and shipped for disposal during the license renewal term.

3.1.4.4 Radioactive Waste Storage

Low-level radioactive waste is classified as Class A, Class B, Class C, or greater than Class C. Class A includes both DAW and WAW. Classes B and C are normally WAWs. The majority of LLW generated at SQN is Class A waste and is shipped to an offsite vendor for volume reduction, packaging, and then shipped to a licensed Class A disposal facility. Classes B and C wastes make up a low percentage by volume of the total LLW generated at SQN. Classes B and C wastes are currently stored in an onsite storage facility at SQN until they are disposed of at a licensed disposal facility.

SQN's onsite storage facility was designed to contain packaged radioactive waste generated at SQN and Watts Bar Nuclear Plant (WBN) Unit 1. The total current radioactive waste inventory of the SQN onsite storage facility, as of August 2012, is 895 ft^3 (25 m^3) and 689 Ci (2.55×10^7 MBq). The applicant states that although TVA may apply to the NRC for approval to transport LLW from WBN Unit 2 to SQN in the future, there are no long-term plans to construct additional onsite storage facilities to accommodate Classes B and C radioactive waste during the license renewal term.

The applicant has, by procedure, limited the total storage capacity of SQN's onsite storage facility to 88,500 Ci (3.27×10^9 MBq). The applicant concludes that for the 20-year license renewal term, even assuming that TVA decides to transport LLW from WBN Unit 2 to SQN at similar annual volumes as currently generated at WBN Unit 1, adequate storage capacity for LLW will be available during the license renewal term.

SQN stores its spent nuclear fuel in a spent fuel pool and also maintains an independent spent fuel storage installation (ISFSI) on site. The ISFSI is used to safely store spent fuel in licensed and approved dry cask storage containers on site. The installation and monitoring of this facility is governed by NRC requirements in 10 CFR Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater Than Class C Waste." The SQN ISFSI would remain in place until the U.S. Department of Energy (DOE) takes possession of the spent fuel and removes it from the site for permanent disposal or processing. Expansion of the onsite spent fuel storage capacity may be required during the license renewal term if DOE does not take responsibility for the permanent storage and disposal of the spent fuel. The SQN ISFSI is located within the existing protected area boundary, southeast of the Unit 2 Reactor Building. The ISFSI storage pad consists of eight sections, which is sufficient to store 90 HI-STORM 100 storage systems (TVA 2013b).

3.1.4.5 Radiological Environmental Monitoring Program

TVA conducts a REMP to assess the radiological impact, if any, to the public and the environment from operations at SQN.

To determine the amount of radioactivity in the environment before the operation of SQN, a preoperational REMP was initiated in 1971 and operated until Unit 1 began operation in 1980. Measurements of the same types of radioactive materials that are measured currently were assessed during the preoperational phase to establish normal background levels for various radionuclides in the environment. The knowledge of preexisting radionuclide patterns in the environment permits a determination, through comparison and trending analyses, of any impact on the environment due to SQN operation. The determination of impact from the plant during the operating phase also utilizes data from control stations (i.e., monitoring stations far from the plant that monitor ambient background radiation levels). The data from environmental samples taken at control stations are compared against the data from indicator stations (i.e., monitoring stations located near the plant) to determine the potential radiological impact of operations at SQN.

The REMP measures the aquatic, terrestrial, and atmospheric environment for radioactivity, as well as the ambient radiation by sampling air, water, milk, foods, soil, fish, and shoreline sediment. In addition, the REMP measures background radiation (i.e., cosmic sources, global fallout, and naturally occurring radioactive material, including radon). The radiation detection devices and analysis methods used to determine the radioactivity in environmental samples are very sensitive to small amounts of radioactivity. The REMP supplements the radioactive effluent monitoring program by verifying that any measurable concentrations of radioactive materials and levels of radiation in the environment are not higher than those calculated using the radioactive effluent release measurements and transport models.

In addition to the REMP, SQN has an onsite groundwater (GW) protection program designed to monitor the onsite plant environment for detection of leaks from plant systems and pipes containing radioactive liquid (TVA 2013b). Information on the GW protection program is contained in Section 3.5.2 of this document.

The NRC staff reviewed 5 years of annual radiological environmental monitoring data: 2008 through 2012 (TVA 2009b, 2010b, 2011a, 2012b, 2013b). A 5-year period provides a data set that covers a broad range of activities that occur at a nuclear power plant, such as refueling outages, routine operation, and maintenance activities that can affect the generation and release of radioactive effluents into the environment. The NRC staff looked for indication of adverse trends (e.g., buildup of radioactivity levels) over the period of 2008 through 2012.

The NRC staff's review of TVA's data showed no indication of an adverse trend in radioactivity levels in the environment. The data showed that there was no measurable impact to the environment from operations at SQN.

3.1.4.6 Reasonably Foreseeable Radiological Projects at SQN

The applicant stated in its ER that SQN has been selected by DOE for irradiation services for the production of tritium. Tritium production at SQN was studied in DOE's environmental impact statement (EIS) for tritium production in a commercial light water reactor (DOE 1999). The production of tritium at SQN could require the addition of employees (fewer than 10 employees per unit), as well as additional plant modifications. TVA has not specified the plant modifications at this time. The DOE expects that the production of tritium at SQN would generate irradiated tritium-producing burnable absorber rod (TPBAR) assemblies, nonradioactive waste, and some additional LLW that would be transported off site for processing and disposal (DOE 1999). To date, SQN has not produced tritium for the DOE. Before the production of tritium at SQN, TVA would need to submit license amendment applications to the NRC. The NRC would perform a safety evaluation and an environmental assessment to determine whether the proposed action meets NRC's safety and radiological requirements. If approved by the NRC, TVA could then proceed with the production of tritium.

TVA is also coordinating with DOE on projects regarding the use of other types of nuclear fuel associated with DOE's disposition of nuclear materials pursuant to U.S. nuclear nonproliferation policies. The DOE's National Nuclear Security Administration may modify the scope of the surplus plutonium disposition program to consider the option of using alternative methods of disposing of surplus plutonium. If this program moves forward, DOE, with TVA as a cooperating agency, will prepare an EIS to analyze the potential environmental impacts of the disposal of plutonium through the use of mixed oxide fuel (MOXF) in reactors operated by TVA, including SQN. Fabricating MOXF entails mixing plutonium oxide with depleted uranium oxide, manufacturing the fuel into pellets, and loading the pellets into fuel assemblies for use in nuclear reactors. If DOE decides to dispose of surplus plutonium as nuclear fuel in this manner, thorough evaluations would need to be made by the NRC and TVA before MOXF is used at SQN. In addition, TVA would need to submit license amendment applications to the NRC for the use of MOXF (TVA 2013n). The NRC would perform a safety evaluation and an environmental review to determine whether the proposed action meets NRC's safety and radiological requirements.

3.1.5 Nonradioactive Waste Management Systems

Like any other industrial facility, nuclear power plants generate wastes that are not contaminated with either radionuclides or hazardous chemicals. These wastes include trash, paper, wood, and sewage.

SQN has a nonradioactive waste management program to handle its nonradioactive hazardous and nonhazardous wastes. The waste is collected in central collection areas within the plant and managed in accordance with SQN's procedures. The waste materials are received in various forms and packaged to meet regulatory requirements before final disposition at an offsite facility licensed to receive and manage the waste. Listed below is a summary of the types of waste materials generated and managed at SQN.

- SQN's hazardous waste generator classification ranges from conditionally exempt small quantity generator to small quantity generator. The amount of hazardous wastes generated are only a small percentage of the total wastes generated—consisting of paints and paint-related materials, spent and shelf-life expired chemicals, laboratory chemical wastes, and project-specific wastes.

  Hazardous wastes from SQN are transferred to TVA's permitted hazardous waste storage facility (HWSF) in Muscle Shoals, Alabama, which serves as a central collection point for all TVA-generated hazardous wastes. From this central collection site, the waste is shipped to an approved licensed facility for disposition.

- Special nonhazardous wastes such as asbestos, sandblast grit, alum sludge, resin, and sand from water treatment systems are transported to the licensed Rhea County Landfill. Special wastes such as oily debris, desiccant, resin, nondestructive examination chemicals, and nonhazardous batteries are transferred to TVA's permitted HWSF and then shipped to a licensed facility for disposition.

- Universal wastes, such as batteries, lighting wastes, oil, scrap metal, aluminum cans, plastic bottles, cardboard, paper, and wooden pallets are collected and shipped to licensed recycling facilities approved by TVA.

- General plant trash is collected in dumpsters and transported to a State-licensed regional landfill permitted to accept solid wastes. General trash typically consists of garbage, paper, plastic, packing materials, leather, rubber, glass, soft drink and food cans, dead animals and fish, floor sweepings, ashes, wood, textiles, and scrap metal. The waste is disposed of in a State-permitted landfill.

TVA holds a State of Tennessee permit (TDEC permit number DML 331050021) for an onsite construction and demolition landfill. This landfill is permitted to accept nonhazardous, nonradioactive solid wastes including scrap lumber, bricks, sandblast grit, crushed metal drums, glass, wiring, nonasbestos insulation, roofing materials, building siding, scrap metal, concrete with reinforcing steel and similar construction and demolition wastes generated at the SQN site. The landfill is approximately 18 ac in size, but, because there is currently no need to use the landfill, it has not received any waste for at least 10 years. The landfill permit is still active and TDEC inspects the landfill quarterly. Instead of using its onsite landfill, SQN sends its construction and demolition wastes to an offsite State-permitted landfill.

Sanitary sewage from all plant locations is collected and pumped off site to the Moccasin Bend publicly owned treatment works for processing and disposal (TVA 2013n).

3.1.6 Utility and Transportation Infrastructure

Existing utility and transport infrastructure characteristics for SQN are briefly described in the following subsections.

3.1.6.1 Electricity

Electrical service to SQN is supplied by generating stations within TVA's distribution network. The adjacent 500-kV and 161-kV switchyards provide independent offsite power to SQN Units 1 and 2 from the grid as needed. Both switchyards and all the high-voltage lines would remain in service if SQN Units 1 and 2 were decommissioned. There are no other lines from SQN that connect to the grid or other outside sources of power (TVA 2013f).

3.1.6.2 Fuel

SQN has five underground diesel fuel oil storage tank assemblies encased in concrete foundations. Each assembly consists of four interconnected tanks with a combined capacity of 68,000 gallons (gal) (17,000 gal/tank). In accordance with TDEC's underground storage tank program regulations 0400-18-01, SQN is subject to and complies with the petroleum release response, remediation, and risk management requirements (TVA 2013f).

3.1.6.3 Water

Systems designed to provide cooling water at SQN are described in Section 3.1.3. In addition to water needed for cooling, SQN requires water for sanitary purposes and for everyday use by personnel (e.g., drinking, showering, cleaning, laundry, toilets, and eyewashes). SQN does not use onsite GW for plant or potable water use. Instead, TVA contracts with Hixson Utility District to access potable and fire protection water at SQN. Hixson Utility District draws GW from an aquifer at Cave Springs, approximately 8 mi (13 km) southwest of the SQN site. No wastewater treatment occurs on the SQN site (TVA 2013n).

3.1.6.4 Transportation Systems

SQN has extensive paved surfaces, including roads and parking lots, connecting power plant infrastructure. Local transportation systems, including roadway access, are detailed in Section 3.10.6 of this SEIS. Norfolk Southern Corporation is the operator of the southwest–to–northeast rail line running near the SQN site through Soddy–Daisy. A railroad spur runs from the Norfolk Southern line to SQN just outside the EAB (TVA 2013n).

3.1.6.5 Power Transmission Systems

TVA is the owner and operator of the power transmission line systems that were constructed for the purpose of connecting SQN to the transmission grid. SQN Unit 1 is connected to the 500-kV transmission network, and SQN Unit 2 is connected to the 161-kV transmission system. The two systems are interconnected at SQN through a 1,200-megavolt ampere, 500–161-kV intertie transformer bank on the SQN site (TVA 2013n).

In scope transmission lines for the NRC's license renewal environmental review are limited to those transmission lines that connect the nuclear plant to the switchyard where electricity is fed into the regional distribution system (NRC 2013c). For SQN, the 500-kV and 161-kV switchyards, adjacent to Units 1 and 2 within the protected area of SQN, serve this purpose (TVA 2013f). The two switchyards and the 500–161-kV intertie transformer bank are located on the SQN site (TVA 2013n). The two switchyards and the intertie transformer bank are the only transmission lines considered in scope for license renewal.

3.1.7 Nuclear Power Plant Operations and Maintenance

Maintenance activities conducted at SQN include inspection, testing, and surveillance to maintain the current licensing basis (CLB) of the facility and to ensure compliance with environmental and safety requirements. Various programs and activities currently exist at SQN to maintain, inspect, test, and monitor the performance of facility equipment. These maintenance activities include inspection requirements for reactor vessel materials, boiler and pressure vessel inservice inspection and testing, and maintenance of water chemistry.

Additional programs include those carried out to meet technical specification (TS) surveillance requirements, those implemented in response to the NRC generic communications, and various periodic maintenance, testing, and inspection procedures. SQN must periodically discontinue the production of electricity for outages supporting refueling, periodic in-service inspection and testing, and maintenance activities. The SQN reactor units are on staggered 18-month refueling cycles (TVA 2013n).

3.2 Land Use and Visual Resources

3.2.1 Land Use

The SQN site comprises two peninsulas totaling 630 ac (253 hectares (ha)). The larger peninsula is 525 ac (212 ha) and includes the power block and support facilities (buildings, parking lots, and roads) surrounded primarily by grass fields. The smaller peninsula is 105 ac (42 ha) and includes the training center surrounded by a mix of mostly evergreen and deciduous forest habitat. No commercial, institutional, residential, or public recreational areas occur within the SQN EAB (see Figure 3–3). Similarly, no public railroads or major highways occur within the SQN EAB. Two rural county roads, Igou Ferry and Stone Sage, run adjacent to and sometimes cross the western boundary of SQN's property (see Figure 3–3). A private-use helipad is located on the site (TVA 2013n). Figure 3–3 shows the SQN site boundary and key features.

The Tennessee River creates the southern and eastern boundaries of the SQN site. This portion of the river is currently dammed, creating the Chickamauga Reservoir. The SQN site is located at Tennessee River Mile (TRM) 484.5, approximately 6 mi (10 km) east of Soddy-Daisy. Land not owned by TVA bounds the northern and western portions of the site. Several new housing subdivisions have been developed adjacent to and near the site boundaries since SQN began operation (TVA 2013n).

Land use is primarily rural within the vicinity of SQN (TVA 2013n). The TVA (2013n) ER determined that the largest amount of land cover within a 6-mi (10-km) radius of SQN was deciduous forest (30 percent), followed by pasture or hay (18 percent), open water (13 percent), and developed land (13 percent). The area within a 50-mi (80-km) radius of SQN includes mostly forested and agricultural lands, with pockets of developed areas (Fry et al. 2011).

The SQN site is located in Hamilton County, one of the most populated counties in Tennessee. The county population grew 8 percent from 2000 to 2008, with an estimated population of 336,463 in 2010 (CHCRPA 2009). The most common land uses (based on parcel land-use activity and zoning) within Hamilton County include agriculture (60 percent), residential (31 percent), and manufacturing and industrial (7 percent) (TVA 2013n). Within developed areas, the majority of the area is suburban (42 percent), followed by rural (30 percent), transitional (rural to suburban development, 23 percent), and urban (6 percent) (CHCRPA 2005).

Tennessee Code 13-3-301 requires Chattanooga–Hamilton County to develop a land-use plan for the future. In accordance with this State requirement, the Chattanooga–Hamilton County Regional Planning Agency (CHCRPA) has adopted an active land-use plan and advisory guide entitled Comprehensive Plan 2030. The goal of the 2030 Comprehensive Plan "is to provide guidance in creating desirable and diverse communities in Hamilton County and to encourage and provide for new development opportunities while protecting neighborhoods, infrastructure, and the environment" (CHCRPA 2005). In addition, the CHCRPA is responsible for continuing to implement its zoning and land-use development strategies, whereby every parcel of land in the county carries a zoning designation (CHCRPA 2005).

3.2.2 Visual Resources

The SQN site is situated on a relatively flat area adjacent to the shore of the Tennessee River. Predominant features at the SQN site include the two reactor buildings, a turbine building, an auxiliary building, a control building, a service and office building, a diesel generator building, an intake pumping station, an ERCW pumping station, two natural draft cooling towers, 161-kilovolt (kV) and 500-kV switchyards, a condensing water discharge and diffuser system, and an independent spent fuel storage installation (TVA 2013n).

The tallest structures on site are the two cooling towers at approximately 459 ft (140 m) high (TVA 2013n). A visible plume of condensation rising up from the cooling towers can be seen when the cooling towers are operating. The height and visibility of the plume depend on weather conditions such as temperature, humidity, and wind speed. The plume is typically several hundred feet tall and can be seen from several miles away. The rolling and forested terrain of Hamilton County provides significant visual screening in the immediate vicinity of SQN.

3.3 Meteorology, Air Quality, and Noise

3.3.1 Meteorology and Climatology

The SQN site is located within the Tennessee River Valley, with the Cumberland Plateau to the west and the Appalachian Mountains to the east. The valley, known as the Great Valley, is oriented in a northeasterly-to-southwesterly direction. The local topography within the Great Valley is complex, characterized by a number of minor ridges and valleys with a similar northeast-to-southwest orientation. The regional climate is characterized as humid subtropical. Because of the moderating influences of the surrounding terrain, extreme heat or cold outbreaks are uncommon. The summer months of June through September are quite warm and are characterized by frequent afternoon thunderstorms (NCDC 2013a). The winter months of December through February are cool and characterized by alternating periods of warming and cooling from mid-latitude, low-pressure systems and associated fronts passing through the area; minimum temperatures during this time are usually near freezing, but temperatures below zero are rarely observed (NCDC 2013a). The regional climate is influenced by the position of the semipermanent high-pressure system, known as the Bermuda High. During the summer months, the Bermuda High is situated off of the Atlantic Coast and draws moisture northwestward from the Atlantic and Gulf of Mexico, resulting in the observed warm and moist summers. During the winter months, the Bermuda High shifts southeastward as the jet stream moves southward; low-pressure systems and fronts accompany the jet stream and pass through the area (NOAA 2013).

The NRC staff obtained climatological information with 30-year averages (1981–2010) for the Chattanooga, Tennessee, first-order National Weather Service (NWS) station. This station is approximately 15 mi (24 km) south-southeast of the SQN site and can be used to characterize the region’s climate because of its nearby location, comparable elevation, and long period of record. Additionally, TVA maintains a SQN meteorological facility that consists of a 91-m (300-ft) tower that is instrumented at three levels for wind and temperature measurements (TVA 2013n). Dewpoint, temperature and precipitation are also measured by a separate 10-m (33-ft) tower (TVA 2013n). Recent meteorological observations from the SQN site were made available to the staff (TVA 2013e, 2013f). These data were evaluated in context of the longer climatological record from the Chattanooga NWS station.

The prevailing wind direction at the Chattanooga NWS station is from the south during most of the year, except during the winter months, when it is generally from the north (NCDC 2013a). In the absence of any large-scale weather systems, low-level winds at the SQN site tend to more closely follow the orientation of the Tennessee River Valley, with daytime south-southwesterly upslope winds and nighttime north-northeasterly downslope winds (TVA 2013e, 2013f). The mean annual wind speed at the Chattanooga NWS station is 5.0 mph (2.2 m/s) and mean monthly wind speed ranges from 4.0 mph (1.8 m/s) in August to 6.5 mph (2.9 m/s) in March (NCDC 2013a). Average wind speeds at the SQN site tend to be slightly lower, but exhibit the same seasonal trend (TVA 2013e). A peak 3-second wind gust of 69 mph (30.8 m/s) was recorded in April of 2011 at the Chattanooga NWS station (NCDC 2013a).

The mean annual temperature at the Chattanooga NWS station is 60.8 °F (16.0 °C), with a mean monthly temperature ranging from a low of 40.5 °F (4.7 °C) in January to a high of 80.0 °F (26.7 °C) in July (NCDC 2013a). Recent temperature observations taken at the SQN site are consistent with these values (TVA 2013h). Extreme temperatures in Chattanooga range from a maximum of 107 °F (41.7 °C) in June and July of 2012 to a minimum of −10 °F (−23.3 °C) in January of 1985 (NCDC 2013a).

Normal annual liquid precipitation measured at the Chattanooga NWS station is 52.48 in. (1,333 mm) (NCDC 2013a). The wettest year from the most recent 30-year period of record was 1994, with 73.70 in. (1,872 mm) (NCDC 2013a); the driest year from the same period was 2007, with 38.62 in. (981 mm) (NCDC 2013a). Monthly precipitation amounts tend to be evenly distributed throughout the year and range from an average of 3.28 in. (83 mm) in October to 5.00 in. (127 mm) in November (NCDC 2013a). Precipitation trends from recent observations made at the SQN site (TVA 2013g) are consistent with precipitation observations at Chattanooga, although precipitation amounts are generally lower at the SQN site. Snowfall is not common in the region; average annual snowfall at the Chattanooga NWS site is 3.9 in. (9.9 cm) (NCDC 2013a), with a maximum monthly snowfall of 20.0 in. (50.8 cm) recorded in March 1993.

Thunderstorms are observed normally on 55 days throughout the year, with the majority occurring during the summer months of May through August (NCDC 2013a). Severe weather can occur in the form of hail and tornadoes. In the past 13 years, there have been 77 large-hail events (greater than 0.75-in. (1.9-cm) diameter) reported in Hamilton County; however, many of the hail reports are associated with the same storm (NCDC 2013b). In the past 13 years, 19 tornado events have been reported in Hamilton County, including 1 tornado classified as an EF4 (166–200 mph (74.2–89.4 m/s) 3-second wind gust) on the Enhanced Fujita Scale (NCDC 2013b). Thirteen of the tornado events, including the EF4 tornado, were associated with a tornado outbreak on April 27, 2011 (NCDC 2013b).

3.3.2 Air Quality

Under the Clean Air Act (CAA), the EPA has set primary and secondary National Ambient Air Quality Standards (NAAQS) for six common criteria pollutants to protect sensitive populations and the environment. The NAAQS criteria pollutants include carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2), and particulate matter (PM). PM is further categorized by size—PM_{10} (diameter between 2.5 and 10 micrometers (μm)) and $PM_{2.5}$ (diameter of 2.5 μm or less).

The EPA designates areas of “attainment” and “nonattainment” with respect to the NAAQS. Areas that have insufficient data to determine designation status are denoted as “unclassifiable.” Areas that were once in nonattainment, but are now in attainment, are called “maintenance” areas; these areas are under a 10-year monitoring plan to maintain the attainment designation status.

Air quality designations are generally made at the county level. For the purpose of planning and maintaining ambient air quality with respect to the NAAQS, EPA has created Air quality control regions (AQCRs). Air quality control regions are intrastate or interstate areas that share a common airshed (40 CFR 81). The SQN site is located in Hamilton County, Tennessee; this county, along with several counties in Georgia, are part of the Chattanooga Interstate AQCR (40 CFR 81.42). With regard to the NAAQS criteria pollutants, Hamilton County is designated as unclassified or in attainment with respect to CO, Pb, SO_2, NO_2, and PM_{10} standards (40 CFR 81.343). Hamilton County was an Early Action Compact [2] (EAC) area with respect to the 1997 8-hour ozone standard and demonstrated attainment to the standard on April 15, 2008 (73 FR 17897). Hamilton County is designated as nonattainment with respect to the 1997 $PM_{2.5}$ annual standard (40 CFR 81.343).

States have primary responsibility for ensuring attainment and maintenance of the NAAQS. Under section 110 of the CAA (42 U.S.C. 7401) and related provisions, states are to submit State Implementation Plans (SIPs) that provide for the timely attainment and maintenance of the NAAQS to EPA for approval. On February 8, 2012, EPA approved and promulgated TDEC's revisions to the SIP in support of $PM_{2.5}$ attainment demonstration (77 FR 6467). Subsequently, on December 14, 2012, EPA strengthened the air quality standards for $PM_{2.5}$. EPA will make final designations with regard to the new $PM_{2.5}$ standards by December 2014 (EPA 2012d).

TVA maintains a synthetic minor operating permit (Source ID: 4706504150) for sources of air pollution at the SQN site (TVA 2013f, 2013i). A synthetic minor source has the potential to emit air pollutants in quantities at or above the major source threshold levels but has accepted federally enforceable limitations to keep the emissions below such levels. Permitted sources include two cooling towers, insulator saws, a carpenter shop, as well as emissions from abrasive blasting, auxiliary boilers, and several emergency/blackout diesel generators (TVA 2013f).

As a condition of the operating permit, TVA is required to submit an annual compliance certification to the Chattanooga–Hamilton County Air Pollution Control Bureau (CHCAPCB), which includes estimated air pollutant emissions (TVA 2013n). The SQN site has been in compliance with the requirements set forth in the air permit, and there are no reported violations in the last 5 years (EPA 2012d). Air emissions from the cooling towers, insulator saws, carpenter shop, and abrasive blasting are primarily PM; total PM emissions from these sources range from 5.8 tons/yr (2009) to 33.8 tons/yr (2008) over the 5-year period from 2007 to 2011 (TVA 2013d). Air emissions from permitted combustion sources, including the auxiliary boilers and diesel generators, are listed in Table 3–1 (TVA 2013d, 2013f, 2013k). Greenhouse gas (GHG) emissions from operation of SQN are discussed in Section 4.15.3, Greenhouse Gas Emissions and Climate Change.

[2] The Early Action Compact program allows states to submit agreements pledging to meet the 1997 8-hour ozone standard earlier than required. This is a voluntary program, and states had to meet a number of criteria and milestones (EPA 2012b).

Table 3–1. Air Emission Estimates for Permitted Combustion Sources at SQN

Year	NO_x (t) [a]	CO (t) [a]	SO_x (t) [a]	$PM_{2.5}$ (t) [a]	PM_{10} (t) [a]	VOC (t) [a]	CO_2e (t) [a]
2007	13.3	3.5	0.218	0.23	0.24	0.34	[b]620.0
2008	11.3	3.0	0.186	0.20	0.20	0.29	[b]530.0
2009	13.3	3.5	0.219	0.23	0.24	0.34	697.7
2010	10.5	2.8	0.005	0.18	0.19	0.27	538.2
2011	11.2	3.0	0.006	0.20	0.20	0.29	574.2

[a] To convert t to MT, multiply by 0.91.

[b] Value not provided by TVA; estimated in accordance with Tier 1 calculation methodology found in § 98.33 of 40 CFR Part 98, Subpart C by NRC staff based on hours of operation of combustion sources for 2007 and 2008.

Key: NOx = nitrogen oxides; CO = carbon monoxide; SOx = sulfur oxides; $PM_{2.5}$ = particulate matter with a diameter of 2.5 µm or less; PM_{10} = particulate matter with an aerodynamic diameter between 2.5 and 10 µm; VOC = volatile organic compounds; CO_2e = carbon dioxide equivalent

Sources: TVA 2013d, 2013f, 2013k

The EPA promulgated the Regional Haze Rule (RHR) to improve and protect visibility in National Parks and Wilderness Areas from haze, which is caused by numerous, diverse sources located across a broad region (40 CFR 51.308–309). Specifically, 40 CFR 81 Subpart D lists mandatory Class I Federal Areas where visibility is of important value. The RHR requires states to develop SIPs to reduce visibility impairment at Class I Federal Areas. The TDEC submitted its Regional Haze SIP for Tennessee to EPA on April 4, 2008. On April 24, 2012, EPA published a final rule granting limited approval of TDEC's Regional Haze SIP (77 FR 24392). The Cohutta Wilderness Area in Georgia is the closest Class I Federal Area to the SQN site; it is approximately 40 mi (64 km) southeast of SQN. Because of limited source emissions, distance from the site, and prevailing wind direction, no adverse impacts on Class I areas are anticipated from SQN operation.

3.3.3 Noise

Noise is unwanted sound and can be generated by many sources. Sound is described in terms of amplitude (perceived as loudness) and frequency (perceived as pitch). Sound pressure levels are typically measured by using the logarithmic decibel scale. A-weighting (denoted by decibels adjusted (dBA)) is widely used to account for human sensitivity to frequencies of sound (i.e., less sensitive to lower and higher frequencies and most sensitive to sounds between 1 and 5 kHz), which correlates well with a human's subjective reaction to sound (ASA 1983, 1985). Table 3–2 presents common noise sources and their respective sound levels. Nuclear power generation is an industrial process that can generate noise. Noise sources at the SQN site include fans, turbine generators, transformers, cooling towers, compressors, emergency generators, main steam-safety relief valves, and emergency sirens (TVA 2011c). As a major industrial facility, SQN noise emissions can reach 65–75 dBA levels on site, which attenuate with distance (TVA 2013f). Most of these noise sources are not audible at the site boundary or are intermittent and considered a minor nuisance. There is scattered residential development in the vicinity of the SQN site; the nearest resident lives 0.5 mi (0.8 km) from the central point of the reactors (TVA 2013f). Noise sources in the vicinity of the SQN site include river and lake traffic, road traffic, dogs barking, insects, and power lines (TVA 2013f). The SQN emergency sirens, when activated, are meant to be heard off site to alert the nearby communities of a possible emergency. Offsite noise levels may sometimes exceed the 55-dBA level that EPA uses as a threshold level to protect against excess noise during outdoor activities (EPA 1974). However, according to EPA this threshold does "not constitute a standard, specification, or regulation," but was intended to provide a basis for state and local governments in establishing noise standards (EPA 1974). The Federal Housing Administration has established noise assessment guidelines and finds that noise of 65 dBA or less is acceptable (HUD 2013). Beyond local ordinances, there are no Federal regulations[3] for public exposures to noise (EPA 2012a).

Table 3–2. Common Noise Sources and Sound Levels

Source	Sound Pressure Level (dBA)
Jet Plane (at 100 ft distance)	130
Diesel truck (at 30 ft distance)	100
Food blender (at 3 ft distance)	90
Car (50 mph at 50 ft distance)	65
Conversation	55
Threshold of hearing	0

Sources: MMSHT 2013; SFU undated

3.4 Geologic Environment

This section describes the current geologic environment of the SQN site and vicinity, including landforms, geology, soils, and seismic conditions.

Physiography and Geology

The SQN site is in the Valley and Ridge physiographic province (TVA 2013a), which is characterized by a sequence of folded and faulted northeast-trending sedimentary rocks that form a series of ridges and alternating valleys. The topography is the result of the folding and faulting of the rocks in combination with differential rates of erosion. More erosion-resistant rocks form the ridges, while less resistant rocks form the valleys. In general, the ridges consist of quartz-rich, coarser-grained rocks like sandstones and conglomerates, while the valleys contain limestone and shale rocks.

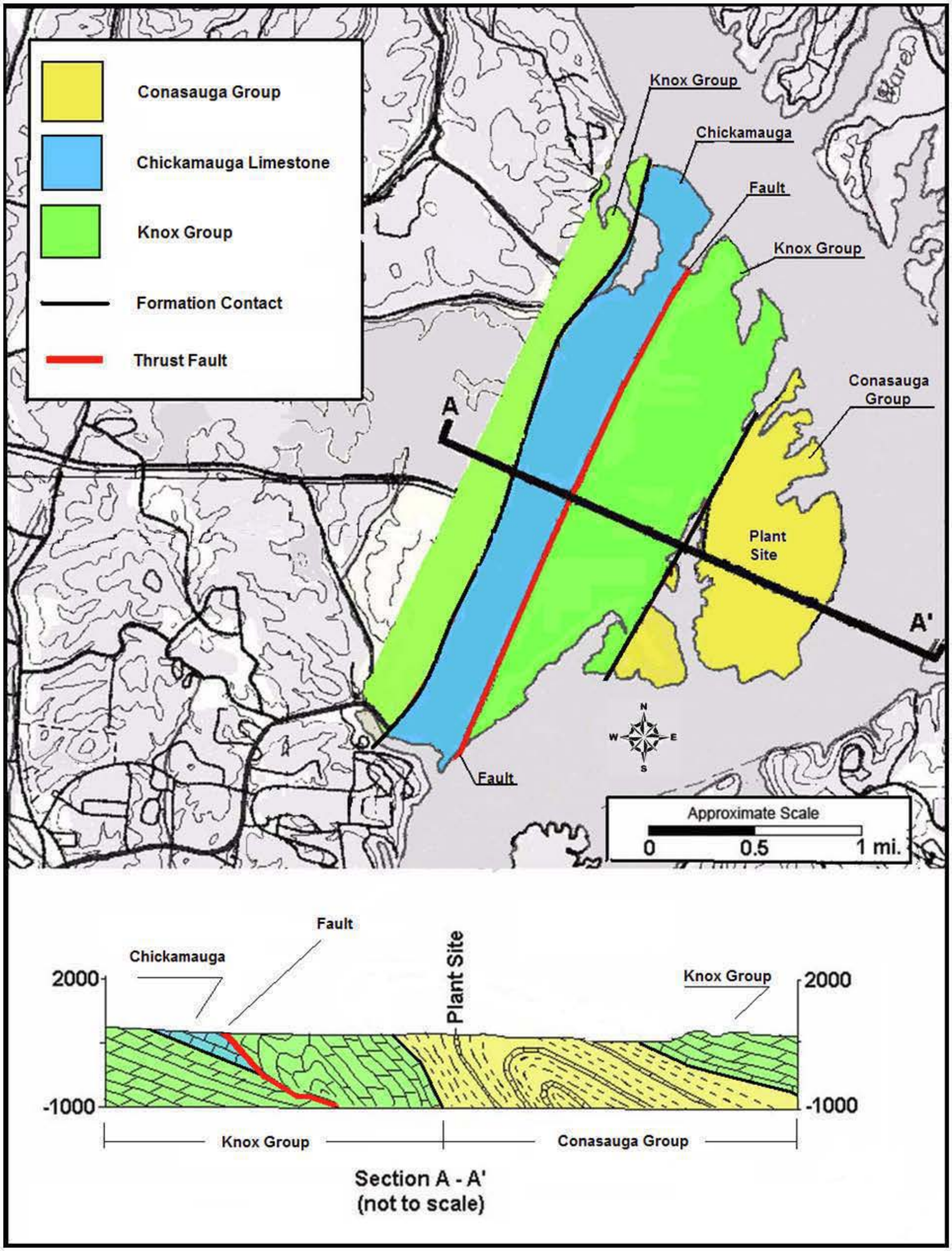
The SQN site is located in a broad northeast-southwest trending valley that contains the Chickamauga Reservoir. The site is on a peninsula on the west bank of the Chickamauga Reservoir. Most of the plant is at an elevation of 705 ft (215 m) above MSL. Where not occupied by the Chickamauga Reservoir, land north and south of the site forms a broad, rolling plain with elevations that range between about 800 ft (244 m) and 900 ft (274 m) above MSL. At 5 mi (8 km) west of the SQN site, the elevation of the land rapidly rises up from the valley floor to approximately 1,600 ft (488 m) above MSL to form the Cumberland Plateau (TVA 2013a). East of the site, on the other side of the Chickamauga Reservoir, a terrain of small hills rises to approximately 900 ft (274 m) above MSL. This hilly terrain continues to the opposite side of the valley, approximately 8 mi (13 km) distant.

[3] In 1972 Congress passed the Noise Control Act of 1972 establishing a national policy to promote an environment free of noise that impacts the health and welfare of the public. However, in 1982 there was a shift in Federal noise control policy to transfer the responsibility of regulation noise to state and local governments. The Noise Control Act of 1972 was never rescinded by Congress but remains unfunded (EPA 2014).

The bedrock beneath the valley is made up of geologic units containing limestone, dolomite, shale, and sandstone, with limestone and dolomite being the most abundant rock type. The primary geologic units from oldest to youngest include the Conasauga Group, Copper Ridge Dolomite, Knox Group, the Chickamauga Limestone, and the Newman Limestone. In the TVA ER (TVA 2013), the Knox Group and Conasauga Group are referred to as ”formations”. However, to be consistent with the public literature, in this SEIS, they will be called “groups”. The bedrock geologic units generally strike northeast/southwest and dip towards the southeast at approximately 20 degrees (Haugh 2002). As a result of the folding and thrust faulting of these units, the same geologic units will be repeatedly encountered in the bedrock in an east-west direction (Haugh 2002, TVA 2013a).

Immediately underlying SQN, the bedrock is composed of several hundred feet of interbedded limestone and shale that make up the Conasauga Group. For this group, shales dominate the rock assemblage. The Conasauga Group is also part of a now eroded anticline (upward fold or arch) with steep eastward dipping beds (Figure 3–5). The eastward dip of the Conasauga Group beds ranges from 60 degrees to near vertical (Julian 2007). The nearest thrust fault to the site is the Kingston Thrust Fault, which occurs approximately 2,000 ft (610 m) northwest of the plant site. This fault is not considered to be active and was formed approximately 250 million years ago in association with the creation of the Appalachian Mountains. Along this fault, the Conasauga Group is in contact with the Knox Group (Figure 3–5) (TVA 2013a).

Figure 3–5. Site Geologic Formations and Structure



Source: Modified from Julian 2007

Soils

At SQN, where the Conasauga Group is not in direct contact with plant structures, it is overlain by structural fill or by soils. Within the main plant site, much of the soil was removed during plant construction. The soils were formed from clayey alluvium and from the shale and limestone of the Conasauga Group. The soils tend to have a high clay content and to be fine grained (silt, loam, or clay). Depth to bedrock ranges from 3 to 34 ft (1 to 10 m) (Julian 2007; TVA 2013a; USDA 2013).

Seismic Setting

The SQN site is located in the "East Tennessee Seismic Zone." The East Tennessee Seismic Zone is an approximately 46-mi (75-km) wide, 218-mi (350-km) long region of seismicity located in the southern Appalachians that extends from NE Alabama and NW Georgia to NE of Knoxville, Tennessee. It is the second most active seismic zone east of the U.S. Rocky Mountains. The East Tennessee Seismic Zone has not recorded historical earthquakes greater than a magnitude of 5 (Hatcher et al. 2012). The largest recorded earthquake in this seismic zone was a magnitude 4.6 that occurred in 1973 near Knoxville, Tennessee. Sensitive seismographs have recorded hundreds of earthquakes too small to be felt in this seismic zone. Small, non-damaging earthquakes occur about once a year (USGS 2013a). The site is located in an area that could experience strong shaking from earthquakes, but the damage associated with them would be light. Should a strong earthquake occur, well-designed ordinary structures might experience slight to moderate damage, but poorly built structures could experience considerable damage (FEMA 2013, USGS 2013b, USGS 2013c, Wood and Ratliff 2011). The The NRC requires every nuclear power plant to be designed for site-specific ground motions that are appropriate for its location.

3.5 Water Resources

3.5.1 Surface Water Resources

3.5.1.1 Site Description and Surface Water Hydrology

Local Hydrology and Drainage

The SQN site is situated on a peninsula on the western shore of Chickamauga Reservoir, part of the Tennessee River System, at Tennessee River Mile (TRM) 484.5.

Chickamauga Reservoir lies within the Upper Tennessee River Basin, based on the U.S. Geological Survey (USGS) established boundary between the upper and lower portions of the basin at TRM 465 in Chattanooga, Tennessee. The Upper Tennessee River Basin encompasses approximately 21,390 mi^2 (55,400 km^2), and includes the entire drainage area of the Tennessee River and its tributaries upstream from the USGS gauging station at Chattanooga, Tennessee. It comprises parts of four states including Tennessee, North Carolina, Virginia, and Georgia. The Upper Tennessee River Basin contains some of the most rugged terrain in the eastern United States, including the Great Smoky Mountains range (Hampson et al. 2000; TVA 2013n). Below Chattanooga, the Tennessee River travels a generally U-shaped course through the Lower Tennessee River Basin, which encompasses the remaining portions of Tennessee, Georgia, Alabama, Mississippi, and Kentucky that drain to it. The Tennessee River ultimately has its confluence with the Ohio River at Paducah, Kentucky (TVA 2013n).

Specific to the SQN site, Chickamauga Reservoir extends approximately 59 river miles upstream from Chickamauga Dam at TRM 471 to Watts Bar Dam at TRM 529.9. The reservoir has a drainage area of 20,790 mi^2 (53,820 km^2), a shoreline length of 784 mi (1,262 km), a volume of 628,000 acre-feet (774.6 million m^3), and a surface water area of 35,400 ac (14,326 ha) at a normal maximum pool elevation of 682.5 ft (208 m) above MSL behind Chickamauga Dam. The reservoir ranges from 700 ft (213 m) to 1.7 mi (2.7 km) wide (TVA 2011c, 2013n). In the vicinity of SQN, the reservoir is approximately 3,000 ft (910 m) wide with water depths ranging between 12 and 50 ft (3.6 and 15 m) at normal maximum pool elevation (TVA 2011d).

The SQN site directly interacts and is connected with Chickamauga Reservoir through modified embayments and a discharge pond system that support plant operations. These features are depicted in Figure 3–4. In summary, on the north end of the main plant site, they include the unlined plant intake embayment (forebay) where the ERCW system intake pump station and the CCW system intake pump station (see Section 3.1.3) and associated intake channel are located. In the central portion of the main plant complex, the unlined CCW discharge channel receives heated condenser water and other effluents (see no. 5 in Figure 3–4) and drains to the unlined diffuser pond (no. 6 in Figure 3–4). As part of this system, several smaller ponds also collect and convey plant stormwater and other wastewaters from plant systems in accordance with SQN's current Tennessee-issued NPDES permit (No. TN0026450). The largest of these is an unlined yard drainage pond (no. 1 in Figure 3–4) which overflows and drains by gravity directly to the diffuser pond. Next are two former metal cleaning waste ponds (nos. 2 and 3 in Figure 3–4), which are regulated at an NPDES internal monitoring point (internal outfall 107). These ponds discharge to the lined, low volume waste treatment pond (no. 4 in Figure 3–4), which, in turn, discharges via NPDES internal outfall 103 to the diffuser pond (no. 6 in Figure 3–4). Ultimately, thermal effluents (including cooling tower blowdown when the plant operates in helper mode) and other wastewaters collected in SQN's diffuser pond system are discharged through the plant's submerged diffuser structure (NPDES outfall 101) into Chickamauga Reservoir. SQN's diffuser structure is detailed in Section 3.1.3.1 of this SEIS. However, should SQN operate in closed-cycle mode, the cooling tower discharge (return) channel (no. 7 in Figure 3–4) would convey cooling water circulated through the cooling towers back to the intake embayment rather than to the diffuser pond. Finally, a separate settling pond yard (no. 8 in Figure 3–4), that is used to dewater dredged sediments, discharges via NPDES outfall 118 to the intake embayment rather than to the diffuser pond system (TVA 2011c, 2013d, 2013e, 2013f, 2013n).

It is noted that there are no GW monitoring requirements imposed by the plant's NPDES permit as it relates to the use of SQN's ponds. SQN's NPDES permit is further discussed in Section 3.5.1.3.

<u>Regional Hydrology and Flow Regulation</u>

The Tennessee River system is regulated by a series of 49 active dams and reservoirs managed by TVA, including Chickamauga Reservoir, which lies between the Watts Bar and Chickamauga Dams. TVA operates the Tennessee River system to provide year-round navigation, flood-damage reduction, power generation, improved water quality, water supply, recreation, and economic growth (Bohac and Bowen 2012; TVA 2011c). System-wide flows are measured at Chickamauga Dam, located near Chattanooga, Tennessee, as it provides the best indication of flow for the upper half of the Tennessee River system (TVA 2013i). The average annual flow of the Tennessee River at the Chickamauga Dam is approximately 32,500 cfs (918 m^3/s, or 21,000 mgd) (TVA 2011c, 2013n). TVA's Watts Bar Nuclear Plant (WBN) is also located on Chickamauga Reservoir at TRM 528, approximately 31 mi (50 km) north-northwest and upstream of SQN (TVA 2013n). The average annual flow at Watts Bar Dam is approximately 27,500 cfs (777 m^3/s, or 17,800 mgd) (NRC 2013a).

In total, the flow of the main stem Tennessee River in the vicinity of SQN and through Chickamauga Reservoir is controlled by releases from Watts Bar and Chickamauga Dams and, to a lesser extent, inflow from the Hiwassee River. The SQN site is approximately 15 TRM downstream from the Hiwassee River's confluence with the Tennessee River at TRM 499. The Hiwassee River discharge accounts for the bulk of the increase in Tennessee River flow between Watts Bar Dam and Chickamauga Dam. The Hiwassee River discharge into the Tennessee River is largely controlled by releases from the Ocoee 1 Dam on the Ocoee River and Apalachia Dam on the Hiwassee River. The Ocoee River empties into the Hiwassee River downstream of Apalachia Dam. As noted by TVA and the NRC staff's review of archived river flow and stage data, regulated inflow to Chickamauga Reservoir from the Hiwassee River is small, ranging from about 5 to 15 percent, as compared to the contribution of the main stem Tennessee River (TVA 2013d-f, 2013j).

Within this highly regulated hydrologic environment, the Tennessee River Basin is one of the wettest regions in the United States. The long-term average annual precipitation and runoff from 1894 to 1993 were 51 and 22 inches, respectively. Average monthly rainfall and runoff maximum is in March and the minimum is in October. The major flood season in the Tennessee Valley is from December to mid-April with the highest frequency of storms in March. Dormant vegetation and ground conditions favor a high rate of runoff during this time period. Nevertheless, natural flow (i.e., the estimated flow that would have occurred had there been no dams) in the Tennessee River for the Chickamauga Reach (i.e., the stretch of the river now encompassed by Chickamuaga Reservoir) for the period 1903 to 1993 averaged 34,300 cfs (969 m^3/s, or 22,170 mgd). The estimated minimum natural flow occurred in 1998 at 15,700 cfs (444 m^3/s, or 10,150 mgd), with the maximum of 51,400 cfs (1,450 m^3/s, or 33,200 mgd) in 1929 (Miller and Reidinger 1998). A comparison of these estimates of natural flow with observed values at Watts Bar and Chickamauga Dams indicates that flow regulation operations closely mimic natural flow on an annualized basis.

In summary, the water levels and flow rates in Chickamauga Reservoir are actively regulated as part of the Tennessee River and reservoir system. The current TVA policy for reservoir operations was implemented in May 2004. The policy specifies flow requirements for (1) individual reservoirs that are designed to prevent dryout of the riverbed downstream and (2) system-wide operation to meet downstream needs. TVA releases enough water to augment natural inflows in order to provide the weekly average minimum flows at Chickamauga Dam according to the minimum operations guide, which is based on the amount of water stored in the reservoirs. When water must be released to meet downstream flow requirements, a fair share of water is drawn from each reservoir, resulting in some drawdown from each source. Furthermore, TVA enhances recreational opportunities by restricting the drawdown of tributary storage reservoirs during the summer (June 1 through Labor Day). During this period, under normal operations, just enough water is released from these reservoirs to meet downstream flow requirements. TVA works to keep the water levels in these reservoirs as close as possible to each reservoir's "flood guide level"—a guideline that reflects how much storage space each reservoir needs to hold back potential flood waters (TVA 2013i, 2013n).

<u>Floodplain Hydrology</u>

Through regulation, changes in water levels within the Tennessee River system are minimized, a situation which greatly reduces the frequency of flooding. Chickamauga, along with Watts Bar and Ft. Loudon-Tellico, are the three main stem reservoirs on the Upper Tennessee River. TVA management of these reservoirs is designed, in part, to reduce the flood crest at Chattanooga (TVA 2011d, 2013p). The flood insurance rate map for the SQN site and vicinity identifies the 100-year flood elevation at 686 ft (209 m) above MSL (FEMA 2002). All SQN buildings, including safety-related structures, are above this elevation, with plant grade at 705 ft (215 m) above MSL. The original licensing basis flood water-surface elevation for SQN was updated in 2002 to account for Tennessee River dam safety modifications. The CLB probable maximum flood (at stillwater-surface elevation) for SQN is 719.6 ft (219.3 m) above MSL (TVA 2011d). Since 2008, TVA has been working on updating, validating, and verifying its legacy hydrology and hydraulic models. TVA submitted a license amendment request for SQN (TVA 2012d) to the NRC on August 10, 2012, to raise the licensing-basis flood stillwater-surface elevation to 722 ft (220 m) above MSL. The NRC staff is currently reviewing TVA's request. By March 2015, TVA is scheduled to submit a reevaluated flood hazard assessment for SQN in response to the NRC's 10 CFR 50.54(f) letter (NRC 2012). The requirement established in NRC's 10 CFR 50.54(f) letter for a reevaluated flood hazard assessment is part of the Fukushima lessons learned effort.

3.5.1.2 Surface Water Use

Surface water withdrawals from the Tennessee River and reservoir system are regulated under Section 26a of the TVA Act (1933). TVA evaluates water intake structure permit requests for environmental impacts to determine the volume of water that can be withdrawn. The conditions for the withdrawal take into account operation of the river system and impact on the river environment. Water withdrawal permit holders are required to report annual usage as a condition of their permits, except for small residential irrigation users who are exempt from reporting requirements. These data are used in tracking existing withdrawals and evaluating proposed increases in withdrawals from the Tennessee River system (TVA 2013h, 2013n).

SQN itself does not have a Section 26a permit as TVA is not required to issue permits to TVA-owned and -operated facilities (TVA 2013j). However, the plant's surface water withdrawals are voluntarily reported to the State of Tennessee in accordance with the Tennessee Water Resources Information Act of 2002. Tennessee requires entities, except for some exempted users, withdrawing 10,000 gallons per day (gpd) (37,500 Lpd) or more of surface or GW to register the withdrawal with the State on an annual basis (TCA 69-7-3; TDEC 2013a).

Table 3–3 summarizes SQN's surface water withdrawals for the period 2008 to 2012. As described in Section 3.1.3 of this SEIS, all primary cooling and auxiliary cooling water needs for plant operation are provided by intake structures in communication with Chickamauga Reservoir. Nominal water demand by the CCW system and the ERCW system require SQN withdrawals from Chickamauga Reservoir at a peak rate of 2,600 cfs (73.5 m^3/s, or 1,680 mgd) (see Section 3.1.3).

Table 3–3. SQN Reported Annual Water Withdrawals and Return Discharges to Chickamauga Reservoir

Year	SQN Withdrawals (mgy)	SQN Discharges (mgy)
2008	612,850	567,345
2009	612,850	528,855
2010	573,123	561,156
2011	579,576	582,888
2012	505,541	536,101
Average	**576,788**	**555,269**

Note: Data in this table showing discharge exceeding withdrawal in a given year may be indicative of inflow from sources other than withdrawal from the Tennessee River (e.g., stormwater or utility water) or measurement inaccuracies.

Sources: TVA 2013d, 2013e, 2013f

Based on the NRC staff's review of TVA's Water Withdrawal Registration reports submitted to the State, SQN continuously withdraws water at a fairly constant rate. Specifically, during the past 5-year period, withdrawals from Chickamauga Reservoir to support SQN operations have averaged 576,788 mgy (2,183 million m^3/y). This is equivalent to a withdrawal rate of 2,445 cfs (69.1 m^3/s, or 1,580 mgd).

For the once-through cooling system at SQN, the condenser flow rate is nearly equal to the surface water withdrawal rate, and the consumption rate is much less than closed-cycle systems with continuous cooling tower operation. Consequently, the volume of water returned to Chickamauga Reservoir from SQN plant cooling operations is nearly equal to or slightly less than the volume withdrawn. There is some consumptive use of water because of evaporation and drift during cooler tower operation in helper mode. During full helper mode operations, consumptive water use could be as much as 31,250 gpm (70 cfs (1.98 m^3/s)) or 45 mgd, as further discussed in Section 3.1.3. This consumptive use is less than 3 percent of the continuous water withdrawal by the plant.

3.5.1.3 Surface Water Quality and Effluents

<u>Water Quality and Standards</u>

TDEC is authorized by the EPA to regulate pollutants discharged from point sources into Tennessee surface waters under the NPDES permit program. In particular, TDEC administers this program for industrial, municipal, State, and Federal facilities discharging pollutants directly to surface waters, including the Tennessee River. TDEC also sets water quality standards within the State, establishes pollutant treatment and control requirements, and reviews monitoring reports to protect the desired and designated uses of the water bodies.

TDEC has established criteria to protect Chickamauga Reservoir water quality for its designated uses including domestic and industrial water supply, fish and aquatic life, recreation, livestock watering and wildlife, irrigation, and navigation (TNR 1200-04-04). Under Section 303(d) of the Clean Water Act (CWA) (officially, the Federal Water Pollution Control Act) of 1972, the State of Tennessee biennially assesses the water quality of streams and develops a list of impaired waters. These are waters that do not meet water quality standards. The law requires priority rankings for waters on the list and the development of total maximum daily loads (TMDLs) of pollutant for these waters.

Chickamauga Reservoir is not listed on TDEC's 2008, 2010, or 2012 Section 303(d) lists for impaired waters. However, nine listed impaired waters that discharge to Chickamauga Reservoir between TRM 529.9 and TRM 478 are listed because of various causes, ranging from high E. coli levels to channel alteration and siltation. They include Watts Bar Reservoir, Little Richland Creek, the Hiwassee River embayment of Chickamauga Reservoir, Roaring Creek, Possum Creek, an unnamed tributary to Chickamauga Reservoir, Savannah Creek, Wolftever Creek, and Rogers Branch. Most notably, the Hiwassee River embayment of Chickamauga Reservoir is listed as impaired for fish consumption because of mercury, primarily attributable to atmospheric deposition and industrial sources. Upstream of SQN, Watts Bar Reservoir is listed as impaired for fish consumption because of polychlorinated biphenyls (PCBs) from industrial sources, as well as mercury and chlordane contamination in sediments. The Emory River Arm of Watts Bar Reservoir is identified as impaired for arsenic, coal ash deposits, and aluminum, as well as mercury, PCBs, and chlordane (TDEC 2010, 2014; TVA 2013n). The Emory River Arm is the area of the reservoir most affected by the ash spill that occurred at TVA's Kingston Fossil Plant in 2008 (NRC 2013; TVA 2013g).

TVA has conducted its Vital Signs Monitoring Program on Chickamauga Reservoir in alternate years since 1994. This program uses metrics to evaluate the ecological health of TVA reservoirs including chlorophyll concentration, sediment contamination, and dissolved oxygen. Values of good, fair, or poor are assigned to each metric. Table 3–4 summarizes the 2011 values for monitoring sites in the deep, still area near the Chickamauga Dam (forebay, TRM 472.3), midreservoir (TRM 490.5), the Hiwassee River embayment (Hiwassee River Mile 8.5), and at the upstream end of the reservoir (inflow, TRM 518 and 527.4). Based on the metric evaluation, the overall ecological health condition of Chickamauga Reservoir rated fair in 2011. Ecological health scores tend to be lower in most Tennessee River reservoirs during years with low flows, because chlorophyll concentrations are typically higher and dissolved oxygen levels are lower near the bottom. In 2011, the individual metrics scored good or fair at all sites except for chlorophyll in the forebay and mid-reservoir stations, which rated poor (TVA 2013c, 2013n).

Table 3–4. Ecological Health Indicators for Chickamauga Reservoir, 2011

Monitoring Locations	Dissolved Oxygen	Chlorophyll	Sediment
Forebay	Good	Poor	Fair
Mid-Reservoir	Good	Poor	Fair
Hiwassee River Embayment	Good	Good	Fair
Inflow	Not Measured	Not Measured	Not Measured

Sources: TVA 2013c, 2013n

Thermal and Chemical Effluent Regulation

Industrial wastewater, cooling water, and stormwater discharges from SQN are governed by a TDEC-issued NPDES permit (No. TN0026450). SQN's current NPDES permit for plant operations was issued to TVA by TDEC with an effective date of March 1, 2011; the permit expired on October 31, 2013 (TVA 2013n). However, TVA submitted a permit renewal application to TDEC on May 2, 2013 (Alexander 2014). Therefore, the current permit remains in effect (i.e., administratively continued) pending issuance of a new permit. TVA expects that TDEC will issue a renewed permit in 2016 (TVA 2013j). Further, TVA expects that the renewed permit will include language indicating that continued NPDES permit coverage also constitutes State water quality certification under Section 401 of the CWA (TVA 2013j, 2013n).

TVA's current permit sets effluent limits and monitoring requirements for the plant's discharges covering five external and two internal outfall (internal monitoring point) locations. The outfalls discharge industrial wastewater (mainly cooling water) or comingled cooling water with stormwater. As noted in Section 3.5.1.1, effluents collected from the yard drainage pond, former metal cleaning waste ponds, low volume waste treatment pond, CCW discharge channel, cooling tower blowdown basin (including liquid radioactive effluents), and stormwater are discharged from the diffuser pond through the plant's submerged diffusers (outfall 101) in the Tennessee River (TVA 2013d-f, 2013n). However, the metal cleaning waste ponds no longer receive process wastewater, which included boiler cleaning and various piping cleaning wastes. The permanent piping to the metal cleaning waste ponds from SQN has been disconnected, and TVA may pursue decommissioning of the ponds through the NPDES permit process (TVA 2013j).

The NPDES permit for SQN identifies outfall 101 for the release of cooling water and associated effluents to the Tennessee River (Chickamauga Reservoir) through the plant's discharge diffusers. The compliance point for water temperature is at the downstream end of the diffuser mixing zone in accordance with the permitted thermal criteria and defined mixing zone, as previously described in Section 3.1.3.1. To restate, SQN's NPDES permit delineates the maximum extent of the mixing zone as an area 750 ft (230 m) wide and extending 1,500 ft

(457 m) downstream and 275 ft (85 m) upstream of the plant's twin diffusers. The depth of the mixing zone varies linearly from the water surface 275 ft (85 m) upstream of the diffusers to the top of the diffuser pipes and then extends to the bottom downstream of the diffusers. For closed-mode operation, the mixing zone also includes the area of the intake forebay to the CCW intake pump station.

The mixing zone geometry is based on a physical model study of the discharge diffusers, which examined the thermal effluent over a wide range of plant and river conditions, including reverse flows in Chickamauga Reservoir (TVA 2013n). Conditions favoring a larger mixing zone with higher temperatures include: (1) low river flow, (2) high ambient river water temperatures, (3) active upriver heat transport processes, and (4) high temperature thermal discharges to the river. When river flow is less than 25,000 cfs (706 m^3/s), heat from the thermal discharge has been observed to migrate upstream to the SQN intake, resulting in intake water temperatures above ambient (Hopping et al. 2009). Nevertheless, NPDES permit limits and conditions governing SQN's thermal discharge via outfall 101 effectively dictate how TVA manages flow through Chickamauga Reservoir. TVA currently avoids scheduling daily average releases from Chickamauga Dam at rates below 6,000 cfs (169 m^3/s, or 3,880 mgd) when both SQN units are in operation, and 3,000 cfs (84.7 m^3/s, or 1,940 mgd) when one SQN unit is in operation.

Part III(F) of SQN's NPDES permit specifies requirements related to monitoring thermal compliance for outfall 101 in accordance with CWA Section 316(a). Ranges for the daily average flow past SQN are defined wherein special field surveys are required to verify the adequacy of TVA's measurements of ambient river temperature and the adequacy of SQN's diffuser mixing zone. TVA operates the Chickamauga Reservoir to meet these NPDES permit requirements (TVA 2013j).

As of July 2013, SQN had operated in compliance with the requirements of Part III(F) of the current NPDES permit. Based on the current operating policy for the TVA reservoir system, the daily average river flow past the SQN site can be as low as 3,000 cfs (84.7 m^3/s, or 1,940 mgd). In practice, the river flow past SQN rarely drops below a daily average of 6,000 cfs (169 m^3/s, or 3,880 mgd). TVA has not released less than 6,200 cfs (175 m^3/s, or 4,000 mgd) of water from Chickamauga Dam since January 2007 (TVA 2013j).

Furthermore, there have been no NPDES thermal violations since SQN began operation. Under the current NPDES criteria, operating conditions for the river and the plant are primarily managed for two of the limits—the 24-hour average maximum downstream temperature and the 24-hour average maximum downstream temperature rise (TVA 2013j).

Boyington et al. (2013) is TVA's most recent study that has been performed to establish the validity of the numerical model prediction of temperature in the mixing zone as required by the current NPDES permit. Using samples from 1982 to 2012 for the calibration study, TVA demonstrated that the existing model continues to provide acceptable estimates for the mixing zone temperatures, with the average discrepancy of 0.38 °F (0.21 °C) for river temperatures above 75 °F (23.9 °C).

The NRC staff also reviewed 5 years of NPDES Discharge Monitoring Reports for SQN as submitted by TVA to TDEC. Specifically monitored are daily maximum upstream ambient temperature (Station 14, TRM 490.4), daily maximum temperature rise from upstream to downstream (TRM 483.4, mixing zone compliance model) of SQN, daily maximum rate of temperature change, outfall 101 flow and water quality (temperature, pH, total suspended solids (TSS), oil and grease, and chlorine), CCW trench and channel extractable hydrocarbons, outfall 103 flow and water quality (pH, TSS, oil and grease), outfall 107 flow and water quality (pH, TSS, oil and grease, copper, and iron), outfall 110 flow and water quality (temperature, pH, TSS, oil and grease, and chlorine), outfalls 116 and 117 floating debris and oil and grease, and outfall 118 flow and water quality (dissolved oxygen, TSS, and settleable solids). Other than two pH exceedances in the low volume waste treatment pond (internal outfall103) on July 8, 2009, and October 1, 2010, no exceedances of effluent limitations were identified. Violations for a missed sampling during biocide/corrosion treatment on October 25, 2009, and a late report during a chlorine leak at the ERCW intake on August 20, 2010, occurred during the period of review (TVA 2013d-f, 2013j).

3.5.2 Groundwater Resources

This section describes the current GW resources of the SQN site and vicinity.

3.5.2.1 Site Description and Hydrogeology

The valley containing SQN can have from 0 to 300 ft (0 to 100 m) of unconsolidated material (regolith and soils) on top of soluble carbonate bedrock. This unconsolidated material is usually composed of insoluble chert and clay residuum formed by the in-situ chemical weathering of the carbonate bedrock. Groundwater flow in this unconsolidated material is recharged by water from local precipitation. Where thicker than 50 ft (15 m), the unconsolidated material can serve as a storage reservoir and supply water to the underlying bedrock (Haugh 2002).

Some of the geologic units that underly the valley are also aquifers which are used as sources of water. These geologic units are the Copper Ridge Dolomite, the Knox Group, the Chickamauga Limestone, and the Newman Limestone (herein after referred to as aquifers). Water movement through these aquifers is largely through interconnected fractures, joints, and bedding planes that have been enlarged by chemical weathering (Lloyd and Lyke 1995). West of the site, these aquifers are recharged with water by direct infiltration (from rain or snow) through the overlying soils and by infiltration from streams that flow along the base of the Cumberland Plateau Escarpment. Most recharge to these aquifers occurs during the winter and spring months (Haugh 2002). In general, GW in these aquifers flows towards the Chickamauga Reservoir, with some of the GW flowing into wells, streams, and springs (Haugh 2002). Chickamauga Reservoir is likely another source of water for these aquifers when they outcrop beneath the reservoir, but this is not considered to be a source of recharge for the area on the west side of the reservoir around SQN (Haugh 2002).

The SQN site is underlain by the Conasauga Group. Neither the Conasauga Group nor the overlying soil would be considered an aquifer. The high clay content of the shale beds in the Conasauga Group make it a poor water producer (Julian 2007, TVA 2013a), while both the high clay content and shallow depth of the soils make them poor sources of GW.

The source of GW in the SQN soil and in the Conasauga Group is from on-site precipitation or from the Chickamauga Reservoir. Chickamauga Reservoir surrounds the SQN site on the north, east, and south. Groundwater levels move up or down as Chickamauga Reservoir water levels move up or down (Julian 2007). When water levels rise in either the reservoir, intake, or discharge channels, water moves from these water bodies into the Conasauga Group and the soil. When water levels in the reservoir, intake, or discharge channels are lowered, GW in the Conasauga Group and the soil flows into these channels and the reservoir. Overall, GW flow direction in the soil and Conasauga Group at SQN is towards the reservoir (Julian 2007; TVA 2013a).

The beds of the Conasauga Group are nearly vertical. For GW within the Conasauga Group to flow westward or eastward from SQN, it would need to cross the low-permeability shale beds contained within the Conasauga Group (TVA 2013a). As a result, little if any GW movement is expected within the Conasauga Group in a west or east direction. Instead, GW within the Conasauga Group is expected to move parallel to the bedding planes (between the shale beds) and within small fractures in a northeast or southeast direction and into Chickamauga Reservoir (Julian 2007; TVA 2013a). West of SQN, the Conasauga Group is in contact with the Knox Group Aquifer. However, the potential for GW to move laterally across bedding planes is so low that significant GW movement from the Conasauga Group into the Knox Group is considered to be very unlikely.

3.5.2.2 Groundwater Use

In the area around the SQN site, well yields are dependent on the local rock type (limestone or shale) and the location of joints, fractures, and faults. Well yields can be variable, ranging from less than one to several hundred gallons per minute. Where the conditions are favorable, the aquifer system is capable of supplying significant quantities of GW. In addition to supplying many small springs, the aquifer system also supplies Cave Springs, which is the second largest spring in East Tennessee. The average discharge for this spring is 17.5 cfs (0.5 m^3/s) (Haugh 2002). The primary GW user of this aquifer system is the Hixson Utility District, which is a local supplier of public water. Their well fields are located approximately 5.5 mi (8.9 km) and 8.5 mi (14 km) southwest of SQN.

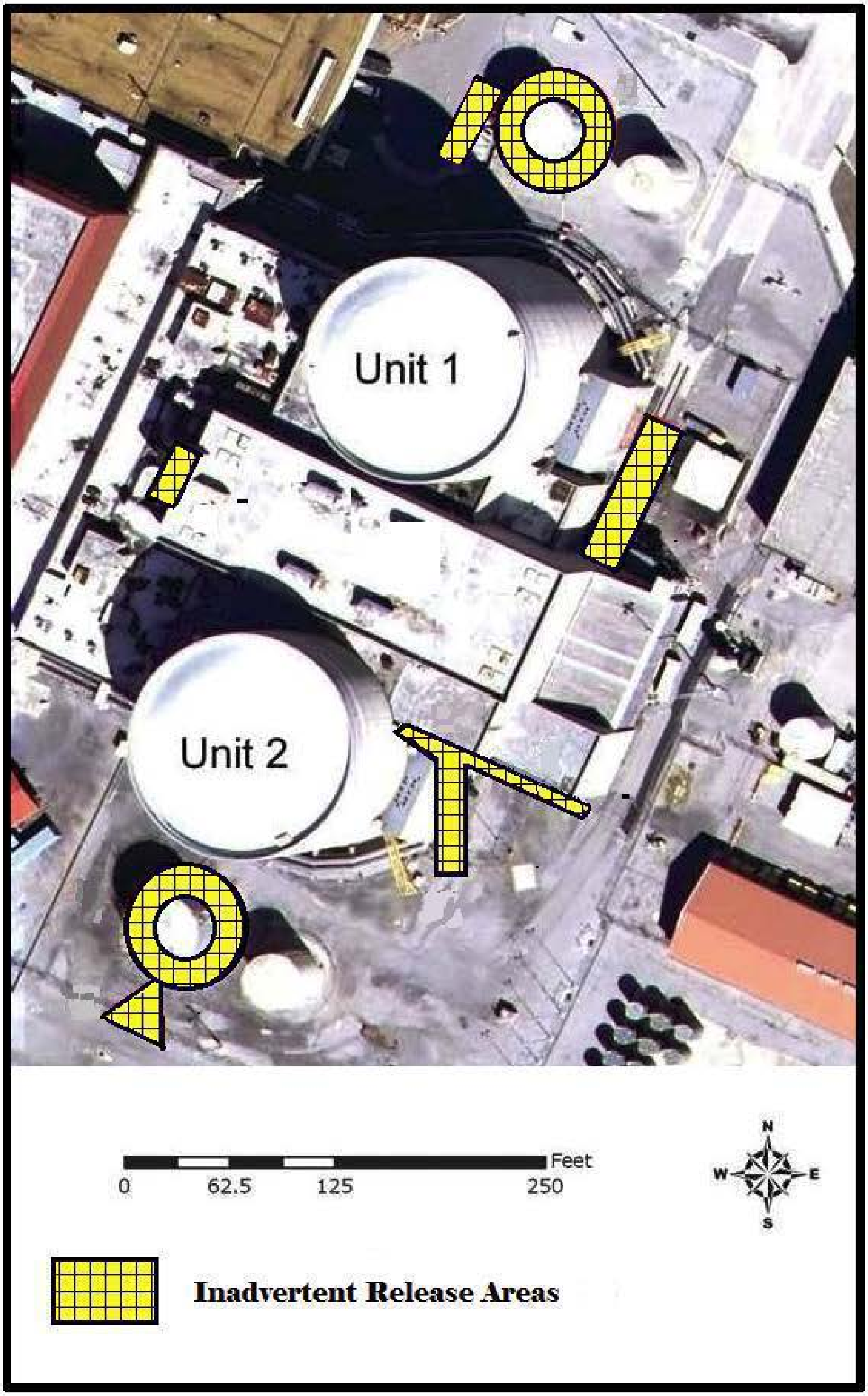
There are no GW supply wells on the SQN site or within a 1-mile (1.6-km) radius (from the plant center point) of the site. The Hixson Utility District supplies SQN with water for all plant potable water needs. In 2011, the SQN average monthly consumption of potable water was 3.3 million gal (12.5 million L), or approximately 110,295 gpd (417,512 Lpd) (TVA 2013a). Potable water for the residential area around SQN is also supplied by Hixson Utility District (TVA 2013a).

3.5.2.3 Groundwater Quality

The GW aquifers around SQN consist largely of dolomite and limestone rock. The GW quality in these aquifers is characterized as calcium bicarbonate and calcium magnesium bicarbonate (Pavlicek 1996). It is generally satisfactory for municipal supplies (TVA 2013a). Water obtained by these aquifers and delivered via the Hixson Utility District is of high quality (Chattanooga Times Free Press 2013, Hixson Utility District 2013, TAUD 2013). As discussed in Section 3.5.2.1, the Conasauga Group is not a good producer of GW at SQN. However, the little data on GW quality that is available states that the water at SQN in the Conasauga Group is generally good (TVA 2013a).

Tritium concentrations in GW above background levels have been detected near some of the plant structures at SQN. Tritium has been detected near the Unit 1 Refueling Water Storage Tank and near the Unit 2 Reactor Building. No ongoing leaks of tritium have been identified. Groundwater data from many wells and geoprobe borings, and data on past water spills, suggest the source of the tritium in the GW is from past inadvertent water spills that occurred on the land surface. These accidental spills were of limited areal extent and occurred close to the plant buildings. Eight water spills occurred from 1981 to 2006. Spills occurred near the Condensate Demineralizer Waste Evaporator Building, the Additional Equipment Building, the Auxiliary Building, the Refueling Water Storage Tank Moat Drain, and the Modularized Transfer Demineralization System (Julian 2007) (see Figure 3–6).

Figure 3–6. Locations of Inadvertent Liquid Releases Containing Tritium



Source: Modified from Julian 2007 and TVA 2011b

Groundwater containing tritium greater than background has been detected in four wells located very close to plant structures. Their tritium concentrations are well below the EPA primary drinking water standard (DWS) of (20,000 pCi/L) (TVA 2013c). These wells monitor GW quality in the structural fill and soil. In addition to these wells, another well also located close to plant structures, but completed in the top of the underlying Conasauga Group, has tritium values that exceed background concentrations (Julian 2007). In this well (W-10), tritium has been detected at a concentration of 26,780 pCi/l (sample collected on May 1, 2013) (TVA 2013c). This exceeds the EPA DWS for tritium. In December 2011, water from this well was analyzed to determine the ratio of tritium (hydrogen-3) to helium-3 in the GW. From these ratios, the tritium was calculated to have last been in contact with the atmosphere 14 years (plus or minus 6 years) ago (TVA 2013c). This age agrees reasonably well with the record of past spills and supports TVA's assertion the source of tritium is from historical water spills and not from ongoing activities.

TVA is actively involved in monitoring the extent of contamination. In 2007, the nuclear power industry began implementing its "Industry Ground Water Protection Initiative" (NEI 2007). Since 2008, the NRC staff has been monitoring implementation of this initiative at licensed nuclear reactor sites. The initiative identifies actions to improve management and response to instances in which the inadvertent release of radioactive substances may result in low but detectible levels of plant-related materials in subsurface soils and water. Results from SQN GW monitoring are reported annually to the NRC (TVA 2010, 2011a, 2012, 2013b).

3.6 Terrestrial Resources

3.6.1 SQN Ecoregion

SQN lies within the ridge and valley ecoregion, which occupies 44,589 km^2 (17,216 mi^2) of land from the southeastern corner of New York to northeastern Alabama. The ridge and valley ecoregion is long and narrow, extending 1,600 km (995 mi). Roughly parallel ridges and lowland valleys characterize most of the area and are the result of extreme folding and faulting geological events. The predominant land cover in the ecoregion includes forests (56 percent), agricultural land (30 percent), and developed areas (9 percent). Although developed land is less prominent than forests and agricultural land, from 1973 to 2000, the percent of developed land has increased 1.4 percent, while the percent of forested and agricultural land has decreased (USGS 2012).

3.6.2 SQN Site and Vicinity

The SQN site is located along the Chickamauga Reservoir. The primary terrestrial habitats on the site include forests, grasslands, wetlands, and scrub-shrub habitats (see Table 3–5 and Figure 3–7).

The SQN site is composed of two peninsulas. The larger peninsula is mostly developed and includes the plant buildings and infrastructure surrounded primarily by grass fields. A small strip of forested habitat borders the Chickamauga Reservoir. The smaller peninsula consists mostly of a mix of evergreen and deciduous forest habitat.

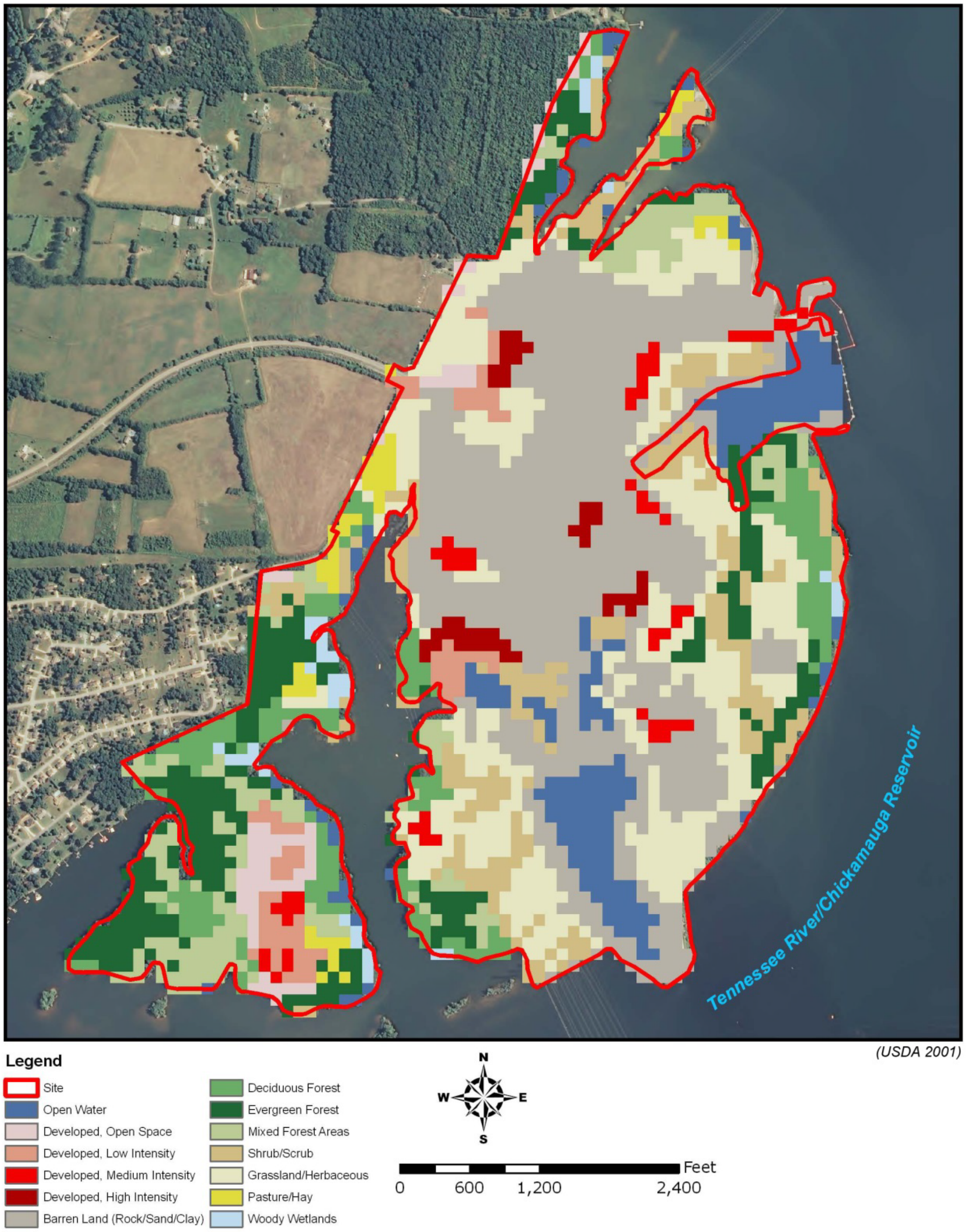
Table 3–5. Primary Land Cover on the SQN Site

Land Cover	Percent
Developed or Cleared Land Cover	
Barren (rocks, sand, clay)	31
Developed (open)	2
Developed (improvements)	6
Undeveloped Land Cover	
Forest (Deciduous)	6
Forest (Evergreen)	10
Forest (Mixed)	7
Grassland	17
Scrub-shrub	9
Open Water	8
Pasture	2
Wetlands	1

Note: Total percentage does not add to 100 because of rounding.

Source: TVA 2013n

Figure 3–7. Land Cover at the SQN Site



Source: TVA 2013n

3.6.2.1 Summary of Past SQN Surveys and Reports Within the Site and Vicinity

The TVA (1974) conducted site surveys of the SQN site and vicinity as part of the construction permit application for SQN Units 1 and 2. These initial site surveys included an assessment of terrestrial plant communities. The TVA (1974) review did not specify survey methodology, although TVA (2013n) assumed that the surveys were conducted on site with additional data extracted from a 1969 Bradley–Hamilton County survey (TVA 1969).

In 2010, TVA staff and contractors (TVA staff) conducted a walkdown of the site to identify general plant populations along fence rows, roadsides, and lawns (TVA 2011c). The TVA walkdown also noted birds and other wildlife observed. In addition, TVA staff conducted a desktop review of natural areas (such as wildlife management areas). On March 27, 2013, TVA staff conducted a follow-up study and surveyed nest sites within 6 mi (10 km) of SQN (TVA 2013f).

These surveys are the primary sources for describing the terrestrial resources at SQN. To supplement such surveys, the NRC staff conducted an environmental site visit and a desktop review of other natural resource databases and surveys within the vicinity of SQN, such as FWS 2013a, Henry 2011, and TDEC 2013b.

3.6.2.2 Vegetation

<u>Common Vegetation</u>

Before construction, 93 percent of the SQN property was forested, including 54 percent pine, 32 percent pine–hardwood, and 7 percent hardwood (TVA 1974). The remaining portions of the peninsula included pasture (3 percent), old field (2 percent), and transmission right-of-ways (2 percent) (TVA 1974). Construction of the SQN plant converted approximately 525 ac (212 ha) of terrestrial habitat, including mixed hardwood forest, pine forest, pasture, and old fields, into buildings, parking lots, landscaped areas, and other industrial uses. Both before and after construction of the SQN plant, agricultural and private land development activities have disturbed forests and other vegetation at and surrounding the plant (TVA 2013n).

TVA (1974) concluded that common tree assemblages on the SQN site include evergreens, such as shortleaf pine (*Pinus echinata*) and Virginia pine (*Pinus virginiana*), and hardwoods, such as oaks (*Quercus* spp.), hickories (*Carya* spp.), beech (*Fagus* spp.), and other typical ridge and valley deciduous species. During the January 2010 SQN site walkdown, TVA observed similar common tree species, such as shortleaf pine and Virginia pine (TVA 2013n). TVA also recorded common flowering plant and grass species, including Japanese honeysuckle (*Lonicera japonica*), trumpet creeper (*Campsis radicans*), various unnamed lawn species, and weedy species such as crabgrass (*Digitaria* spp.). TVA (2011c) concluded that the types of plants currently existing on the SQN site are typical of hardy species that can tolerate environmental conditions near industrial facilities.

As part of the ER for the 2009 power uprate (TVA 2009c), TVA characterized common invasive species found on the SQN site. Observed invasive species included Chinese privet (*Ligustrum sinense*), Japanese honeysuckle, Japanese stilt grass (*Microstegium vimineum*), multiflora rose (*Rosa multiflora*), and Chinese bush clover or sericea lespedeza (*Lespedeza cuneata*).

TVA (1974) conducted a field survey of dominant vegetation within the vicinity of SQN. The studies indicated that dominant tree species included the following: white oak (*Q. alba*), post oak (*Q. stellata*), black oak (*Q. velutina*), southern red oak (*Q. falcata*), shagbark hickory (*Carya ovata*), mockernut hickory (*Carya tomentosa*), yellow poplar (*Liriodendron tulipifera*), and American beech (*F. grandifolia*).

<u>Wetlands</u>

TVA (2013n) determined the presence of wetlands on the SQN site and in the vicinity of SQN by examining U.S. Department of Agriculture (USDA) land cover maps and National Wetland Inventory maps. Wetlands compose approximately 1 percent of the SQN site. The majority of the wetlands occur on the edge of the site adjacent to the Chickamauga Reservoir. The

U.S. Fish and Wildlife Service (FWS) (FWS 2013a) classifies these wetlands as lacustrine, which means that the wetlands occur in a topographic depression or a dammed river channel; trees, shrubs, or other persistent vegetation is less than 30 percent of the areal coverage; and the total area exceeds 8 ha (20 ac). In addition to the lacustrine wetlands, a single, 0.88-ac (0.35-ha) wetland occurs on the north side of the SQN site. The FWS (2013a) classifies this wetland as palustrine scrub or shrub, or a nontidal wetland with woody vegetation that includes woody shrubs, young trees, or trees with stunted growth. The FWS (2013a) also classifies several onsite ponds as palustrine (nontidal), unconsolidated bottom, and permanently flooded habitats. These ponds are described in the aquatic resources section of this SEIS.

Additional wetlands occur within the vicinity (6 mi (10 km)) of SQN, including freshwater forested and scrub-shrub wetlands and freshwater emergent wetlands (FWS 2013a; TVA 2013n). These wetlands primarily occur along the Chickamauga Reservoir or its tributaries.

State-Listed Vegetation

This section discusses plant species protected only by the State, and Section 3.8 discusses those species protected under the Endangered Species Act of 1973, as amended (ESA), alone or in combination with the State. Table 3–6 identifies the 23 plants that are considered threatened or endangered by the State of Tennessee within Hamilton County. Within 6 mi (10 km) of SQN, one State endangered, one State threatened, and five species of special concern have been identified (TDEC 2013b; TVA 2011c). Plant species of special concern include species or subspecies that are uncommon or have unique or very specific habitat requirements or scientific value. The seven species identified within 6 mi (10 km) of SQN are described below, including where the species was observed in relation to SQN.

Table 3–6. State-listed Plant Species in Hamilton County

Scientific Name	Common Name	State of Tennessee Status	Habitat
Nonvascular Plants			
Lejeunea sharpii	Sharp's lejeunea	Endangered	*Calcareous bluffs, rock & logs of wet sinks*
Vascular Plants			
Clematis fremontii	Fremont's virgin's-bower	Endangered	*Limestone barrens*
Clematis glaucophylla	White-leaved leatherflower	Endangered	*Wooded stream banks*
Delphinium exaltatum	Tall larkspur	Endangered	*Glades and barrens*
Diamorpha smallii	Small's stonecrop	Endangered	*Sandstone outcrops*
Diervilla lonicera	Northern bush-honeysuckle	Threatened	*Rocky woodlands and bluffs*
Diervilla sessilifolia var. *rivularis*	Mountain bush-honeysuckle	Threatened	*Dry cliffs and bluffs*
Gratiola floridana	Florida hedge-hyssop	Endangered	*Wooded swamps*
Lilium canadense	Canada lily	Threatened	*Rich woods and seeps*
Lilium philadelphicum	Wood lily	Endangered	*Dry openings, powerlines*
Lonicera flava	Yellow honeysuckle	Threatened	*Rocky woods and thickets*
Lysimachia fraseri	Fraser's loosestrife	Endangered	*Dry open woods*
Nestronia umbellula	Nestronia	Endangered	*Upland woods*
Phemeranthus mengesii	Menge's fameflower	Threatened	*Dry rock ledges*
Phemeranthus teretifolius	Roundleaf fameflower	Threatened	*Dry sandy rock outcrops*
Ribes curvatum	Granite gooseberry	Threatened	*Rocky woods*
Sabatia capitata	Cumberland rose gentian	Endangered	*Dry open woods, powerlines*
Silphium laciniatum	Compass plant	Threatened	*Barrens*
Silphium pinnatifidum	Southern prairie-dock	Threatened	*Barrens*
Solidago ptarmicoides	Prairie goldenrod	Endangered	*Barrens*
Stylisma humistrata	Southern morning-glory	Threatened	*Dry piney woods*
Trillium lancifolium	Narrow-leaved trillium	Endangered	*Alluvial woods and moist ravines*
Trillium rugelii	Southern nodding trillium	Endangered	*Rich mountain woods*

Source: TDEC 2013b

Southern Prairie-Dock (*Silphium pinnatifidum*)

Southern prairie-dock, a State threatened species, was identified in 2011 on private property less than 4 mi (6 km) from SQN (TVA 2013f). Southern prairie-dock grows in areas exposed to full sun and with average to poor soil. This perennial plant is relatively tall and grows as high as 3 m (10 ft). When in bloom, southern prairie-dock can be identified by its large flower heads with yellow ray and disc flowers (USDA 2004).

Tall Larkspur (*Delphinium exaltatum*)

Tall larkspur, a State endangered species, was observed historically from an area less than 6 mi (10 km) from SQN; the last sighting was in 1939 (TVA 2011c). Tall larkspur is a herbaceous perennial plant that belongs to the buttercup family. In Tennessee, primary habitat includes ridge and valley cedar barrens on thin cherty loam over limestone (dolomite). However, the plant has also been observed within oak-cedar woods, mixed pine-cedar woodlands, and disturbed areas (e.g., powerlines, roadsides, and pastures) that provide similar habitat as barrens (NatureServe 2013f).

Pink Lady's Slipper (*Cypripedium acaule*)

Pink lady's slipper, a species of special concern, was observed in 2007 approximately 6 mi (10 km) from SQN (TVA 2011c). Pink lady's slipper is an orchid that requires bees for pollination. This species lives in a variety of habitats, including mixed hardwood coniferous forests of pine and hemlock and in deep humus and acidic but well-drained soil near birch and other deciduous trees (USDA 2011).

Fragrant Bedstraw (*Galium uniflorum*)

Fragrant bedstraw, a State species of concern, was identified in 1997 approximately 6 mi (10 km) from the SQN site (TVA 2011c). Fragrant bedstraw is a perennial forb.

Gibbous Panic-grass (*Sacciolepis striata*)

Gibbous panic-grass, a species of special concern, was identified approximately 1.5 mi (2 km) from SQN in 1985 (TVA 2011c). Gibbous panic-grass grows within wetlands, although suitable habitat does not occur on the SQN site (TVA 2013n).

Ovate-Leaved Arrowhead (*Sagittaria platyphylla*)

Ovate-leaved arrowhead, a species of special concern, was observed in 1980 approximately 6 mi (10 km) from SQN (TVA 2011c). Ovate-leaved arrowhead is a rhizomatous aquatic plant. It can grow up to 5 ft (1.5 m) (NBII and ISSG 2006).

American Ginseng (*Panax quinquefolius*)

American ginseng, a commercially exploited State species of concern, was observed in 2007 approximately 6 mi (10 km) from the SQN site (TVA 2011c). This perennial plant grows primarily in moist woods under a closed canopy (NatureServe 2013f).

3.6.2.3 Wildlife

Common Wildlife

The SQN site provides several types of terrestrial habitats for birds, mammals, and other wildlife. For example, shoreline along the Chickamauga Reservoir is used extensively by birds and waterfowl. During periods of reservoir drawdown, exposed mudflats along the shoreline provide several important food sources for birds, such as aquatic invertebrates (Henry 2011). Plant communities that develop along the shoreline also provide an important source of food and refuge for birds. The combination of food, protection, and other resources available make the Chickamauga Reservoir an important habitat for many birds and wildlife. In addition, the reservoir is part of the Mississippi flyway, an important stopover location for many birds, including sandhill cranes (*Grus canadensis*) (TVA 2013n; TWRA 2013b).

Farther inland, wetlands occur within continually or regularly flooded areas, which provides food and shelter for a variety of birds, amphibians, and wildlife. Forested areas also occur on the SQN site, as described above. Because of the limited size of the SQN site and surrounding development, most wildlife species that occur on the SQN site are those that are relatively tolerant of semiurban conditions.

Several important terrestrial habitats occur within the vicinity of SQN. As described above, this area is part of the Mississippi flyway, used by migrating birds as important stopover points during long seasonal migrations. High-quality bird habitats within the region surrounding SQN include Soddy Mountain, Hiwassee National Wildlife Refuge, Harrison Bay State Park, and Chester Frost Park (Henry 2011; TVA 2013n; TWRA 2013b).

Another relatively unique and important habitat within 6 mi (10 km) of SQN is three caves (TVA 2011c). Caves provide a unique habitat because of the combination of geologic requirements and environmental conditions created inside caves. The Tennessee cave salamander (*Gyrinophilus palleucus*) typically occurs within caves in Hamilton County.

Table 3–7 describes the most common or abundant birds, mammals, reptiles, and amphibians on the SQN site and within the vicinity.

Table 3–7. Most Common or Abundant Wildlife on or Within the Vicinity of the SQN Site

Birds	
Passerines (Songbirds)	
American crow (*Corvus brachyrhynchos)*	**northern cardinal** (*Cardinalis cardinalis*)
American robin (*Turdus migratorius*)	**sedge wren** *(Cistothorus platensis*)
eastern bluebird (*Sialia sialis)*	**tree swallow** (*Tachycineta bicolor)*
marsh wren (*Cistothorus palustris*)	
Waterfowl (Ducks and Geese)	
black duck (*Anas rubripes)*	**hooded merganser** (*Lophodytes cucullatus)*
Canada goose (*Branta canadensis)*	**mallard** (*Anas platyrhynchos*)
gadwall (*Anas strepera)*	**wood duck** (*Aix sponsa*)
green-winged teal (*Anas crecca)*	
Birds of Prey (Eagles, Hawks, Ospreys, and Vultures)	
bald eagle (*Haliaeetus leucocephalus)*	**red-tailed hawk** (*Buteo jamaicensis*)
black vulture (*Coragyps atratus*	**sharp-shinned hawk** (*Accipiter striatus*)
broad-winged hawk (*Buteo lineatus*)	**turkey vulture** (*Cathartes aura*)
osprey *(Pandion haliaetus)*	

Other Nonpasserine Birds	
great blue heron (*Ardea herodias*)	**sandhill crane** (*Grus canadensis)*
gull (*Larus spp.)*	**turkey** (*Meleagris gallopavo)*
killdeer (*Charadrius vociferous)*	**whooping crane** (*Grus americana)*
Mammals	
coyote (*Canis latrans)*	**least shrew** (*Cryptotis parva*)
eastern cottontail (*Sylvilagus floridanus*)	**North American beaver** (*Castor canadensis*)
eastern mole (*Scalopus aquaticus)*	**striped skunk** (*Mephitis mephitis*)
eastern Virginia opossum (*Didelphis virginiana)*	**whitetail deer** (*Odocoileus virginianus*)
hispid cotton rat (*Sigmodon hispidus*)	
Reptiles and Amphibians	
American toad (*Bufo americanus*)	**Tennessee cave salamander** (*Gyrinophilus palleucus*)
Fowler's toad (*Bufo fowleri*)	**upland chorus frog** (*Pseudacris feriarum*)
northern cricket frog (*Acris crepitans*)	

Sources: Henry 2011; TVA 2009c, 2011c, 2013n, 2013f; TWRA 2013b, 2013c, 2013d, 2013e

<u>State-Listed and Other Important Wildlife</u>

This section discusses bird, mammal, and reptile species protected only by the State, the Bald and Golden Eagle Protection Act, and the Migratory Bird Treaty Act. Section 3.8 discusses those species protected under the ESA alone or in combination with the State.

<u>Birds</u>

Table 3–8 identifies the three birds that are considered threatened or endangered by the State of Tennessee within Hamilton County.

Neither the Bachman's sparrow (*Aimophila aestivalis*) nor the Bewick's wren (*Thryomanes bewickii*) are likely to occur at SQN because of a lack of available habitat.

Table 3–8. State-Listed Bird Species in Hamilton County

Scientific Name	Common Name	State of Tennessee Status	Habitat
Aimophila aestivalis	Bachman's sparrow	Endangered	*Dry open pine or oak woods; nests on the ground in dense cover*
Falco peregrinus	peregrine falcon	Endangered	*Varied habitats, including farmlands, marshes, river mouths, and cities; often nests on ledges*
Thryomanes bewickii	Bewick's wren	Endangered	*Brushy areas, thickets and scrub in open country, open and riparian woodlands*

Source: TDEC 2013b

Peregrine falcons (*Falco peregrinus*) are medium-sized hawks and have the potential to occur at or near SQN. The FWS removed the peregrine falcon from the Federal list of endangered species in 1999 (64 FR 46542). However, it is still considered endangered by the State of Tennessee (TDEC 2013b). Peregrine falcons are present in a variety of habitats, including large cities. They eat birds and small mammals. Peregrine falcons nest in loose material on a cliff or the ledge of a building in an area with a protective overhang. They prefer sites that are 100 ft (30 m) or higher (TWRA 2013c). A nest in Hamilton County was active below Chickamauga Dam until 2007 (TWRA 2013c). Because peregrine falcons are present along the Tennessee River and known to nest on ledges, there is a potential for them to be present at the SQN site. In April 2013, the NRC staff observed that TVA had taken steps to ensure permanent structures, including buildings and equipment regarded as suitable falcon nesting sites, were equipped with structures that would deter nest building.

The State of Tennessee lists seven bird species in Hamilton County as "deemed in need of management" (TDEC 2013b). Of these seven species, barn owls (*Tyto alba*), sharp-shinned hawks (*Accipiter striatus*), and bald eagles (*Haliaeetus leucocephalus*) have been observed along the Chickamauga Reservoir near the SQN site. Bald eagles are also protected under the Bald and Golden Eagle Protection Act and are discussed later in this section.

The State of Tennessee lists four additional Hamilton County bird species as "deemed in need of management" (TDEC 2013b) that have not been observed on the SQN site or within 6 mi (10 km):

- Swainson's warbler (*Limnothylpis swainsonii*),
- least bittern (*Ixobrychus exilis*),
- king rail (*Rallus elegans*), and
- golden-winged warbler (*Vermivora chrysoptera*).

Species Protected Under the Bald and Golden Eagle Protection Act

The Bald and Golden Eagle Protection Act of 1940, as amended (16 U.S.C. §668-668c), prohibits anyone from taking bald or golden eagles (*Aquila chrysaetos*), including their nests or eggs, without a permit issued by the FWS. The Act defines the word "take" to mean, among other things, to pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, destroy, molest, or disturb (50 CFR 22.3). The Act defines the word "disturb" to mean, among other things, to take action that (1) causes injury to an eagle or (2) decreases its productivity or nest abandonment, by substantially interfering with breeding, feeding, or sheltering behavior (50 CFR 22.3).

Bald eagles have been observed downstream of the SQN site near Harrison Bay State Park and Chester Frost Park, as well as other locations along the Tennessee River and its tributaries (eBird 2013; TWRA 2013d). A bald eagle nest was observed approximately 1 mi (1.6 km) from the site during 2006. Although the nest was not present during the survey completed in 2013, it is possible that in the future a pair of bald eagles will nest near the site (TVA 2013f).

Species Protected Under the Migratory Bird Treaty Act

The Migratory Bird Treaty Act of 1918, as amended (16 U.S.C. §§703–712, herein referred to as MBTA), is administered by the FWS. The Act prohibits anyone from taking native migratory birds, their eggs, feathers, or nests. The MBTA defines “take” to mean to pursue, hunt, shoot, wound, kill, trap, capture, or collect, or any attempt to carry out these activities (50 CFR 10.12). However, “take” does not include habitat destruction or alteration. All Tennessee State listed species shown in Table 3–8 are protected under the MBTA.

<u>Mammals</u>

Three mammals are listed by the State of Tennessee as being “deemed in need of management”: the Allegheny woodrat (*Neotoma magister*), the smoky shrew (*Sorex fumeus*), and the southeastern shrew (*S. longirostris*). This classification is analogous to the category “special concern” discussed above for plants. None of these mammals have been reported near the SQN site (TVA 2013f).

<u>Reptiles</u>

The eastern slender glass lizard (*Ophisaurus attenuatus longicaudus*) is listed by the State as “deemed in need of management.” A legless lizard, it is approximately 13 in. (33 cm) from the head to the base of the tail, or up to 41.9 in. (106 cm) including the tail (NPS 2013). The eastern slender glass lizard is rarely seen. They are found in dry soil or on dry grassy areas (VDGIF 2013), often in open areas such as powerline right-of-ways, fields, and open woods (NPS 2013), and occasionally in vacant lots or farms (TWRA 2013e). They burrow in sandy soils and live in old rodent burrows or under grass mats (VDGIF 2013).

3.6.3 Transmission Line Corridors

Section 3.1.6.5 describes the transmission lines under consideration in this SEIS as those that connect the nuclear power plant to the switchyard where electricity is fed in to the regional distribution system (NRC 2013c). For SQN, the 500-kV and 161-kV switchyards serve this purpose (TVA 2013f). The switchyards are adjacent to Units 1 and 2 and within the protected area of SQN (see Figure 3–3). Therefore, the above discussion of the affected terrestrial environment for the SQN site is representative of the affected environment for these transmission lines.

3.7 Aquatic Resources

3.7.1 Description of the Tennessee River

The only aquatic community in the vicinity of the SQN site is the Tennessee River. The Tennessee River drains an area of approximately 105,000 km^2 (40,540 mi^2) in portions of Virginia, North Carolina, Tennessee, Georgia, Alabama, Mississippi, and Kentucky. TVA constructed a series of impoundments from the 1920s through the 1960s that altered the character of the Tennessee River Valley (TVA 2013n). Chickamauga Dam, completed in 1940 by TVA, impounded the river to create the Chickamauga Reservoir, which is proximate to the SQN site (TVA 1974). A total of 49 dams and reservoirs in the Tennessee and Cumberland watersheds are owned or operated by TVA, 9 of which are located on the main stem of the Tennessee River (TVA 2013n).

According to Etnier and Starnes (1993), "Tennessee has the richest freshwater fauna of any of the United States" and further, that "the richest fish fauna are from the Tennessee and Cumberland drainages." Parmalee and Bogan (1998) find that the Tennessee River and its tributaries "harbored the most diverse and abundant assemblage" of freshwater mussels known in historic times. Impoundment of the river and the subsequent habitat loss, pollution, and introduced species have greatly altered the diversity of the mussels and fish, however, and changed the ecosystem processes in the Tennessee River system (White et al. 2005). White et al. (2005) provide examples of these processes, including the loss of "shallow shoals, large snags and accumulations of woody debris," which affect benthic ecosystem processes and make the water chemistry of the river more dependent on releases from upstream.

The assemblage of organisms living in the river has changed in response to the impoundments that have produced conditions that allow nonnative species to invade and proliferate. Species that were not able to adapt to the new conditions have been and are being decimated, extirpated, or driven to extinction. According to Parmalee and Bogan (1998), only one-third of the 130 species of freshwater mussels known to occur or to have occurred in Tennessee are considered stable. For example, all 11 species of the unionid mussel genus *Epioblasma* that inhabited the shoal and riffle areas in the Tennessee River and its tributaries are now extinct (Parmalee and Bogan 1998). Parmalee and Bogan attribute these extinctions directly or indirectly to impoundment. According to Neves and Angermeier (1990), obligatory riverine species, those that require riverine habitat for at least part of their life history, typically do not survive in reservoirs. Further, Neves and Angermeier (1990) report that even though fish sampling on the Tennessee River was not extensive in the years before construction of the dams began (late 1930s), enough surveys were conducted to document the adverse effects of impoundment on native fish species. For example, fish surveys conducted before and after the impoundment of Melton Hill Reservoir, located in East Tennessee upstream of the Watts Bar Dam on the Clinch River, demonstrate a shift in the fauna—species requiring shoal and riffle habitats that were present before impoundment were no longer present in the postimpoundment surveys. Such adverse impacts have been extensive, and Neves and Angermeier found that "[t]here is little doubt that the integrity of the resident fish fauna of these rivers [the Tennessee River and its tributaries] and their associated drainages has been and will be compromised by such extensive alterations of habitat."

White et al. (2005) summarized one aspect of the problem as follows:

> Because reservoirs create ecosystem conditions that did not exist previously in the basin, conceptually these are "new" ecosystems…Although most species occurred in the system prior to impoundment the dominant species now are those adapted to the new set of environmental conditions.

Further, the impoundments created good reservoir fisheries for sport and commercial fishermen. This, in turn, contributed to the change in composition of the aquatic biota. According to Etnier and Starnes (1993), resource managers and others, whether purposely or accidentally, introduced other species (including nuisance species) into the system. These species include carp (various species, including *Cyprinus carpio, Ctenopharyngodon idella*, and *Hypophthalmichthys* spp.), striped bass (*Monrone saxatilis*), yellow perch (*Perca flavescens*), and possibly the threadfin shad (*Dorosoma petenense*) (Etnier and Starnes 1993). Nuisance species (i.e., nonnative species whose introduction causes, or is likely to cause, economic or environmental harm) include Eurasian water milfoil (*Myriophyllum spicatum*), spiny leaf naiad (*Najas minor*), hydrilla (*Hydrilla verticillata),* zebra mussels (*Dreissena polymorpha*), and Asiatic clams (*Corbicula fluminea*) (TWRA 2008). These species and their potential effect on the native aquatic biota are discussed in detail later in this section.

3.7.2 Description of Chickamauga Reservoir

The SQN site is on the western shore of the Chickamauga Reservoir at Tennessee River Mile (RM) 484.5. The Chickamauga Reservoir extends approximately 59 mi (95 km) from Chickamauga Dam (Tennessee RM 471) to Watts Bar Dam (Tennessee RM 529.9).

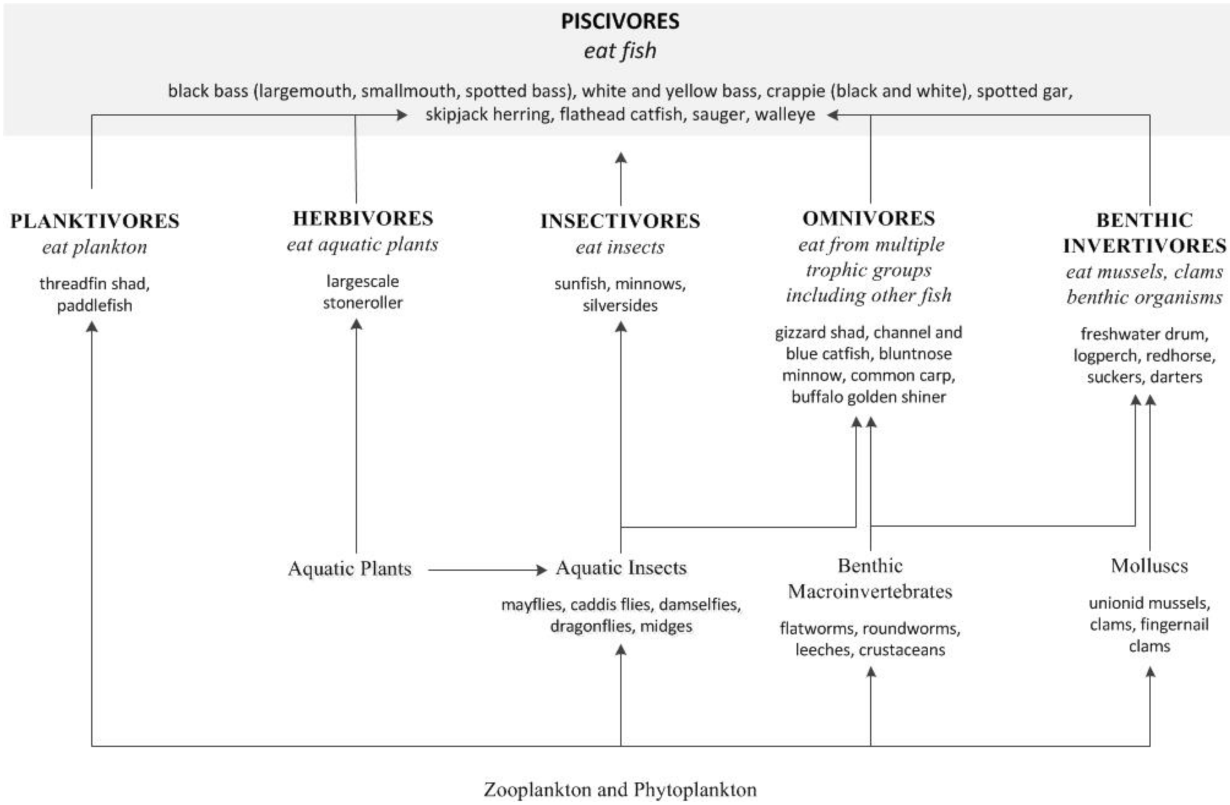
The characteristics of the reservoir at different locations (e.g., water velocity, water depth and temperature, substrate, aquatic vegetation) determine, to a large degree, the types of and relationships among the organisms in these locations. Reservoirs on the Tennessee River main stem are divided into three functional zones based on hydrology and limnology characteristics: riverine, transitional, and lacustrine (White et al. 2005). The riverine zone in Chickamauga Reservoir is located at the inflow of Watts Bar Dam, upstream of the SQN site. This zone has characteristics similar to those of a river, although the flows are variable depending on releases from upstream dams. The riverine zone tends to have higher turbidity, swifter water velocities, and sand and gravel river bottoms. The transitional zone in Chickamauga Reservoir is located midreservoir, and has slower water velocity, and bottom substrates that are mixed sand, gravel, and organic deposits. The lacustrine zone, also called the forebay, is a lake-like area where water amasses behind a downstream dam (Chickamauga Dam). The bottom substrate of lacustrine zones in the Chickamauga Reservoir is commonly composed of clay deposits with low organic content.

The SQN site is located where the Chickamauga Reservoir changes from a transitional zone to a lacustrine zone. TVA (Simmons 2011) characterized substrates in the sampling areas upstream and downstream of the site in the autumn of 2009. The three most dominant substrate types upstream of the site (centered at Tennessee RM 490.5) were silt (51.2 percent), mollusk shell (18.4 percent), and bedrock (8.8 percent). The downstream sites (centered at Tennessee RM 482.0) were composed of mollusk shells (27.6 percent), silt (19.9 percent), and clay (16.4 percent). However, TVA (Simmons 2011) reported that the overall average water depths at the sampling sites upstream and downstream of the SQN site were similar. Depths at the sampling locations ranged from 27 to 44.7 ft (8.2 to 13.6 m) at the downstream transects and 26.1 to 34.9 ft (8.0 to 10.6 m) at the upstream transect. Actual depths in the river at these locations range from 7.4 to 78.5 ft (2.3 to 23.9 m) at the downstream transect and 6.4 to 55.2 ft (2.0 to 16.8 m) at the upstream transect (Simmons 2011). Most TVA impoundments suffer depletion of dissolved oxygen and have characteristics similar to eutrophic lakes, which renders the environment inhospitable to many species, including many freshwater mussels. In summer and autumn of 2011, dissolved oxygen readings tended to be higher at the downstream sampling location than at the upstream location (Simmons 2011), which would not be the case if the SQN effluent was depleting dissolved oxygen levels and encouraging eutrophication.

3.7.2.1 Habitat and Biological Communities

The following sections describe the habitat and aquatic organisms of Chickamauga Reservoir in the vicinity of the SQN site. Figure 3–8 depicts a typical food web for this location and illustrates the connectivity of aquatic resources.

Figure 3–8. Typical Food Web for the Chickamauga Reservoir (Showing Fish by Trophic Group)



Plankton

Plankton are small plants or animals that float, drift, or weakly swim in the water column of any body of water. There are two main categories of plankton: phytoplankton and zooplankton. Phytoplankton contain chlorophyll and require sunlight to live and grow. Zooplankton are small microscopic animals. In addition to other ecological services, phytoplankton and zooplankton form the basis of many aquatic food webs. Many types of zooplankton feed on phytoplankton and then become the primary source of food for other invertebrates and larval fish (White et al. 2005). As a result, plankton plays key ecosystem roles in the distribution, transfer, and recycling of nutrients and minerals.

In general, the density of plankton in Chickamauga Reservoir increases from upstream to downstream during normal water flows (TVA 1990). Tennessee main stem reservoirs have a spring diatom (a type of phytoplankton) peak in late March to early April. White et al. (2005) report that water velocity and turbidity are high in the upper part of each reservoir and, as a result, primary productivity (growth of phytoplankton) is low. Further downstream in the reservoir, water velocity and turbidity decrease and primary productivity may be high during the early spring if enough nitrogen and phosphorus are available for algae growth. By early summer, the nitrogen and phosphorus concentrations are usually too low to measure in the water column, and less algal growth occurs. By midsummer the dominant phytoplankton are green algae, diatoms, and cyanobacteria (White et al. 2005). Because very little primary or secondary production occurs in the bottom sediments, most of the fixed carbon (i.e., inorganic carbon that has been fixed by photosynthesis into organic compounds and typically is part of living organisms and detritus) likely moves through the dams or is metabolized in the water column.

Smaller zooplankton (including small planktonic crustaceans such as *Bosmina longirostris* and *Daphnia retrocurva*) quickly consume the spring diatom peak. In turn, these smaller zooplankton are consumed by other organisms including larger zooplanktonic crustaceans, such as copepods, or by mollusks, aquatic insects, and various larval fish.

Surveys of phytoplankton and zooplankton were conducted between 1980 and 1985 (Dycus 1986), in 1986, 1987, and 1988 with altered protocols (TVA 1989), in 1989 (TVA 1990), and, most recently, in 2011 (TVA 2012c). The 2011 study characterized phytoplankton in the vicinity of the SQN site and found that cyanophytes (formerly known as blue-green algae) were the numerically dominant taxa in the summer, comprising 96 to 99 percent of the 67 phytoplankton species identified. Diatoms (bacillariophytes) were the numerically dominant taxa in autumn and the group with the greatest biovolume in both summer and autumn (TVA 2012c). Cryptophytes (mostly genus *Cryptomonas*) were the next dominant phytoplankton taxa in autumn. The 2011 study identified 35 zooplankton taxa, of which cladocerans, copepods, and rotifers were the dominant groups (TVA 2012c).

The TVA surveys conducted in the 1980s noted reduced phytoplankton cell densities (but not changes in the composition of the plankton community) in samples taken downstream of the diffuser at Tennessee RM 483.4. These reductions occurred during times when the plant entrained at least 10 percent of the river flow and had a buoyant heated discharge (Dycus 1986; TVA 1989). TVA (1989) suggested that this reduction was likely due to the withdrawal and subsequent discharge of water drawn from below the skimmer wall. This water has lower phytoplankton cell densities, which are lowered further due to passage through the plant. The discharge water has reduced cell densities where it is reintroduced into the reservoir.

These observations were supported in the 2011 study (TVA 2012c), which showed a reduction in phytoplankton density in the vicinity of the discharge structure (Tennessee RM 483.4) but no changes in community composition. The study also showed that just over 2 mi (3 km) downstream from the diffuser, at Tennessee RM 481.1, the levels increased to be similar to those found at the upstream sampling location (Tennessee RM 490.5). Reductions in zooplankton have also been observed. These reductions are, in part, due to passage through the SQN cooling system (which is harder on the softer-bodied zooplankton than it is on the phytoplankton, such as diatoms). TVA (2012c) postulates that the reduction in zooplankton and phytoplankton at the site is partially due to the complex hydrology of the area caused by the original channel morphology and complicated by the addition of the dam across the main river channel.

<u>Aquatic Macrophytes</u>

Aquatic macrophytes include vascular aquatic plants (i.e., plants with true stems, roots, and leaves), mosses, and some large algae. Tennessee Wildlife Resources Agency (TWRA 2008) reports that introduced or nonnative species of aquatic macrophytes make up the most abundant aquatic plant species in the Tennessee River, which include exotic or nonnative species such as Eurasian water milfoil, spiny leaf naiad, and hydrilla. In addition, alligatorweed (*Alternanthera philoxeroides*), a vascular plant that roots in bottom sediments, and Asian spiderwort (*Murdannia keisak*) have been found in Chickamauga Reservoir (TWRA 2008).

Aquatic plants provide benefits (e.g., food and cover) for waterfowl, fish, and smaller organisms and reduce wave action, filter sediments suspended in the water, add oxygen to the water, and help protect shorelines from erosion. TVA (Scott 1993) monitored the population trends of fish and aquatic macrophytes in Chickamauga Reservoir and observed temporal changes in fish populations, including an increase in abundance of certain species. Fish species positively affected by increased vegetation include midwater species that feed on insects (e.g., bluegill (*Lepomis macrochirus*), brook silverside (*Labidesthes sicculus*), yellow bass (*Morone mississippiensis*), black crappie (*Pomoxis nigromaculatus*), warmouth (*Lepomis gulosus*), golden shiner (*Notemigonus crysoleucas*), and yellow perch). Fish species that feed in the shallow, silted overbank areas decline in abundance as the vegetation in these areas increases. These species include freshwater drum (*Aplodinotus grunniens*), channel catfish (*Ictalurus punctatus*), smallmouth buffalo (*Ictiobus bubalus*), spotted sucker (*Minytrema melanops*), and carp (Scott 1993). Scott observes that the responses of the fish populations to changes in aquatic vegetation are more complex than simple correlations, however, and that the fish communities have been destabilized due to highly variable water conditions such as rate of spring warming, discharges, turbidity, and water level fluctuations that affect not only aquatic macrophytes but also planktonic food webs, fish spawning times and success, and interspecific competition among early life stages of fish species.

TVA (2013n) reported that rooted aquatic macrophytes were not abundant near the SQN site until Eurasian water milfoil was established in Chickamauga Reservoir. Eurasian water milfoil was introduced into Watts Bar Reservoir (upstream of Chickamauga Reservoir) around 1953 and expanded into Chickamauga Reservoir in 1961. Spiny leaf naiad became the most common submerged aquatic macrophyte during the 1980s (TVA 2013n). Aquatic macrophyte coverage in Chickamauga Reservoir was less than 100 hectares (ha) (247 ac) between 1970 and 1975 and increased to nearly 2,800 ha (6,920 ac) between 1982 and 1988 (Scott 1993; TVA 2013n). The coverage of spiny leaf naiad in the reservoir correlates negatively with water flow levels, and increased in several drought years occurring during the 1982 to 1988 period (Scott 1993; TVA 2013n; TWRA 2008). Increased water flows caused a decrease in vegetation to 155 ha (383 ac) by 1992 (TVA 2013n), but vegetation increased again to 1,400 ac (567 ha) by 2007 (TVA 2007). TVA (2007) reports the dominant aquatic plant on Chickamauga Reservoir was the spiny leaf naiad, a species that grows in shallow water areas of the reservoir (e.g., embayments, sloughs, and overbank areas).

TVA (Simmons 2011) conducted the initial and most recently published survey of aquatic macrophyte coverage in the vicinity of the SQN site in autumn 2009 during a shoreline habitat study. TVA assessed the percentage of aquatic macrophytes in the shallow areas along both shorelines of eight line-of-sight transects across the Chickamauga Reservoir. The transects were sited between Tennessee RM 481.1 and 483.6, downstream of the SQN site, and from Tennessee RM 487.9 to 491.1, upstream of the SQN site. No aquatic macrophytes were observed in the upstream sampling area (Tennessee RM 487.9 to 491.1). At the downstream sampling areas (Tennessee RM 481.1 to 483.6), slightly fewer than half of the locations had aquatic macrophytes. The average percentage of macrophytes was 2 percent along the left descending bank and 5 percent along the right descending bank (TVA 2012c).

TVA plans to continue sampling habitats in the vicinity of the SQN site every 3 years in autumn unless there are significant changes to the river system as based on the initial characterization (in 2009), in which case the sampling would occur the next autumn (TVA 2012c).

Macroinvertebrates

Invertebrates are animals that do not have a true backbone. Macroinvertebrates are typically invertebrates large enough to see with the human eye and include animals such as flatworms; roundworms; leeches; crustaceans; aquatic life stages of insects; and mollusks such as snails, clams, and mussels. Macroinvertebrates perform a variety of ecosystem services and are an important food source for other aquatic organisms, including some fish. Their distribution depends partly on their habitat (e.g., substrate type, amount of cover, food availability, dissolved oxygen levels, flow patterns, and water temperature). The term “benthic macroinvertebrates” refers to macroinvertebrates that live all or part of their life near, on, or in the bottom of streams or reservoirs. Researchers use studies of benthic macroinvertebrate abundance and distribution to detect major environmental changes because these animals do not migrate rapidly and, in general, do not make major changes in location.

White et al. (2005) find that transitional zones of the main stem Tennessee reservoirs have greater diversity and density of benthic invertebrates than riverine or lacustrine zones. The transition zone is dominated by worms that feed on subsurface deposits. The primary insects in the transition zones are the larvae of mayflies, caddisflies, and chironomids (midges). The lacustrine zone has less organic matter, as discussed previously, and the tubificid worms are the primary feeders on sediment deposits and filters. Mayfly and chironomid larvae are the most common insects. Filter-feeding mollusks (e.g., fingernail clams (family Sphaeriidae), Asiatic clams (family Corbiculidae), and some unionid mussels (native freshwater mussels)) are found in the lacustrine zone, although unionid mussels are found in much greater densities in the riverine zone.

TVA performed studies of macroinvertebrates before the start of operations at SQN, Units 1 and 2 (i.e., from 1971 to 1978), and following the start of operations (i.e., from 1980 to 1985) (Dycus 1986). Studies were conducted at an upstream control site at Tennessee RM 490.5 (midchannel) and at three downstream sites, Tennessee RM 483.4 (right descending channel margin), Tennessee RM 482.6 (left descending channel margin), and Tennessee RM 478.2 (midchannel). TVA (Dycus 1986) reports that results of the studies between 1971 and 1985 show no evidence of decline in the community and that spatial and temporal differences are associated with factors other than the operation of SQN. At one location, a macroinvertebrate community appeared to be stressed, although TVA attributed that stress to habitat limitations. Because no changes were observed in the macroinvertebrate community, TVA decided not to continue the studies after the early 1985 sampling season.

In 1999, TVA reinitiated surveys of benthic macroinvertebrates as part of its annual monitoring program to verify that balanced indigenous populations were being maintained at TVA’s thermal plants with alternative thermal limits (TVA 2013n). Sample locations for benthic macroinvertebrates are located upstream (Tennessee RM 490.5) and downstream (Tennessee RM 482.0). Table 3–9 provides a comparison of the data from the two sampling locations during the four most recent sampling years, 2008 to 2011 (Shaffer et al. 2010; Simmons 2011; Simmons and Baxter 2009; TVA 2012c). From 2008 to 2011, the density of organisms is higher at the upstream locations, and this difference appears to be largely driven by the high upstream density of Chironomidae (midges) as densities of most other taxa are higher at the downstream sampling location. According to TVA (2013n), lower densities and numbers of macroinvertebrates were found in sampling near the SQN site than were found in other sampling locations in Chickamauga Reservoir.

Mollusks, a subset of macroinvertebrates, include snails, freshwater clams, and mussels. The Tennessee River is home to both introduced and native mussel and clam species. Approximately 130 of nearly 300 species of freshwater mussels in the United States live, or are known to have lived, in waters within Tennessee (Parmalee and Bogan 1998). Stressors such as farming, strip mining, industry, hydropower dam construction, and commercial exploitation have greatly reduced species distributions and abundances (Parmalee and Bogan 1998).

Table 3–9. Average Mean Density Per Square Meter of Benthic Taxa Collected at Downstream and Upstream Sites Near SQN

Taxa	Downstream				Upstream			
	2008	2009	2010	2011	2008	2009	2010	2011
	TRM 482.0	TRM 482.0	TRM 482.0	TRM 481.3	TRM 490.5	TRM 490.5	TRM 490.5	TRM 490.5
Turbellaria								
Planariidae (flatworms)	5	0	0	4	0	0	0	0
Annelida								
Oligochaeta (segmented worms)	133	15	30	150	93	18	8	154
Hirudinea (leeches)	35	0	10	27	3	7	2	3
Crustacea								
Amphipoda	57	0	0	3	12	0	0	0
Insecta								
Ephemeroptera (mayflies)	15	39	33	26	2	23	25	11
Trichoptera (caddisflies)	15	0	0	10	0	0	0	5
Diptera Chironomidae (midges)	238	164	125	264	352	285	505	348
Gastropoda (snails)	17	13	7	0	3	5	5	5
Bivalvia (mussels and clams)								
Unionidae (mussels)	2	2	0	0	0	0	0	2
Corbiculidae (≤10 mm (0.4 in.))	48	40	17	[a]38	2	5	50	[a]67
Corbiculidae (>10 mm (0.4 in.))	13	11	18		0	12	2	
Sphaeriidae (fingernail clams)	8	26	13	74	20	27	85	168
Dreissenidae (zebra mussels)	8	9	0	0	0	3	0	0
Density of total organisms	594	319	253	558	487	385	682	696
Total area sampled (m^2 (11 ft^2))	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6

[a] TVA 2012c did not designate sizes of *Corbicula fluminea*

TRM = Tennessee River Mile

Sources: Shaffer et al. 2010; Simmons 2011; Simmons and Baxter 2009; TVA 2012c

Mussels spend their entire juvenile and adult lives buried, either partially or completely, in the substrate. Although mussels are able to change their position and location, they rarely move more than a few hundred yards during their lifetime unless dislodged. Individuals from some species of freshwater mussels live for more than 100 years (Parmalee and Bogan 1998). Freshwater mussels filter organic particles and microorganisms (e.g., protozoans, diatoms, and bacteria) from the water. Native freshwater mussels have a unique reproductive cycle. Males release sperm into the water, where they are carried into the female mussel's body via tubes in the gills, where they fertilize the eggs. The fertilized eggs develop into small larvae, called glochidia, that release into the water. If the glochidia do not encounter a passing fish and attach to its gills or body, they fall to the bottom and die a short time later. The glochidia that attach to a fish's gills remain on that fish for 1 to 6 weeks before falling off and beginning their growth into adulthood. Each mussel species has particular species of fish that serve as hosts for the glochidia (Parmalee and Bogan 1998). The survival of freshwater mussel species depends not only on the environmental conditions for the mussel, but on the survival and health of the host fish populations.

The numbers of native mussels have been declining since the early 1940s when TVA filled the Chickamauga and Watts Bar reservoirs. Parmalee et al. (1982) studied aboriginal shell middens in the Chickamauga Reservoir (Tennessee RM 495 to 528). The five most abundant species during the Middle Woodland (A.D. 1) to Late Woodland Mississippian times (approximately A.D. 600 to 1600) included the currently endangered dromedary pearly mussel (*Dromus dromas*), spike mussel (*Elliptio dilatatus*), mucket (*Actiononaias ligamentina*), elephant-ear (*E. crassidens*), and rough pigtoe (*Pleurobema plenum*). Together these species composed about 66 percent of the community surveys at 16 prehistoric aboriginal sites along the Chickamauga Reservoir. Watters (2000) points to impoundments, dredging, snagging, and channelization as having long-term detrimental effects on freshwater mussels. The impoundments result in silt accumulation, loss of shallow water habitat, stagnation, accumulation of pollutants, and nutrient-poor water.

As a result of the loss of diversity in mussel species, the State of Tennessee created a freshwater mussel sanctuary in the riverine zone of Chickamauga Reservoir immediately below Watts Bar Dam. The mussel sanctuary extends 16 km (10 mi) from Tennessee RM 520.0 to Tennessee RM 529.9 (NRC 2013a). Mussel harvesting is illegal in this area.

TVA observed unionid mussels and snails in the annual monitoring surveys in the vicinity of the SQN site (Table 3–10). Two unionid mussels were identified in 2008 and 2009 at the sampling location downstream of the site at Tennessee RM 482 (Simmons and Baxter 2009), and two unionid mussels were identified at the upstream survey location in 2011 (TVA 2012c). Aquatic snails are routinely found in the annual monitoring survey as shown in Table 3–10. Invasive mussels were also identified including the Asiatic clam and zebra mussel (*Dreissena polymorpha*) but their numbers not quantified.

Additional field surveys were conducted between June 28 and July 9, 2010, to document the number and diversity of the unionid mussels and snails, along with their habitat conditions in the vicinity of SQN in areas that could be affected by plant operations and in areas beyond those affected areas (Third Rock 2010a, 2010b). Reconnaissance dives (timed searches) were made in specific areas within 1 to 2 mi (1.6 to 3.2 km) of the plant. The dives identified eight survey sites. At each site, four 100-m (328-ft) long sampling transects were set up perpendicular to the bank. Densities of both mussels and snails were reported to be low throughout the survey area. Sampling resulted in the identification of 280 mussels from 11 species. The most abundant were the threehorn wartyback mussel (*Obliquaria reflexa*), which comprised almost 69 percent of the individuals observed; the pink heelsplitter (*Potamilus alatus*) with 13 percent; and the pimpleback (*Quadrula pustulosa*) with 7 percent. Invasive, nonnative zebra mussel numbers were not recorded, although the authors indicate that zebra mussels "were prevalent and attached to the majority of the live mussels recorded in the survey." Of the 280 unionid mussels observed, approximately half (136) were infested with zebra mussels that covered between 5 and 15 percent of the surface area of the live unionid mussels, and, in some cases, zebra mussels covered 50 percent of the surface area of a given unionid mussel.

Four species of snails, consisting of 281 individuals, were identified during the survey. The most abundant was the olive mysterysnail, which comprised 49 percent; the sharp hornsnail with 42 percent; the silty hornsnail with 5 percent; and the pointed campeloma with 4 percent (Third Rock 2010b).

Table 3–10. Results of the Native Mussel and Snail Survey Near the SQN Site in 2010

Taxonomic Class and Scientific Name	Common Name	Number of Individuals	Percent of Total
Mussels			
Obliquaria reflexa	threehorn wartyback	192	69
Potamilus alatus	pink heelsplitter	35	13
Quadrula pustulosa	pimpleback	19	7
Pyganodon grandis	giant floater	13	5
Anodonta suborbiculata	flat floater	9	3
Megalonaias nervosa	washboard	4	1
Leptodea fragilis	fragile papershell	5	2
Amblema plicata	threeridge	1	<1
Truncilla truncate	deertoe	1	<1
Elliptio crassidens	elephant-ear	1	<1
Snails			
Vivaparus subpurpureus	olive mysterysnail	137	49
Pleurocera acuta	sharp hornsnail	119	42
Pleurocera canaliculata	silty hornsnail	14	5
Campeloma decisum	pointed campeloma	11	4

Source: Third Rock 2010b

Densities of both snails and mussels were generally low with mean densities in quantitative samples ranging from zero to 0.7 mussels per square meter and 0.008 to 1 snail per square meter. Densities were higher at sites 5 (immediately above discharge), 6 (in the mixing zone), and 7 (downstream of the mixing zone) than they were further upstream or further downstream of the discharge. This may have been influenced by the substrate in the vicinity of the sampling transects. The substrate at site 5, where the greatest number of mussels were observed, was predominately a mix of sand/cobble/gravel substrates. The remaining locations had substrates of silt over either clay or sand or silt over a combination of clay and sand (Third Rock 2010b).

Fish

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

Fish populations in the Chickamauga Reservoir near the SQN site have been sampled fairly consistently over the past 50 years. Considerable data are available on fish abundance and diversity in the vicinity of the SQN site. Rotenone studies were initiated in various coves in Chickamauga Reservoir in 1947 and continued throughout the reservoir through 1959 (excluding 1948 and 1953) and then began again in 1970 and continued through 1993, at which time they were conducted biennially until 1999. Rotenone is a toxic chemical that kills fish and allows for the collection and identification of fish when added to water in a cove or other limited area. It is detoxified with the release of another chemical. Rotenone sampling sites were located approximately 10 mi (16.1 km) upstream or 6 mi (9.7 km) downstream of the SQN site (Baxter 2000). Although the purpose of the rotenone sampling was to understand the density of forage, sport, and commercially valued fish species, it also provided a characterization of the fish community and occurrence data for fish in the reservoir. However, rotenone sampling is known to underestimate the number of certain species such as common carp (*Cyprinus carpio*), smallmouth buffalo, flathead catfish (*Pylodictis olivaris*), white crappie (*Pomoxis annularis*), and sauger (*Sander canadensis*) (Baxter 2000; Wilson and Sawyer 1994).

The rotenone sampling study results were used to identify trends in fish populations. For example, threadfin shad populations showed dramatic declines in 1978, 1979, 1982, 1984, and 1989 (Baxter 2000). Threadfin shad are susceptible to extensive winter kills (Etnier and Starnes 1993; Loar et al. 1978), and estimates of numbers killed in Chickamauga Reservoir, as in other reservoirs and lakes, vary dramatically depending on winter water temperatures. Baxter (2000) attributed the increased population estimates for centrarchids such as warmouth, redear sunfish (*Lepomis microlophus*), bluegill, and largemouth bass (*Micropterus salmoides*) to the large increase in aquatic macrophytes between 1980 and 1988. In particular, warmouth and bluegill are known to find habitat and protection in areas of vegetative and sometimes dense cover (e.g., debris or weedbeds) (Etnier and Starnes 1993). Other species, however, such as the freshwater drum, may be displaced to areas not inhabited by macrophytes (Baxter 2000; Wilson and Sawyer 1994).

In 1986, data obtained by the rotenone studies and TWRA creel surveys of Chickamauga Reservoir caused concern from TWRA and the Tennessee Division of Water Pollution Control regarding the possible declining populations of specific fish species in Chickamauga Reservoir. The species, including sauger, white crappie, white bass (*Morone chrysops*), and channel catfish, were the subjects of additional analyses and studies conducted by TVA in following years (Buchanan 1994; Buchanan and McDonough 1990; Hevel and Hickman 1991; Hickman and Buchanan 1995; Peck and Buchanan 1991), and each species is discussed later in this section.

In 1942, TVA sampled using rotenone and gillnets. Gillnets were also used during preoperational monitoring between 1971 and 1978 in the vicinity of the SQN site. TVA sampled quarterly using gillnets and trap nets at locations upstream (Tennessee RM 495), below Tennessee RM 473, and adjacent to the site (Tennessee RM 483.6) (Dycus 1986; Simmons 2010a). TVA conducted additional monitoring after the start of SQN operations (from 1980 to 1985) using standard gillnets at approximately the same locations (Dycus 1986; Simmons 2010a). TVA used experimental gillnets, which are composed of panels with varying mesh sizes to capture a variety of species, during a study in 1986 between Tennessee RM 482.7 and Tennessee RM 487.6 (Simmons 2010a).

TVA began evaluating the ecological health of fish communities in the reservoir using the Reservoir Fish Assemblage Index methodology in 1993 (TVA 2012c). This annual survey uses gillnets and electrofishing from boats and is conducted primarily at monitoring stations located at the inflow (Tennessee RM 529), upper end (Tennessee RM 518 and 527.4), transition zone, (Tennessee RM 490.5), and forebay zone (Tennessee RM 472.3) of the reservoir and in the embayment of the Hiwassee River (Hiwassee RM 8.5). In 1990, TVA added an additional sampling site at Tennessee RM 482.0, just downstream of the SQN site, to assess the effects of site discharge on fish (TVA 2013n).

Table 3–11 is a list of species by family that were identified during the sampling studies that ran from 1999 to 2011. Fifty-three species from 13 families are present in the vicinity of the SQN site. Tables 3–12 (electrofishing) and 3–13 (gillnetting) provide the percentage of the catch composed of each of the most dominant species at each sampling location (upstream of the site at Tennessee RM 490.5 or downstream of the site at Tennessee RM 482) during the most recent 10 years of sampling (2002 to 2011). As expected, variations exist between electrofishing and gillnetting results, as smaller fish escape gillnets. Bluegill was the numerically dominant species caught during electrofishing at both upstream and downstream sample sites for the past 11 years (TVA 2013n), followed by the gizzard shad (*Dorosoma cepedianum*) (Table 3–12). Other numerically dominant species include the redbreast sunfish, redear sunfish, spotted bass, and largemouth bass. Results from gillnet samples indicated the gizzard shad was the numerically dominant species at both upstream and downstream sample sites. Other numerically dominant species include the yellow bass, blue catfish, spotted bass, redear sunfish, black crappie, skipjack herring, channel catfish, redear sunfish, and drum (Table 3–13).

Table 3–11. Species Identified During Sampling Studies in the Vicinity of the SQN Site From 1999 to 2011

Family	Scientific Name	Common Name
Acipenseridae	*Acipenser fulvescens*	lake sturgeon
Atherinopsidae	*Labidesthes sicculus*	brook silverside
	Menidia audens	Mississippi silverside
	Menidia beryllina	inland silverside
Catostomidae	*Hypentelium nigricans*	northern hog sucker
	Ictiobus bubalus	smallmouth buffalo
	Ictiobus niger	black buffalo
	Minytrema melanops	spotted sucker
	Moxostoma duquesnei	black redhorse
	Moxostoma erythrurum	golden redhorse
Centrarchidae	*Ambloplites rupestris*	rock bass
	hybrid Lepomis spp.	hybrid sunfish
	hybrid Micropterus sp.	hybrid bass
	Lepomis auritus	redbreast sunfish
	Lepomis cyanellus	green sunfish
	Lepomis gulosus	warmouth
	Lepomis macrochirus	bluegill
	Lepomis megalotis	longear sunfish
	Lepomis microlophus	redear sunfish
	Micropterus dolomieu	smallmouth bass
	Micropterus punctulatus	spotted bass
	Micropterus salmoides	largemouth bass
	Pomoxis annularis	white crappie
	Pomoxis nigromaculatus	black crappie

Family	Scientific Name	Common Name
Clupeidae	*Alosa chrysochloris*	skipjack herring
	Dorosoma cepedianum	gizzard shad
	Dorosoma petenense	threadfin shad
	hybrid Dorosoma sp.	hybrid shad
Cyprinidae	*Campostoma oligolepis*	largescale stoneroller
	Cyprinella spiloptera	spotfin shiner
	Cyprinella whipplei	steelcolor shiner
	Cyprinus carpio	common carp
	Gambusia affinis	western mosquitofish
	Notemigonus crysoleucas	golden shiner
	Notropis atherinoides	emerald shiner
	Pimephales notatus	bluntnose minnow
	Pimephales vigilax	bullhead minnow
Hiodontidae	*Hiodon tergisus*	mooneye
Ictaluridae	*Ictalurus furcatus*	blue catfish
	Ictalurus punctatus	channel catfish
	Pylodictis olivaris	flathead catfish
Lepisosteidae	*Lepisosteus oculatus*	spotted gar
	Lepisosteus osseus	longnose gar
Moronidae	*hybrid Morone (chrysops × sax.)*	hybrid striped × white bass
	Morone chrysops	white bass
	Morone mississippiensis	yellow bass
	Morone saxatilis	striped bass
Percidae	*Perca flavescens*	yellow perch
	Percina caprodes	logperch
	Sander canadensis	sauger
	Sander vitreum	walleye
Petromyzontidae	*Ichthyomyzon castaneus*	chestnut lamprey
Sciaenidae	*Aplodinotus grunniens*	freshwater drum

Sources: Shaffer et al. 2010; Simmons 2011; TVA 2012c

Another way to view the differences between the upstream and the downstream sites is to examine the percentages of fish in each location based on their trophic groups (see Table 3–14) for the trophic groups and the fish species in each group). In 2011, insectivores and omnivores dominated the fishery ecosystem both upstream and downstream of the SQN site in both summer and autumn (TVA 2012c, Table 3.7). In general, upstream and downstream locations exhibited fairly similar proportions of fish in each trophic level, regardless of season, with the exception of planktivores, which were significantly more abundant in downriver locations in autumn. The planktivore trophic group includes threadfin shad, which are schooling fish with patchy distribution, and the random capture of a school can strongly influence abundance estimates.

Table 3–12. Percent Composition of the Dominant Species Caught Upstream (Tennessee RM 490.5) and Downstream of the SQN Site (Tennessee RM 482) by Electrofishing, 2002 Through 2011

Species [a]	2002		2003		2004		2005		2006		2007		2008		2009		2010		2011	
	up	down	up	down	up	down	up	down	up	down	up	down	up	down	up	down	up	down	up	down
brook silverside	1.2	1.9	1.6	2.0	1.8	1.1	0.80	1	0	0	0	0	3.9	0	1.0	0.43	0	0.21	0	0
Mississippi silverside	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.8	35
inland silverside	0	0	0	0	1.4	0	0.64	0.23	0.81	4.2	0.36	0.36	0	1.9	3.6	4.5	32	46	0	0
redbreast sunfish	3.5	4.3	9.4	4.2	5.8	6.1	10	17	8.8	7.7	11	12	1.9	7.8	3.9	3.6	0.91	0.36	4.7	0.92
bluegill	32	31	31	25	30	30	39	25	23	34	28	36	54	58	40	51	35	20	43	12
longear sunfish	1.2	1.4	4.4	4.2	1.8	0.77	1.9	1.4	2.0	1.2	1.6	1.6	0.08	1.6	1.5	0.21	0.96	0.50	0	0.08
redear sunfish	6.3	8.6	7.3	14	10	8.3	5.1	9.2	5.7	12	5.3	7.1	3.2	7.2	5.1	8.5	3.3	3.3	3.5	1.3
spotted bass	5.4	6.0	3.4	6.1	6.6	3.2	3.5	3.4	3.3	3.3	2.3	1.6	1.1	1.7	1.9	2.8	1.0	0.57	1.4	0.42
largemouth bass	5.0	5.5	2.4	3.2	5.4	4.5	5.6	2.3	0.54	2.5	2.1	3.6	1.6	1.8	5.0	6.2	0.57	2.4	1.7	1.6
smallmouth bass	2.6	1.4	1.9	0.29	2.4	0.55	3.8	0.11	2.3	0.0	0.61	0.18	0.62	0.17	0.62	1.2	0.24	0.036	0.87	0.040
black crappie	1.5	0.52	3.1	0.58	3.1	0.55	0.48	0.68	1.6	0.22	0.24	0.18	0.62	0.25	4.1	2.6	0.91	1.1	1.4	1.9
gizzard shad	14	29	14	18	12	16	19	23	35	21	30	19	28	9.0	15	11	17	16	31	26
threadfin shad	12	0	2.7	0	0.68	1.8	1.1	3.0	7.9	0.55	0.12	0.36	0.23	1.8	9.0	0.32	0.05	0	1.2	17
common carp	0.62	0.52	0.97	0.29	0.54	0.88	0.16	0.23	0	0	0.49	0	0	0.17	0.31	0.32	0.10	0.21	0.05	0.27
spotfin shiner	0.62	0	3.1	2.9	0.27	0.11	0.16	0	0.81	4.2	1.1	3.6	0.46	1.7	2.6	1.6	0.29	0.50	0.22	0.46
emerald shiner	4.8	3.3	2.4	14	8.4	20	3.3	8.1	3.1	2.8	4.4	7.1	0.23	0.33	0.18	0	0	0	0	0
golden shiner	1.4	0.17	4.0	0.87	0.81	0.33	0.16	1.8	1.2	0.44	3.0	0	1.1	0.92	1.2	0.75	0.24	0.57	0.22	0.34
bluntnose minnow	0	0	1.9	0	0.68	0.33	0.32	0.11	0.14	3.3	0.36	0.18	0	1.2	1.1	0.85	0.24	1.6	0.11	0.54
channel catfish	1.5	2.2	0.32	0.87	1.4	1.6	0	0.68	0.54	0.33	0.12	2.1	0.23	1.5	0.84	1.3	0.14	0.57	0.65	0.19
logperch	0.09	0.34	0.65	1.3	0.41	0.11	0.48	0.68	0.54	1.6	0.85	0	0.31	0.33	0.04	0	4.6	2.2	0.05	0
freshwater drum	0.62	0.34	0.81	0.73	2.6	1.4	0.32	0.34	0.41	0.22	1.1	0	0.15	0.50	0.70	0.64	0.19	0.43	0.76	0.27
other species	5.4	3.8	4.8	1.6	4.6	1.8	3.0	1.6	1.8	1.1	7.2	4.1	2.7	1.9	2.2	2.2	2.3	2.6	2.4	1.7

Columns may not add to 100 due to rounding.
[a]Species are ordered alphabetically by family name (not shown) and then by scientific name (not shown).

Sources: Shaffer et al. 2010; Simmons 2011; TVA 2012c

Table 3–13. Percent Composition of the Dominant Species Caught Upstream (Tennessee RM 490.5) and Downstream of the SQN Site (Tennessee RM 482) by Gillnetting, 2002 Through 2011

Species[a]	2002		2003		2004		2005		2006		2007		2008		2009		2010		2011	
	up	down	up	down	up	down	up	down	up	down	up	down	up	down	up	down	up	down	up	down
spotted sucker	0	3.7	1.2	3.4	1.1	0.63	1.6	0.47	0.40	0.70	0.93	0	0	0.52	0.65	0	0.96	1.8	2.9	0.82
bluegill	0	0	0	2.7	1.1	3.1	4.0	0.94	3.2	3.5	0.93	3.5	0	0	1.3	4.3	0.96	0.92	0.72	0.82
longear sunfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0
redear sunfish	4.5	2.5	19	11	10	5.0	6.3	4.2	15	4.9	3.7	1.3	7.2	0	21	8.6	6.2	3.7	11	0.82
largemouth bass	0	0	1.2	1.4	0	2.5	0	0.94	1.6	0.70	2.8	0.88	2.8	2.1	1.9	3.6	0.96	0.4	0	0.82
smallmouth bass	1.5	2.5	0	8.1	0	0	0	0	0.40	0	0	0.44	0	0	0	0.71	0	0.92	0	0.82
spotted bass	16	42	2.8	5.4	9.6	11	14	9.9	4.0	6.3	2.2	5.3	1.1	23	10	12	0.96	5.1	6.5	4.1
black crappie	6.1	1.2	3.2	0.68	5.3	2.5	3.2	0.94	7.2	9.2	17	9.2	12	10	5.2	7.9	6.7	2.8	12	7.4
skipjack herring	11	3.7	8.4	4.7	15	9.4	5.6	8.0	12	15	10	7.9	0	0	0	0	2.9	0.92	8.6	1.6
gizzard shad	9.1	3.7	28	20	21	30	19	41	25	23	24	32	44	38	25	25	39	52	40	63
golden shiner	0	0	0	0.68	0.53	9.4	0	0	0	1.4	0.62	0.44	0	0	0.65	4.3	5.3	0.46	0.72	0
blue catfish	0	2.5	10	8.1	8.0	5.0	13	11	0.40	11	2.2	14	3.9	6.3	1.9	14	3.3	8	5.8	10
channel catfish	2.3	11	5.6	10	3.7	4.4	4.8	6.1	1.6	9.9	0.62	3.5	1.1	2.6	3.2	7.9	0	1.8	5	3.3
flathead catfish	2.3	3.7	1.6	2.0	2.1	1.3	1.6	3.8	0	2.1	0.31	1.8	2.2	1.0	1.9	0	1.9	1.4	0.72	2.5
white bass	3.0	0	0	0	0	0	0	1.4	3.2	0	0.62	0	1.1	1.6	0.65	1.4	4.8	2.8	1.4	0.82
yellow bass	35	1.2	13	12	16	11	20	8.5	22	6.3	28	14	20	7.3	20	7.1	24	12	2.9	1.6
striped bass	1.5	3.7	0	0	0.53	0.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
sauger	3.0	7.4	0.40	1.4	1.1	0	0.79	0	0.40	0	0	0	0	0.52	3.2	0	0	0	0	0
freshwater drum	2.3	7.4	2.8	6.8	2.7	3.1	4.8	2.4	2.4	2.1	4.4	2.6	3.3	3.7	1.3	2.1	1.4	1.8	0	0.82
other species	2.3	3.7	2.0	2.0	2.1	1.3	0.8	0.5	0.8	4.9	1.6	3.5	0.6	2.6	1.4	1.4	0.5	1.8	1.7	0.8

Columns may not add to 100 due to rounding.
[a]Species are ordered alphabetically by family name (not shown) and then by scientific name (not shown).

Sources: Shaffer et al. 2010; Simmons 2011; TVA 2012c

Table 3–14. Percent of Fish in Each Trophic Group by Season and Location in 2011

Diet	Summer 2011 Percent		Autumn 2011 Percent	
	Upstream	Downstream	Upstream	Downstream
Benthic Invertivores	2.6	1.7	1.3	0.8
Herbivores	0	0	0.1	0
Insectivores	52	52	46	48
Omnivores	36	35	33	30
Piscivores	8.8	11	8.2	5.2
Planktivores	0.1	0.1	1.1	16

Source: Table 3 of TVA 2012c

Fish Egg and Larval Studies

Between 1981 and 1985, TVA (Dycus 1986) conducted studies as part of entrainment monitoring after the start of SQN operations. As part of this monitoring, samples of fish eggs and larvae were collected at transects near the diffuser (Tennessee RM 482.7), near the plant (Tennessee RM 484.8), at the skimmer wall, and in the intake channel. In addition, entrainment monitoring was conducted during a 12-week period from April through June 2004 (Baxter and Buchanan 2010).

During the sampling in 1985, 99.5 percent of all fish eggs collected were freshwater drum eggs. Eggs were first observed in mid-April (3 weeks earlier than in previous years) and were present through the season (i.e., until August 27). Peak density of 4,430 eggs per 1,000 m^3 was observed on June 17 at the transect closest to the diffuser (Dycus 1986). The majority of fish larvae collected in 1985 were clupeid (shad) larvae (61 percent in 1985 as compared to 79 percent in 1984 and 74 percent in 1983). *Lepomis,* or sunfish larvae, were next in abundance (17 percent), followed by freshwater drum (15 percent), and temperate bass larvae (*Morone*) (4 percent).

Average density of total fish larvae for the season was 2,169 per 1,000 m^3 of water at the plant and 2,108 per 1,000 m^3 of water at the diffuser transects. Densities were lower by a factor of 4 at the skimmer wall and intake. The peak seasonal density was 9,671 larvae per 1,000 m^3 of water at the plant transect on May 6. Freshwater drum dominated peak densities at the skimmer wall (82 percent) and in the intake basin (85 percent), while clupeid larvae dominated peak densities at the plant (86 percent) and diffuser transects (72 percent) (Dycus 1986).

Ichthyoplankton sampling in 2004 occurred from April 20 through July 12 (Baxter and Buchanan 2010). Results were similar to those from the 1980s; most were freshwater drum eggs (98.8 percent), and they were collected during all 12 sampling periods. Peak densities occurred on May 25 with 24,367 per 1,000 m^3 of water and June 2 with 1,594 per 1,000 m^3 of water. Average seasonal densities were slightly less in the intake channel (549 drum eggs per 1,000 m^3 of water) than those observed in the reservoir samples (652 drum eggs per 1,000 m^3 of water).

During sampling in 2004, the majority of fish larvae collected were clupeids (87.9 percent) followed by *Morone* spp. (white and yellow bass) at 5.5 percent, freshwater drum (3.2 percent), and centrarchids (3.1 percent). Average density for the season was 2,639 per 1,000 m^3 in the intake and 3,946 per 1,000 m^3 in the reservoir samples.

Commercially and Recreationally Important Fish Species

The continued operation of SQN may directly or indirectly affect commercially, recreationally, and biologically important species. TVA and TWRA allow commercial fishing on Chickamauga Reservoir.

The most recent report on commercial fishing indicates small numbers of paddlefish (*Polyodon spathula*) have been harvested in the Chickamauga Reservoir. Summaries of 2008 to 2012 commercial roe harvest from Chickamauga Reservoir are provided in Table 3–15. Table 3–16 summarizes nonroe harvest for 2008 through 2012. The majority of fish caught for commercial use include catfish (blue, channel, and flathead (*Ictalurus* spp. and *Pylodictis olivaris*)), buffalo (*Ictiobus* spp.), and carp (bighead, silver, and common (*Hypophthalmichthys* spp. and *Cyprinus carpio*)). Freshwater drum, gar (*Lepisosteus* sp.), and a small number of snapping turtles (*Chelydra serpentina*) were also taken (Black 2010).

Table 3–15. Commercial Harvest Rates for Paddlefish From Chickamauga Reservoir: 2008 to 2012

	Chickamauga Reservoir			
Paddlefish	**2008/2009**	**2009/2010**	**2010/2011**	**2011/2012**
Number	169	201	971	1,667
Roe (eggs) (lb)	99	54	1,384	4,725
Flesh (lb)	2,029	1,801	14,541	15,019

Sources: TVA 2013d, 2013e, 2013f

Chickamauga Reservoir is a popular location for recreational fishing. In 2011, Chickamauga Reservoir ranked first among lakes in the State of Tennessee in terms of angling effort (number of hours spent angling) and number of fish caught. In addition, Chickamauga Reservoir had the second highest number of fish caught per hour of any reservoir in Tennessee. Table 3–17 shows the number of fish caught recreationally during the last 5 years (Black 2008, 2009, 2010, 2011, 2012) based on the annual creel survey of the entire Chickamauga Reservoir by the State of Tennessee. Because the data are reported for the entire reservoir, some fish listed in Table 3–17 were not observed in the gillnet or electrofishing sampling results reported in Table 3–12 and Table 3–13. For each year from 2007 through 2011, the most frequently caught fish species was bluegill, followed by largemouth bass, blue catfish, black crappie, and yellow bass. Drum, striped bass, and black bass are frequently released. Crappie, yellow perch, and catfish are less likely to be released (Black 2008, 2009, 2010, 2011, 2012).

Table 3–16. Commercial Harvest Rates for Nonroe Fish and Turtles From Chickamauga Reservoir From 2008 to 2011

Species	Common Name	Chickamauga Reservoir Total Weight (lb) [a]			
		2008[a]	2009[a]	2010	2011
Alosa chrysochloris	shad (skipjack herring)	317	0	NR	NR
Aplodinotus grunniens	freshwater drum	6,674	7,456	4,276	445
Chelydra serpentina	snapping turtle	70	349	NR	NR
Cyprinus carpio	common carp	2,536	3,944	775	NR
Hypophthalmichthys molitrix and *H. nobilis*	silver or bighead carp	331	63	NR	NR
Ictalurus furcatus and *I. punctatus*	blue or channel catfish	147,104	244,035	95,414	37,639
Ictiobus bubalus	buffalo fish	14,641	5,525	12,002	160
Lepisosteus sp.	gar	67	881	25	NR
Morone mississippiensis	yellow bass	10	0	NR	NR
Multiple species	catfish	1,289	13,814	7,975	NR
Pylodictis olivaris	flathead catfish	2,806	9,132	2,226	NR

NR = not reported

[a] Black 2010; Ganus 2013

Table 3–17. Number of Fish Caught in Annual Creel Surveys of the Chickamauga Reservoir

Species	Common Name	Chickamauga				
		2007	2008	2009	2010	2011
Centrarchidae						
Lepomis gulosus	warmouth	1,192	609	42	6,150	4,804
Lepomis macrochirus	bluegill	573,417	490,803	332,956	370,552	375,262
Micropterus dolomieu	smallmouth bass	18,821	17,921	18,631	19,578	11,446
Micropterus punctulatus	spotted bass	72,874	69,585	48,309	63,156	34,147
Micropterus salmoides	largemouth bass	238,006	223,018	226,986	344,798	262,997
Pomoxis annularis	white crappie	54,654	31,070	20,934	63,400	57,561
Pomoxis nigromaculatus	black crappie	201,365	114,294	138,077	208,103	156,174
Pomoxis nigromaculatus	blacknose crappie	662	48	3,594	2,364	1,091
Others						
Alosa chrysochloris	skipjack herring	3,812	0	0	0	0
Alosa pseudoharengus	alewife	185	0	0	0	0
Cyprinus carpio	common carp	92	0	0	0	0
Notemigonus crysoleucas	golden shiner	196	1,340	0	0	730
Esox masquinongy × lucius	tiger muskie	100	0	0	0	0
Ictalurus furcatus	blue catfish	167,105	156,086	160,927	206,950	158,383
Ictalurus punctatus	channel catfish	54,917	67,755	38,180	56,770	17,565
Pylodictis olivaris	flathead catfish	10,751	11,100	5,596	5,686	7,833
Lepisosteus osseus	longnose gar	0	92	0	0	0
Hybrid striped bass × white bass	Cherokee bass	40	64	0	0	0
Morone chrysops	white bass	52,626	93,407	67,490	53,282	40,623
Morone mississippiensis	yellow bass	159,219	142,693	82,770	148,053	143,234
Morone saxatilis	striped bass	7,789	18,489	9,646	22,672	9,422
Aplodinotus grunniens	freshwater drum	36,095	65,696	24,906	33,219	40,718
Perca flavescens	yellow perch	0	0	105	0	1,228
Sander canadensis	sauger	1,666	22,784	22,806	11,533	5,996
Polyodon spathula	paddlefish	137	0	0	166	123

Sources: Black 2008, 2009, 2010, 2011, 2012

Biologically Important Fish Species

This section describes biologically important species, their relationship to the aquatic habitat near the SQN site, and their interactions with each other. Discussion includes species that are numerically dominant, thermally sensitive, use the area as spawning or nursery grounds, migrate past the site to spawn, have recreational or commercial value, are important links in the local food web, or are critical to the ecosystem.

Gizzard Shad (*Dorosoma cepedianum*). Gizzard shad are prolific spawners. An average size female gizzard shad produces about 300,000 eggs per year. Gizzard shad deposit their eggs in substrate (e.g., 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 (Etnier and Starnes 1993). After spawning, gizzard shad larvae migrate away from the shoreline to the limnetic zone (open water). Garvey and Stein (1998) observed that larval gizzard shad always emerged in the limnetic zone before larval threadfin shad. As larvae, gizzard shad feed primarily on zooplankton. As juveniles, gizzard shad are strictly planktivores (i.e., feeding on plankton). Once they reach 2.5 to 3.5 cm (0.98 to 1.4 in.) in total length, gizzard shad become omnivores and feed on detritus in addition to zooplankton and phytoplankton (Stein et al. 1995).

Threadfin Shad (*Dorosoma petenense*). Threadfin shad are smaller than gizzard shad (less than 8.5 in. (22 cm)) and usually live for only 2 to 3 years. Spawning occurs along the shoreline in the spring and possibly in autumn (Etnier and Starnes 1993). After hatching, the larvae move into the limnetic zone (open water away from the shore) (Armstrong et al. 1998). Threadfin shad synchronize their spawning time and spawn in groups a few hours after sunrise. Ecologists believe the synchronous behavior allows predator avoidance and rapidly strengthens populations that may have been depleted during the winter (Etnier and Starnes 1993). Both the young and adult are planktivores, eating about half their diet from phytoplankton and half from zooplankton (Etnier and Starnes 1993). Threadfin shad are not cold tolerant and are susceptible to large winter die-offs when temperatures drop. 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).

Bluegill (*Lepomis macrochirus*). Bluegill is one of the sunfish species found around the SQN site. Bluegill are both a forage and a game fish. The young are abundant and provide prey for bass. Bluegill frequent shallow water with vegetative cover, submerged wood, or rocks. They spawn from late spring into summer. Like other sunfish, male bluegill construct nests in shallow water on varied substrates (although they prefer gravel) and guard the eggs until hatching occurs. Young sunfish frequent weed beds or other heavy cover. Bluegill eat a varied diet, including midge larvae and microcrustaceans (Etnier and Starnes 1993). Etnier and Starnes (1993) report that bluegill select larger prey when abundant but become less selective as the abundance of their preferred prey decreases. Because juvenile bluegill are prey for largemouth bass, the population of bluegill can affect the largemouth bass population.

Black Bass (*Micropterus* spp.). Black bass include largemouth bass (*Micropterus salmoides*), smallmouth bass (*M. dolomieu*), and spotted bass (*M. punctulatus*). Largemouth bass and spotted bass inhabit lower velocity portions of streams and larger lakes and reservoirs. In reservoirs, smallmouth bass prefer steep rocky slopes along 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. For smallmouth bass, hatching requires about 4 to 6 days; fry swim up from the nest 5 to 6 days later. The fecundity of females varies with the size of the fish, but they may produce from 2,000 to 145,000 eggs. Young bass feed on zooplankton, insects, and small fish, and are cannibalistic (Etnier and Starnes 1993). Smallmouth and spotted bass feed primarily on small fish, crayfish, and aquatic insects. Largemouth bass prey on bluegill, redear sunfish, shad, minnows, crayfish, and amphibians (Mettee et al. 1996). Gizzard shad are reported by numerous sources to be preferred by largemouth bass and other piscivores over bluegill or other *Lepomis* species

(Aday et al. 2003). Gizzard shad grow too large to be the primary prey for largemouth bass; thus, largemouth bass likely switch to other prey (Aday et al. 2003).

The TWRA has been stocking Florida black bass fingerlings into Chickamauga Reservoir since 2000. The goal of this stocking program is to encourage hybridization and introgression of the stocked fish with those native to the Tennessee River system. Florida largemouth bass are a subspecies of largemouth bass and they have greater size and longevity compared to the largemouth bass found in the Tennessee River (TWRA 2013f). Over 250,000 Florida largemouth bass were stocked in Chickamauga Reservoir in the spring of 2013 (TWRA 2013a).

Interactions Between Shad, Bluegill, and Largemouth Bass. Multiple ecological interactions occur between sunfish and shad, which, in some cases, are stimulated by the timing of the increase in reservoir water levels and spring warming.

Larval gizzard shad can be a strong competitor with other fish, such as bluegill, for zooplankton in reservoirs because of their high numbers, feeding preference for smaller zooplankton (based on their mouth size), and the timing of their appearance. Many factors may influence the timing, abundance, and size of the shad larvae and so intensify or mitigate the competition for zooplankton. Such factors include the relative timing of hatching of the bluegill larvae, water fluctuations (e.g., spring reservoir water levels), temperature (specifically the timing of spring warming), primary productivity, and turbidity (Garvey and Stein 1998). Hatchery experiments conducted by Garvey and Stein (1998) show that gizzard shad, when introduced 2 weeks before the introduction of bluegill, depleted the zooplankton and affected the growth of the bluegill but not their survival. When both species were introduced simultaneously, the abundance of zooplankton declined only slightly with only a small effect on bluegill growth and survival.

Aday et al. (2003) conjecture that other indirect effects (e.g., serving as an alternative prey for largemouth bass) may have a greater influence on the size structure of the bluegill population than competition between bluegill and shad larvae for zooplankton. Gizzard shad appear to be preferred by largemouth bass and other piscivores over bluegill or other *Lepomis* species (Aday et al. 2003). Aday et al. (2003) indicate that gizzard shad may grow too rapidly and ultimately become too large of a prey for largemouth bass.

In addition, timing of increased spring reservoir water levels can affect the nesting sites and forage areas for bluegills and other sunfish, including the largemouth bass. This, in turn, can affect shad competition for zooplankton as well as the number of adult largemouth bass that will prey upon the shad.

Armstrong et al. (1998) examined the similarities and differences between gizzard shad and threadfin shad larvae and found that they were ecologically similar, especially in terms of diet, taxonomy, prey-size selection, and mouth structure, which relates to prey selection. Threadfin shad and gizzard shad larvae likely compete when resources are limiting, although spatial and temporal distribution of the larvae differ once they move into the limnetic zone of the reservoir (Armstrong et al. 1998).

<u>Black and White Crappie (*Pomoxis nigromaculatus* and *P. annularis*)</u>. Both black and white crappie are popular sport and food fishes. The white crappie inhabits slow-moving streams and lakes and is tolerant of turbidity. The black crappie prefers clear waters and is more abundant in natural lakes, although it does well in less turbid reservoirs. Spawning for both occurs from April to June. In general, black and white crappie spawn in shallow, protected areas (e.g., coves and deeper overflow pools near vegetation (black crappie), brush, and overhanging banks). Hatching requires 2 to 5 days depending on the water temperature. Adult males guard the nests until the fry have dispersed. Females contain from 10,000 to 160,000 mature eggs

and spawn repeatedly in the nests of several males over the season. Young crappie feed on small invertebrates, including microcrustaceans and small insects, but prey progressively more on fish as they mature. Adults feed heavily on forage fish (e.g., shad) but they also consume microcrustaceans and other plankton (Etnier and Starnes 1993; Mettee et al. 1996).

In the 1980s, the adult white crappie population appeared to be declining. TVA (Buchanan and McDonough 1990) conducted a study from 1986 through 1989 to determine the status of the white crappie in Chickamauga Reservoir and to determine if the operation of SQN was a contributing factor to the decline. The study investigated larval fish, young-of-the-year, and adult fish. The decline in white crappie population was substantiated. The more recent gillnetting and electrofishing studies between 1999 and 2012 (TVA 2012c) both upstream and downstream of the plant reveal a larger number of black crappie than white. Factors correlating with the decline of the white crappie population in the study in the late 1980s include an increased density of aquatic macrophytes and competition between species (Buchanan and McDonough 1990). Based on the distribution of crappie in the reservoir, the lack of apparent attraction to the thermal discharge, and the identification of preferred spawning habitat distant from the SQN site, those authors attributed no connection to the operation of SQN.

White and Yellow Bass (*Morone chrysops* and *M. mississippiensis*). White and yellow bass are important game fish in the Chickamauga and Watts Bar reservoirs. Yellow bass school and avoid flowing water habitats more so than the white bass (Etnier and Starnes 1993). Both species spawn in midwater, although the yellow bass can migrate into large streams or tributaries to spawn. Spawning runs for white and yellow bass occur in mid-February and in April and May, respectively. The eggs of both species drift to the bottom and are adhesive. White and yellow bass larvae hatch in 2 days and in 4 to 6 days, respectively. Rather than being passively transported downstream with the river flow, the larvae of white bass in the Tennessee River appear to use areas of low velocity as refuge or stay near the bottom of the river. Juveniles eat small invertebrates (e.g., cladocerans, copepods, and midge larvae) (Etnier and Starnes 1993). Adults are aggressive predators and feed on threadfin and gizzard shad (Mettee et al. 1996), silverside, and occasionally young sunfish (Etnier and Starnes 1993). In some populations, adult yellow bass continue to feed heavily on aquatic insects (Etnier and Starnes 1993).

Emerald Shiner (*Notropis atherinoides*). The emerald shiner was observed more frequently at the sampling site upstream from the SQN site (Tennessee RM 490.5) prior to 2008; very few have been found since 2008. A similar decrease in the emerald shiner population was observed in the vicinity of the Watts Bar Nuclear site (NRC 2013a), although the timing of the decline indicated that the operation of the Watts Bar plant was not likely the cause. Crowder (1980) documented cases of dramatic reductions in emerald shiner populations in other locations. In several cases, competition with another fish species (alewife (*Alosa pseudoharengus*)) contributed to the decline. Alewife have not been found in Chickamauga Reservoir, but other clupeids (e.g., gizzard shad and threadfin shad) are prolific in the reservoir. Short et al. (1998) identified a decline in water quality as the impetus for reduced emerald shiner populations.

Freshwater Drum (*Aplodinotus grunniens*). Freshwater drum are common in large rivers and reservoirs and prefer backwaters and areas with slow current. They are an important part of the commercial fishery in the larger rivers and reservoirs of Tennessee. Freshwater drum are broadcast spawners and spawn large numbers of eggs (40,000 to 60,000 per female) in midwater at water temperatures in the range of 18 to 20 °C (64 to 68 °F) (Etnier and Starnes 1993). Spawning in this stretch of the Tennessee River typically occurs in late spring, although it can also continue into the late summer (TVA 2012c). The eggs are pelagic and float until they hatch, within 1 to 2 days (Etnier and Starnes 1993). The larvae are small, about

3.2 mm (0.13 in.) long at hatching, and grow rapidly; they are considered juveniles a few weeks later when 1.5 cm (0.60 in.) long. The larvae feed on other fish larvae, especially shad and younger drum. Individuals are 10 to 12 cm (4 to 5 in.) long by autumn, at which time they begin to feed on zooplankton, small crustaceans (e.g., amphipods), and aquatic insects. Freshwater drum grow rapidly with the young-of-the-year reaching 10 to 12 cm (4 to 5 in.) (Becker 1983).

Sauger (*Sander canadensis*). Sauger inhabit large, often turbid rivers and have been successful in many reservoirs (Etnier and Starnes 1993). They spawn from April through May, commonly over rubble and gravel in tailwaters (Etnier and Starnes 1993). In Chickamauga Reservoir, spawning occurs approximately 13 km (8 mi) downstream of Watts Bar Dam (TVA 1989) at Hunter Shoals (Hevel and Hickman 1991). Eggs adhere to rubble and gravel immediately after spawning, but soon become nonadhesive and may be widely dispersed in currents. Larger females can produce over 100,000 eggs annually, but most produce 20,000 to 60,000 eggs. Larvae feed on cladocera, copepods, and midge larvae. Juveniles switch to a diet almost exclusively of fish, primarily gizzard and threadfin shad in the Tennessee River Basin (Etnier and Starnes 1993), although they are also known to feed on young walleye (*Sander vitreum*), sauger, white bass, crappie, and yellow perch (Mettee et al. 1996).

In an effort to understand the population dynamics of sauger in Chickamauga Reservoir, TVA used standard and experimental gillnets during special studies conducted from 1993 to 1994 in the upper 24 km (14.9 mi) of the reservoir (Hickman and Buchanan 1995). Hickman and Buchanan concluded that an instantaneous minimum discharge of 8,000 cfs (227 m^3/s) was necessary and sufficient to ensure appropriate conditions for successful sauger reproduction. Hickman and Buchanan (1995) also concluded that the thermal variance instituted for SQN discharge from November through March had no adverse impact on the sauger population in Chickamauga Reservoir and, further, that the sauger did not show an attraction to or an avoidance of the diffuser area and the thermal plume. Based on tagging studies and returns by fishermen, sauger appear to move through Watts Bar Dam into the upstream reservoir, although in low numbers (3 to 9 percent during the 1993 and 1994 study (Hickman and Buchanan 1995)).

Catfish (*Ictalurus* spp.). Catfish in the Chickamauga Reservoir include the blue catfish (*I. furcatus*) and channel catfish (*I. punctatus*). Catfish are both recreationally and commercially important species. Members of the family Ictaluridae spawn in summer and deposit their eggs in depressions or nests constructed in natural cavities and crevices in rivers. Male catfish display territorial behavior after spawning and aggressively defend their eggs. Catfish are opportunistic feeders and eat aquatic insect larvae, crayfish, mollusks, and small fish (live and dead) (Etnier and Starnes 1993; Mettee et al. 1996).

Paddlefish (*Polyodon spathula*). Paddlefish are large fish (generally greater than 40 in. (1 m) and 44 to 66 lb (20 to 30 kg)) with a life span that may exceed 20 years. They spawn in swift water over gravel bars in the spring. Although female paddlefish do not spawn every year, they do produce large numbers of eggs (more than 500,000 eggs) during spawning. Paddlefish are commercially fished in Chickamauga Reservoir (Table 3–15) for both meat and roe (eggs). Juvenile paddlefish are reportedly susceptible to impingement on cooling water intake screens (Etnier and Starnes 1993).

Nonindigenous Species

Five nonindigenous species were collected during the sampling studies between 1999 and 2011 (TVA 2012c). Redbreast sunfish, yellow perch, and striped bass are considered valuable sports and commercial fishing species. The common carp and inland silversides are considered aquatic nuisance species.

<u>Redbreast sunfish (*Lepomis auritus*)</u>. Redbreast sunfish, native to the Atlantic slope drainages, were introduced intentionally for sport fishing and are considered an invasive species. Redbreast sunfish have been found in the vicinity of the SQN site. This species may have caused the decline or extirpation of many native longear sunfish populations through direct competition (Etnier and Starnes 1993), although longear sunfish still occur in the Chickamauga Reservoir (TWRA 2008).

<u>Yellow perch (*Perca flavescens*)</u>. Yellow perch have been introduced into many states, including Tennessee, from their native range in the middle Mackenzie drainage in Canada through the northern states east of the Rocky Mountains and to the Atlantic Slope drainages south to South Carolina. They were introduced in the late 1800s for food and sport fishing. Yellow perch are known to compete for food resources with trout and are valuable prey for walleye (TWRA 2008). Yellow perch have been found in the vicinity of the SQN site.

<u>Striped bass (*Morone saxatilis*)</u>. Etnier and Starnes (1993) characterize striped bass as "an extremely important game and commercial species." Striped bass in North American inland waters are offspring of the anadromous striped bass that became land-locked when the Santee River in South Carolina was impounded in the 1940s. The eggs of the striped bass must remain suspended in the current until the larvae hatch (1 to 3 days). As a result, the impoundment of the Tennessee River eliminated most, if not all, reproduction, and the striped bass in Chickamauga Reservoir are introduced from hatcheries (Etnier and Starnes 1993).

<u>Inland silverside (*Menidia beryllina*)</u>. Inland silversides are native to coastal and freshwater habitats from Massachusetts to Mexico. They were not found in the Tennessee River until 1991, when first collected from the Kentucky Reservoir. In 2004, the first individuals were collected in the Chickamauga Reservoir at the upstream sampling location near the SQN site (Simmons 2010a). By 2010, inland silversides made up over 32 percent of the fish caught during electrofishing upstream of the SQN site (Tennessee RM 490.5) and 46 percent of the fish caught during electrofishing at the downstream site (Tennessee RM 482). Percentages at both sites dropped to zero by 2011, although large numbers of Mississippi silversides (*M. audens*) were reported from the electrofishing surveys. *M. audens* is reported to be a synonym for *M. beryllina* (ITIS 2013) and is considered to be the same species, so the zeros no doubt represent a reporting difference rather than a disappearance of inland silversides. In the last 2 years, the inland silverside has been the numerically dominant species in the downstream electrofishing samples. Inland silversides introduced in Oklahoma almost completely replaced brook silversides; however, more time is needed to understand the impact on the brook silverside populations in the Tennessee River, as well as on other species with similar ecological niches (TWRA 2008).

<u>Carp (*Cyprinus carpio*, *Ctenopharyngodon idella*, and *Hypophthalmichthys* spp.)</u>. Carp are nonnative fish introduced into North America from Eurasia. Carp are considered invasive species and have clearly changed the population dynamics of Tennessee River aquatic communities. Several species of carp are present in Tennessee River aquatic communities. Common carp have been present for over 100 years and currently exist in all reservoirs, including the vicinity of the SQN site. Grass carp (*Ctenopharyngodon idella*) have been introduced throughout much of the United States for biological control of nuisance aquatic plants, but were not identified in the sampling studies in the vicinity of the SQN site. Grass carp primarily inhabit the lower portions of the river system. Silver carp (*Hypophthalmichthys molitrix*) and bighead carp (*H. nobilis*) have been found in parts of Chickamauga Reservoir (Black 2010) but were not identified in the sampling studies in the vicinity of the SQN site. Carp are detrimental to the native fauna and negatively affect water quality. They are highly tolerant of poor water-quality conditions, and researchers expect them to continue to spread throughout the Tennessee River system.

Carp are important commercial fish, and the grass carp has a recreational value in some Tennessee River reservoirs such as Guntersville Reservoir. These fish tend to frequent deep water (up to 6 m (20 ft) deep). They are omnivores that feed on the bottom (mostly in mud) and eat worms; insect larvae; plankton; vascular plants; and, occasionally, small fish (Etnier and Starnes 1993; Mettee et al. 1996). Carp increase the turbidity of the water as they feed and spawn, decreasing light penetration and primary productivity and covering the eggs of other fish species with silt, both of which are detrimental environmental effects. Spawning occurs in the spring, in flooded fields or along the shore of the reservoir, and the eggs are small and adhesive. Female carp may produce over 2,000,000 eggs in a given season and may release 600,000 or more in a given spawning period (Etnier and Starnes 1993). Carp are long-lived fish species (20 years) and reach sizes of 23 to 36 kg (50 to 80 lb) (Etnier and Starnes 1993).

State-Listed Aquatic Species

The State of Tennessee has identified species that occur near the SQN site for special protection. Table 3–18 lists those species that are present in Hamilton County and protected by the State of Tennessee. The list includes one amphibian, two fish, five freshwater mussels, and one crustacean. Some of these species (all five mussels and the snail darter) are also Federally protected under the ESA. This section discusses those species protected only by the State, and Section 3.8 discusses those species protected under the ESA alone or in combination with the State. The species protected only by the State include a crustacean, the Chickamauga crayfish (*Cambarus extraneus*); one fish, the highfin carpsucker (*Carpiodes velifer*); and an amphibian, the Tennessee cave salamander (*Gyrinophilus palleucus*).

Table 3–18. State-Listed Protected Aquatic Species Present in Hamilton County, TN

Scientific Name	Common Name	State of Tennessee Status	Federal Status	Habitat
Crustacean				
Cambarus extraneus	Chickamauga crayfish	Threatened	None	Springs & small- to medium-sized streams under rocks or in vegetation; South Chickamauga Creek watershed, Hamilton County
Mussels				
Dromus dromas	dromedary pearly mussel	Endangered	Endangered	Medium-large rivers with riffles and shoals with relatively firm rubble, gravel and stable substrates
Lampsilis abrupta	pink mucket	Endangered	Endangered	Generally a large river species, preferring sand-gravel or rocky substrates with moderately strong currents
Plethobasus cooperianus	orangefoot pimpleback pearlymussel	Endangered	Endangered	Large rivers in sand-gravel-cobble substrates in riffles and shoals in deep flowing water
Pleurobema plenum	rough pigtoe	Endangered	Endangered	Medium-to-large rivers in sand, gravel and cobble substrates of shoals
Quadrula intermedia	Cumberland monkeyface	Endangered	Endangered	Shallow riffle and shoal areas of headwater streams and bigger rivers, in coarse sand/gravel substrates Tennessee River system
Fish				
Carpiodes velifer	highfin carpsucker	Deemed in Need of Management	None	Large rivers, mostly in Tennessee River drainage
Percina tanasi	snail darter	Threatened	Threatened	Sand and gravel shoals of moderately flowing, vegetated, large creeks
Amphibian				
Gyrinophilus *palleucus*	Tennessee cave salamander	Threatened	None	Aquatic cave obligate; cave streams and rimstone pools; Central Basin, Eastern Highland Rim and Cumberland Plateau

Sources: FWS 2013b; TDEC 2013b

Crustacean

Chickamauga crayfish are threatened in the State of Tennessee but not Federally listed. They have a very small range and are found in the South Chickamauga Creek basin in Hamilton County and in Walker and Whitfield Counties in Georgia. They prefer moderately flowing shallow streams; are usually found under rocks or in leaf litter debris; and are omnivorous scavengers that eat aquatic vegetation, small fish, snails, and aquatic insects (Georgia Museum of Natural History 2008). South Chickamauga Creek enters the Tennessee River downstream of Chickamauga Dam. For this reason, Chickamauga crayfish would not be affected by operation of SQN and are not discussed further in this SEIS.

Fish

The State deems the highfin carpsucker, the smallest carpsucker in Tennessee, as “in need of management” for Hamilton County. They live in areas of gravel substrate in relatively clear medium-to-large rivers. Highfin carpsuckers are more susceptible to impoundment and siltation than other carpsuckers and, in Tennessee, are known to persist in the Nolichucky, French Broad, Clinch, Hiwassee, Sequatchie, and Duck River systems (Etnier and Starnes 1993). In 2004, TVA found a single individual approximately 5 mi (8 km) upstream from the intake of the SQN plant during an electrofishing survey (TVA 2013d-f).

Amphibians

Tennessee cave salamanders are listed as threatened. They are found only in the southern Appalachian Mountains of Tennessee, Georgia, and Alabama. They inhabit limestone caves with subterranean waters (SREL 2013). No caves are present on the SQN site. For this reason, the Tennessee cave salamander would not be affected by operation of SQN and is not discussed further in this SEIS.

<u>Reintroductions</u>

The State of Tennessee and various partner groups are working to reintroduce the lake sturgeon into the upper Tennessee River watershed (TWRA 2013f). Since 2000, the TWRA has stocked over 125,000 lake sturgeon (Tennessee Aquarium 2013) into rivers including the French Broad, Holston, and Tennessee rivers downstream of Douglas and Cherokee Reservoirs (TWRA 2013f). In addition, the Tennessee Aquarium introduced approximately 100 lake sturgeon into Nickajack Reservoir between 2010 and 2011 (TWRA 2013a). The sampling studies conducted by TVA between 1999 and 2011 identified a single lake sturgeon, collected in 2003 by gillnet, from the sampling site located upstream of the SQN intake at Tennessee RM 490.5 (TVA 2012c).

Lake sturgeon are considered endangered by the State of Tennessee, but are not Federally listed by the Fish and Wildlife Service. Lake sturgeon are large fish that can reach 4 m (13 ft) and 310 lb (141 kg). They are slow to mature; first spawning occurs between 14 and 25 years for females and 12 and 20 years for males. Lake sturgeon are considered to be the longest lived North American freshwater fish, with a maximum age estimate of 154 years, although populations in Tennessee would be expected to have a smaller size and shorter life span than those farther north (Etnier and Starnes 1993).

3.8 Special Status Species and Habitats

This section addresses species and habitats that are Federally protected under the ESA and the Magnuson–Stevens Fishery Conservation and Management Act, as amended (16 U.S.C. §1801–1884, herein referred to as Magnuson–Stevens Act). The ESA, along with the Magnuson–Stevens Act, put requirements on Federal agencies such as the NRC. The terrestrial and aquatic resource sections of this SEIS (Sections 3.6 and 3.7, respectively) discuss other species and habitats protected by other Federal acts and the State of Tennessee that do not put requirements on the NRC.

3.8.1 Species and Habitats Protected Under the Endangered Species Act

The FWS and the National Marine Fisheries Service (NMFS) jointly administer the ESA. The FWS manages the protection of, and recovery effort for, listed terrestrial and freshwater species, and NMFS manages the protection of and recovery effort for listed marine and anadromous species. This section describes the action area and considers those species that could occur in the action area under both FWS's and NMFS's jurisdictions. Section 4.8 assesses potential impacts to Federally listed species and habitats that could result from the proposed action and alternatives, and Appendix C describes the NRC's consultation with FWS pursuant to section 7 of the ESA.

3.8.1.1 Action Area

The implementing regulations for section 7(a)(2) of the ESA define "action area" as all areas affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). The action area effectively bounds the analysis of ESA-protected species and habitats because only species that occur within the action area may be affected by the Federal action.

For the purposes of the ESA analysis in this SEIS, the NRC staff considers the action area to be the SQN site (described in Sections 3.1 and 3.6) and the Chickamauga Reservoir (described in Section 3.7) from the point of river water intake at the site (at Tennessee River Mile (TRM) 485.1) and extending 4.1 mi (6.6 km) downstream to TRM 481.0. This area of the reservoir corresponds to the area over which the thermal plume extends during the summer measurement period (as discussed in Section 4.7). The NRC staff expects all direct and indirect effects of the proposed action to be contained within these areas.

The NRC staff recognizes that while the action area is stationary, Federally listed species can move in and out of the action area. For instance, a migratory fish species could occur in the action area seasonally as it travels up and down the river past SQN. Similarly, a flowering plant known to occur near, but outside, of the action area could appear within the action area over time if its seeds are carried into the action area by wind, water, or animals. Thus, in its analysis, the NRC staff considers not only those species known to occur directly within the action area, but those species that occur near the action area. The staff then considers whether the life history of each species makes the species likely to move into the action area where it could be affected by the proposed SQN license renewal.

Within the action area, Federally listed terrestrial species could experience impacts such as habitat disturbance associated with refurbishment or other ground-disturbing activities, cooling tower drift, collisions with cooling towers and transmission lines, exposure to radionuclides, and other direct and indirect impacts associated with station, cooling system, and in-scope transmission line operation and maintenance (NRC 2013d). The proposed action has the potential to affect Federally listed aquatic species in several ways: impingement or entrainment of individuals into the cooling system; alteration of the riverine environment through water level reductions, changes in dissolved oxygen, gas supersaturation, eutrophication, and thermal discharges from cooling system operation; habitat loss or alteration from dredging; and exposure to radionuclides (NRC 2013d).

3.8.1.2 Species and Habitats Under the FWS's Jurisdiction

Table 3–19 identifies the species under FWS's jurisdiction that may occur within Hamilton County. Hamilton County includes approximately 369,000 ac (149,000 ha) of varying land uses and habitat types. Thus, a Federally listed species that occurs within Hamilton County does not necessarily occur within the action area. The NRC staff uses this geographical range as a starting point for its analysis because Federally listed species distribution and critical habitat information is readily available at the county level. Additionally, the action area is a small area of land near the center of and wholly contained within the geographical boundaries of the county. Following the table, descriptions of each species include a determination of whether each species occurs in the action area based on the species' habitat requirements, life history, and available occurrence information.

The NRC compiled the list of species in Table 3–19 from the FWS's Endangered Species Program online database (FWS 2014); correspondence between the NRC and the FWS (FWS 2013b, 2013c; NRC 2013g); information from TVA's ER (TVA 2013n) and Natural Heritage Database (TVA 2013j); and available scientific studies, surveys, and literature.

The NRC staff did not identify any candidate species or proposed or designated critical habitats within the action area.

Table 3–19. Federally Listed Species in Hamilton County, TN

Species[(a)]	Common Name	Federal Status	Habitat
Mammals			
Myotis grisescens	gray bat	Endangered	limestone karst areas within the southeastern United States
Myotis septentrionalis	northern long-eared bat	Protected	Hardwood forests; caves and mines with cool, moist air
Myotis sodalis	Indiana bat	Endangered	Hardwood forests and hardwood-pine forests; old-growth forest; agricultural lands, and old fields
Fish			
Percuba tanasi	snail darter	Threatened	Sand and gravel shoals of moderately flowing, vegetated, large creeks
Freshwater Mussels			
Dromus dromas	dromedary pearlymussel	Endangered	Medium to large rivers with riffles and shoals with relatively firm rubble, gravel, and stable substrates
Lampsilis abrupta	pink mucket	Endangered	Generally a large river species, preferring sand-gravel or rocky substrates with moderate to strong currents
Plethobasus cooperianus	orangefoot pimpleback	Endangered	Large rivers in sand-gravel-cobble substrates in riffles and shoals in deep flowing water
Pleurobema plenum	rough pigtoe	Endangered	Medium to large rivers in sand, gravel, and cobble substrates of shoals
Plants			
Isotria medeoloides	small whorled pogonia	Threatened	Hardwood or conifer-hardwood forest floors near stream beds
Scutellaria montana	large-flowered skullcap	Threatened	Mid- to late-successional forests dominated by oak and pine trees
Spiraea virginiana	Virginia spiraea	Threatened	Floodplains, riverbanks, and other riparian habitat in the southern Appalachian Mountains

[(a)] The NRC preliminarily considered two additional species—the Cumberland monkeyface (*Quadrula intermedia*; Federally endangered) and the white fringeless orchid (*Platanthera integrilabia*; candidate for Federal listing)—in its early correspondence with FWS (NRC 2013g). However, the NRC staff determined that these species do not occur within Hamilton County, and thus, would not occur within the action area based on historical and known occurrence information and habitat requirements.

Sources: FWS 2013b, 2013c, 2014; NRC 2013g; TVA 2013j, 2013n

Gray Bat (*Myotis grisescens*)

The FWS listed the gray bat as endangered in 1976 (40 FR 17590). No critical habitat has been designated for this species. White nose syndrome, human disturbance, water impoundments, and other activities resulting in loss of habitat are factors that have contributed to this species' decline. Unless otherwise indicated, information on this species below is derived from the FWS's *Gray Bat Recovery Plan* (Brady et al. 1982).

The gray bat is the largest Myotis species with a wingspan of 40 to 46 mm (1.7 to 1.8 in.), and it is distinguishable from other bat species by its unicolor dorsal fur, which is dark gray after molting in July and August and chesnut brown to russet between moltings. The species mainly inhabits five states in the southeastern United States (Alabama, Arkansas, Kentucky, Missouri, and Tennessee) and is also found in small numbers as far north as Illinois and as far south as northwestern Florida. Distribution of the species has always been patchy, but fragmentation and isolation of populations has increased as the species has become more in danger of extinction.

Gray bats migrate seasonally between hibernating and maternity caves. Upon arrival at hibernating caves in September through early October, adults mate and enter hibernaculum. Adults emerge beginning in late March, at which time they migrate to summer habitat. Mortality is typically high during this time because fat reserves and food supplies are low. Summer colonies occupy traditional home ranges that include a maternal cave and several roost caves typically located along a river or reservoir. Hibernating females store sperm until spring, and give birth to one pup in late May or early June. Females raise young in maternity colonies.

Gray bats possess very specific microclimate requirements and are limited to limestone karst areas, typically within 1 km (0.6 mi) of rivers or reservoirs. Foraging territories may include lands farther from water. Brady et al. (1982) indicates that because of its habitat requirements, the species is restricted to fewer than five percent of available caves, and in 1982, 95 percent of the known population hibernated in only nine caves each winter. In 1982, the gray bat population was estimated to include 1,575,000 individuals, of which 300,000 individuals were located in Tennessee. Mitchell and Martin (2002) estimated the population to have risen to 2.3 million bats by 2001.

In a final environmental statement for operation of Watts Bar 2 in Rhea County (located 31 mi [50 km] north of SQN), the NRC (2013b) found that gray bats are known to roost in two caves near the Watts Bar 2 site. The gray bat has also been documented within the Chickamauga and Chattanooga National Military Park according to a FWS (2012) press release announcing the discovery of white-nose syndrome in a park cave. The Military Park includes lands in Hamilton County, Tennessee, and Catoosa, Dade, and Walker Counties, Georgia. Three caves exist near the action area (within 6 mi (10 km) of the SQN site): Posey Cave, Havens Cave, and Harrison Bluff Cave (TVA 2013a). However, none of these caves are associated with occurrences of Federally listed species (TVA 2013a, 2013b). Additionally, during the NRC staff's environmental site audit, TVA provided NRC staff with records for review from its Natural Heritage Database, which included detailed occurrence information on Federally listed species, State-listed species, and other special status species throughout the TVA power service area. The NRC reviewed database records of species and habitat occurrences within a 6-mi (10-km) radius of the SQN site and found that TVA (2013b) has not identified the gray bat within this area.

Given the available information, the NRC staff concludes that the gray bat is unlikely to occur within the action area.

<u>Northern Long-Eared Bat (*Myotis septentrionalis*)</u>

The FWS published a proposed rule to list the northern long-eared bat as endangered throughout its range on December 2, 2013 (78 FR 72058). The FWS did not propose to designate critical habitat for the species because it found that such habitat is “not determinable at this time” (78 FR 61046). White nose syndrome, wind energy development, and loss of habitat specifically linked to surface coal mining in prime summer habitat are factors that have contributed to this species’ decline. Unless otherwise indicated, information on this species is derived from the FWS’s *Federal Register* notice for the proposed rule to list the species (78 FR 61046).

The northern long-eared bat is a medium-sized bat that is distinguished from other Myotis species by its long ears, which average 0.7 in. (17 mm) in length. This bat inhabits 39 states in the eastern and north central United States and all Canadian provinces west to the southern Yukon Territory and eastern British Columbia. Populations tend to be patchily distributed and are typically composed of small numbers. More than 780 winter hibernacula have been recorded in the United States (11 in Tennessee), most of which contain only a few (1 to 3) individuals. The FWS recognizes four United States populations, and northern long-eared bats inhabiting Tennessee are considered part of the Southern population. The northern long-eared bat is less common in the southern portion of its range than in the northern portion of the range. Thompson (2006) considers the species common within Tennessee, and in 2010, individuals were caught in summer mist-net surveys as well as observed in 11 caves during Tennessee hibernacula censuses. The proximity of these occurrences to the SQN site is unknown because survey locations are not provided in the proposed rule or otherwise published.

In summer, northern long-eared bats roost alone or in small colonies under the bark of live or dead trees; in caves or mines; or in man-made structures, such as barns, sheds, and other buildings. The species opportunistically roosts in a variety of trees, including several species of oaks, maples, beech, and pine. Northern long-eared bats forage both in-flight and on the ground and eat a variety of moths, flies, leafhoppers, caddisflies, and beetles. The species breeds from late July to early October, after which time it will migrate to winter hibernacula. Northern long-eared bats are short-distance migrators and will travel 35 to 55 mi (56 to 89 km) from summer roosts to winter hibernacula. Hibernating females store sperm until spring, and give birth to one pup approximately 60 days after fertilization. Females raise young in maternity colonies of up to 30 individuals.

The action area does not contain suitable habitat for hibernation. As indicated in the description of the gray bat, three caves exist near the action area, but none of the caves are associated with occurrences of Federally listed species (TVA 2013a, 2013b). For roosting and foraging, over half of the action area is developed or composed of unsuitable habitat types. The remainder of the action area includes approximately 278 ac (113 ha) of suitable habitat types: 150 ac (60 ha) of forest habitat of various types; 120 ac (50 ha) of grasslands or agricultural lands; and 8 ac (3 ha) of wooded wetlands (TVA 2013a). However, none of the available FWS records indicate occurrences of hibernacula, maternity colonies, or individual northern long-eared bats in the action area or in the larger geographical area of Hamilton County. Additionally, during the NRC staff’s environmental site audit, TVA provided NRC staff with records for review from its Natural Heritage Database, which included detailed occurrence information on Federally listed species, State-listed and other special status species throughout the TVA power service area. The NRC reviewed database records of species and habitat occurrences within a 6-mi (10-km) radius of the SQN site and found that TVA (2013b) has not identified northern long-eared bat hibernacula, maternity colonies, or individuals within this area.

Given the available information, the NRC staff concludes that the northern long-eared bat is unlikely to occur within the action area.

Indiana Bat (*Myotis sodalis*)

The FWS listed the Indiana bat as endangered in 1967 (32 FR 4001). The FWS designated critical habitat for the Indiana bat in 1976 (41 FR 41914) to include 11 caves and 2 mines in six states including a cave in Blount County, Tennessee. No critical habitat for this species occurs in Hamilton County.

The Indiana bat is an insectivorous, migratory bat that inhabits the central portion of the eastern United States and hibernates colonially in caves and mines. The decline of Indiana bats is attributed to urban expansion, habitat loss and degradation, human-caused disturbance of caves or mines, insecticide poisoning, and white nose syndrome (FWS 2007, 2011).

During summer months, reproductive female bats tend to roost in colonies under slabs of peeling tree bark or cracks within trees in forest fragments, often near agricultural areas (FWS 2007). Colonies may also inhabit closed-canopy, bottomland deciduous forest; riparian habitats; wooded wetlands and floodplains; and upland communities (FWS 2007). Maternity colonies typically consist of 60 to 80 adult females (Whitaker and Brack 2002). Colonies occupy multiple trees for roosting and rearing young (Watrous et al. 2006) and, once established, usually return to the same areas each year (FWS 2007). Nonreproductive females and males do not roost in colonies during the summer; they may remain near the hibernacula or migrate to summer habitat (FWS 2007). High-quality summer habitat includes mature forest stands containing open subcanopies, multiple moderate- to high-quality snags, and trees with exfoliating bark (Farmer et al. 2002). In summer, bats forage for insects along forest edges, riparian areas, and in semiopen forested habitats. In the winter, Indiana bats rely on caves for hibernation. The species prefers hibernacula in areas with karst (limestone, dolomite, and gypsum) and may also use other cave-like locations, such as mines.

The FWS's *Indiana Bat Recovery Plan* (FWS 2007) indicates that Indiana bats are distributed across 21 Tennessee counties. Thirty-four winter hibernacula (21 extant, 7 of uncertain status, and 6 historic) are located throughout these counties. Three extant maternity colonies occur in Blount and Monroe Counties. Additionally, adult males and/or nonreproductive females have been captured during summer surveys within 9 of the 21 counties. In 2007, the FWS estimated that Tennessee's total population of Indiana bats was 8,906 individuals (FWS 2009). According to more recent estimates based on winter surveys conducted in January and February of 2013, the FWS (2013d) estimate that the Tennessee population of Indiana bats is currently 15,537 individuals.

The action area does not contain suitable habitat for hibernation. As indicated in the description of the gray bat, three caves exist near the action area, but none of the caves are associated with occurrences of Federally listed species (TVA 2013j, 2013n). For roosting and foraging, over half of the action area is developed or composed of unsuitable habitat types. The remainder of the action area includes approximately 278 ac (113 ha) of suitable habitat types: 150 ac (60 ha) of forest habitat of various types; 120 ac (50 ha) of grasslands or agricultural lands; and 8 ac (3 ha) of wooded wetlands (TVA 2013n). However, none of the available FWS records indicate occurrences of hibernacula, maternity colonies, or individual Indiana bats in the action area or in the larger geographical area of Hamilton County. Additionally, during the NRC staff's environmental site audit, TVA provided NRC staff with records for review from its Natural Heritage Database, which included detailed occurrence information on Federally listed species throughout the TVA power service area. The NRC reviewed database records of species and habitat occurrences within a 6-mi (10-km) radius of the SQN site and found that TVA (2013j) has not identified Indiana bat hibernacula, maternity colonies, or individuals within this area.

Given the available information, the NRC staff concludes that the Indiana bat is unlikely to occur within the action area.

Snail Darter (*Percina tanasi*)

The FWS listed the snail darter as endangered in 1975 (40 FR 47505) and reclassified the species as threatened in 1984 after additional populations were identified in several Tennessee River tributaries and reservoirs (FWS 2013e). The FWS designated critical habitat for the species in the Little Tennessee River at the time of listing. However, creation of Tellico Dam destroyed the darter's entire critical habitat area, and the FWS rescinded the critical habitat designation upon reclassifying the species as threatened in 1984 (FWS undated d).

Snail darters inhabit larger creeks where they frequent sand and gravel shoal areas in low turbidity water. They are also found in deeper portions of rivers and reservoirs where current is present (Etnier and Starnes 1993). The FWS believes the snail darter originally inhabited the main stem of the Tennessee River and possibly ranged from the Holston, French Broad, Lower Clinch, and Hiwassee rivers downstream within the Tennessee drainage to northern Alabama (FWS undated d). However, impoundments have fragmented much of the species' range (Etnier and Starnes 1993). The FWS (2013e) has records of the snail darter occurring in Chickamauga Reservoir in Hamilton, Meigs, and Rhea Counties in 1976 (before the construction of SQN). TVA has not collected the species during its stream samplings of tributaries to the Tennessee River within Chickamauga Reservoir in the available data years (1995–2009) (Simmons 2010b). The NRC staff's review of records from the TVA (2013j) Natural Heritage Database also did not identify information that would suggest the species occurs in vicinity of the plant. Furthermore, the snail darters' habitat requirements make it unlikely to occur in the portion of Chickamauga Reservoir within the action area.

Given the available information, the NRC staff concludes that the snail darter is unlikely to occur within the action area.

Dromedary Pearlymussel (*Dromus dromas*)

The FWS listed the dromedary pearlymussel as endangered in 1976 (41 FR 24062). The FWS has not designated critical habitat for this species.

The dromedary pearlymussel is a medium-sized freshwater mussel with a yellowish green shell that has two sets of broken green rays. Juveniles and adults inhabit riffles on sand and gravel substrates with stable rubble within small to medium streams that have low turbidity and high to moderate gradients. Individuals have also been observed in slower waters and to depths of 5.5 m (18 ft). The species has as many as 11 glochidial (larval) hosts. The fantail darter (*Etheostoma flabellare*) is a known host, and laboratory studies indicate that the following species may also be hosts: banded darter (*E. zonale*), tangerine darter (*Percina aurantiaca*), logperch (*P. caprodes)*, gilt darter (*P. evides*), black sculpin (*Cottus baileyi*), greenside darter (*E. blennioides*), snubnose darter (*E. simoterum*), blotchside logperch (*P. burtoni*), channel darter (*P. copelandi*), and Roanoke darter (*P. roanoka*) (FWS undated a).

Dromedary pearlymussels, which were historically widespread in the Cumberland and Tennessee River systems, have been eliminated from the majority of the species' historic riverine habitat because of impoundments. Only three reproducing populations are thought to exist: one in the upper Clinch River, Tennessee; one in the Powell River, Tennessee; and one in Virginia above Norris Reservoir (NatureServe 2013a).

TVA's (2013j) Natural Heritage Database records indicate that one dromedary pearlymussel individual was identified near the mouth of Soddy Creek (approximately 2.4 mi (4 km) upstream of the action area) in a 1918 publication by A.E. Ortmann. The most recent observation of a dromedary pearlymussel in Chickamauga Reservoir occurred during a September 1983 survey; it was observed in a mussel bed near the reservoir inflow at TRM 520.0 to 520.8, approximately 35 mi (56 km) upstream of the action area (Baxter et al. 2010). In 2010, Third Rock Consultants, LLC (Third Rock 2010a) conducted a survey to document the existing mollusk community and habitat conditions in Chickamauga Reservoir near SQN in both areas that may be affected by plant operations and those that would not be affected by operations. The dromedary pearlymussel was not identified during this survey, and TVA (2013j) reports that the Chickamauga Reservoir adjacent to SQN is not suitable habitat to sustain a breeding population of the species. Table 3–20 summarizes known dromedary pearlymussel occurrences in and near the action area.

Given the available information, the NRC staff concludes that the dromedary pearlymussel is unlikely to occur within the action area.

<u>Pink Mucket (*Lampsilis abrupta*)</u>

The FWS designated the pink mucket mussel as endangered in 1976 (41 FR 24062). The FWS has not designated critical habitat for this species.

Pink muckets are medium-sized freshwater mussels with smooth, yellow to yellow-green shells and faint green rays. The species inhabits sand and gravel substrates in medium to large rivers with strong currents, and it can also survive in impounded, but flowing waters. Confirmed suitable glochidial hosts include the largemouth bass (*Micropterus salmoides*), spotted bass (*M. punctulatus*), smallmouth bass (*M. dolomieu*), and walleye (*Stizostedion vitreum*). Additionally, sauger (*S. canadense*) and freshwater drum (*Aplodinotus grunniens*) may act as hosts (FWS undated b).

Historically, this species was distributed in 25 rivers and tributaries in the Mississippi, Ohio, Cumberland, and Tennessee Rivers (NatureServe 2013c). The species is now likely extirpated from Ohio, Pennsylvania, and New York (NatureServe 2013c). It has also been mostly extirpated from Tennessee, though a few localized, but stable populations remain in the Cumberland River and the Tennessee River below Pickwick Dam (Parmalee and Bogan 1998). Occasional individuals also occupy several small- to medium-sized tributaries of large rivers including the Holston, French Broad, and Upper Clinch rivers (Parmalee and Bogan 1998). A 1963 survey identified a pink mucket mussel in the Tennessee River at Houseboat Cove of Harrison Bay State Park between TRM 477 and 483 (TVA 2013j). The location range of this record overlaps with the action area for about a 2-river-mile (3.2-river-kilometer) stretch, which means that this historic sighting could have occurred within the most downstream portion of the action area. TVA's Natural Heritage Database contains no other records indicating any more recent occurrences of the species within 6 mi (10 km) of the SQN site, and the pink mucket was not observed during a 2010 mussel survey conducted by Third Rock Consultants, LLC (Third Rock 2010a). Upstream of the action area, TVA has found the pink mucket in the vicinity of the Watts Bar Nuclear Plant site during mussel surveys in 10 data years between 1983 and 1997, though the number of specimens in a single year has never amounted to more than 10 (NRC 2013b). Additionally, a single pink mucket individual was found between TRM 526 and 527 (roughly 42 river mi upstream of the action area) in a September 2010 survey (Third Rock 2010b). Table 3–20 summarizes known pink mucket occurrences in and near the action area.

The available information (the historical sighting of one individual that may have occurred within the downstream portion of the action area) does not indicate the current-day presence of the species within the action area. However, given that the species has been consistently observed in studies in the Chickamauga Reservoir upstream of the action area, the NRC staff considered whether the species could move into the action area when attached to a host fish. Of the known and potential host species, all but the walleye occur both up and downstream of SQN (see Section 4.7), and could, thus, transport pink mucket glochidia into the action area. However, the results of the 2010 mussel survey (Third Rock 2010a) indicate that the silty substrate conditions in the action area are not suited for pink mucket. Therefore, the species, which currently does not occur in the action area, is unlikely to successfully colonize the action area if it were to be transported into it. This assumption is supported by the fact that while the species has been consistently observed in small numbers in studies upstream of the action area since the 1980s, it has not appeared in the action area.

Given the available information, the NRC staff concludes that the pink mucket is unlikely to occur within the action area.

<u>Orangefoot Pimpleback (*Plethobasus cooperianus*)</u>

The FWS listed the orangefoot pimpleback as endangered in 1976 (41 FR 24062). The FWS has not designated critical habitat for this species.

The orangefoot pimpleback is a round freshwater mussel with a thick light-brown to chestnut or dark-brown shell that grows up to 4 in. (10 cm) in size. It inhabits sand, gravel, or cobble substrates of medium to large rivers (Cummings and Mayer 1992). Its glochidial host is unknown (Mirarchi et al. 2004; Parmalee and Bogan 1998).

Historically, the species inhabited the Ohio, Wabash, Cumberland, lower Clinch, and Tennessee rivers. Within the Tennessee River, the species is believed to occur in nine Tennessee counties, including Hamilton County (FWS 2013g). The largest remaining population occurs in a short reach of the Tennessee River below Pickwick Dam (FWS 1997), which lies 133 river mi (214 river km) downstream of Chickamauga Dam. The species was not observed during Third Rock Consultants, LLC's 2010 mussel survey (Third Rock 2010a) near SQN, and TVA's Natural Heritage Database contains no records indicating the occurrence of the species within 6 mi (10 km) of the SQN site. This information suggests that the species does not occur within the action area.

The NRC also considered whether the orangefoot pimpleback glochidia could move into the action area when attached to a host fish. Glochidia could possibly attach to a host fish below Pickwick Dam (where the closest population of orangefoot pimpleback is known to occur; see Table 3–20), although the host would not be able to travel the 133 river mi (214 river km) upstream to Chickamauga Reservoir because of the occurrence of six dams (many of which do not have fish ladders) between the known population and the action area. It is also unlikely that a host fish would carry glochidia downstream because no known populations occur upstream of the action area within Chickamauga Reservoir. In 2013, the NRC evaluated the potential for the orangefoot pimpleback to occur near Watts Bar Nuclear Plant, which lies approximately 45 river mi (72 river km) upriver of SQN and found that, based on both historic and recent surveys, the species does not occur near that plant (NRC 2013b).

Given the available information, the NRC concludes that the orangefoot pimpleback is unlikely to occur within the action area.

<u>Rough Pigtoe (*Pleurobema plenum*)</u>

The FWS listed the rough pigtoe mussel as endangered in 1976 (41 FR 24062). The FWS has not designated critical habitat for this species.

The rough pigtoe is a medium-sized freshwater mussel with a yellowish brown to light brown shell with faint green rays. It inhabits sand, gravel, and cobble substrate within medium to large rivers. Its glochidial host is unknown (FWS undated c).

Historically, this species occurred in the Ohio, Cumberland, and Tennessee River drainages in nine states. Within Tennessee, the species is currently known to occur downstream of the Pickwick, Wilson, and Guntersville Dams on the Tennessee River and in the Clinch River (NatureServe 2013d). Available records indicate no historic or recent occurrences of the rough pigtoe in the action area. The species was not identified during the 2010 mussel survey near SQN (Third Rock 2010a). Additionally, TVA's Natural Heritage Database contains no records indicating the occurrence of the species within 6 mi (10 km) of the SQN site. In 2013, the NRC (2013b) evaluated the results of 15 native mussel surveys to determine the potential for the rough pigtoe to occur near Watts Bar Nuclear Plant (upstream of the action area). The NRC identified three instances of specimen collection between TRM 520.0 and 528.9 (two individuals in 1983, two individuals in 1984, and one individual in 1985). No individuals were identified in seven additional surveys of the mussel beds upstream of the action area from 1985 to 1997 or in 2010. The NRC (2013b) concluded that the rough pigtoe was no longer present in the vicinity of the Watts Bar Nuclear Plant. Thus, the potential for individuals to move into the action area from upstream is not present. Table 3–20 summarizes known rough pigtoe occurrences in and near the action area.

Given the available information, the NRC staff concludes that the rough pigtoe is unlikely to occur within the action area.

Table 3–20. Known Occurrences of Federally Listed Mussels in and Near the Action Area

Species	Upstream of the Action Area	Action Area	Downstream of the Action Area
dromedary pearlymussel	1 individual in 1918 near the mouth of Soddy Creek approx. 2.4 mi upstream (TVA 2013j) 1 individual in 1983 in mussel bed at TRM 520.0–520.8 (Baxter et al. 2010)	*No known occurrences*	*No known occurrences*
pink mucket	63 individuals over 10 data years (1983–1997) from TRM 520–529.2 (summarized in NRC 2013b) 1 individual in 2010 in mussel bed survey at TRM 526–527 (Third Rock 2010b)	1 individual in 1963 at Houseboat Cove of Harrison Bay State Park between TRM 477 and 483 (TVA 2013j)	Localized, stable population inhabits Tennessee River below Pickwick Dam (Parmalee and Bogan 1998)
orangefoot pimpleback	*No known occurrences*	*No known occurrences*	Largest remaining population of the species inhabits a short reach of the Tennessee River below Pickwick Dam (FWS 1997)
rough pigtoe	5 individuals over 3 data years (1983–1985) from TRM 520–529.2 (summarized in NRC 2013b)	*No known occurrences*	*No known occurrences*

Sources: Baxter et al. 2010; FWS 1997; NRC 2013b; Parmalee and Bogan 1998; Third Rock 2010b; TVA 2013j

Small Whorled Pogonia (*Isotria medeoloides*)

The FWS listed the small whorled pogonia as endangered in 1982 (47 FR 39827) and reclassified it as threatened in 1994 (59 FR 50852). The FWS has not designated critical habitat for this species (FWS 2013h).

The small whorled pogonia is a small, herbaceous, perennial orchid. Its primary range extends through the Atlantic seaboard states, although it also occurs at the southern end of the Appalachian chain in the Blue Ridge Mountains. The species generally grows in young and maturing stands of mixed deciduous or mixed deciduous/coniferous forests that are in second- or third-growth stages of succession. The species inhabits areas with sparse to moderate ground cover, a relatively open understory, or areas in proximity to logging roads, streams, or other features that create long-persisting breaks in the forest canopy. Throughout its range, the small whorled pogonia is associated with understories containing red maple (*Acer rubrum*) and oak species (*Quercus* spp.) (FWS 1992). Habitat destruction, disease, and predation by deer and rabbits threaten the species' continued existence (FWS 1992, 2008).

The FWS (2013h) identifies Carter and Hamilton Counties as the only Tennessee counties in which the small whorled pogonia is known or believed to occur. However, TVA has not identified the species as occurring on the SQN site (TVA 2013n), and the NRC staff did not identify any information in its review of TVA's Natural Heritage Database that would indicate historic or recent occurrences of the species within 6 mi (10 km) of the SQN site (TVA 2013f).

Given the available information, the NRC staff concludes that the small whorled pogonia is unlikely to occur within the action area.

<u>Large-Flowered Skullcap (*Scutellaria montana*)</u>

The FWS listed the large-flowered skullcap as endangered in 1986 (51 FR 22521). Subsequent discovery of additional populations led the FWS to reclassify the species as threatened in 2002 (67 FR 1662).

The large-flowered skullcap is a member of the mint family (Lamiaceae). It is a perennial herb that ranges from 12 to 20 in. (30 to 50 cm) tall. The plant flowers from mid-May to early June and produces mature fruit in June or early July (FWS 1996). Mature fruit consists of four seed-containing nutlets, which are expelled from the calyx (CPC 2010). Large-flowered skullcap is a mid- to late-successional species that typically inhabits slopes, ravines, and stream banks that are rocky, well-drained, and slightly acidic (FWS 1996).

The species is known or believed to occur in four Tennessee counties, including Hamilton County, and nine Georgia counties (FWS 2013f). The FWS (1996) reports three populations of the species in Hamilton County on private lands on White Oak Mountain, Chestnut Ridge, and Walden Ridge. Additionally, TVA manages several habitat protection areas (HPAs) that contain populations of large-flowered skullcaps (TVA 2013n):

- Chigger Point TVA HPA lies across Chickamauga Reservoir approximately 1.0 mi (0.6 km) to the east of the action area. It includes 15 ac (6 ha) of steeply wooded shoreline.
- Ware Branch Bend TVA HPA lies 2.6 mi (4.2 km) northwest of the action area. It contains 42 ac (17 ha) of steep, rocky shoreline.
- Murphy Hill TVA HPA lies 4.7 mi (7.6 km) northeast of the action area. It encompasses 194 ac (79 ha) and includes a steep bluff that runs along the river front.

In total, TVA has identified 16 populations of large-flowered skullcaps in these locations, which range from 1.0 to 6.0 mi (0.6 to 10 km) away from the action area (TVA 2013n). TVA maintains a formal monitoring program for these populations.

TVA has no records of the large-flowered skullcap occurring within the action area (TVA 2013j, 2013n). However, because the species is known to occur near the action area, the NRC staff considered whether the species could colonize habitat within the action area over time. Because the species is not mobile, colonization of the action area would occur through seed dispersal and subsequent germination in suitable habitat. Nutlets, however, are not adapted to long-distance dispersal and likely fall less than 5 m (16 ft) from the parent plant (NatureServe 2013b). Those nutlets that travel farther from being washed downslope by rainwater or carried by small animals only have a remote chance of dispersal beyond the existing population (NatureServe 2013b). Given that seeds from the nearest known population would have to travel a distance of at least 1.0 mi (0.6 km) and across Chickamauga Reservoir to occur in the action area, successful seed dispersal is unlikely.

Thus, the NRC staff concludes that the large-flowered skullcap is unlikely to occur within the action area.

<u>Virginia Spiraea (*Spiraea virginiana*)</u>

The FWS listed the Virginia spiraea as threatened in 1990 (55 FR 24241). The FWS has not designated critical habitat for this species.

The Virginia spiraea is a perennial shrub in the rose family. It grows 3 to 10 ft (0.9 to 3 m) tall and blooms from late May through July, although vegetative reproduction is more common than seed dispersal (Ogle 1992). Because of this, most occurrences are thought to represent a single genetic type, which means that there are about as many genetically distinct individuals as there are extant populations (NatureServe 2013e). The species is typically found in disturbed areas along rocky rivers and stream banks (Ogle 1992).

Historically, the species occurred within the Appalachian (Cumberland) Plateau and Blue Ridge physiographic regions of Pennsylvania and Ohio, south to Georgia and Tennessee (NatureServe 2013e). NatureServe (2013e) reports that an estimated 61 extant populations exist within seven states, and 17 of the extant populations occur in Tennessee. The FWS Recovery Plan (Ogle 1992) does not include Hamilton County in the species' historical or present range; however, the FWS's (2013i) current species profile includes Hamilton and nine other Tennessee counties as being among those where the plant is known or believed to occur. TVA has not identified the species as occurring on the SQN site (TVA 2013n), and the NRC staff did not identify any information in its review of TVA's Natural Heritage Database that would indicate historic or recent occurrences of the species within 6 mi (10 km) of the SQN site (TVA 2013j).

Given the available information, the NRC staff concludes that the Virginia spiraea is unlikely to occur within the action area.

3.8.1.3 Species and Habitats Under NMFS's Jurisdiction

As discussed in Section 3.7, Chickamauga Reservoir does not contain marine or anadromous fish species. Therefore, no species or habitats under NMFS's jurisdiction occur within the action area.

3.8.2 Species and Habitats Protected Under the Magnuson–Stevens Act

NMFS has not designated essential fish habitat in the Chickamauga Reservoir. Therefore, this section does not contain a discussion of any species or habitats protected under the Magnuson–Stevens Act.

3.9 Historic and Cultural Resources

This section discusses the cultural background and the known historic and archaeological resources found on and in the vicinity of SQN. The discussion is based on a review of recent historic and archaeological resource studies and other background information on the region surrounding SQN. In addition, a records search was performed at TDEC to obtain the most up-to-date information about historic and cultural resources in the region.

The National Historic Preservation Act of 1966, as amended (NHPA), requires Federal agencies to consider the effects of their undertakings on historic properties, and renewing the operating license of a nuclear power plant is an undertaking that could potentially affect historic properties. Historic properties are defined as resources eligible for listing in the National Register of Historic Places (NRHP). The criteria for eligibility are listed in the 36 CFR Part 60.4 and include (1) association with significant events in history; (2) association with the lives of persons significant in the past; (3) embodiment of distinctive characteristics of type, period, or construction; and (4) sites or places that have yielded, or are likely to yield, important information.

The area of potential effect (APE) is the area at the SQN site, the transmission lines up to the first substation and immediate environs that may be affected by the license renewal decision, and land-disturbing activities associated with continued reactor operations. The APE may extend beyond the immediate environs in instances in which land-disturbing maintenance and operations activities during the license renewal term could potentially have an effect.

3.9.1 Cultural Background

This section discusses the cultural history of the SQN site and the surrounding area. In addition, the cultural history of the State of Tennessee and the Tennessee River Valley has been described in other NRC EISs, including the following:

- Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 21, Regarding Browns Ferry, Units 1, 2 and 3, June 2006, and
- Final Environmental Impact Statement: Related to the Operation of Watts Bar Nuclear Plant, Unit 2 (Supplement 2, Docket Number 50-391, Tennessee Valley Authority) (NUREG-0498) May 30, 2013.

The SQN site and surrounding area are rich in cultural history and contain significant cultural resources. For 12,000 years, humans have occupied the Tennessee River valleys and surrounding areas. The record indicates prehistoric occupation of the area was approximately as follows:

- Paleo-Indian (12,000 to 8000 B.C.),
- Archaic (8000 to 1200 B.C.),
- Woodland (1200 B.C. to A.D. 1000), and
- Mississippian (A.D. 1000 to 1500) (NRC 2013b).

In addition, the prehistoric period and archaeological record in the region are described in the TVA's ER for SQN (TVA 2013n).

Spanish explorers first made contact with indigenous peoples living in the area now known as Hamilton County during the 16th century. During this time, the Cherokee were living in eastern Tennessee, western North Carolina, and northern Georgia. In the late 1700s and early 1800s, various treaties were established between the U.S. Government and the Cherokee that included lands along the Tennessee River. According to regional historians, some of the treaty land could have included the SQN site (NRC 2013b).

Euro-American settlers began moving into the region in large numbers in the early 19th century, and Hamilton County was established in 1819. Settlers staked claims for farmsteads and small port towns, and many ferry crossings were established along the Tennessee River. Because of these developments, the U.S. Government removed the Cherokee from the area in 1838, which led to the intensification of Euro-American settlement in the region (TVA 2013n). TVA was established in the 1930s, and the Chickamauga Reservoir was completed in 1940, after which the surrounding area was flooded below the 693-ft (211-m) contour level (TVA 2013n).

3.9.2 Historic and Cultural Resources

The following sources of information were used to identify historic and cultural resources on the SQN site and the surrounding area:

- TVA ER (TVA 2013n);
- environmental audit at SQN that included a cultural resources records review and a cultural resources field tour by NRC staff (NRC 2013m);
- NRC meeting with the Tennessee Historical Commission and site file query with Division of Archaeology, Tennessee Department of Environment and Conservation (NRC 2013e);
- phone call to the Tennessee Historical Commission on May 22, 2013, for additional information on the Igou Cemetery within the APE (NRC 2013l);
- scoping and consultation letters—see Appendices C and D for a complete list (NRC 2013i, 2013j);
- request for additional information (RAI) responses from TVA dated July 23, 2013 (TVA 2013f);
- NRC phone call with TVA on August 13, 2013, to clarify responses to cultural resource RAI (NRC 2013k);
- TVA ER revisions (TVA 2013c);
- TVA cultural resource compliance reports (publicly available at the Tennessee Historical Commission):
  - 2013 Phase I Cultural Resources Survey of the TVA Sequoyah Nuclear Plant, Hamilton County, Tennessee: Revised Final Report, TRC Environmental Corporation;
  - 2009 Phase I Cultural Resource Survey of the Proposed Improvements to the TVA Sequoyah Nuclear Power Plant, Hamilton County, Tennessee, prepared by TRC Environmental Corporation;
  - 2010 Phase I Cultural Resources Survey of the TVA Sequoyah Nuclear Plant, Hamilton County, Tennessee, prepared by TRC Environmental Corporation; and
  - 1973 Archaeological Investigations of the Sequoyah Nuclear Plant Area by Calabrese, Hood, and Leaf.

3.9.2.1 Cultural Resource Investigations at SQN

TVA's ER (TVA 2013n) describes all of the cultural resource investigations that have been conducted on the SQN site between 1936 and 2013 and identifies cultural resources found within the APE. The earliest TVA cultural resources surveys at what is now the SQN site occurred in 1936 and 1937, before construction of the Chickamauga Dam and reservoir. Surveys at the SQN site conducted prior to 1983 may not meet the Secretary of the Interior's Historic Preservation Professional Qualification Standards, which define the minimum education and experience required for the identification, evaluation, registration, and treatment and preservation of archaeological and historic resources.

Early surveys and literature reviews show that southern portions of the SQN site were owned by a General Samuel Igou, who established a homestead and ferry crossing connecting roads on the east and west banks of the Tennessee River near the SQN site. The 1936 TVA cultural resource investigation confirmed that there was no active ferry at the time of the survey. A family cemetery was also established by Igou on what is now the SQN site. Today, TVA maintains the Igou Cemetery and allows access only by special request. In addition, the McGill Cemetery was identified in the northern portion of the SQN site during the mid-1930s surveys. All 11 graves in the McGill Cemetery were subsequently relocated to a nearby cemetery across the river, prior to 1983. Early surveys also revealed that a Union Army camped in this area during the Civil War (TVA 2013n).

In 1937, TVA surveyed properties in the SQN area to generate a land acquisition map for the Chickamauga Dam and reservoir. The survey generated a land map identifying public and private roads, structures, fields, orchards, fences, property boundaries, and cemeteries. At least 14 residences and 2 cemeteries were identified within what are now the SQN site boundaries. In 1938, TVA recorded the names and location of each burial. These cemetery reports were the last cultural resource investigations involving the SQN site until 1973, when surveys were conducted for the construction of SQN (TVA 2013n). These surveys confirmed the findings from the earlier surveys that identified the Igou and McGill Cemeteries and Igou ferry crossing and homestead.

The most recent cultural resource investigations were conducted in 2009 for a proposed SQN steam generator replacement project and in 2010 in preparation for the license renewal of SQN Units 1 and 2. The 2009 investigation determined that no cultural resources would be affected by the proposed steam generator replacement project, as the affected areas had been extensively disturbed by the construction of SQN (TVA 2013n). The 2010 investigation, which surveyed the entire SQN site, reported one new archaeological site (Site 40HA549) and three isolated finds (TVA 2013n). Site 40HA549 was characterized by two unbroken Early or Middle Archaic projectile points and was determined ineligible for listing in the National Register of Historic Places (NRHP); the Tennessee Historical Commission concurred with this finding (TVA 2013n). In addition, the 2010 survey confirmed the condition of previously recorded archaeological sites on the SQN property. In 2013, TVA revised its 2010 survey of SQN property to correct information related to new information about Site 40HA22, which is discussed below (TVA 2013c).

3.9.2.2 Cultural Resources Located within SQN

Site 40HA20 was first recorded in 1936 and was described as a Late Woodland or Early Mississippian mound complex. Cultural resource investigations completed in 1973 documented that Site 40HA20 had been destroyed by the construction of SQN Unit 1 and Unit 2. The 2010 cultural resources investigation confirmed that Site 40HA20 was destroyed during construction (TVA 2013n).

Site 40HA22 was first recorded and tested in 1913. It was first described as an undisturbed mound on the SQN site measuring 52 ft (16 m) in diameter and 7.5 ft (2.3 m) in height with midden materials documented in the surrounding cultivated field. Early excavation into the top of the mound encountered eight human burials, with the disturbed remnants of a ninth found to the side of the mound. In 1936, the mound was still visible and ceramic fragments were noted on the surface. Cultural resource investigations completed in 1973 documented that Site 40HA22 had been destroyed by the construction of SQN Units 1 and Unit 2 (TVA 2013n). The 2010 cultural resources investigation confirmed that Site 40HA22 was destroyed during construction (TVA 2013n). However, during the April 2013 NRC environmental audit, Site 40HA22 was found to be partially intact and incorrectly identified as within the SQN property boundary (NRC 2013k). In September 2013, after discussion with the NRC, TVA reopened Section 106 consultation with the Tennessee State Historic Preservation Office (SHPO) and submitted revisions to its previous 2010 cultural resource survey and an updated site form to the Tennessee Division of Archaeology, the keeper of archaeological records for the State of Tennessee (TVA 2013m). TVA also reinitiated consultation with tribes (TVA 2013n). The mound has been reassessed to be approximately 30 ft (9 m) in diameter with a depression several feet across and likely to include human remains (TRC 2013). Fire-cracked rock, a byproduct of the use of hot rocks for cooking and heating purposes, and chert artifacts were also identified surrounding the mound (TRC 2013). There has been no formal eligibility determination of the site for the NRHP, although TVA believes the site is eligible (TVA 2013c).

Site 40HA549 was found and recorded during the 2010 cultural resources investigation and is described as a prehistoric period short-term open habitation. Two unbroken Early or Middle Archaic projectile points and one small quartz flake were found during shovel tests. Three isolated finds were also discovered. TVA determined the site and isolates were ineligible for listing in the NRHP; the Tennessee Historical Commission concurred in May 2010 (TVA 2013n).

Site HS-2, identified during the 2010 cultural resources investigation, is the previously mentioned Igou Cemetery (TVA 2013n). TVA determined Site HS-2 to be ineligible for listing in the NRHP; the Tennessee Historical Commission concurred in May 2010 (TVA 2013n). The 2010 cultural resources investigation confirmed that all the burials at the former McGill Cemetery site identified before construction of SQN were relocated to the McGill Cemetery No. 2 across the Tennessee River. The NRC staff contacted the Tennessee Historical Commission to discuss the eligibility determinations for sites within the APE. The Tennessee Historical Commission confirmed Site HS-2 (Igou Cemetery) was not eligible for listing in the NRHP (NRC 2013l).

In summary, the NRC performed a confirmatory analysis and queried the Division of Archaeology of the Tennessee Department of Environment and Conservation to identify cultural resources present at the SQN site. Table 3–21 lists the cultural resources recorded within the SQN site. Section 4.9.1 provides a status on cultural resources consultation. No cultural resources were identified as being listed in the NRHP within the APE; however, Site 40HA22 is located near the SQN site boundary and is potentially eligible for listing in the NRHP. Site 40HA22 is located on TVA-controlled lands and, as such, will be treated by TVA staff as eligible for the NRHP (TVA 2013c). On September 23, 2013, the Tennessee SHPO concurred that there are no sites eligible for listing on the NRHP within the SQN plant boundary (TVA 2013l). All human remains, either historic or ancient, in the State of Tennessee are protected by Tennessee State law. The Igou Cemetery (HS-2) is located in the southern area of the SQN site and is protected by several State statutes. The Tennessee Code Annotated (T.C.A.) 39-17-311 is the primary statute providing protection for the historic cemetery, which is maintained by TVA.

Table 3–21. Cultural Resources Within the SQN Site

Site	Located on the SQN Site	Description	NRHP
40HA20	Yes	Late Woodland/Early Mississippian Mound Complex	Destroyed/Not Eligible
40HA22	No	Burial Mound	Potentially Eligible
40HA549	Yes	Two Complete Early/Middle Archaic Projectile Points and a Quartz Flake	Not Eligible
HS-2	Yes	Igou Cemetery (Historic)	Not Eligible/Protected by State Statutes

3.10 Socioeconomics

This section describes current socioeconomic factors that have the potential to be directly or indirectly affected by changes in operations at SQN. SQN, and the communities that support it, can be described as a dynamic socioeconomic system. The communities supply the people, goods, and services required to operate the nuclear power plant. Power plant operations, in turn, supply wages and benefits for people and dollar expenditures for goods and services. The measure of a community's ability to support SQN operations depends on its ability to respond to changing environmental, social, economic, and demographic conditions.

3.10.1 Power Plant Employment and Expenditures

The socioeconomic region of influence (ROI) is defined by the areas where SQN employees and their families reside, spend their income, and use their benefits, thus affecting the economic conditions of the region. SQN employs a permanent workforce of approximately 1,141 employees (TVA 2013n). Approximately 84 percent of SQN employees reside in a two-county area in southeastern Tennessee dominated by Hamilton County and Chattanooga, including Rhea County. Most of the remaining 16 percent of the workforce are spread among 24 other counties in Alabama, Georgia, and Tennessee, and among five other states, with numbers ranging from 1 to 30 employees per county (TVA 2013n). Given the residential locations of SQN employees, the most significant effects of continued plant operations are likely to occur in Hamilton and Rhea Counties. The focus of the socioeconomic impact analysis in this SEIS is, therefore, on the impacts of continued SQN operations on these two counties, also termed the ROI. Table 3–22 summarizes the SQN workforce geographic distribution.

SQN purchases goods and services to facilitate its operations. While specialized equipment and services are procured from a wider region, some proportion of the goods and services used in plant operations are acquired from within the ROI. These transactions fuel a portion of the local economy, as jobs are provided and additional local purchases are made by plant suppliers.

Refueling outages at SQN typically have occurred at 18-month intervals. During refueling outages, site employment typically increases by an average of 750 temporary contract workers for approximately 30 to 33 days (TVA 2013n). Outage workers are drawn from all regions of the country; however, the majority would be expected to come from Tennessee, Georgia, and other southeastern states.

Table 3–22. 2010 SQN Employee Residence by County

County/State	Number of Employees	Percentage of Total
Hamilton, TN	893	78
Rhea, TN	70	6
Other TN (17 other counties)	102	9
Alabama (3 counties)	18	2
Georgia (4 counties)	50	4
Other States (5 other states)	8	1
Total	**1,141**	**100**

Source: TVA 2013n. Includes TVA and permanent contract workers.

3.10.2 Regional Economic Characteristics

This section presents information on employment and income in the ROI. The two-county SQN ROI is predominantly rural. Hamilton County is home to Chattanooga, a regional transportation hub in southeast Tennessee. Nearly 26 percent of the county is urbanized (USDA 2013). Agricultural and forested land makes up the majority of the land use In Rhea County, and urban lands make up about 7 percent of the total county land area (USDA 2013).

3.10.2.1 Employment and Income

From 2000 to 2012, the civilian labor force in the SQN ROI increased 3.5 percent to just over 180,000. The number of employed persons declined by about 1 percent over the same period, to over 166,000. Consequently, the number of unemployed people in the ROI has increased nearly 130 percent in the same period, to over 13,900, or about 7.7 percent of the current workforce – up from 3.5 percent in 2000 (BLS 2013).

In 2011, the health care and social assistance industry made up the largest sector of the economy in terms of employment (10.7 percent), followed by manufacturing (10.1 percent), retail trade (9.6 percent), accommodations and food services (8.1 percent), and finance and insurance industry (7.7 percent) (BEA 2013). A list of selected major employers in the ROI is given in Table 3–23. SQN's 1,141 full-time employees are included in the TVA total, which is the third largest employer in the ROI, as shown in the table.

Estimated income information for the SQN ROI and Tennessee is presented in Table 3–24. According to the U.S. Census Bureau's (USCB's) 2007–2011 American Community Survey (ACS) 5-Year Estimates, people living in Hamilton County had median household and per capita incomes above the State average, while Rhea County had median household and per capita incomes lower than the State average. The same trend is evident for families and individuals living below the official poverty level. The relative lack of economic development in rural Rhea County contributes to higher than average poverty and lower than average median incomes compared to the more economically developed Chattanooga in Hamilton County.

Table 3–23. Major Employers of the SQN ROI in 2012

Employer	Industry	Full-Time Employees
Hamilton County Dept. of Education	Elementary & Secondary Schools	4,480
BlueCross BlueShield of Tennessee	Health Care Financing	4,282
Tennessee Valley Authority	Utility – Electric Service	4,180
Erlanger Health System	Hospital	3,176
Memorial Health Care System	Health Care	3,171
Unum	Insurance	2,800
McKee Foods Corporation	Mfr. Cakes & Cookies	2,650
Volkswagen Chattanooga	Mfr. Automobiles	2,459
LA-Z-Boy Chair Company	Sofas, Sleepers, Recliners	2,350
City of Chattanooga	Government	2,251
Amazon.com.dedc LLC	Distribution Center	1,879
Hamilton County Government	Government	1,763
Pilgrim's Pride Corporation	Poultry Slaughtering & Processing	1,500
CIGNA HealthCare	Health Services	1,350
Astec Industries, Inc.	Mfr. Asphalt & Construction Equipment	1,348
Roper Corporation	Mfr. Cooking Products	1,200
The University of TN at Chattanooga	University	1,153
Parkridge Medical Center, Inc.	Healthcare – Hospital	1,135

Sources: CACC 2013; SEIDA 2012

Table 3–24. Estimated Income Information for the SQN ROI in 2011

	Hamilton	Rhea	Tennessee
Median household income (dollars)[a]	45,826	36,934	43,989
Per capita income (dollars)[a]	26,924	17,860	24,197
Individuals living below the poverty level (percent)	15.9	20.3	16.9
Families living below the poverty level (percent)	12.0	14.7	12.7

[a] In 2011 inflation adjusted dollars

Source: USCB 2013b

3.10.2.2 Unemployment

Unemployment rates in the SQN ROI have mirrored State and national trends from 2007 to 2012. Table 3–25 illustrates the unemployment rates for the SQN ROI counties compared to State and SQN ROI rates.

The effects of the recent economic recession (often referred to as the Great Recession that began in December 2007 and lasted to June 2009) on employment are visible in the two counties, the ROI, and the State. Rhea County has had consistently higher unemployment rates than its urban neighbor, Hamilton County, through this period. As a whole, the ROI experienced slightly less unemployment than the State during the recent economic recession.

Table 3–25. 2007−2012 Annual Unemployment Rates in the SQN ROI

ROI Counties	2007	2008	2009	2010	2011	2012
Hamilton	4.1	5.8	9.1	8.6	8.2	7.5
Rhea	6.1	8.1	13.7	12.5	11.6	10.5
ROI	4.3	6.0	9.5	8.9	8.5	7.7
Tennessee	4.9	6.7	10.5	9.8	9.2	8.0

Source: TDLWD 2013; for consistency all values not seasonally adjusted.

3.10.3 Demographic Characteristics

According to the 2010 Census, an estimated 472,684 people lived within 20 mi (32 km) of SQN, which equates to a population density of 376 persons per square mile (TVA 2013n). This translates to a Category 4, "least sparse" population density using the generic environmental impact statement (GEIS) measure of sparseness (greater than or equal to 120 persons per square mile within 20 mi). An estimated 1,080,361 people live within 50 mi (80 km) of SQN with a population density of 138 persons per square mile (TVA 2013n). Because Chattanooga is located within 50 mi (80 km) of SQN, this translates to a Category 3 density, using the GEIS measure of proximity (one or more cities with 100,000 or more persons and less than 190 persons per square mile within 50 mi) (NRC 2013d). Therefore, SQN is located in a high population area based on the GEIS sparseness and proximity matrix.

Table 3–26 shows population projections and percent growth from 1970 to 2060 in the two-county SQN ROI. The population in the ROI has increased over the previous two decades (2000 and 2010). Based on State forecasts (UT 2012), the population is expected to continue to increase at a moderate rate.

Table 3–26. Population and Percent Growth in SQN ROI Counties 1970–2010, 2012 (estimated), and Projected for 2020–2060

	Hamilton County		Rhea County	
Year	Population	Percent growth	Population	Percent growth
1970	254,236	–	17,202	–
1980	287,740	13.2	24,235	40.9
1990	285,536	-0.8	24,344	0.4
2000	307,910	7.8	28,400	16.7
2010	336,463	9.3	31,809	12.0
2012	**345,545**	**2.7**	**32,247**	**1.4**
2020	352,163	4.7	35,062	10.2
2030	355,597	1.0	37,252	6.2
2040	353,136	-0.7	38,843	4.3
2050	354,605	0.4	40,517	5.1
2060	355,092	0.1	42,248	4.6

Sources: Population data for 1970–1990 (State of Tennessee 1996); population data for 2010, population data for 2000–2010 and projections for 2020–2040 by Tennessee State Data Center (UT 2012); 2012 (USCB 2013f); 2050–2060 calculated.

The 2010 Census demographic profile of the two-county ROI population is presented in Table 3–27. According to the 2010 Census, minorities (race and ethnicity combined) comprised 26.3 percent of the total two-county population. The minority population is mostly comprised of Black or African-American residents.

Table 3–27. Demographic Profile of the Population in the SQN Socioeconomic Region of Influence in 2010

	Hamilton	Rhea	ROI
Total Population	336,463	31,809	368,272
Race (percent of total population, not Hispanic or Latino)			
White	72.0	92.1	73.7
Black or African-American	20.1	1.9	18.5
American Indian & Alaska Native	0.2	0.4	0.3
Asian	1.7	0.4	1.6
Native Hawaiian & Other Pacific Islander	0.0	0.0	0.0
Some other race	0.1	0.1	0.1
Two or more races	1.4	1.3	1.4
Ethnicity			
Hispanic or Latino	14,993	1,187	16,180
Percent of total population	4.5	3.7	4.4
Minority population (including Hispanic or Latino ethnicity)			
Total minority population	94,309	2,506	96,815
Percent minority	28.0	7.9	26.3

Source: USCB 2013e

3.10.3.1 Transient Population

Within 50 mi (80 km) of SQN, colleges and recreational opportunities attract daily and seasonal visitors who create a demand for temporary housing and services. In 2012, approximately 42,032 students attended colleges and universities within 50 mi (80 km) of SQN (NCES 2013a).

Based on the 2007−2011 ACS estimates, approximately 27,650 seasonal housing units are located within 50 miles (80 kilometers) of SQN. Of those, 2,517 are located in the SQN two-county ROI. Table 3–28 presents information about seasonal housing for the counties located all or partly within 50 mi (80 km) of SQN.

Table 3–28. 2007-2011 Estimated Seasonal Housing in Counties Located Within 50 Mi of SQN

County [(a)]	Total Housing Units	Vacant Housing Units: for Seasonal, Recreational, or Occasional Use	Percent
Alabama			
DeKalb	30,942	924	3.0
Jackson	24,794	569	2.3
County Subtotal	**55,736**	**1,493**	**2.7**
Georgia			
Catoosa	26,473	293	1.1
Chattooga	10,990	127	1.2
Dade	7,242	232	3.2
Fannin	16,156	4,726	29.3
Floyd	40,444	166	0.4
Gilmer	16,422	3,132	19.1
Gordon	22,095	206	0.9
Murray	15,973	115	0.7
Walker	29,942	693	2.3
Whitfield	39,420	229	0.6
County Subtotal	**225,157**	**9,919**	**4.4**
North Carolina			
Cherokee	17,360	4,517	26.0
Tennessee			
Bledsoe	5,691	521	9.2
Bradley	41,208	169	0.4
Coffee	23,277	212	0.9
Cumberland	27,743	1,955	7.0
Franklin	18,635	1,050	5.6
Grundy	6,427	310	4.8
Hamilton	***150,379***	***1,750***	***1.2***
Loudon	21,467	295	1.4
McMinn	23,270	389	1.7
Marion	12,962	290	2.2
Meigs	5,601	508	9.1
Monroe	20,581	1,118	5.4
Polk	7,962	391	4.9
Rhea	***14,266***	***767***	***5.4***
Roane	25,604	642	2.5
Sequatchie	6,257	230	3.7
Van Buren	2,660	210	7.9
Warren	17,754	161	0.9
White	11,449	753	6.6
County Subtotal	**443,193**	**11,721**	**2.6**

County [(a)]	Total Housing Units	Vacant Housing Units: for Seasonal, Recreational, or Occasional Use	Percent
Total	**741,446**	**27,650**	**3.7**

[(a)] Counties within 50 mi (80 km) of SQN with at least one block group located within the 50-mi (80-km) radius. A block group is defined by the U.S. Census Bureau as a statistical division generally containing 600 to 3,000 people.

Source: USCB 2013a

3.10.3.2 Migrant Farm Workers

In the 2002 Census of Agriculture, farm operators were asked for the first time whether or not they hired migrant workers. Migrant farm workers are individuals whose employment requires travel to harvest agricultural crops. These workers may or may not have a permanent residence. Some migrant workers follow the harvesting of crops, particularly fruit, throughout rural areas of the United States. Others may be permanent residents near SQN and travel from farm to farm harvesting crops.

Migrant workers may be members of minority or low-income populations. Because they travel and can spend a significant amount of time in an area without being actual residents, migrant workers may be unavailable for counting by census takers. If uncounted, these workers would be “underrepresented” in USCB minority and low-income population counts.

Table 3–29 supplies information about migrant farm workers and temporary farm labor (less than 150 days) within 50 mi (80 km) of SQN. Approximately 9,400 farm workers were hired to work for less than 150 days and were employed on 3,557 farms within 50 mi (80 km) of SQN. The county with the highest number of temporary farm workers (1,190) on 460 farms was DeKalb County, Alabama (USDA 2012). A total of 312 farms, in the 50-mi radius of SQN, reported hiring migrant workers in the 2007 Census of Agriculture. Warren County, Tennessee, reports the most farms with migrant farm labor (64 farms) (USDA 2012).

Table 3–29. Migrant Farm Workers and Temporary Farm Labor in Counties Located Within 50 Mi of SQN

	Number of Farms With Hired Farm Labor [(b)]	Number of Farms Hiring Workers for Less Than 150 Days [(b)]	Number of Farm Workers Working for Less Than 150 Days [(b)]	Number of Farms Reporting Migrant Farm Labor [(b)]
Alabama				
DeKalb	550	460	1,190	27
Jackson	261	229	594	12
County Subtotal	**811**	**689**	**1,784**	**39**
Georgia				
Catoosa	65	55	117	5
Chattooga	45	42	77	1
Dade	44	34	107	2
Fannin	39	30	80	1
Floyd	127	96	310	2
Gilmer	118	82	184	16
Gordon	146	107	298	2
Murray	48	33	115	3
Walker	108	81	D	14
Whitfield	78	59	184	3
County Subtotal	**818**	**619**	**1,472**	**49**
North Carolina				
Cherokee	64	60	199	7
Tennessee				
Bledsoe	148	121	395	12
Bradley	196	155	457	16
Coffee	184	150	481	9
Cumberland	154	140	431	9
Franklin	226	187	518	18
Grundy	80	71	254	5
Hamilton	***100***	***86***	***133***	***3***
Loudon	151	124	263	12
McMinn	199	171	443	21
Marion	81	73	202	3
Meigs	81	76	D	0
Monroe	175	145	387	22
Polk	44	35	79	4
Rhea	***63***	***59***	***231***	***7***
Roane	98	82	178	1
Sequatchie	33	26	54	1
Van Buren	30	29	D	1
Warren	361	286	1,017	64
White	203	173	397	9
County Subtotal	**2,607**	**2,189**	**5,920**	**217**
Total	**4,300**	**3,557**	**9,375**	**312**

[(a)] Counties within 50 mi (80 km) of SQN with at least one block group located within the 50-mi radius

[(b)] Table 7. Hired farm Labor—Workers and Payroll: 2007

[D] = Data not disclosed by USDA

Source: 2007 Census of Agriculture — County Data (USDA 2012)

3.10.4 Housing and Community Services

This section presents information regarding housing and local public services, including education and water supply.

3.10.4.1 Housing

The socioeconomic ROI is dominated by Hamilton County, which is part of the Chattanooga metropolitan area. The size of the Chattanooga area weighs heavily on the housing statistics, and Rhea County is considerably more rural and less like the ROI averages in terms of housing statistics. Table 3–30 lists the total number of occupied and vacant housing units, vacancy rates, and median value in the two-county ROI. Based on USCB's 2007–2011 ACS 5-Year Estimates, there were nearly 165,000 housing units in the socioeconomic region, of which nearly 97,000 were occupied. The median values of owner-occupied housing units in the ROI range from $151,000 in Hamilton County to about $104,000 in Rhea County. The vacancy rate also varied considerably between the two counties, from 10.9 percent in Hamilton County to 16.2 percent in Rhea County (USCB 2013c).

Table 3–30. Housing in the SQN ROI (2007−2011, 5-year estimate)

	Hamilton County	Rhea County	ROI
Total housing units	150,379	14,266	164,645
Owner occupied units	88,103	8,598	96,701
Median value (dollars)	151,000	103,800	146,910
Owner vacancy rate (percent)	2.4	0.9	2.3
Renter occupied units	45,927	3,351	49,278
Median rent (dollars/month)	695	536	684
Rental vacancy rate (percent)	9.8	7.4	9.6
Total vacant housing units	16,349	2,317	18,666
Percent vacant	10.9	16.2	11.3

Source: USCB 2013c

3.10.4.2 Education

Three public school districts serve Hamilton and Rhea counties: the Hamilton County Schools, Rhea County Schools, and the Dayton School District (NCES 2013b). Table 3–31 lists the school system enrollments based on National Center for Education Statistics (NCES) data.

Table 3–31. Public School System Statistics, 2010–11 School Year

County	District	Schools	Total Enrollment
Hamilton	Hamilton County	76	42,589
Rhea	Rhea County	7	4,303
Rhea	Dayton	1	777
ROI	Total	84	47,669

Source: NCES 2013b

3.10.4.3 Public Water Supply

The SQN ROI includes Hamilton and Rhea counties, which is where 84 percent of SQN workers reside. The discussion of public water supply systems is limited to major municipal water systems in the local area. Table 3–32 provides information on municipal water supply systems located near SQN. In aggregate, these systems are operating at approximately 72 percent of design capacity. The source of potable water at SQN is GW supplied by the Hixson Utility District water system.

Table 3–32. Local Public Water Supply Systems

Water System	Capacity (mgd)	Usage (mgd)	Population Served
Eastside Utility District	15.31	9.90	46,011
Hixson Utility District	9.22	7.74	56,117
Mowbray Mountain Utility District	0.46	0.42	3,938
Sale Creek Utility District	0.37	0.23	1,730
Savannah Valley Utility District	5.60	2.44	19,338
Signal Mountain Water System	2.34	0.94	7,869
Soddy-Daisy–Falling Water Utility District	5.97	1.81	10,840
Tennessee-American Water Company	45.14	37.38	179,191
Union Fork-Bakewell Utility District	0.80	0.48	4,372
Walden Ridge Utility District	2.10	1.58	7,037

Source: TVA 2013n

3.10.5 Tax Revenues

Per Section 13 of the TVA Act of 1933, as amended, 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 2013n). 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 this amount, 30 percent 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 is allocated to counties based on each county's share of TVA-owned land in the State. The payments in lieu of taxes received by Hamilton County, Chattanooga, and Soddy-Daisy are provided in Table 3–33. TVA is exempt from sales and use taxes per Section 13 of the TVA Act of 1933, as amended. TVA indicates that the portion of its total payments in lieu of taxes attributable to SQN is 7 percent (TVA 2013n).

Table 3–33. 2008−2011 Payments in Lieu of Taxes Attributable to SQN ($)

Government	2008	2009	2010	2011
City of Chattanooga	104,097	107,431	122,793	125,552
City of Soddy-Daisy	7,493	7,740	8,879	9,083
Hamilton County	187,439	196,120	225,500	230,552
ROI	299,029	311,290	357,172	365,187

Source: Based on TVA 2013n

3.10.6 Local Transportation

The area surrounding SQN is largely rural. Highway access to Hamilton County and SQN from population centers is via US-27, a principal arterial originating in Chattanooga and paralleling the Chickamauga Reservoir and the Tennessee River through Hamilton and Rhea Counties. The Sequoyah Access Road from Soddy-Daisy provides primary access to the site for SQN employees. The Chattanooga area is connected by interstate freeways to the larger metropolitan areas of Atlanta, Georgia, Birmingham, Alabama, Nashville, Tennessee, and Knoxville, Tennessee.

The ROI is served by CSX and Norfolk Southern freight rail services, and a Norfolk Southern spur line provides rail access to the SQN site (TVA 2013n). Freight also is transported by navigable waterway on the Tennessee River between Knoxville, Tennessee, and the confluence of the Tennessee and Ohio rivers, via a system of locks and dams (TVA 2013n). The SQN site is served by a barge slip on the Chickamauga Reservoir.

Table 3–34 lists commuting routes to the SQN site and average annual daily traffic (AADT) volume values. The AADT values represent traffic volumes for a 24-hour period factored by both the day of the week and the month of the year.

Table 3–34. Major Commuting Routes in the Vicinity of SQN: 2012 AADT

Roadway and Location	Average Annual Daily Traffic (AADT) [(a)]
Sequoyah Access Rd. W of Hixson Pike	2,765
Iguo Ferry Rd. @ TVA Access Rd.	917
SR 319 Hixson Pike N of Sequoyah Access Rd.	940
SR 319 Hixson Pike S of Sequoyah Access Rd.	3,034
Hamby Rd. N of Lakesite	704
SR 319 Hixson Pike @ Trail Ridge Rd.	4,261
Sequoyah Access Rd. E of Trail Ridge Rd.	6,714
Sequoyah Access Rd. S of US 27 Exit	11,553

(a) All AADT values represent traffic volume during the average 24-hour day during 2012.

Source: TDOT 2013

3.11 Human Health

3.11.1 Radiological Exposure and Risk

As required by NRC regulation 10 CFR 20.1101, SQN has a radiation protection program designed to protect onsite personnel, including TVA employees, contractor employees, visitors, and offsite members of the public from radiation and radioactive material generated at SQN.

The radiation protection program is extensive and includes, but is not limited to, the following:

- organization and administration (i.e., Radiation Protection Manager who has overall control of the program and having trained and qualified workers),
- implementing procedures,
- ALARA program to minimize dose to workers and members of the public,
- dosimetry program (i.e., measuring of radiation dose to plant workers),
- radiological controls (i.e., protective clothing, shielding, filters, respiratory equipment, and individual work permits with specific radiological requirements),
- radiation area entry and exit controls (i.e., locked or barricaded doors, interlocks, local and remote alarms, personnel contamination monitoring stations),
- posting of radiation hazards (i.e., signs and notices alerting plant personnel of potential hazards),
- record keeping and reporting (i.e., documentation of worker dose and radiation survey data),
- radiation safety training (i.e., classroom training and use of mockups to simulate complex work assignments),
- radioactive effluent monitoring management (i.e., control and monitoring of radioactive liquid and gaseous effluents released into the environment),
- radioactive environmental monitoring (i.e., sampling and analysis of environmental media such as air, water, vegetation, food crops, direct radiation, and milk, to measure the levels of radioactive material in the environment that may affect human health), and
- radiological waste management (i.e., control, monitoring, processing, and disposal of radioactive solid waste).

Regarding the radiation exposure to SQN personnel, the NRC staff reviewed the data contained in NUREG-0713, *Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities 2011: Forty-Fourth Annual Report (NUREG-0713, Volume 33*) (NRC 2013f). This report, which was the most recent available at the time of this review, summarizes the occupational exposure data through 2011 that are maintained in the NRC's Radiation Exposure Information and Reporting System (REIRS) database. Nuclear power plants are required by 10 CFR 20.2206 to report their occupational exposure data to the NRC annually.

NUREG-0713 calculates a 3-year average collective dose per reactor for all nuclear power reactors licensed by the NRC. The 3-year average collective dose is one of the metrics that the NRC uses in the Reactor Oversight Program to evaluate the effectiveness of the licensee's ALARA program. Collective dose is the sum of the individual doses received by workers at a facility licensed to use radioactive material over a one year time period. Based on the data for operating pressurized-water reactors (PWRs) like those at SQN, the average annual collective dose per reactor was 59.71 person-rem. In comparison, SQN had a reported annual collective dose per reactor of 55.52 person-rem.

In addition, as reported in NUREG-0713, for 2011, no worker at SQN received an annual dose greater than 0.5 rem (0.005 Sv), which is well below the NRC occupational dose limit of 5.0 rem (0.05 Sv) in 10 CFR 20.1201.

3.11.2 Chemical Hazards

The use, storage, and discharge of chemicals, biocides, and sanitary wastes, as well as minor chemical spills are regulated by State and Federal environmental agencies. Chemical hazards to plant workers resulting from continued operations and refurbishment associated with license renewal are expected to be minimized by the applicant's implementing good industrial hygiene practices as required by permits and Federal and State regulations. Plant discharges of these chemical and sanitary wastes are monitored and controlled as part of the plant's NPDES permit process to minimize impacts to the public and the environment. In addition, proposed changes in the use of cooling water treatment chemicals would require review by the plant's NPDES permit-issuing authority and possible modification of the existing NPDES permit, including examination of the human health effects of the change. The GEIS concluded that the impacts from these chemical and sanitary wastes, when released within the limits specified in the NPDES permit, would be SMALL and classified the issue as Category 1 (NRC 2013c).

The use, storage, and discharge of chemicals and sanitary wastes at SQN are controlled in accordance with site and fleet chemical control procedures and site-specific chemical spill prevention plans. SQN's Spill Prevention, Control, and Countermeasures (SPCC) Plan serves as the site's hazardous waste contingency plan. Chemical wastes are controlled and managed in accordance with SQN's waste management procedure. These plant procedures and plans are designed to prevent and minimize the potential for a chemical or hazardous waste release that could affect workers, members of the public, and the environment (TVA 2013n).

3.11.3 Microbiological Hazards

Microbiological hazards associated with nuclear plant cooling operations and thermal discharge include thermophilic microorganisms such as enteric pathogens (*Salmonella* spp., *Shigella* spp., and *Pseudomonas aeruginosa*), thermophilic fungi, bacteria (*Legionella* spp.), and the free-living amoeba (*Naegleria fowleri*). The presence of these microorganisms could result in adverse effects to the health of nuclear power plant workers in plants that use cooling towers and to the health of the public where thermal effluents discharge into cooling ponds, lakes, canals, or rivers.

3.11.3.1 Background Information on Microorganisms of Concern

Salmonella typhimurium and *S. enteritidis* are two species of enteric bacteria that cause salmonellosis, which is more common in summer than in winter. Salmonellosis is transmitted through contact with contaminated human or animal feces and may be spread through water transmission or contact with food or infected animals (CDC 2013d). The bacteria grow at temperatures ranging from 77 to 113 °F (25 to 45 °C), have an optimal growth temperature around human body temperature (98.6 °F (37 °C)), and can survive extreme temperatures as low as 41 °F (5 °C) and as high as 122 °F (50 °C) (Oscar 2009). Research studies examining the persistence of *Salmonella* spp. outside of a host found that the bacteria can survive for several months in water and in aquatic sediments (Moore et al. 2003).

Shigellosis infections are caused by the transmission of *Shigella* spp. from person to person through contaminated feces and unhygienic handling of food. Like salmonellosis, infections are more common in summer than in winter (CDC 2013d). The bacteria grow at temperatures between 77 and 99 °F (25 and 37 °C) and can survive temperatures as low as 41 °F (5 °C) (PHAC 2010).

Pseudomonas aeruginosa can be found in soil, hospital respirators, water, sewage, and on the skin of healthy individuals. It is most commonly linked to infections transmitted in healthcare settings. It is a waterborne pathogen, and infections from exposure to *P. aeruginosa* in water can lead to development of mild respiratory illness (CDC 2013c). These bacteria have an optimal growth temperature of 98.6 °F (37 °C) and can survive in temperatures as high as 107.6 °F (42 °C) (Todar 2004).

Legionella spp. infections result in legionellosis (e.g., Legionnaires' disease), which manifests as a dangerous form of pneumonia or an influenza-like illness. Legionellosis occurrences vary by season and geographic location; mid-Atlantic states report the highest numbers of cases during summer and early fall (CDC 2011). *Legionella* spp. thrive in aquatic environments as intracellular parasites of protozoa and are only infectious in humans through inhalation contact from an environmental source (CDC 2013a). Conditions that favor *Legionella* spp. growth are stagnant water between 95 and 115 °F (35 and 46 °C), although the bacteria can grow at temperatures as low as 68 °F (20 °C) and as high as 122 °F (50 °C) (OSHA 1999).

The free-living amoeba *Naegleria fowleri* prefers warm freshwater habitats and is the causative agent of human primary amoebic meningoencephalitis. Infections occur when *N. fowleri* penetrate the nasal tissue through direct contact with water in warm lakes, rivers, or hot springs and migrate to the brain tissues (CDC 2013b). This free-swimming amoeba is rarely found in water temperatures below 95 °F (35 °C), and infections rarely occur at those temperatures (Tyndall et al. 1989).

3.11.3.2 Studies of Microorganisms in Cooling Towers

A 1981 study (Tyndall 1982) found pathogenic *Naegleria fowleri* in heated cooling water at 2 of 11 nuclear power plant sites and infectious *Legionella* spp. at 7 of the 11 sites. The concentrations of these organisms at these sites increased less than 10-fold in heated waters relative to source water. Tyndall's (1982) recommendations for disease prevention include the use of protective devices for plant personnel in close contact with cooling water sources known to contain infectious microorganisms.

In another study, Tyndall (1983) examined the distribution and abundance of *Legionella* spp. and *N. fowleri* near large industrial cooling towers. *Legionella* spp. were detected at low abundances in air discharged from cooling towers and in some upwind and downwind air samples during high-wind events. *N. fowleri* were detected but were not pathogenic. Tyndall (1983) concludes that industrial hygiene measures to limit plant worker exposure during maintenance of cooling water systems may be appropriate.

A more recent study (Berk et al. 2006) examined 40 natural aquatic environments and 40 cooling towers to determine the relative abundance of amoebae that may harbor infectious bacteria due to cooling tower operations from industries, hospitals, and public buildings. Those authors find that infected amoebae are 16 times more likely to occur in cooling towers than in natural environments and that cooling towers may be possible “hot spots” for emerging pathogenic bacteria.

3.11.3.3 Microbiological Hazards to Plant Workers

Plant workers are most likely to be exposed to pathogenic microorganisms from power plant operations when cleaning or providing other maintenance services that involve the cooling water system, including cooling towers and condensers. Diseases (e.g., legionellosis and primary amoebic meningoencephalitis) that involve respiratory or nasal infectivity routes are of primary concern, and workers should wear appropriate respiratory protection. Workers performing underwater activities should wear protective gear to prevent oral or nasal exposure to amoebae or other pathogenic bacteria. Plant operators should continue using proven industrial hygiene principles to minimize workforce exposures to microbiological organisms that may occur in the cooling water system (NRC 2013c).

3.11.3.4 Microbiological Hazards to the Public

Thermal effluents produced during nuclear power plant operations are discharged to lakes, ponds, canals, or rivers and, therefore, may enhance the growth of naturally occurring thermophilic microorganisms. The public may come into contact with these water bodies through swimming and boating activities. NPDES permits limit the maximum daily temperature for the discharge. Although public access to these freshwater sources is often limited, at some locations, depending on the NPDES limits, the temperatures could support survival of the thermophilic microorganisms during summer conditions. The Tennessee Department of Health (TDH) (Cooper et al. 2009) found no reported cases of *Naegleria fowleri* infection and 386 reported cases of legionellosis between 2000 and 2009.

3.11.4 Electromagnetic Fields

Based on the GEIS, the Commission found that electric shock resulting from direct access to energized conductors or from induced charges in metallic structures has not been found to be a problem at most operating plants and generally is not expected to be a problem during the license renewal term. However, a site-specific review is required to determine the significance of the electric shock potential along the portions of the transmission lines that are within the scope of this SEIS.

In the GEIS, the NRC found that without a review of the conformance of each nuclear plant transmission line with National Electrical Safety Code (NESC) criteria, it was not possible to determine the significance of the electric shock potential (IEEE 2002). Evaluation of individual plant transmission lines is necessary because the issue of electric shock safety was not addressed in the licensing process for some plants. For other plants, land use in the vicinity of transmission lines may have changed, or power distribution companies may have chosen to upgrade line voltage. To comply with 10 CFR 51.53(c)(3)(ii)(H), the applicant must provide an assessment of the impact of the proposed action on the potential shock hazard from the transmission lines if the transmission lines that were constructed for the specific purpose of connecting the plant to the transmission system do not meet the recommendations of the NESC for preventing electric shock from induced currents. The NRC uses the NESC criteria and the applicant’s adherence to it during the current operating license as its baseline to assess the potential human health impact of the induced current from an applicant’s transmission lines. As discussed in the GEIS, the issue of electric shock is of small significance for transmission lines that are operated in adherence with the NESC criteria.

TVA completed a detailed analysis of the current state of compliance with NESC criteria in 2012. In addition, TVA did an aerial light detection and ranging (LIDAR) survey on all of its

500-kV transmission lines that connect SQN to the electric grid. TVA used the data from the survey to calculate the potential for induced shock effects for four reference vehicles, including utility trailers, sport utility vehicles, and large farm machinery. TVA used the Power Line Systems Software (PLS-CADD) program to analyze the three-dimensional models created from the LIDAR data. All electromagnetic field calculations in PLS-CADD are based on Electric Power Research Institute (EPRI) methodology. Of the 500-kV transmission lines studied, TVA reported that there are nine transmission line spans that have insufficient clearance to limit the steady-state current caused by the electrostatic effects to the NESC standard of 5 milliamperes (mA). These line spans are as follows: Widows Creek (three spans), Franklin (two spans), Watts Bar, Unit 1 (two spans), and Watts Bar, Unit 2 (two spans).

In accordance with 10 CFR 51.53(c)(3)(iii), TVA has provided information on actions it is considering to reduce the potential impacts from those transmission lines that exceed the NESC standard. Using a 500-kV transmission line uprate program with defined projects, TVA plans to correct the deficiencies with improvements in various stages of planning or design. These projects are all scheduled for construction and completion by June 2017, before the end of SQN's current operating license.

In addition, the following physical adjustments are being considered that could lower the calculated short-circuit loads to below 5 mA:

- Add tower extensions to elevate the 500-kV conductors in the problem spans.
- Replace existing towers with taller towers.
- Supply shield wires below the 500-kv phase wires in the problem spans.

For all but the nine spans listed above, the vertical clearances of the transmission lines built to connect SQN to TVA's transmission system are sufficient to limit the steady-state current caused by electrostatic effects to 5 mA, should the largest anticipated truck, vehicle, or equipment under the line be short-circuited to ground.

In its ER, TVA stated that the location of these nine spans are in areas where the potential for induced shock would be of a low risk, and a more aggressive remediation schedule is not warranted. However, as previously stated, TVA plans to correct the deficiencies, which are scheduled for completion before the end of SQN's current operating license.

3.11.5 Other Hazards

Two additional human health issues are addressed in this section: physical occupational hazards and electric shock hazards.

Nuclear power plants are industrial facilities that have many of the typical occupational hazards found at any other electric power generation utility. Workers at or around nuclear power plants would be involved in some electrical work, electric power line maintenance, repair work, and maintenance activities, and thus exposed to some potentially hazardous physical conditions (e.g., falls, excessive heat, cold, noise, electric shock, and pressure). The issue of physical occupational hazards is generic to all nuclear power plants (NRC 2013c).

The Occupational Safety and Health Administration (OSHA) is responsible for developing and enforcing workplace safety regulations. OSHA was created by the Occupational Safety and Health Act of 1970 (29 U.S.C. § 651 et seq.), which was enacted to safeguard the health of workers. With specific regard to nuclear power plants, plant conditions that result in an occupational risk, but do not affect the safety of licensed radioactive materials, are under the statutory authority of OSHA rather than the NRC as set forth in a Memorandum of Understanding (53 FR 47279, November 22, 1988) between the NRC and OSHA. Occupational hazards can be minimized when workers adhere to safety standards and use appropriate protective equipment; however, fatalities and injuries from accidents can still occur.

Physical occupational safety and health hazards are generic to all types of electrical generating stations, including nuclear power plants (NRC 2013c). As discussed above, worker safety is regulated by OSHA. As a Federal agency, TVA is not directly subject to regulation from OSHA; however, TVA and its contractors use health and safety practices that comply with OSHA's substantive requirements.

3.12 Environmental Justice

Under Executive Order (E.O.) 12898 (59 FR 7629), Federal agencies are responsible for identifying and addressing, as appropriate, disproportionately high and adverse human health and environmental impacts on minority and low-income populations. In 2004, the Commission issued a *Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions* (69 FR 52040), which states, "The Commission is committed to the general goals set forth in E.O. 12898, and strives to meet those goals as part of its [National Environmental Policy Act] NEPA review process."

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

> **Disproportionately High and Adverse Human Health Effects.**
>
> Adverse health effects are measured in risks and rates that could result in latent cancer fatalities, as well as other fatal or nonfatal adverse impacts on human health. Adverse health effects may include bodily impairment, infirmity, illness, or death. Disproportionately high and adverse human health effects occur when the risk or rate of exposure to an environmental hazard for a minority or low-income population is significant (as employed by NEPA) and appreciably exceeds the risk or exposure rate for the general population or for another appropriate comparison group (CEQ 1997).
>
> **Disproportionately High and Adverse Environmental Effects.**
>
> A disproportionately high environmental impact that is significant (as employed by NEPA) refers to an impact or risk of an impact on the natural or physical environment in a low-income or minority community that appreciably exceeds the environmental impact on the larger community. Such effects may include ecological, cultural, human health, economic, or social impacts. An adverse environmental impact is an impact that is determined to be both harmful and significant (as employed by NEPA). In assessing cultural and aesthetic environmental impacts, impacts that uniquely affect geographically dislocated or dispersed minority or low-income populations or American Indian tribes are considered (CEQ 1997).

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

> **Minority Individuals**
>
> Individuals who identify themselves as members of the following population groups: Hispanic or Latino, American Indian or Alaska Native, Asian, Black or African-American, Native Hawaiian or Other Pacific Islander, or two or more

races, meaning individuals who identified themselves on a Census form as being a member of two or more races; for example, Hispanic and Asian.

Minority Populations

Minority populations are identified when (1) the minority population of an affected area exceeds 50 percent or (2) the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis.

Low-Income Population

Low-income populations in an affected area are identified with the annual statistical poverty thresholds from the Census Bureau's Current Population Reports, Series P60, on Income and Poverty.

3.12.1 Minority Population

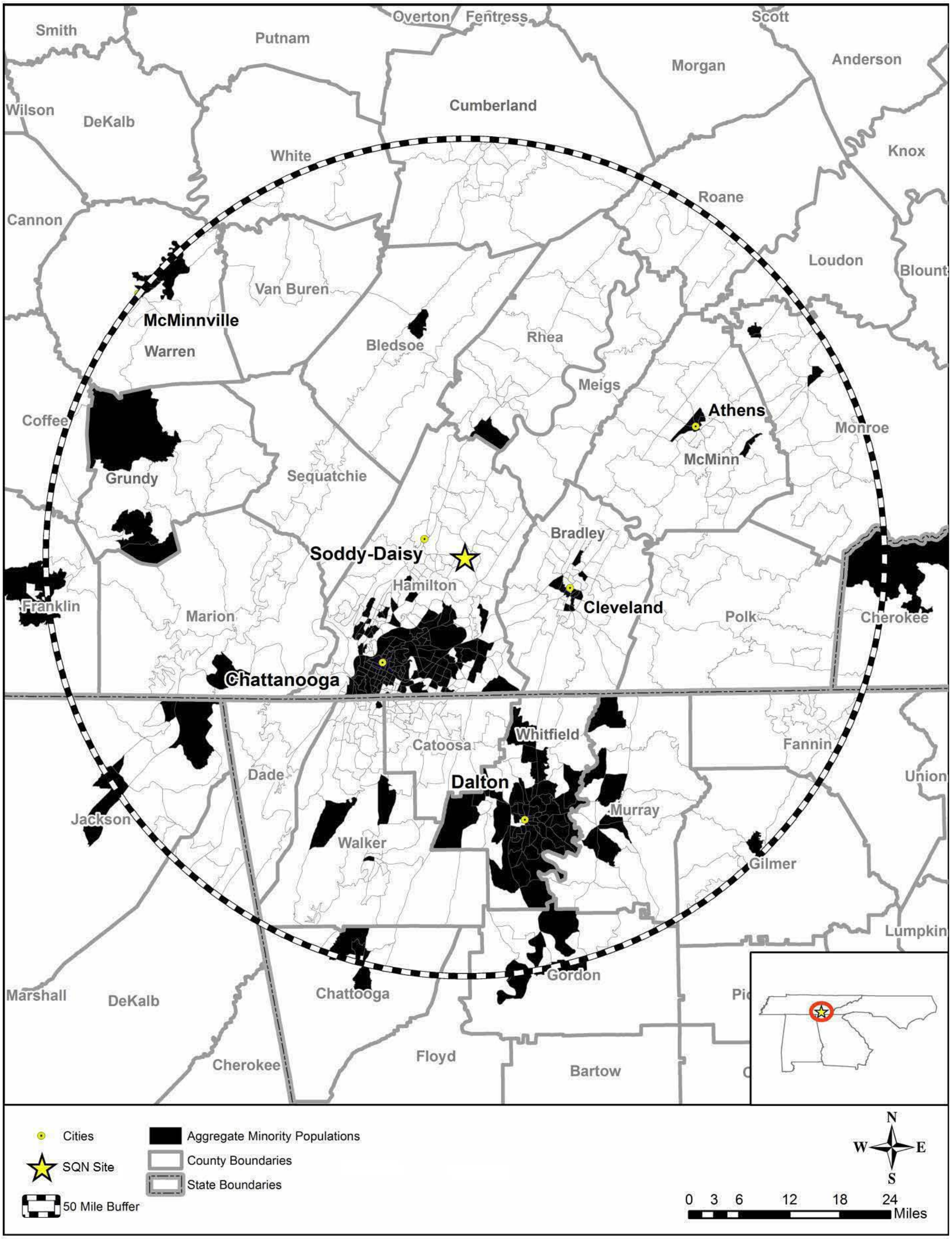
According to 2010 Census data, 17.5 percent of the population residing within a 50-mi (80-km) radius of SQN identified themselves as minority individuals. The largest minority group was Black or African-American (8.1 percent), followed by Hispanic or Latino (of any race) (6.7 percent) (CAPS 2012).

According to 2010 Census data, minority populations in the socioeconomic ROI (Hamilton and Rhea Counties) composed 26.3 percent of the total two-county population (see Table 3–27). Figure 3–9 shows predominantly minority population block groups, using 2010 Census data for race and ethnicity, within a 50-mi (80-km) radius of SQN.

Census block groups were considered minority population block groups if the percentage of the minority population within the block group exceeded 17.5 percent (the percent of the minority population within the 50-mi radius of SQN). A minority population exists if the minority percentage of the population within the block group is meaningfully greater than the minority population percentage in the 50-mi (80-km) radius. Approximately 237 of the 779 census block groups located within the 50-mi (80-km) radius of SQN have meaningfully greater minority populations.

As shown in Figure 3–9, minority population block groups are mostly clustered near Chattanooga and Cleveland, Tennessee, and Dalton, Georgia. None of the block groups near Soddy-Daisy and SQN have meaningfully greater minority populations.

Figure 3–9. 2010 Census Minority Block Groups Within a 50-mi Radius of SQN



Source: USCB 2013d

3.12.2 Low-Income Population

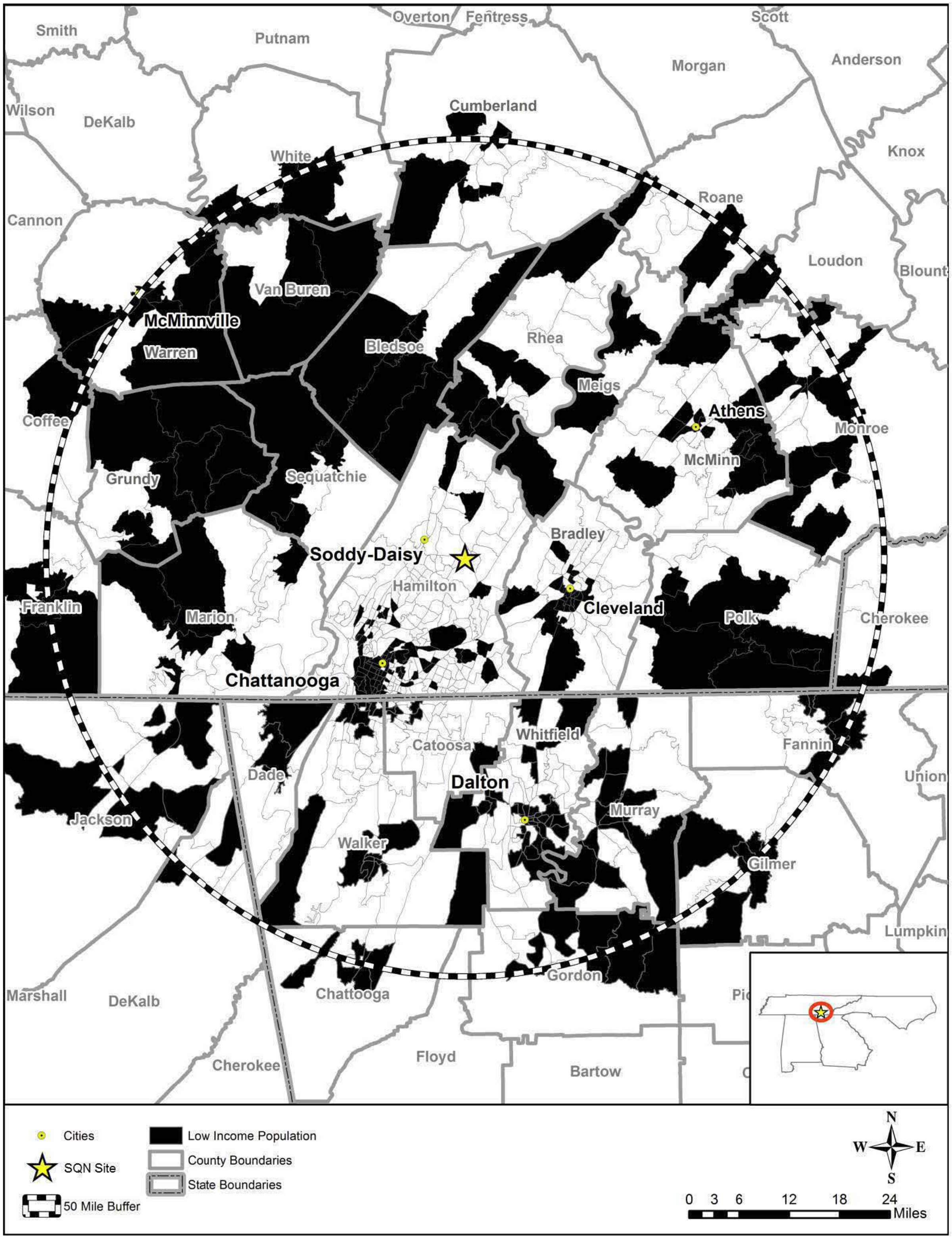
According to 2011 ACS data, an average of 14.5 percent of families and 18.7 percent of individuals residing in the 29 counties within a 50-mi (80-km) radius of SQN were identified as living below the Federal poverty threshold in 2011 (USCB 2013d). The 2011 Federal poverty threshold was $22,350 for a family of four.

Based on ACS data, 12.7 percent of families and 16.9 percent of individuals in Tennessee were living below the Federal poverty threshold in 2011, and the median household income for Tennessee was $43,989 (USCB 2013d). Hamilton County had higher median household incomes and lower percentages of families and individuals living in poverty compared to State averages. In Rhea County, just the opposite occurs; the county has lower household incomes and higher poverty levels than the State average. Hamilton County had a median household income average of $45,826 and 15.9 percent of individuals and 12.0 percent of families living below the poverty level. Rhea County had a median household income average of $36,934 and 20.3 percent of individuals and 14.4 percent of families living below the poverty level (USCB 2013).

Figure 3–10 shows the location of predominantly low-income population block groups within a 50-mi (80 km) radius of SQN. Census block groups were considered low-income population block groups if the percentage of individuals living below the Federal poverty threshold within any block group exceeded the percent of the individuals living below the Federal poverty threshold within the 50-mi radius of SQN. Approximately 310 of the 779 census block groups located within the 50-mi (80-km) radius of SQN have meaningfully greater low-income populations.

As shown in Figure 3–10, low-income block groups are evenly distributed with no particular concentrations. Wide areas of rural land and urban centers show pockets of block groups that meet the low-income criteria. None of the block groups near Soddy-Daisy and SQN have meaningfully greater low-income populations.

Figure 3–10. 2010 Census Low-Income Block Groups Within a 50-mi (80 km) Radius of SQN



Source: USCB 2013d

3.13 Waste Management and Pollution Prevention

3.13.1 Radioactive Waste

As discussed in Section 3.1.4 of this SEIS, SQN uses liquid, gaseous, and solid waste processing systems to collect and treat, as needed, radioactive materials produced as a byproduct of plant operations. Radioactive materials in liquid and gaseous effluents are reduced before being released into the environment so that the resultant dose to members of the public from these effluents is well within NRC and EPA dose standards. Radionuclides that can be efficiently removed from the liquid and gaseous effluents before release are converted to a solid waste form for disposal in a licensed disposal facility.

3.13.2 Nonradioactive Waste

Waste minimization and pollution prevention are important elements of operations at all nuclear power plants. The applicants are required to consider pollution prevention measures as dictated by the Pollution Prevention Act of 1990 (42 U.S.C. 13101 et seq.) and Resource Conservation and Recovery Act of 1976 (42 U.S.C. 6901 et seq., herein referred to as RCRA).

As described in Section 3.1.5, SQN has a nonradioactive waste management program to handle this nonradioactive waste. In addition to managing its nonradioactive waste, TVA has programs in place to minimize the generation of this waste. As stated by TVA in its ER, SQN is committed to the requirements of the Tennessee Hazardous Waste Reduction Act of 1990, which requires that, wherever feasible, the generation of hazardous waste is to be reduced or eliminated as expeditiously as possible. Waste generated should, in order of priority, be reduced at its source, recovered and reused, recycled, treated, or disposed of to minimize the present and future threat to human health and the environment.

SQN implements a hazardous waste minimization plan to reduce, to the extent feasible, waste generated, treated, accumulated, or disposed. This plan documents waste streams that have been eliminated and lists current waste streams generated at the facility. The plan is updated annually and used in conjunction with plant waste management procedures on solid, special, hazardous, and mixed waste, and chemicals to control and minimize waste generation to the maximum extent practicable.

3.14 References

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4.0 ENVIRONMENTAL CONSEQUENCES AND MITIGATING ACTIONS

4.1 Introduction

In this chapter, the U.S. Nuclear Regulatory Commission (NRC) evaluates the environmental consequences of the proposed action (i.e., license renewal of Sequoyah Nuclear Plant, Units 1 and 2 (SQN)), including the (1) impacts associated with continued operations similar to those that have occurred during the current license terms; (2) impacts of various alternatives to the proposed action; (3) impacts from the termination of nuclear power plant operations and decommissioning after the license renewal term (with emphasis on the incremental effect caused by an additional 20 years of operation); (4) impacts associated with the uranium fuel cycle; (5) impacts of postulated accidents (design-basis accidents (DBAs) and severe accidents); (6) cumulative impacts of the proposed action; and (7) resource commitments associated with the proposed action, including unavoidable adverse impacts, the relationship between short-term use and long-term productivity, and irreversible and irretrievable commitment of resources. The NRC also considers new and potentially significant information on environmental issues related to operation during the renewal term.

The *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS) (NRC 2013e) identifies 78 issues to be evaluated in the license renewal environmental review process. Generic issues (Category 1) rely on the analysis presented in the GEIS, unless otherwise noted. Applicable site-specific issues (Category 2) have been analyzed for SQN and assigned a significance level of SMALL, MODERATE, or LARGE. Section 1.4 of this SEIS provides an explanation of the criteria for Category 1 and Category 2 issues, as well as the definitions of SMALL, MODERATE, and LARGE. Resource-specific impact significance level definitions are provided where applicable.

4.2 Land Use and Visual Resources

This section describes the potential impacts of the proposed action (license renewal) and alternatives to the proposed action on land use and visual resources.

4.2.1 Proposed Action

The land use and visual resource issues applicable to SQN during the license renewal term are listed in Table 4–1. Section 3.2 describes the land use and visual resources associated with SQN. There are no Category 2 issues for land use and visual resources.

The NRC staff did not identify any new and significant information related to the generic (Category 1) issues listed above during the review of TVA’s Environmental Report (ER), the site audit, or the scoping process. Therefore, no impacts are associated with these issues beyond those discussed in the GEIS. The GEIS concludes that the impact levels for these issues are SMALL.

Table 4–1. Land Use and Visual Resources

Issue	GEIS Section	Category
Land Use		
Onsite land use	4.2.1.1	1
Offsite land use	4.2.1.1	1
Offsite land use in transmission line right-of-ways (ROWs)	4.2.1.1	1
Visual Resources		
Aesthetic impacts	4.2.1.2	1

(a) This issue applies only to the in-scope portion of electric power transmission lines, which are defined as transmission lines that connect the nuclear power plant to the substation where electricity is fed into the regional power distribution system and transmission lines that supply power to the nuclear plant from the grid.

Source: Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51

4.2.2 No-Action Alternative – Land Use and Visual Resources

4.2.2.1 Land Use

Plant shutdown would not affect onsite land use prior to decommissioning. Plant structures and other facilities would remain in place until decommissioning, and no additional land would be required. The staff expects no impacts associated with this issue beyond those discussed in the GEIS, which concludes that the impact level for this issue would be SMALL.

4.2.2.2 Visual Resources

The overall appearance of the major plant structures is not expected to change prior to decommissioning. Once the cooling towers stop operating, the condensate plumes from the onsite cooling towers would no occur and therefore, would no longer be part of the viewshed.

The NRC staff expects no impacts associated with this issue beyond those discussed in the GEIS. The GEIS concludes that the impact level for this issue would be SMALL.

4.2.3 NGCC Alternative – Land Use and Visual Resources

4.2.3.1 Land Use

The analysis of land use impacts focuses on the amount of land area that would be affected by the construction and operation of a natural gas combined-cycle (NGCC) plant at an existing power plant or brownfield site other than SQN. Locating the new NGCC power plant at or near an existing power plant site would maximize the availability of support infrastructure and reduce the need for additional land.

Construction of an NGCC plant would require approximately 48 acres (ac) (19 ha) of land for the plant and associated infrastructure. This estimate is based on NETL's (2010b) scaling factor of 0.02 ac/MW. Depending on the site location and availability of existing natural gas pipelines, a 100-ft-wide (30.5-m-wide) ROW would be needed for a new pipeline. Collocating a new pipeline within an existing ROW would minimize land use impacts. Assuming the NGCC alternative is built within the footprint of an existing power plant site, land use impacts from NGCC construction would be SMALL.

In addition to onsite land requirements, land would be required off site for natural gas wells and collection stations during operations. The 1996 GEIS indicates that 3,600 ac (1,457 ha) would be necessary for wells, collection stations, and associated pipelines for a 1,000-MW gas-fired power plant. Using scaled 1996 GEIS figures, the NGCC alternative may require up to 8,640 ac (3,497 ha) of land for gas extraction and collection. The elimination of uranium fuel for SQN could partially offset some, but not all, of the land requirements for the NGCC. Scaling from GEIS (NRC 1996) estimates, approximately 240 ac (97 ha) per year, or 4,800 ac (1,900 ha) over 20 years, of land would be used for uranium mining to supply fuel to SQN (based on 100 ac (40 ha) of temporarily disturbed land per 1,000-MW nuclear plant). Therefore, land use impacts from operation of the NGCC alternative would be SMALL.

4.2.3.2 Visual Resources

The analysis of aesthetic impacts focuses on the visibility of the NGCC alternative and its degree of contrast to the surrounding landscape. During construction, all clearing and excavation would occur on the existing power plant or brownfield site and be visible off site. Since the existing power plant site would already appear industrial, construction of the NGCC power plant would appear similar to other ongoing onsite activities. The tallest structures at the new plant would include two exhaust stacks up to 150 ft (46 m) tall and two mechanical draft cooling towers over 100 ft (30 m) high (NRC 2013d). The facility would be visible off site during daylight hours, and some structures may require aircraft warning lights. The addition of mechanical draft cooling towers and associated condensate plumes could add to the visual impact. The power block of the NGCC alternative could look similar to the existing power plant.

In general, given the industrial appearance of the existing power plant site, the new NGCC power plant would blend in with the surroundings and the NGCC power plant could be similar in appearance to the existing power plant. Aesthetic changes would be limited to the immediate vicinity of the existing power plant site, and any impacts would be SMALL assuming the NGCC alternative is built at an existing power plant site that has infrastructure of a similar appearance and height to that of the NGCC alternative.

4.2.4 SCPC Alternative – Land Use and Visual Resources

4.2.4.1 Land Use

The analysis of land use impacts focuses on the amount of land area that would be affected by the construction and operation of a supercritical pulverized coal (SCPC) power plant at an existing power plant site or a brownfield site with available infrastructure. Locating the new SCPC power plant at or near an existing power plant site, or a brownfield site with available infrastructure, would maximize the availability of support infrastructure and reduce the need for additional land.

The NRC staff assumed that the SCPC alternative would require approximately 131 ac (53 ha), based on a scaling factor of 0.05 ac/MW (NETL 2010a, 2010b). Depending on existing power plant infrastructure, additional land may be needed to build sufficient infrastructure for frequent coal and limestone deliveries by rail or barge. This land may not have been previously industrial, particularly if the SCPC alternative is sited at a smaller previous plant site or brownfield site. For example, an NGCC plant is typically one-half to one-third the size of an SCPC plant. If an SCPC plant is built on an existing NGCC site, the footprint of the SCPC plant would likely exceed the existing footprint of the NGCC site. Impacts could range from minimal, if the newly disturbed land surrounding the NGCC site was previously used for industrial purposes, to noticeable, if newly disturbed land that exceeded the original footprint of the NGCC site was previously used for nonindustrial land uses. Therefore, the land use impacts from construction would range from SMALL to MODERATE depending on the amount of new infrastructure required for operation (e.g., new railroads) and the extent that land adjacent to the site is converted to an industrial land use.

Offsite land use impacts would occur from coal mining, in addition to land use impacts from the construction and operation of the new power plant. The 1996 GEIS indicates that 22,000 ac (8,900 ha) would be necessary for coal mining and processing for a 1000-MW coal-fired power plant, or 22 ac/MW. A NETL study from 2010, however, found that 1,709 ac (692 ha) would be needed for coal mining for a 550-MW facility, or 3.1 ac/MW (NETL 2010c). Based on the 1996 GEIS and the NETL study, the NRC assumed a range of 7,440 ac (3,011 ha) (NETL 2010c) to 52,800 ac (21,400 ha) (NRC 1996) of land for coal mining and processing for the SCPC alternative.

The elimination of uranium fuel for SQN could partially offset some, but not all, of the land requirements for the SCPC alternative. Scaling from GEIS estimates, approximately 240 ac (97 ha) per year, or 4,800 ac (1,900 ha) over 20 years, of land used for uranium mining to supply fuel to SQN (based on 100 ac (40 ha) of temporarily disturbed land per 1,000-MW nuclear plant) no longer would be needed for mining and processing uranium during the operating life of the SCPC plant. Based on the 7,440 ac (3,011 ha) to 52,800 ac (21,400 ha) of land that would be required for coal mining and processing, land use impacts during operations could range from SMALL to MODERATE.

4.2.4.2 Visual Resources

The analysis of aesthetic impacts focuses on the visibility of the SCPC alternative and its degree of contrast to the surrounding landscape. During construction, all of the clearing and excavation would occur on the existing power plant site and would be visible off site. The coal-fired power plant could be approximately 100 ft (30 m) tall, with two to four exhaust stacks several hundred feet tall with natural-draft cooling towers approximately 500 ft (152 m) in height (NRC 2013d). The facility would be visible off site during daylight hours, and some structures may require aircraft warning lights. The condensate plumes from the cooling towers could also add to the visual impact.

In general, given the industrial appearance of the existing power plant site on which it would be built, the new SCPC power plant would blend in with the surroundings. The power block of the SCPC alternative could look very similar to the existing power plant and construction would appear similar to other ongoing onsite activities. However, if natural draft cooling towers did not previously exist at the site, the impact could be noticeable. Aesthetic impacts would therefore range from SMALL to MODERATE, depending on if aesthetic changes are limited to the immediate vicinity of the existing power plant site, or if the construction of new natural draft cooling towers results in a noticeable change within the viewshed of the plant.

4.2.5 New Nuclear Alternative – Land Use and Visual Resources

4.2.5.1 Land Use

The analysis of land use impacts focuses on the amount of land area that would be affected by the construction and operation of a new two-unit nuclear power plant at or adjacent to an existing nuclear power plant site. Locating the new nuclear power plant at or near an existing power plant site would maximize the availability of support infrastructure and reduce the need for additional land.

TVA (2013a) estimated 1,000 ac (405 ha) (excluding transmission lines) for construction of the two new units, based on the sizes of TVA's existing nuclear plant sites (e.g., Bellefonte, Sequoyah, and Watts Bar, which range from 600 to 1,500 ac (243 to 607 ha)). Based on the 2013 GEIS, a new reactor at an alternate site would require approximately 500 to 1,000 ac

(202 to 405 ha). Land would be required for the construction of spent nuclear fuel and low-level radioactive waste storage facilities. The NRC staff determined that TVA's estimate of 1,000 ac (405 ha) is consistent with a scaling factor of approximately 0.49 ac/MW for a new nuclear plant used in recent SEISs, and is therefore used in this analysis. Locating the new units at or adjacent to an existing nuclear power plant would mean that the majority of the affected land area would already be zoned for industrial use. Making use of the existing infrastructure would reduce the amount of land needed to support the new units. Assuming the new nuclear alternative is built within the footprint of an existing nuclear power plant site, land use impacts from constructing two new units at an existing nuclear power plant site would be SMALL.

The amount of land required to mine uranium and fabricate nuclear fuel during reactor operations would be similar to the amount of land required to support SQN. Impacts associated with uranium mining and fuel fabrication to support the new nuclear alternative would generally be no different from those occurring in support of the existing SQN reactors. Overall, land use impacts from nuclear power plant operations would be SMALL because the NRC staff assumed that the new nuclear plant would be sited entirely within an existing nuclear power plant site.

4.2.5.2 Visual Resources

The analysis of aesthetic impacts focuses on the visibility of the new nuclear alternative and its degree of contrast to the surrounding landscape. During construction, all of the clearing and excavation would occur on site and may be visible off site. Since the existing power plant site already appears industrial, construction of the new nuclear power plant would appear similar to other ongoing onsite activities. The tallest power plant structures would be the natural draft cooling towers, with a height of approximately 400 to 500 ft (122 to 152 m) (NRC 2013d). The towers would be visible off site during daylight hours, and they may require aircraft warning lights. Associated condensate plumes could add to the visual impact. The power block of the two new units would look very similar to the power block(s) at the existing nuclear power plant.

In general, given the industrial appearance of an existing nuclear power plant site, the new nuclear power plant would blend in with its surroundings. Aesthetic changes would therefore be limited to the immediate vicinity of the existing power plant site. However, if natural draft cooling towers did not previously exist at the site, the impact could be noticeable. Aesthetic impacts would therefore range from SMALL to MODERATE, depending on if aesthetic changes are limited to the immediate vicinity of the existing power plant site, or if the construction of new natural draft cooling towers results in a noticeable change within the viewshed of the plant.

4.2.6 Combination Alternative – Land Use and Visual Resources

4.2.6.1 Land Use

The analysis of land-use impacts focuses on the amount of land area that would be affected by the construction and operation of a combination of wind turbines and PV solar installations.

Wind turbines would be located at multiple sites throughout the TVA region, or, if TVA used purchased power agreements, could include wind farm sites in other parts of the country. Wind energy facilities would require approximately 0.3 ac (0.12 ha)/MW (NRC 2013d), for a total land requirement 1,410 to 1,890 ac (570 to 765 ha) to build and operate 2,350 to 3,150 land-based wind turbines for this alternative. Although a relatively large area of land would be required for the wind portion of this alternative, only about 5 to 10 percent of the land area would be used by turbines, power collection and conditioning systems, and other support facilities. During operations, land areas between the turbines can be put to other beneficial (nonintrusive) use or may be able to remain as the same land use prior to construction. For example, most of the wind farms would likely be located on open agricultural cropland or grazing pasture, which would remain largely unaffected by the wind turbines during operations.

The solar PV capacity would mostly be installed at already-developed sites, including on existing buildings. Based on calculations using NREL (2008) estimates, 12,400 to 17,980 ac (5,018 to 7,276 ha) could be necessary for a solar PV alternative at stand-alone sites. However, this likely overstates the potential impacts as it is anticipated that the solar PV capacity would mostly be installed at already-developed sites, including on existing buildings.

The elimination of uranium fuel for the SQN would partially offset some, but not all, new land requirements. Scaling from GEIS estimates, approximately 240 ac (97 ha) per year, or 4,800 ac (1,900 ha) over 20 years of land used for uranium mining to supply fuel to Sequoyah (based on 100 ac (40 ha) of temporarily disturbed land per 1,000-MW nuclear plant), would no longer be needed for mining and processing uranium. Based on the substantial amount of land required to construct and operate the wind and solar alternative, overall land use impacts from the combination alternative would range from SMALL to MODERATE, depending on the number of existing buildings that would be used during construction of the solar alternative and whether most of the area required for wind farms would revert back to the original land use.

4.2.6.2 Visual Resources

The analysis of aesthetic impacts focuses on the degree of contrast between the wind and solar installations and surrounding landscapes and the visibility of new wind turbines at existing wind farms and PV solar technologies on existing buildings. In general, aesthetic changes would be limited to the immediate vicinity of PV solar installations, but could expand for wind installations depending on the location, topography, and other structures and trees near the chosen sites.

Wind turbines would have the greatest potential visual impact. Modern wind turbines have rotor diameters greater than 300 ft (100 m) on towers that are hundreds of feet tall (NRC 2013d). Spread across multiple sites, wind turbines often dominate the viewshed and become a major focus of attention. However, adding additional wind turbines to existing wind farms is not likely to increase the visual impact of the wind farm unless the number of wind turbines is considerably increased. Any PV solar technologies located on building rooftops or within preexisting solar farms, may or may not be seen off site, but would be less noticeable in urban settings.

Based on this information, aesthetic changes caused by this combination alternative would range from SMALL to MODERATE, depending on visibility of new wind installation and whether wind turbines are added to existing wind farms or whether entirely new wind farms are required to support the combination alternative.

4.3 Air Quality and Noise

This section describes the potential impacts of the proposed action (license renewal) and alternatives to the proposed action on air quality and noise conditions.

4.3.1 Proposed Action

4.3.1.1 Air Quality

The air quality issues applicable to SQN during the license renewal term are listed in Table 4–2. Section 3.3 describes the meteorological, air quality, and noise conditions in the vicinity of SQN. There are no Category 2 issues for air quality.

Table 4–2. Air Quality and Noise

Issue	GEIS Section	Category
Air Quality impacts (all plants)	4.3.1.1	1
Air Quality effects of transmission lines	4.3.1.1	1
Noise Impacts	4.3.1.2	1

Source: Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51

The Category 1 issue “air quality impacts (all plants)” considers the air quality impacts from continued operation associated with license renewal. Section 3.3.2 discusses the air quality conditions in the vicinity of SQN as well as air emissions resulting from operation of SQN. Air emissions from SQN operations are regulated by the synthetic minor operating permit conditions (Clean Air Act (CAA) Source ID: 4706504150) and these would continue in effect during the license renewal period. There are no planned refurbishment activities associated with license renewal and, therefore, no associated additional air emissions with refurbishment activities. The only expected equipment change that could increase air emissions will be from a blackout diesel generator and up to three emergency diesel generators (EDGs) being installed at each unit in 2016 in response to NRC’s order (Order Number: EA-12-049) titled “Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events” (TVA 2013d, 2013m). The diesel generators are expected to be operated only in the event of loss of alternating current (AC) power to the site and during periodic routine testing. In periodic tests of the diesel generators they are estimated to emit 0.11, 0.11, 4.1, 1.0, 0.002 MT/year of PM_{10}, $PM_{2.5}$, nitrogen oxides, carbon monoxide, sulfur dioxide, respectively (TVA 2013k). Installation and operation of the new generators will result in limited emissions and are not associated with license renewal (TVA 2013e, 2013i).

The Category 1 issue “air quality effects of transmission lines” considers the production of ozone and oxides of nitrogen; the GEIS found that minute and insignificant amounts of ozone and nitrogen oxides are generated during transmission. Results of field testing in the vicinity of SQN’s transmission lines are consistent with GEIS conclusions, in that ozone levels were not measurable above ambient amounts at ground level (TVA 2013a).

The NRC staff did not identify any new and significant information during the review of TVA’s ER (TVA 2013a), the site audit, or during the scoping process. As a result, no information or impacts related to these issues were identified that would change the conclusions presented in the GEIS. Therefore, there are no impacts related to these issues beyond those discussed in the GEIS. For these two Category 1 issues, the GEIS concluded that the impacts are SMALL.

4.3.1.2 Noise

One Category 1 noise issue is applicable to SQN, “noise impacts” (see Table 4–2). Section 3.3.3 discusses the noise conditions in the vicinity of SQN as well as noise resulting from operation of SQN. There is no planned refurbishment associated with license renewal and, therefore, no associated noise emissions with refurbishment activities. The NRC staff did not identify any new and significant information during the review of TVA’s ER (TVA 2013a), the site audit, or during the scoping process. No major facility construction or refurbishments are planned to occur during the license renewal period. Therefore, there are no impacts related to this issue beyond those discussed in the GEIS. For this Category 1 issue, the GEIS concluded that the impacts are SMALL.

4.3.2 No-Action Alternative – Air Quality and Noise

4.3.2.1 Air Quality

When the plant stops operating, there will be a reduction in emissions from activities related to plant operation, such as use of diesel generators and employee vehicles. In Section 4.3.1, the NRC staff determined that these emissions would have a SMALL impact on air quality during the renewal term. Therefore, if emissions decrease, the impact on air quality would also decrease and would be SMALL.

4.3.2.2 Noise

When the plant stops operating, there will be a reduction in noise that is generated from sources associated with plant operations, such as fans, turbine generators, transformers, cooling towers, compressors, emergency generators, main steam-safety relief valves, and emergency sirens. In Section 4.3.1, the NRC staff determined that these noise sources have a SMALL impact on ambient noise levels during the renewal term. Therefore, if these noise sources are reduced, the impact on ambient noise levels would also be reduced and would be SMALL.

4.3.3 NGCC Alternative – Air Quality and Noise

4.3.3.1 Air Quality

This alternative includes the construction and operation of six 400-MWe NGCC generation units with a total output of 2,400 MWe. Because of land restrictions at the SQN site, the NGCC generating plant would likely be located near an existing power plant or brownfield site with available infrastructure within the TVA region (including parts of Tennessee, North Carolina, Virginia, Kentucky, Georgia, Alabama, and Mississippi).

Construction of the NGCC plant would result in temporary impacts on local air quality. Activities including earthmoving and vehicular traffic generate fugitive dust. In addition, emissions from these activities would contain various air pollutants, including carbon monoxide, oxides of nitrogen, oxides of sulfur, particulate matter (PM), volatile organic compounds (VOCs), as well as various greenhouse gases (GHGs). Air emissions would be intermittent and vary based on the level and duration of a specific activity throughout the construction phase. Gas-fired power plants are constructed relatively quickly; construction lead times for NGCC plants are approximately 2 to 3 years (Dujardin 2005; EIA 2011). Various mitigation techniques could be utilized to minimize air emissions and reduce fugitive dust. Since air emissions from construction activities would be limited, local, and temporary, the NRC staff concludes that the associated air quality impacts from construction would be SMALL.

Operation of the NGCC plant would result in significant emissions of certain criteria pollutants, including carbon monoxide, nitrogen oxides, sulfur oxides, and PM. Consequently, a new NGCC plant would qualify as a major-emitting industrial facility and would be subject to a New Source Review (NSR) under requirements of the CAA to ensure air emissions are minimized and the local air quality is not substantially degraded (EPA 2013c). The NGCC plant would need to comply with the standards of performance for stationary combustion turbines set forth in Title 40, Part 60, of the *Code of Federal Regulations* (40 CFR Part 60) Subpart KKKK. Subpart P of 40 CFR Part 51.307 contains the visibility protection regulatory requirements, including review of the new sources that may affect visibility in any Federal Class I area. If the NGCC alternative were located near a mandatory Class I area, additional air pollution control requirements would be required.

A new NGCC plant would also have to comply with Title IV of the CAA (42 U.S.C. 7651) reduction requirements for SO_x and NO_x, which are the main precursors of acid rain and the major causes of reduced visibility. Title IV establishes maximum SO_x and NO_x emission rates from the existing plants and a system of SO_x emission allowances that can be used, sold, or saved for future use by new plants.

More recently, the U.S. Environmental Protection Agency (EPA) has promulgated additional rules and requirements that apply to certain fossil-fuel-based power plants, such as NGCC generation. The Clean Air Interstate Rule[4] (CAIR) and the Title V Greenhouse Gas (GHG) Tailoring Rule impose several additional standards to limit ozone, particulate, and GHG emissions from fossil-fuel-based power plants (EPA 2013d). A new NGCC plant would be subject to these additional rules and regulations.

The EPA has developed standard emission factors that relate the quantity of released air pollutants to a variety of regulated activities. Emission for a NGCC plant can be estimated once the plant capacity and gas heat content are known (EPA 2000). Assuming a plant gross capacity of 2,400 MWe, a capacity factor of 0.85, and a gas heat content of 1,021 British thermal units per cubic foot, the NRC staff estimates the following air emissions for an NGCC alternative plant:

- sulfur oxides (SO_x) – 330 tons (300 MT) per year,
- nitrogen oxides (NO_x) – 960 tons (870 MT) per year,
- carbon monoxide (CO) – 1,450 tons (1,320 MT) per year,
- particulate matter (PM_{10}) – 640 tons (580 MT) per year,
- carbon dioxide (CO_2) – 10,643,500 tons (9,655,621 MT) per year, and
- methane (CH_4) – 830 tons (760 MT) per year.

Carbon capture and storage (CCS) could be used as a method to reduce carbon dioxide by up to 90 percent; however, it would also decrease the power production capacity of an NGCC plant by up to 15 percent (NETL 2013).

As noted above, a new NGCC plant would be subject to several EPA regulations designed to minimize air quality impacts from operations. Nevertheless, a new NGCC plant would be a major source of criteria pollutants and GHGs and the overall air quality impacts from the operation of a new NGCC plant located within the TVA region would be SMALL to MODERATE.

4.3.3.2 Noise

Construction vehicles and equipment associated with the construction of the NGCC plant would generate noise; these impacts would be intermittent and last only through the duration of plant construction. Noise emissions from common construction equipment would be in the 85 to 95 decibels adjusted (dBA) range (FHWA 2012). However, noise abatement and controls can be incorporated to reduce noise impacts.

Noise impacts from operations would include cooling towers (water pumps, cascading water, or fans), transformers, turbines, pumps, compressors, exhaust stack, the combustion inlet filter house, condenser fans, high-pressure steam piping, and vehicles (Saussus 2012). The NRC staff does not expect noise impacts for operation of an NGCC plant to be any greater than those

[4] The Clean Air Interstate Rule (CAIR) was first issued by EPA in 2005; however, the Federal rule was vacated by the D.C. Circuit Court on February 8, 2008. In December 2008, the U.S. Court of Appeals for the D.C. Circuit reinstated the rule, allowing it to remain in effect but also requiring EPA to revise the rule and its implementation plan. On July 6, 2010, EPA proposed replacing CAIR with the Cross-State Air Pollution Rule (CSAPR) for control of sulfur dioxide and nitrogen oxide emissions that cross state lines, the regulations of which would be implemented in 2011 and finalized in 2012. However, CSAPR was vacated by the D.C. Circuit Court on August 21, 2012. On April 29, 2014, the U.S. Supreme Court reversed the D.C. Circuit opinion vacating CSAPR. EPA is reviewing the opinion and CAIR remains in effect.

associated with the existing SQN site. Therefore, the noise impacts of a new NGCC plant located within the TVA region would be SMALL.

4.3.4 SCPC Alternative – Air Quality and Noise

4.3.4.1 Air Quality

This alternative includes the construction and operation of two to four SCPC units with a total output of 2,400 MWe. Because of land restrictions at the SQN site, the SCPC generating plant would likely be located near an existing power plant or brownfield site with available infrastructure within the TVA region (including parts of Tennessee, North Carolina, Virginia, Kentucky, Georgia, Alabama, and Mississippi).

Construction of the SCPC plant would result in temporary impacts on local air quality. Activities including earthmoving and vehicular traffic generate fugitive dust. In addition, emissions from these activities would contain various air pollutants, including carbon monoxide, oxides of nitrogen, oxides of sulfur, particulate matter (PM), volatile organic compounds (VOCs), as well as various GHGs. Air emissions would be intermittent and vary based on the level and duration of a specific activity throughout the construction phase. Construction lead times for coal plants are around 5 years (NETL 2013). Various mitigation techniques could be utilized to minimize air emissions and reduce fugitive dust. Since air emissions from construction activities would be limited, local, and temporary, the NRC staff concludes that the associated air quality impacts from construction would be SMALL.

Operation of the SCPC plant would result in significant emissions of certain criteria pollutants, including carbon monoxide, nitrogen oxides, sulfur oxides, and PM. Consequently, a new SCPC plant would qualify as a major-emitting industrial facility and would be subject to a New Source Review (NSR) under requirements of the CAA to ensure air emissions are minimized and the local air quality is not substantially degraded (EPA 2013c). The SCPC plant would need to comply with the standards of performance for electric utility steam generating units set forth in 40 CFR Part 60 Subpart Da. Subpart P of 40 CFR Part 51.307 contains the visibility protection regulatory requirements, including review of the new sources that may affect visibility in any Federal Class I area. If the SCPC alternative were located near a mandatory Class I area, additional air pollution control requirements would be required.

A new SCPC plant would also have to comply with CAA (42 U.S.C. 7651) Title IV reduction requirements for sulfur oxides and nitrogen oxides, which are the main precursors of acid rain and the major causes of reduced visibility. Title IV establishes maximum sulfur oxide and nitrogen oxide emission rates from existing plants and a system of sulfur oxide emission allowances that can be used, sold, or saved for future use by new plants.

More recently, EPA has promulgated additional rules and requirements that apply to certain fossil-fuel-based power plants, such as SCPC generation. The CAIR, the Mercury and Air Toxics Standards (MATS), and the Title V Greenhouse Gas (GHG) Tailoring Rule impose several additional standards to limit ozone, particulate, mercury, sulfur oxides and GHG emissions from fossil-fuel-based power plants (EPA 2013d). A new SCPC plant would be subject to these additional rules and regulations.

EPA has developed standard emission factors that relate the quantity of released air pollutants to a variety of regulated activities. Emission for an SCPC plant can be estimated once the plant capacity, type and method of coal burning, and pollution control devices are known (EPA 1998a). Assuming a dry-bottom, tangentially fired, bituminous coal plant with a capacity of 2,400 MWe, the NRC staff estimates the following air emissions for an SCPC alternative plant:

- sulfur oxides (SO_x) – 10,660 tons (9,670 MT) per year,
- nitrogen oxides (NO_x) – 2,110 tons (1,910 MT) per year,
- carbon monoxide (CO) – 2,110 tons (1,910 MT) per year,
- particulate matter (PM_{10}) – 670 tons (610 MT) per year,
- particulate matter ($PM_{2.5}$) – 330 tons (300 MT) per year,
- carbon dioxide (CO_2) – 19,158,400 tons (17,380,500 MT) per year, and
- mercury (Hg) – 0.35 tons (0.32 MT) per year

The above emission estimates assume a limestone wet scrubber is used to reduce sulfur oxide emissions by 95 percent, a low NO_x burner (LNB) is used to reduce nitrogen oxide emissions by 95 percent, and a fabric-filter baghouse with a 98-percent efficiency is used to control particulate emissions. Carbon capture and storage (CCS) could be used as a method to reduce carbon dioxide by up to 90 percent; however, it would also decrease the power production capacity of an SCPC plant by up to 28 percent (NETL 2013).

As previously noted, a new SCPC plant would be subject to several EPA regulations designed to minimize air quality impacts from operations. Nevertheless, a new SCPC plant would be a major source of criteria pollutants and GHGs and the overall air quality impacts from the operation of a new SCPC plant located within the TVA region would be MODERATE.

4.3.4.2 Noise

Construction vehicles and equipment associated with the construction of an SCPC plant would generate noise; these impacts would be intermittent and last only through the duration of plant construction. Noise emissions from common construction equipment are estimated to be in the 85 to 95 dBA range (FHWA 2012). However, noise abatement and controls can be incorporated to reduce noise impacts.

Noise impacts from operations would include cooling towers (water pumps, cascading water, or fans), transformers, turbines, pumps, boiler, compressors, and other auxiliary equipment, such as standby generators, and vehicles (Fahda et al. 2012). The NRC staff does not expect noise impacts for an SCPC plant to be any greater than those associated with the existing SQN site. Therefore, the noise impacts of a new SCPC plant located within the TVA region would be SMALL.

4.3.5 New Nuclear Alternative – Air Quality and Noise

4.3.5.1 Air Quality

This alternative includes the construction and operation of two new nuclear units with a total output of 2,400 MWe. Because of land restrictions at the SQN site, the new nuclear plants would likely be located near an existing power plant within the TVA region (including parts of Tennessee, North Carolina, Virginia, Kentucky, Georgia, Alabama, and Mississippi).

Construction of the new nuclear plant would result in temporary impacts on local air quality. Activities including earthmoving and vehicular traffic generate fugitive dust. In addition, emissions from these activities would contain various air pollutants, including carbon monoxide, oxides of nitrogen, oxides of sulfur, particulate matter (PM), volatile organic compounds (VOCs), as well as various GHGs. Air emissions would be intermittent and vary based on the level and duration of a specific activity throughout the construction phase. Construction lead times for nuclear plants are anticipated to be 7 years (NRC 2013a). Various mitigation techniques could be utilized to minimize air emissions and reduce fugitive dust. Since air emissions from construction activities would be limited, local, and temporary, the NRC staff concludes that the associated air quality impacts from construction would be SMALL.

Operation of a new nuclear generating plant would result in similar air emissions to those of the existing SQN site; air emissions would be primarily from backup diesel generators and boilers as well as particulates from the cooling towers. As noted in Section 3.3, TVA maintains a synthetic minor operating permit for sources of air pollution at the SQN site (TVA 2013a). A synthetic minor source has the potential to emit air pollutants in quantities at or above the major source threshold levels but has accepted federally enforceable limitations to keep the emissions below such levels. Because air emissions from a new nuclear plant would be similar to those from SQN, the NRC staff expects similar air permitting conditions and regulatory requirements. Subpart P of 40 CFR Part 51.307 contains the visibility protection regulatory requirements, including the review of the new sources that may affect visibility in any Federal Class I area. If a new nuclear plant were located near a mandatory Class I area, additional air pollution control requirements may be required.

The NRC staff estimates the following air emissions from a new nuclear plant:

- sulfur oxides (SO_x) – 0.22 tons (0.19 MT) per year,
- nitrogen oxides (NO_x) – 13 tons (12 MT) per year,
- carbon monoxide (CO) – 4 tons (3 MT) per year,
- total suspended particles (TSP) – 5.8 tons (5.2 MT) per year,
- particulate matter (PM_{10}) – 0.2 tons (0.18 MT) per year, and
- carbon dioxide equivalent (CO_2e) – 700 tons (635 MT) per year.

As previously noted, a new nuclear plant would be considered a minor source of criteria pollutants and GHGs and the overall air quality impacts from the operation of a new nuclear plant located within the TVA region would be SMALL.

4.3.5.2 Noise

Construction vehicles and equipment associated with the construction of the new nuclear plant would generate noise; these impacts would be intermittent and last only through the duration of plant construction. Noise emissions from construction equipment are estimated to be in the 85 to 95 dBA range (FHWA 2012). However, noise abatement and controls can be incorporated to reduce noise impacts.

Noise impacts from operations would include cooling towers (water pumps, cascading water, or fans), transformers, turbines, pumps, compressors, and other auxiliary equipment, such as standby generators, and vehicles. The NRC staff does not expect noise impacts for a new nuclear plant to be any greater than that analyzed for the existing SQN site. Therefore, the noise impacts of a new nuclear plant located within the TVA region would be SMALL.

4.3.6 Combination Alternative – Air Quality and Noise

4.3.6.1 Air Quality

The combination alternative relies on wind and solar generating capacity to replace SQN. This alternative includes an installed wind capacity of 4,700 to 6,300 MW (based on a 30 to 40 percent capacity factor range) and an installed solar photovoltaic (PV) capacity of 2,000 to 2,900 MW (based on a 17 to 24 percent capacity factor range) to provide replacement power. Wind generation would occur at multiple wind farm sites scattered across the TVA region, or, if TVA used purchased power agreements, could include wind farm sites in other parts of the country. Solar PV generation would mostly be located on existing buildings at already-developed sites throughout the TVA region.

Construction of the combination alternative would result in temporary impacts on local air quality. Activities including earthmoving and vehicular traffic generate fugitive dust. In addition, emissions from these activities would contain various air pollutants, including carbon monoxide, oxides of nitrogen, oxides of sulfur, particulate matter (PM), volatile organic compounds (VOCs), as well as various GHGs. Air emissions would be intermittent and vary based on the level and duration of a specific activity throughout the construction phase. The construction of wind farms and solar PV can be completed in about 1 year (First Solar 2013; Tegen 2006). Various mitigation techniques could be utilized to minimize air emissions and reduce fugitive dust. Since air emissions from construction activities would be limited, local, and temporary, the NRC staff concludes that the associated air quality impacts from construction would be SMALL.

Operation of the combination alternative would result in no routine direct air emissions. However, there would be intermittent air emissions associated with maintenance equipment and vehicles servicing the wind turbines and solar PV systems. These emissions would be similar to air pollutants from construction, and include carbon monoxide, nitrogen oxides, sulfur oxides, PM, and VOCs, as well as various GHGs, but would be minimal compared to those from construction activities. Emissions from operations would be limited, local, and intermittent; therefore, the NRC staff concludes that the associated air quality impacts from operation would be SMALL.

4.3.6.2 Noise

Construction vehicles and equipment associated with the construction of the combination alternative would generate noise; these impacts would be intermittent and last only through the duration of construction. Noise impacts from wind generation operations would include aerodynamic noise from the turbine rotors and mechanical noise from the turbine drivetrain components; noise levels are dependent on the wind and atmospheric conditions, which vary with time. Studies show that at approximately 1,000 ft (300 m) from a wind turbine, noise levels can reach 48 dBA (GE 2010; Hessler 2011). Except for intermittent noise associated with servicing and maintenance, there would be no routine operational noise impacts associated with the solar PV systems. The NRC staff does not expect noise impacts for the combined alternative to be any greater than those associated with the existing SQN site. Therefore, the noise impacts of wind and solar PV facilities located within the TVA region would be SMALL.

4.3.7 Air Quality and Noise Summary

Table 4–3 compares estimated air emissions resulting from the proposed action, NGCC alternative, SCPC alternative, new nuclear alternative, and the combination alternative. This table presents only direct emissions from operations of the electricity generating technologies and does not include emissions from construction or workforce vehicle emissions. The NGCC and SCPC alternatives will produce significantly greater air pollutant emissions than those associated with the proposed action (license renewal of SQN), new nuclear alternative, or the combination alternative.

As discussed in the sections above, noise levels and impacts from operation of the NGCC, SCPC, new nuclear, and combination alternatives would not be greater than those associated with operation of the SQN site.

Table 4–3. Estimated Direct Air Emissions from Operation of SQN, NGCC, SCPC, New Nuclear, and Combination Alternative

	Proposed Action [a]	NGCC	SCPC	New Nuclear [b]	Combination [c]
NO_x	13.3	1,000	2,110	13	0
SO_x	0.220	330	10,660	0.22	0
PM_{10}	0.24	640	670	0.2	0
CO	3.5	1,450	2,110	4	0
CO_2e	697	9,743,500	17,538,400	700	0

[a] SQN emissions presented are from the 2009 annual compliance report of combustion sources.

[b] Values presented are rounded values from the 2009 SQN estimated air emissions.

[c] Operation of the combined alternative would result in no routine direct air emissions.

Source: TVA 2013d

4.4 Geologic Environment

This section describes the potential impacts of the proposed action (license renewal) and alternatives to the proposed action on geologic and soil resources.

4.4.1 Proposed Action

The geology and soils issue applicable to SQN during the license renewal term is listed in Table 4–4. Section 3.4 discusses the geologic environment of the SQN site and vicinity. There are no Category 2 issues for geology and soils.

Table 4–4. Geology and Soils

Issue	GEIS Section	Category
Geology and soils	4.4.1	1

Source: Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51

The NRC staff did not identify any new and significant information associated with the Category 1 geology and soils issue identified in Table 4–4 during the review of the applicant's ER, the site audit, the scoping process, or the evaluation of other available information. As a result, no information or impacts related to this issue was identified that would change the conclusions presented in the GEIS (NRC 2013). For this geology and soil issue, the GEIS concludes that the impacts are SMALL. It is expected that there would be no incremental impacts related to this Category 1 issue during the renewal term beyond those discussed in the GEIS and therefore the impacts associated with this issue by the proposed action would be SMALL.

4.4.2 No-Action Alternative – Geology and Soils

There would not be any impacts to the geology and soils at the SQN site with shut down of the facility. With the shutdown of the facility, no additional land would be disturbed. Therefore, impacts would be SMALL.

4.4.3 Alternatives to the Proposed Action – Geology and Soils

For all alternatives, impacts to geology and soil resources would occur during construction and no additional land would be disturbed during operations. During construction, for all the alternatives to the proposed action discussed in this section, sources of aggregate material, such as crushed stone and sand and gravel, would be required to construct buildings, foundations, roads, and parking lots. The NRC staff presumes that these resources would likely be obtained from commercial suppliers using local or regional sources. Land clearing during construction and the installation of power plant structures and impervious surfaces would expose soils to erosion and alter surface drainage. The NRC staff also presumes that best management practice (BMP) would be implemented in accordance with applicable permitting requirements so as to reduce soil erosion. These practices would include the use of sediment fencing, staked hay bales, check dams, sediment ponds, riprap aprons at construction and laydown yard entrances, mulching and geotextile matting of disturbed areas, and rapid reseeding of temporarily disturbed areas. Removed soils and any excavated materials would be stored onsite for redistribution such as for backfill at the end of construction. Construction activities would be temporary and localized. Therefore, for all the alternatives to the proposed action, construction impacts would be SMALL.

4.4.4 NGCC Alternative – Geology and Soils

The impact significance level on geology and soil resources is the same for all alternatives as discussed in Section 4.4.3 above. Therefore, impacts of the NGCC alternative on geology and soils resources would be SMALL.

4.4.5 SCPC Alternative – Geology and Soils

The impact significance level on geology and soil resources is the same for all alternatives as discussed in Section 4.4.3 above. Therefore, impacts of the SCPC alternative on geology and soils resources would be SMALL.

4.4.6 New Nuclear Alternative – Geology and Soils

The impact significance level on geology and soil resources is the same for all alternatives as discussed in Section 4.4.3 above. Therefore, impacts of the new nuclear alternative on geology and soils resources would be SMALL.

4.4.7 Combination Alternative – Geology and Soils

The impact significance level on geology and soil resources is the same for all alternatives as discussed in Section 4.4.3 above. Therefore, impacts of the combination alternative on geology and soils resources would be SMALL.

4.5 Water Resources

This section describes the potential impacts of the proposed action (license renewal) and alternatives to the proposed action on surface water and groundwater (GW) resources.

4.5.1 Proposed Action

4.5.1.1 Proposed Action Surface Water Resources

The surface water use and quality issues applicable to SQN during the license renewal term are listed in Table 4–5. Surface water resources relevant to the SQN site are described in Section 3.5.1.

Table 4–5. Surface Water Resources

Issues	GEIS Section	Category
Surface water use and quality (noncooling system impacts)	4.5.1.1	1
Altered current patterns at intake and discharge structures	4.5.1.1	1
Altered salinity gradients	4.5.1.1	1
Altered thermal stratification of lakes	4.5.1.1	1
Scouring caused by discharged cooling water	4.5.1.1	1
Discharge of metals in cooling system effluent	4.5.1.1	1
Discharge of biocides, sanitary wastes, and minor chemical spills	4.5.1.1	1
Surface water use conflicts (plants with once-through cooling systems)	4.5.1.1	1
Surface water use conflicts (plants with cooling ponds or cooling towers using makeup water from a river)	4.5.1.1	2
Effects of dredging on surface water quality	4.5.1.1	1
Temperature effects on sediment transport capacity	4.5.1.1	1

Sources: Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51 (78 FR 37282); NRC 2013

<u>Generic Surface Water Resources</u>

The NRC staff did not identify any new and significant information with regard to Category 1 (generic) surface water issues based on review of the SQN ER (TVA 2013a), the public scoping process, or as a result of the environmental site audit. As a result, no information or impacts related to these issues were identified that would change the conclusions presented in the GEIS. Therefore, it is expected that there would be no incremental impacts related to these Category 1 issues during the renewal term beyond those discussed in the GEIS. For these surface water issues, the GEIS concludes that the impacts are SMALL.

<u>Surface Water Use Conflicts</u>

This section presents the NRC staff's review of the plant-specific (Category 2) surface water use conflict issue listed in Table 4–5.

Plants with Cooling Ponds or Cooling Towers Using Makeup Water From a River

For nuclear power plants like SQN that use cooling towers or cooling ponds supplied with makeup water from a river, the potential impact on the flow of the river and its availability to meet the demands of other users is a Category 2 issue. This designation requires a plant-specific assessment.

In evaluating the potential impacts resulting from surface water use conflicts associated with license renewal, the NRC staff uses as its baseline the surface water resource conditions as described in Sections 3.1.3 and 3.5.1 of this SEIS. Terrestrial and aquatic resources are described in Sections 3.6 and 3.7, respectively. These baseline conditions encompass the defined hydrologic (flow) regime of the surface water(s) potentially affected by continued operations as well as the magnitude of surface water withdrawals for cooling and other purposes (as compared to relevant appropriation and permitting standards). The baseline also considers other downstream uses and users of surface water.

As described in Section 3.5.1.1 of this SEIS, TVA operates and regulates the Tennessee River system and its many impoundments, including the Chickamauga Reservoir, to provide for multiple, year-round uses for navigation, flood control, power generation, water-quality improvement and aquatic resources, water supply, recreation, and economic growth. The SQN site is located on a peninsula on the western shore of Chickamauga Reservoir. As such, SQN operations are included in system-wide planning and management.

Peak water demand by the condenser circulating water (CCW) system and the essential raw cooling water (ERCW) system require SQN withdrawals from Chickamauga Reservoir at a rate of 2,600 cubic feet per second (cfs) (73.5 m^3/s, or 1,680 mgd) (TVA 2011b) (see Section 3.1.3). During the 5-year period from 2008 to 2012, withdrawals from Chickamauga Reservoir to support the operations of SQN have averaged 2,445 cfs (69.1 m^3/s, or 1,580 mgd) (see Section 3.5.1.2). Limitations on withdrawals are closely related to thermal compliance for plant diffuser discharges through NPDES permitted outfall 101 to the Tennessee River. As detailed below, SQN uses once-through cooling both with and without the assistance of cooling towers (termed helper and open modes, respectively). SQN operates in a once-through CCW system during most of the year. In the open mode, the water bypasses the cooling tower lift pumps and is returned to the Chickamauga Reservoir through the diffuser pond and the discharge diffusers (TVA 2013a).

Annual average flow of the Tennessee River at Chickamauga Dam is approximately 32,500 cfs (920 m^3/s, or 21,000 mgd). Under the reservoir operations study of 2004, TVA must provide a daily average release of at least 3,000 cfs (84.7 m^3/s, or about 1,940 mgd) from Chickamauga Dam from October through April. From May through September, there are no minimum daily release requirements; only weekly requirements (TVA 2013i) (see Table 4–6). Thus, during periods of minimum daily average flow, SQN could in theory withdraw (at its peak withdraw rate of 2,600 cfs (73.5 m^3/s)) more than 80 percent of the Tennessee River flow. However, NPDES permit (No. TN0026450) requirements for SQN thermal discharges have the added effect of capping SQN water withdrawals. In consideration of SQN operations and thermal discharge limits, TVA currently avoids scheduling daily average releases from the Chickamauga Dam at rates below 6,000 cfs (169 m^3/s, or 3,880 mgd) when both SQN units are in operation, and 3,000 cfs (84.7 m^3/s, or 1,940 mgd) when one SQN unit is in operation. Since January 2007, no daily release from Chickamauga Dam has been less than 6,200 cfs (175 m^3/s, or 4,000 mgd), including during the recent drought years of 2007 and 2008 (TVA 2013i).

Table 4–6. Reservoir Operating System, Minimum Flows for Chickamauga Dam

Month	Flow
January	3,000 cfs daily average
February	3,000 cfs daily average
March	3,000 cfs daily average
April	3,000 cfs daily average
May	7,000 cfs biweekly average
June – July	13,000–25,000 cfs weekly average, depending on week and amount of water in tributary reservoir storage
August	25,000–29,000 cfs weekly average, depending on amount of water in tributary reservoir storage (through Labor Day)
September	7,000 cfs biweekly average (after Labor Day)
October	3,000 cfs daily average
November	3,000 cfs daily average

Note: To convert cfs to m^3/s, divide by 35.4. To convert cfs to mgd, divide by 1.547.

Source: TVA 2013i

Within this operating environment, once-through cooling operations at SQN essentially return all the water withdrawn to the Chickamauga Reservoir. However, surface water is consumed through evaporation and drift when the plant operates in helper mode. In this mode, the cooling towers are used to ensure that Chickamauga Reservoir temperatures remain within the limits specified in SQN's NPDES permit, as described in Section 3.1.3.1, and also discussed below.

SQN's NPDES permit limits the daily maximum 24-hour average river temperature at the downstream end of the diffuser mixing zone to 86.9 °F (30.5 °C). This limit may be exceeded when the 24-hour average ambient temperature exceeds 84.9 °F (29.4 °C) and the plant is operated in helper mode. In that case, the 1-hour average river temperature downstream of the mixing zone cannot exceed 93.0 °F (33.9 °C) without the consent of the Tennessee Department of Environment and Conservation (TDEC).

To date, no thermal discharge limit has been exceeded under the current NPDES permit (TVA 2013i). The temperature of the SQN thermal discharge is primarily a function of the intake water temperature, heat added by the plant condensers, and heat removed by the cooling towers. Other sources and sinks of heat along the flow path of the condenser cooling water are small compared to the contributions by the condensers and the cooling towers. For a given level of power generation and helper mode cooling, higher intake water temperature will result in higher temperature of the thermal discharge from SQN. Under low flow conditions, heated effluent from outfall 101 can propagate 1.1 mi (1.8 km) upstream to the plant intake. When this recirculation of heat occurs, helper mode is often employed to prevent the progressive increase in the intake water temperature, even when there is no immediate risk of exceeding an NPDES temperature limit. Specifically, in the springtime, TVA may implement helper mode operation if the daily average river flow past the plant drops below about 8,000 cfs (226 m^3/s, or about 5,170 mgd) (TVA 2013i).

Helper mode operation averaged 113 days per year for 2006 to 2009 (TVA 2011b). For the period 2007 to 2011, helper mode use averaged about 120 days per year. Helper mode usage increased to 125 days per year for the period 2007 to 2013. Based on a long-term forecasting model using projected temperature increases for the license renewal term, TVA has projected that helper mode operation may increase in certain years by as much as 70 percent compared to the average recent operational experience. However, this conservative projection does not account for TVA's ability to implement options (e.g., increasing river flow) to address extreme hydrothermal conditions that would otherwise require unit derates (reduction of power generation rates) and shutdowns (TVA 2013i).

When operated in full helper mode under design conditions, water losses to the atmosphere from evaporation and drift resulting from cooling tower operation could consume up to 70 cfs (1.98 m^3/s, or 45 mgd). TVA identifies this as a conservative, upper-bounding scenario (TVA 2013a). It reflects a condition in which both cooling towers and all seven cooling tower lift pumps (CTLPs) are operating. This peak consumptive loss of water is approximately 2.7 percent of the peak amount (2,600 cfs (73.5 m^3/s, or 1,680 mgd)) that is withdrawn from the reservoir for two-unit operation, circulated through the plant, and then returned to the reservoir. Further, the net consumptive loss on an average daily basis because of helper cooling tower operation is not likely to exceed 1.2 percent of the typical minimum daily river flow (6,000 cfs), and 0.2 percent of the annual average daily river flow (32,500 cfs) past the SQN site (TVA 2013a).

In reality and as noted above, SQN has historically operated in helper mode only about one-third of the year. The number of recorded "days" of helper mode operation is based on at least one of SQN's seven CTLPs being placed into operation for some number of hours. For the majority of the days where cooling tower helper mode is necessary, SQN averages no more than about four CTLPs in operation (TVA 2013i). As a result, on an annualized basis, the average net consumptive use of water is approximately 9 cfs (0.25 m^3/s, or 6 mgd) (TVA 2013a), which is about 0.15 percent of the typical minimum flow. Relative to the cited magnitude of the variability of flows in the Tennessee River and through Chickamauga Reservoir (as managed by TVA) (see Table 4–6), the hydrologic impacts of surface water withdrawals associated with SQN operations are minor.

In conclusion, operation of SQN during the license renewal term is not expected to result in a water use conflict on the Chickamauga Reservoir. The operation of the Tennessee River system and its many impoundments, including the Chickamauga Reservoir, is and will likely continue to be managed to safeguard resources for a wide range of uses. As discussed in Section 3.5.1.1 of this SEIS, water levels within the system are regulated to ensure adequate instream and downstream flows, which minimizes the impacts on aquatic and riparian resources. To maintain adequate water depth for navigation, water levels in the Chickamauga Reservoir are maintained within an operating range of 6.5 ft (1.98 m) above MSL between winter and summer (TVA 2013a). The NRC staff believes that consumptive water use from continued SQN operations will continue to be a very small percentage of the overall flow of the Tennessee River through the Chickamauga Reservoir. Thermal criteria imposed by TDEC, through SQN's NPDES permit, effectively limit SQN's water withdrawals and consumptive water use to ensure that cooling tower discharges support the designated uses of the reservoir for water supply and aquatic resources. Therefore, the NRC staff concludes that the impact on surface water resources and downstream water availability from SQN consumptive water use during the license renewal term would be SMALL.

4.5.1.2 Proposed Action Groundwater Resources

The GW issues applicable to SQN during the license renewal term are listed in Table 4–7. Section 3.5.2 describes GW resources at SQN.

Table 4–7. Groundwater

Issue	GEIS Section	Category
GW contamination and use (noncooling system impacts)	4.5.1.2	1
GW use conflicts (plants that withdraw <100 gpm)	4.5.1.2	1
Radionuclides released to GW	4.5.1.2	2

Source: Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51

The NRC staff did not identify any new and significant information associated with the Category 1 GW issues identified in Table 4–7 during the review of the applicant's ER, the site audit, the scoping process, or the evaluation of other available information. As a result, no information or impacts related to these issues were identified that would change the conclusions presented in the GEIS (NRC 2013). For these issues, the GEIS concludes that the impacts are SMALL. Therefore, it is expected that there would be no incremental impacts related to these Category 1 issues during the renewal term beyond those discussed in the GEIS, and therefore the impacts associated with these issues by the proposed action would be SMALL.

The Category 2 issue (see Table 4–7) related to GW during the renewal term is discussed in the following text.

Radionuclides Released to Groundwater

This issue considers potential contamination of GW from the release of radioactive liquids from plant systems into the environment. Section 3.5.2.3 of this document contains a description of tritium contamination in GW detected close to some plant structures. In evaluating the potential impacts on GW quality associated with license renewal, the NRC staff uses as its baseline the existing GW conditions as described in Section 3.5.2.3 of this SEIS. These baseline conditions encompass the existing quality of GW potentially affected by continued operations (as compared to relevant State or EPA primary drinking water standards) as well as the current and potential onsite and offsite uses and users of GW for drinking and other purposes. The baseline also considers other downgradient or in aquifer uses and users of GW.

Groundwater contaminated with tritium is not close to the site boundary and has not been detected off site. At SQN, neither the soils, structural fill, nor the underlying Conasauga Group is considered to be an aquifer or a source of water.

Tritium concentrations in GW from 2006 to the present show some variation but do not exhibit a discernible trend, either higher or lower (Julian and Williams 2007; TVA 2010, 2011b, 2012, 2013a, 2013b). The water levels, permeability measurements, and lack of changes in tritium concentrations indicate a lack of significant GW movement. In effect, a small volume of GW is contaminated with tritium and is moving very slowly. Past liquid spills that caused the tritium contamination in GW have been corrected. In the future, the tritium in the GW is projected to move very slowly with the GW and eventually reach Chickamauga Reservoir. Therefore, because of the very slow rate of GW discharge into the much larger volume of water contained in the reservoir, tritium concentrations would be highly diluted to very low concentrations.

Remediation of the contaminated GW at the site is not planned by TVA because of the limited areal extent of tritium concentrations in GW, low exposure and dose risks, and negligible potential for offsite GW migration (TVA 2013c). The NRC will continue to monitor any unanticipated radionuclide releases and take appropriate regulatory action. Final cleanup of the site, including contaminated geologic materials, would be addressed by TVA with NRC oversight during decommissioning of the facility.

There does not appear to be any immediate threat to GW resources. Present and future operations are not expected to impact the quality of GW in any aquifers that are a current or potential future source of water for offsite users. Water use in the area should not be affected. Based on the information presented and the NRC staff's review, the NRC staff concludes that inadvertent releases of tritium have not substantially impaired site GW quality or affected GW use. The NRC staff further concludes that GW quality impacts are SMALL and would remain SMALL during the license renewal term.

4.5.2 No-Action Alternative - Water Resources

4.5.2.1 No-Action Alternative Surface Water Resources

The rate of consumptive use of surface water would decrease as SQN is shut down and the reactor cooling system continues to remove the decay heat from the reactor fuel. The thermal component of plant discharges would be greatly reduced upon shutdown. Wastewater discharges would be reduced considerably. Shutdown would reduce the impacts on surface water use and quality. These impacts would remain SMALL.

4.5.2.2 No-Action Alternative Groundwater Resources

There are no aquifers beneath the SQN site. Groundwater is not presently used from SQN and would not be used when the facility ceases operation. Therefore, the impact on GW is SMALL.

4.5.3 NGCC Alternative - Water Resources

4.5.3.1 NGCC Alternative Surface Water Resources

The NGCC alternative would be located at an existing power plant site or brownfield site with available resources. Construction activities associated with the NGCC alternative would be similar to construction activities for most large industrial facilities. A new NGCC plant would occupy a much smaller footprint (i.e., about 48 ac (19 ha)) than the current SQN or the proposed SCPC or new nuclear alternatives. This would also result in less extensive excavation and earthwork than under either of the other conventional replacement-power facility alternatives. The staff assumes that there would be no direct use of surface water during construction, because it is assumed GW would be used, or water could be supplied by a local water utility. In addition, the dewatering of excavations is unlikely to consume enough water to affect surface water bodies.

For the NGCC alternative, the NRC staff also assumes that any existing intake and discharge infrastructure at an alternative site location would be refurbished to maximize use of existing facilities. This would reduce construction-related impacts on surface water quality. Dredge-and-fill operations would be conducted under a permit from the United States Army Corps of Engineers (USACE) and State-equivalent permits requiring the implementation of BMPs to minimize impacts. Construction activities associated with these alternatives will alter onsite surface water drainage features. Some temporary impacts to surface water quality may result from increased sediment loading and from any pollutants in stormwater runoff from disturbed areas, from excavation, and dredge-and-fill activities. Stormwater runoff from construction areas and spills and leaks from construction equipment could potentially affect downstream surface water quality. Nevertheless, for this alternative, it is anticipated that appropriate soil erosion and sediment control measures would be observed. Application of BMPs in accordance with a State-issued NPDES general permit, including appropriate waste management, water discharge, stormwater pollution prevention plan, and spill prevention practices, would prevent or minimize surface water quality impacts during construction.

Depending on the path of any required new gas pipelines and transmission lines to service the NGCC plant, some stream crossings could be necessary. However, because of the short-term nature of any required dredging and filling and stream-crossing activities, the hydrologic alterations and sedimentation would be localized and water-quality impacts would be temporary. In addition, modern pipeline construction techniques, such as horizontal directional drilling, would further minimize the potential for water-quality impacts in the affected streams. Such activities, including any dredge-and-fill operations, would be conducted under a permit from the USACE or State-equivalent permits for dredge-and-fill and stream encroachment, requiring the implementation of BMPs to minimize impacts.

For onsite facility operations, the NGCC alternative would require much less cooling water than SQN, and total consumptive water use would also be much less on an annualized basis. The staff assumes that a new NGCC plant at an alternative TVA site would utilize a closed-cycle cooling system employing mechanical draft cooling towers. It is projected that an NGCC plant would require approximately 23 cfs (0.65 m^3/s, or 14.9 mgd) of water for cooling and related processes, with consumptive use totaling approximately 77 percent of the total withdrawn (or about 17.6 cfs (0.5 m^3/s, or 11.4 mgd)). While the significance of cooling water withdrawals on a particular water body would vary based on the site selected within TVA's service area, peak consumptive water use from operation of a new NGCC plant at an alternative site would be about 25 percent of that associated with existing SQN operations. However, on an annualized basis, an NGCC plant's consumptive use would actually be twice that of current SQN operations (i.e., 9 cfs (0.25 m^3/s, or 6 mgd)), as detailed in Section 4.5.1.1. Surface water withdrawals would be subject to applicable State water appropriation or registration requirements to manage surface water use conflicts. Cooling water treatment additives would essentially be the same as SQN. While the discharge water quality would be chemically similar, the discharge volume from a new NGCC plant would be a small fraction of the cooling water discharge, blowdown, and related effluents discharged from SQN during either once-through cooling or helper mode. All effluent discharges would be subject to State-issued NPDES individual permits for the discharge of wastewater and industrial stormwater to waters of the United States. Therefore, based on the above assessment, the impacts on surface water use and quality under the NGCC alternative would be SMALL.

4.5.3.2 NGCC Alternative Groundwater Resources

For the NGCC alternative, the staff assumed that construction water would be obtained from GW or from a local water utility. Construction water would be required for such uses as potable and sanitary use by the construction workforce and for concrete production, equipment washdown, dust suppression, and soil compaction. The dewatering of excavations is unlikely to consume enough water to affect GW supplies. During construction and throughout the life of this alternative, GW withdrawals would be subject to applicable State water appropriation and registration requirements. The application of BMPs in accordance with a State-issued NPDES general permit, including appropriate waste management, water discharge, stormwater pollution prevention plan, and spill prevention practices, would prevent or minimize GW quality impacts during construction. For this alternative, after the facility is constructed and operational, GW from onsite wells would be used as a source of potable water and for fire protection. During operations, the consumptive use of potable water and water for fire protection would be similar to the proposed action. Therefore, the impact of this alternative on GW resources would be SMALL.

4.5.4 SCPC Alternative - Water Resources

4.5.4.1 SCPC Alternative Surface Water Resources

Impacts from construction activities associated with the SCPC alternative on surface water resources would be expected to be similar to but somewhat greater than those under the NGCC alternative (see Section 4.5.3.1). This is attributable to the additional land required (i.e., 131 ac (53.0 ha)) for construction of the power block and for excavation and construction of other onsite facilities for coal handling and storage, and for coal ash and scrubber waste management. The staff assumes that there would be no direct use of surface water during construction because it is conservatively assumed that GW would be used, or water could be supplied by a local water utility.

Some temporary impacts to surface water quality may result from increased sediment loading and from pollutants in stormwater runoff from disturbed areas and from excavation and dredge-and-fill activities. There also would be the potential for water-quality effects to occur from the extension or refurbishment of rail spurs to transport coal to the site location. Nevertheless, as described in Section 4.5.3.1 for the NGCC alternative, water-quality impacts would be minimized by the application of BMPs and compliance with State-issued NPDES permits for construction. Any dredge-and-fill operations would be conducted under a permit from USACE and State-equivalent permits requiring the implementation of BMPs to minimize impacts.

Cooling water treatment additives would essentially be the same so that the discharge water quality would be chemically similar to SQN. During peak cooling operations, the SCPC alternative would consumptively use less water than SQN does operating in helper cooling mode, because of the greater generation efficiency of the SCPC technology. The staff assumes that a new SCPC plant at an alternative TVA site would utilize natural draft cooling towers. It is projected that an SCPC plant would require approximately 53 cfs (1.5 m^3/s, or 34 mgd) of water for cooling makeup and related processes, with consumptive use totaling approximately 80 percent of the total withdrawn (about 42 cfs (1.2 m^3/s, or 27 mgd)). Nevertheless, on an annualized basis, an SCPC plant’s consumptive use would actually be substantially greater than that of current SQN operations (i.e., 9 cfs (0.25 m^3/s, or 6 mgd)), as detailed in Section 4.5.1.1.

Surface water withdrawals and effluent discharges would be subject to applicable regulatory requirements under this alternative. As a result, the overall impacts on surface water use and quality from construction and operations under the SCPC alternative would be SMALL.

4.5.4.2 SCPC Alternative Groundwater Resources

Facts considered, assumptions made, and conclusion reached in determining the impact significance level on GW resources from the SCPC alternative are the same as for the NGCC alternative described in Section 4.5.3.2. Therefore, impacts of the SCPC alternative on GW resources would be SMALL.

4.5.5 New Nuclear Alternative - Water Resources

4.5.5.1 New Nuclear Alternative Surface Water Resources

Impacts from construction activities on surface water resources associated with the new nuclear alternative would be greater in scale than those described for the SCPC alternative (see Section 4.5.4.1) by virtue of the larger land area required (i.e., up to 1,000 ac (405 ha)). While coal storage or ash and scrubber waste management facilities would not be required as under the SCPC alternative, deep excavation work for the nuclear island as well as more extensive site clearing and larger laydown area for facility construction would have potentially greater impacts on water resources caused by stream alteration, water use, and stormwater runoff.

The NRC staff assumes that there would be no direct use of surface water during construction, because it is conservatively assumed that GW would be used, or water would be supplied by a local water utility. During construction, the dewatering of excavations is unlikely to affect offsite surface water bodies. In support of new nuclear unit construction, temporary impacts to surface water quality may result from increased sediment loading and from pollutants in stormwater runoff from disturbed areas, deep excavations, and from any required dredge-and-fill activities. Nevertheless, as described in Section 4.5.3.1 water-quality impacts would be minimized by the application of BMPs and compliance with State-issued NPDES permits for construction. Any dredge-and-fill operations would be conducted under a permit from the USACE and State-equivalent permits requiring the implementation of BMPs to minimize impacts.

To support operations of a new nuclear power plant, the staff expects that the new facility would utilize natural draft cooling towers operating in a closed-cycle configuration. Consequently, it is estimated that the operation of two new nuclear units would require up to 96 cfs (2.7 m^3/s, or 62 mgd) of water for cooling makeup and related processes, with consumptive use totaling approximately 80 percent of the total withdrawn (about 74 cfs (2.1 m^3/s, or 48 mgd)). While cooling water makeup requirements would be considerably less under this alternative (less than 5 percent) as compared to current SQN operations, consumptive water use would be considerably greater than SQN, and consumptive use would be continuous throughout the year, subject to seasonal variation. While the relative significance of cooling water withdrawals on a particular water body would vary based on the site selected within TVA's service area for the new nuclear units, SQN's peak daily consumptive use is similar to the projected average consumptive loss under this alternative.

The NRC assumes that water treatment additives for new nuclear plant operations and effluent discharges would be relatively similar in quality and volume to SQN. As summarized in Section 4.5.3.1, surface water withdrawals and effluent discharges would be subject to applicable regulatory requirements under this alternative. As a result, the overall impacts on surface water use and quality from construction and operations under the new nuclear alternative would be SMALL.

4.5.5.2 New Nuclear Alternative Groundwater Resources

Facts considered, assumptions made, and conclusion reached in determining the impact significance level on GW resources from the new nuclear alternative are the same as for the NGCC alternative described in Section 4.5.3.2. Therefore, impacts of the new nuclear alternative on GW resources would be SMALL.

4.5.6 Combination Alternative - Water Resources

4.5.6.1 Combination Alternative Surface Water Resources

Impacts on surface water resources from constructing up to 3,150 land-based wind turbines would primarily be limited to the relatively small amounts of water needed at each installation site for dust suppression and soil compaction during site clearing and for concrete production. Construction of utility-scale solar PV farms would require relatively larger volumes of water per site due to the much larger land area required per megawatt of replacement power produced.

The NRC assumes that required water would be procured from offsite sources and trucked to the point of use on an as-needed basis. Water could also be supplied by a local water utility. The likely use of ready-mix concrete would also reduce the need for onsite use of nearby water sources for construction.

In addition, the installation of land-based wind turbines and utility-scale solar PV farms would require installation of access roads and possibly transmission lines (especially for sites not already proximal to transmission line corridors). Access road construction would also require some water for dust suppression and roadbed compaction and would have the potential to result in soil erosion and stormwater runoff from cleared areas. For construction, water would likely be trucked to the point of use from offsite locations along with road construction materials. In all cases, it is expected that construction activities would be conducted in accordance with State-issued NPDES or equivalent permits for stormwater discharges associated with construction activity, which would require the implementation of appropriate BMPs to prevent or mitigate water-quality impacts. In contrast to land-based wind turbine sites and utility-scale solar PV farms, installation of small solar PV units on rooftops and at already-developed sites within the TVA service area would have little or no impact on surface water resources.

To support the operation of wind turbine and PV installations, no direct use of surface water would be expected. Water would likely be obtained from GW or purchased from a water utility. Regardless, only very small amounts of water would be needed to periodically clean turbine blades and motors and could be trucked to the point of use as part of routine servicing. Water also would be required to clean panels at solar PV farms. Adherence to appropriate waste management and minimization plans, spill prevention practices, and pollution prevention plans during servicing of wind turbine and solar PV installations and operation of vehicles connected with site operations would minimize the risks to soils and surface water resources from spills of petroleum, oil, and lubricant products and stormwater runoff. In consideration of the information above, the impacts on surface water use and quality from construction and operations under the combination alternative would be SMALL.

4.5.6.2 Combination Alternative Groundwater Resources

Construction dewatering would be minimal because of the small footprint of foundation structures, pad sites, and piling emplacements. Little or no impacts on GW use or water quality would be expected from routine operations. Consequently, the impacts on GW use and quality under this alternative would be SMALL.

4.6 Terrestrial Resources

This section describes the potential impacts of the proposed action (license renewal) and alternatives to the proposed action on terrestrial resources.

4.6.1 Proposed Action

Terrestrial resources issues applicable to SQN during the license renewal term are listed in Table 4–8. Terrestrial resources at SQN are described in Section 3.6.

Table 4–8. Terrestrial Resources

Issue	GEIS Section	Category
Effects on terrestrial resources (non-cooling system impacts)	4.6.1.1	2
Exposure of terrestrial organisms to radionuclides	4.6.1.1	1
Cooling system impacts on terrestrial resources (plants with once-through cooling systems or cooling ponds)	4.6.1.1	1
Cooling tower impacts on vegetation (plants with cooling towers)	4.6.1.1	1
Bird collisions with plant structures and transmission lines[a]	4.6.1.1	1
Water use conflicts with terrestrial resources (plants with cooling ponds or cooling towers using makeup water from a river)	4.6.1.1	2
Transmission line ROW management impacts on terrestrial resources[a]	4.6.1.1	1
Electromagnetic fields on flora and fauna (plants, agricultural crops, honeybees, wildlife, livestock)	4.6.1.1	1

[a] This issue applies only to the in-scope portion of electric power transmission lines, which are defined as transmission lines that connect the nuclear power plant to the substation where electricity is fed into the regional power distribution system and transmission lines that supply power to the nuclear plant from the grid.

Source: Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51

4.6.1.2 Generic Terrestrial Resource Issues

For the Category 1 terrestrial resources issues listed in Table 4–8, the NRC staff did not identify any new and significant information during the review of the ER (TVA 2013a), the NRC staff's site audit, the scoping process, or the evaluation of other available information. Therefore, there are no impacts related to these issues beyond those discussed in the GEIS. For these issues, the GEIS concludes that the impacts are SMALL.

4.6.1.3 Effects on Terrestrial Resources (Non-Cooling System Impacts)

The geographic scope for the assessment of this issue is the SQN site and area near the site. Section 3.6 describes the terrestrial resources on and in the vicinity of the SQN site, including State-protected plants, birds, mammals, reptiles, and amphibians as well as birds protected under the Migratory Bird Treaty Act and Bald and Golden Eagle Protection Act. Construction of the SQN plant converted approximately 525 ac (212 ha) of terrestrial habitat, such as mixed hardwood forest, pine forest, pasture, and old fields, into buildings, parking lots, landscaped areas, and other industrial uses. The remaining terrestrial and associated wetland habitats have not changed significantly since construction (TVA 2013a). As discussed in Chapter 3 and according to the applicant's ER (TVA 2013a), TVA has no plans to conduct refurbishment or replacement actions associated with license renewal to support the continued operation of SQN. Further, TVA (2013a) anticipates no new construction in previously undisturbed habitats. Nor does TVA (2013a) expect changes in operations or changes in existing land use conditions because of license renewal.

TVA would continue to conduct ongoing plant operational and maintenance activities during the license renewal period. However, these activities are expected to have minimal impacts on terrestrial resources because activities would not occur within previously undisturbed habitats and because regulations, permits, and policies are in place to protect terrestrial resources at

SQN (TVA 2013a). For example, TVA manages the SQN site in accordance with the U.S. Army Corps of Engineers' Section 404 permitting process, TVA's NPDES Permit TN0026450, TVA's Multi-Sector General Stormwater Permit TNR 050015 issued by the Tennessee Department of Environment and Conservation (TDEC), and TVA's Spill Prevention, Control, and Countermeasures (SPCC) Plan, as appropriate (TVA 2013a). Under TVA's Multi-Sector General Stormwater Permit, TVA is required to develop, maintain, and implement a Stormwater Pollution Prevention Plan (SWPPP) that identifies potential sources of pollution that could affect the quality of stormwater and identifies how TVA will prevent or reduce pollutants from stormwater discharges (TVA 2013a). Similarly, TVA has an SPCC plan that identifies and describes the procedures, materials, equipment, and facilities used at the station to minimize the frequency and severity of oil spills (TVA 2013a). In accordance with the Federal Insecticide, Fungicide, and Rodenticide Act, only certified personnel conduct pesticide and herbicide applications at SQN (TVA 2013a).

When new activities that could impact the environment occur at SQN, TVA implements various procedural controls and BMPs to protect terrestrial habitats and wildlife, State-listed and important species, wetland areas, and water quality (TVA 2013a). For example, as a Federal agency, TVA is required to conduct environmental reviews for such activities, which include an analysis of the potential environmental impacts. TVA uses such analyses to inform its decisions and determine what action, if any, is to be taken to protect, restore, and enhance the environment. In its ER for the proposed SQN license renewal, TVA (2013a) determined that these control measures ensure that activities at SQN comply with the National Environmental Policy Act (NEPA), TVA's implementing regulations, the Council on Environmental Quality (CEQ) regulations, and other environmental laws, regulations, and executive orders.

Based on the NRC staff's independent review, the staff concludes that operation and maintenance activities that TVA might undertake during the renewal term, such as maintenance and repair of plant infrastructure (e.g., roadways, piping installations, onsite transmission lines, fencing and other security infrastructure), would likely be confined to previously disturbed areas of the site. Furthermore, TVA has established and implements several policies, procedures, and control measures to ensure that activities at SQN comply with NEPA, TVA's implementing regulations, the CEQ's regulations, and other environmental laws, regulations, and executive orders. Therefore, the NRC staff expects non-cooling system impacts on terrestrial resources during the license renewal term to be SMALL.

4.6.1.4 Water Use Conflicts with Terrestrial Resources (Plants with Cooling Ponds or Cooling Towers Using Makeup Water from a River)

For nuclear power plants using cooling towers or cooling ponds supplied with makeup water from a river, the potential impact on the flow of the river and its availability to meet the demands of other users is a Category 2 issue. This designation requires a plant-specific assessment of the potential impacts resulting from surface water use conflicts, which is discussed in detail in Section 4.5.1. This section addresses the effects of water use conflicts on terrestrial resources in riparian communities, and the potential impacts on aquatic (instream) communities are discussed in Section 4.7.1. Water use conflicts with terrestrial resources in riparian communities could occur when water that supports these resources is diminished either because of decreased availability due to droughts; increased water demand for agricultural, municipal, or industrial usage; or a combination of such factors (NRC 2013d).

The NRC staff concluded in Section 4.5.1 of this SEIS that the operation of SQN during the license renewal term is not expected to result in a surface water use conflict on the Chickamauga Reservoir. This conclusion was reached because TVA regulates water levels in the Chickamauga Reservoir and the Tennessee River system to ensure adequate instream and downstream flows for aquatic and riparian resources. The NRC staff concluded that consumptive water use from continued SQN operations has been and will continue to be a very small percentage of the overall flow of the Tennessee River through the Chickamauga Reservoir. Therefore, the NRC staff concludes that the impact of water use conflicts with riparian communities during the license renewal term would be SMALL.

4.6.2 No-Action Alternative – Terrestrial Resources

If the plant were to cease operating, the terrestrial ecology impacts would be SMALL, assuming that no additional land disturbances on or off site would occur prior to decommissioning activities.

4.6.3 NGCC Alternative – Terrestrial Resources

Construction of an NGCC plant would occur at the site of an existing power plant other than SQN or a brownfield site with available resources and would require about 48 ac (19 ha) of land for the plant itself and up to 8,640 ac (3,497 ha) of additional land off site for wells, collection stations, and pipelines to bring the gas to the plant (see Section 4.2.3.1). Because the onsite land requirement is relatively small, the plant operator would likely be able to site most of the construction footprint in previously disturbed, degraded habitat, which would minimize impacts to terrestrial habitats and species. Offsite construction would occur mostly on land where gas extraction is occurring already. Siting any new gas pipelines or transmission lines along existing utility corridors would minimize impacts. Erosion and sedimentation, fugitive dust, and construction debris impacts would be minor with implementation of appropriate BMPs. Impacts to terrestrial habitats and species from transmission line operation and corridor vegetation maintenance, and operation of the mechanical-draft cooling towers would be similar in magnitude and intensity as those resulting from operating nuclear reactors and would, therefore, be SMALL (NRC 2013d). Overall, the impacts of construction and operation of an NGCC plant to terrestrial habitats and species would be SMALL.

4.6.4 SCPC Alternative – Terrestrial Resources

Construction of an SCPC plant would require approximately 131 ac (53 ha), as described in Section 4.2.4.1. Because of the relatively large land requirement for the SCPC alternative, a portion of the site may be land that had not been previously disturbed, especially if the SCPC alternative is sited at an existing NGCC plant site. Construction within undisturbed land would directly affect terrestrial habitat by removing existing vegetative communities and displacing wildlife. The level of direct impacts would vary substantially based on the amount and ecological importance of directly affected habitats. Construction of a railroad spur may be necessary, depending on the existing infrastructure at the site. Siting the spur along an existing, previously disturbed railroad corridor would minimize impacts to terrestrial habitat. Otherwise, the rail spur could create new edge habitat and reduce the availability of continuous tracts of habitat. Erosion and sedimentation, fugitive dust, and construction debris impacts would likely be minor with the implementation of appropriate BMPs. Impacts to terrestrial habitats and species from transmission line operation and corridor vegetation maintenance, and operation of the cooling system would be similar in magnitude and intensity as those resulting from operating nuclear reactors and would, therefore, be SMALL (NRC 2013d). The SCPC alternative may require 7,440 ac (3,011 ha) to 52,800 ac (21,400 ha) of additional land for coal mining and processing, as described in Section 4.2.4.1. Offsite activities would occur mostly on land where coal extraction is ongoing. Because of the potentially large area of undisturbed habitat that could be affected from construction of an SCPC plant, the impacts of construction on terrestrial habitats and species could range from SMALL to MODERATE depending on the amount and ecological importance of directly affected habitats. The impacts of operation would be SMALL.

4.6.5 New Nuclear Alternative – Terrestrial Resources

The new nuclear alternative, including the new reactor units and auxiliary facilities, would affect 1,000 ac (405 ha) of land at the site of an existing nuclear power plant other than SQN (TVA 2013a), as described in Section 4.2.5.1. Because of the significant land requirement for the site, impacts to terrestrial species and habitats would vary depending on the amount of previously undisturbed land that would be cleared for the new nuclear alternative. By siting the new nuclear alternative at an existing nuclear site, the majority of land that would be affected by construction would be developed or previously disturbed. However, as with the SCPC alternative, the level of direct impacts would vary based on the extent and ecological importance of habitat disturbed during construction activities. For the purposes of this analysis, the NRC staff assumed that the new nuclear alternative is built within the footprint of an existing nuclear power plant site. Erosion and sedimentation, fugitive dust, and construction debris impacts would be minor with implementation of appropriate BMPs. Impacts to terrestrial habitats and species from transmission line operation and corridor vegetation maintenance, and operation of the cooling system would be similar in magnitude and intensity to those resulting from operating nuclear reactors and would, therefore, be SMALL (NRC 2013a). The offsite land requirement would be about 2,400 ac (971 ha) (NRC 1996) and impacts associated with uranium mining and fuel fabrication to support the new nuclear alternative would be no different from those occurring in support of SQN (see Section 4.2.5.1). Assuming the new nuclear alternative is built within the footprint of an existing nuclear power plant site, the impacts of construction and operation of a new nuclear facility on terrestrial species and habitats would be SMALL.

4.6.6 Combination Alternative – Terrestrial Resources

4.6.6.1 Wind

The wind portion of the combination alternative would contain between 2,350 to 3,150 land-based wind turbines requiring approximately 1,410 to 1,890 ac (570 to 765 ha) of land, although only 5 to 10 percent of this area would be affected during operations, as discussed below. The remaining area would be relatively unaffected after construction is complete.

During construction of wind farms, the logistics of delivering heavy or oversized components to ideal locations such as hilltops or ridgelines could require extensive modifications to existing road infrastructures and construction of access roads that take circuitous routes to their destination to avoid unacceptable grades. However, once construction was completed, many access roads could be reclaimed and replaced with more-direct access to the wind farm for maintenance purposes. Likewise, land used for equipment laydown and turbine component assembly and erection could be returned to its original state. Following construction, BMPs that include plans to restore disturbed land would also reduce the impact of construction on terrestrial habitats. Overall, construction impacts on terrestrial species and habitats could range from SMALL to MODERATE depending upon the degree of undisturbed and forested habitat that is directly affected by the wind portion of the combination alternative.

Because wind turbines require ample spacing between one another to avoid air turbulence between them, the footprint of utility-scale wind farms would range from 410 to 1,890 ac (570 to 765 ha). During operations, however, only 5 to 10 percent of the total acreage within the footprint of wind installations would actually be occupied by turbines, access roads, support buildings, and associated infrastructure while the remaining land areas could be put to other compatible uses, including agriculture. Habitat loss and some habitat fragmentation may occur as a result, especially for wind turbines installed in forested areas. Operation of wind turbines could uniquely affect terrestrial species from noise, collision with turbines and meteorological towers, site maintenance activities, disturbance associated with activities of the project workforce, and interference with migratory behavior. Bat and bird mortality from turbine collisions is a concern for operating wind farms; however, recent developments in turbine design have reduced the potential for bird and bat strikes. Additionally, impacts to those bird and bat species protected by the Migratory Bird Treaty Act or the Bald and Golden Eagle Protection Act could be mitigated through licensee and NRC interactions with the appropriate agencies. Impacts to terrestrial habitats and species from transmission line operation and corridor vegetation maintenance would be similar in magnitude and intensity to those resulting from operating nuclear reactors and would, therefore, be SMALL (NRC 2013d). Overall, operational impacts to terrestrial species and habitats could range from SMALL to MODERATE depending on the likelihood of bird strikes and interference with migratory behaviors.

4.6.6.2 Solar

Up to 12,400 to 17,980 ac (5,018 to 7,276 ha) could be necessary for a solar PV alternative at standalone sites (see Section 4.2.6.1). However, the amount of land would likely be less because some of the solar installation would include many relatively small installations on building roofs or existing residential, commercial, or industrial sites. Constructing solar installations on existing structures would have minimal impacts to terrestrial resources given that these sites provide negligible, if any, terrestrial habitat. Construction at standalone solar sites could have greater impacts given the large amount of land required. Siting standalone installations in previously disturbed areas would minimize impacts. Because many of the installations would likely be installed in developed areas that are already connected to the regional electric grid, construction of additional transmission lines or access roads to solar PV installation sites would likely be unnecessary. During operations, impacts would be minimal because of relatively flat and low design of most installations. Therefore, the NRC staff determined that the impact from construction on terrestrial habitats and species could range from SMALL to MODERATE, depending on the number of installations built within previously undisturbed habitats, and the impacts of operation to terrestrial habitats and species would be SMALL.

4.6.6.3 Conclusion

Overall, construction of the combination alternative would have a SMALL to MODERATE impact on terrestrial habitats and species, and operation would also have a SMALL to MODERATE impact.

4.7 Aquatic Resources

This section describes the potential impacts of the proposed action (license renewal) and alternatives to the proposed action on aquatic resources.

4.7.1 Proposed Action

The aquatic resource issues applicable to SQN during the license renewal term are listed in Table 4–9. Section 3.1.3 describes the SQN cooling water system. Section 3.7 describes the aquatic resources. The impacts of managing the transmission line right-of-way do not apply because the proposed license renewal will use the existing onsite switchyard and transmission facilities (TVA 2013g). The NRC staff did not consider impacts along existing transmission system right-of-ways off site as a part of this SEIS.

Table 4–9. Aquatic Resources

Issues	GEIS Section	Category
Impingement and entrainment of aquatic organisms (plants with once-through cooling systems or cooling ponds)	4.6.1.2	2
Impingement and entrainment of aquatic organisms (plants with cooling towers)	4.6.1.2	1
Entrainment of phytoplankton and zooplankton (all plants)	4.6.1.2	1
Thermal impacts on aquatic organisms (plants with once-through cooling systems or cooling ponds)	4.6.1.2	2
Thermal impacts on aquatic organisms (plants with cooling towers)	4.6.1.2	1
Infrequently reported thermal impacts (all plants)	4.6.1.2	1
Effects of cooling water discharge on dissolved oxygen, gas supersaturation, and eutrophication	4.6.1.2	1
Effects of nonradiological contaminants on aquatic ecosystems	4.6.1.2	1
Exposure of aquatic organisms to radionuclides	4.6.1.2	1
Effects of dredging on aquatic organisms	4.6.4.2	1
Water use conflicts with aquatic resources (plants with cooling ponds or cooling towers using makeup water from a river)	4.6.1.2	2
Effects on aquatic resources (noncooling system impacts)	4.6.1.2	1
Losses from predation, parasitism, and disease among organisms exposed to sublethal stresses	4.6.1.2	1

Source: Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51

4.7.1.1 Aquatic Ecology Issues

The NRC staff did not identify any new and significant information related to the generic (Category 1) issues listed above during the review of TVA's ER, the site audit, or the scoping process. Therefore, no impacts are associated with these issues beyond those discussed in the GEIS. The GEIS concludes that the impact levels for these issues are SMALL.

For the site-specific (Category 2) issues, the NRC staff examined the present and past impacts resulting from plant operation to infer future impacts over the license renewal term, i.e., the remainder of the present term plus an additional 20 years. Two related concepts bound the analysis of direct and indirect impacts in time and space: the timeframe and geographic extent. The timeframe defines how far back and how far forward the analysis will extend, and the timeframe for the direct and indirect impacts is less extensive than the timeframe for cumulative impacts (discussed in section 4.16.5 of this SEIS). The timeframe of analyses for ecological resources centers on the present and extends far enough into the past to understand trends and to determine whether the resource is stable, which the NRC definitions of impact levels require. For assessing direct and indirect impacts, the geographic extent depends on the biology of the species under consideration.

In assessing the level of impact, the NRC staff looks at the projected effects in comparison to a baseline condition. Consistent with NEPA guidance (CEQ 1997), the baseline of the assessment is the condition of the resource without the action, i.e., under the no-action alternative. Under the no-action alternative, the plant would shut down and the resource would conceptually be in its present condition without the plant, which is not necessarily the condition of the resource before the plant was constructed.

4.7.1.2 Impingement and Entrainment of Aquatic Organisms

Impingement and entrainment of aquatic organisms are site-specific (Category 2) issues for assessing impacts of license renewal at plants with once-through cooling systems.

Impingement, according to EPA (66 FR 65256),

> …takes place when organisms are trapped against intake screens by the force of the water passing through the cooling water intake structure. Impingement can result in starvation and exhaustion (organisms are trapped against an intake screen or other barrier at the entrance to the cooling water intake structure), asphyxiation (organisms are pressed against an intake screen or other barrier at the entrance to the cooling water intake structure by velocity forces that prevent proper gill movement, or organisms are removed from the water for prolonged periods of time), and descaling (fish lose scales when removed from an intake screen by a wash system) and other physical harms.

The impingement rate is influenced by factors including flow, intake velocity, and swimming speed. Death from impingement (impingement mortality) can occur immediately or subsequently as an individual succumbs to physical damage upon its return to the water body. The NRC staff assumes a 100 percent mortality rate for impinged organisms in the absence of a fish-return system. The SQN intakes do not have a fish-return system.

Entrainment, as defined by the EPA (66 FR 65256) occurs when

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

EPA indicated that "entrainment is related to flow" and that "[l]arger withdrawals of water may result in commensurately greater levels of entrainment" (69 FR 41576). For entrainment assessment, the NRC staff assumes 100 percent mortality of entrained organisms.

The GEIS (NRC2013e) lists species commonly impinged or entrained at power plants. The list includes species found in the Chickamauga Reservoir, including alewife (*Alosa pseudoharengus*), gizzard shad (*Dorosoma cepedianum*), common carp (*Cyprinus carpio*), white bass (*Morone chrysops*), sunfish (*Lepomis* spp.), crappie (*Pomoxis annularis* and *P. nigromaculatus*), yellow perch (*Perca flavescens*), and freshwater drum (*Aplodinotus grunniens*). Further, the GEIS reports that impingement at some plants is often seasonal with order-of-magnitude greater numbers of fish impinged in the colder months. For some southern plants (e.g., McGuire Nuclear Plant in North Carolina or V.C. Summer Nuclear Generating Station in South Carolina), most of the fish that were impinged (gizzard shad or threadfin shad) were already dead or moribund at the time they were impinged, and the GEIS concludes that they would have been lost even if they had not been impinged.

Because of the various linkages between entrainment and impingement at different life stages for the species present in the Chickamauga Reservoir, the NRC staff used a weight-of-evidence approach to evaluate the effects of impingement and entrainment on the aquatic resources in the Chickamauga Reservoir. The term “weight-of-evidence” has many meanings. Menzie et al. (1996) provides an overview of the weight-of-evidence approach as “…the process by which multiple measurement endpoints are related to an assessment endpoint to evaluate whether significant risk of harm is posed to the environment.” The NRC’s final SEIS regarding Cooper Nuclear Station (NRC 2010) defined weight-of-evidence as “an organized process for evaluating information or data from multiple sources to determine whether there is evidence to suggest that an existing or future environmental action has the potential to result in an adverse impact.” The EPA (1998b) recommends a weight-of-evidence approach for ecological risk assessments. The NRC (2010, 2013c, 2013f) has used this approach in the SEISs for other license renewal applications.

The NRC staff examined multiple lines of evidence to determine if the operation of the SQN cooling system has the potential to cause adverse impacts to aquatic organisms in the vicinity of the SQN site. The first line of evidence is based on impingement data obtained by TVA during studies conducted from 1981 to 1985 (Dycus 1986), a short winter study in 2001–2002 (Kay and Baxter 2002), and studies from 2005 to 2007 (TVA2007c) in response to EPA’s 2004 then-proposed 316(b) Rule. The second line of evidence is based on entrainment data provided by TVA during studies that occurred from 1981 through 1985 (Dycus 1986) and in 2004 (Baxter and Buchanan 2010). The third line of evidence utilizes TVA’s (2012c) monitoring of fish populations prior to and during operations at the two sampling sites above and below the SQN site.

The lines of evidence directly relate to NRC’s definitions of SMALL, MODERATE, and LARGE, as described in Section 1.4 are as follows:

- The NRC staff categorized the impingement and entrainment impacts as SMALL and concluded that impingement and entrainment will not destabilize or noticeably alter the aquatic resources if
  - monitoring data show the same species were consistently entrained or impinged without resulting in an observable decrease over time in the abundance of the species most affected by entrainment and impingement and
  - the number of equivalent adults and the amount of production foregone from impingement were small in comparison to the adult population of the same species in the reservoir.
- The NRC staff categorized the impingement and entrainment impacts as MODERATE and concluded that impingement and entrainment noticeably alters but does not destabilize the aquatic resources near the SQN site if
  - the monitoring data show a sustained decrease over time in the abundance of entrained or impinged species at sampling locations

above and below the site but no change in the abundance of species that feed on the entrained or impinged species and

- the number of equivalent adults and the amount of production foregone from impingement were high enough to noticeably change but not cause a decreasing trend in the population of one or more of the species in the reservoir over a period of more than one or two years.

- The NRC staff categorized the impingement and entrainment impacts as LARGE and concluded that impingement and entrainment effects are clearly noticeable and destabilize the aquatic resources near the SQN site if

  - monitoring data indicate a sustained decrease over time in the abundance of an entrained or impinged species at sampling locations above and below the site and a similar decrease over time in the abundance of species that feed on the entrained or impinged species and

  - the number of equivalent adults and the amount of production foregone for impinged species were high enough to noticeably change and decrease the population of any species.

Impingement

TVA conducted three impingement studies at the SQN intake. The first study occurred between 1981 and July 1985 (Dycus 1986), starting the same year as the commercial operation of SQN Unit 1 began. TVA discontinued impingement sampling prior to the end of the fifth consecutive year of impingement sampling because of low impingement rates. During the 4.5 years of sampling, threadfin shad was the dominant species impinged (Dycus 1986). Threadfin shad made up between 30 percent and 80 percent of the fish impinged in any given year (based on data presented in Dycus 1986). Other species with high impingement rates included gizzard shad (0.6 percent to 24 percent), freshwater drum (4 percent to 19 percent), and bluegill (6 percent to 17 percent).

TVA researchers (Kay and Baxter 2002) conducted the second impingement study in the winter, from December 19, 2001, through February 25, 2002. During this study, TVA collected 10 impingement samples based of about 24 hours of operation per sample (48 hours for one sample in January) and identified 13,570 individuals from 15 fish species representing 8 families and weighing a total of 50,532 g (111 lb). Because one sample was of 48 hours duration, this is equivalent to 11 sampling days collected over a period of 69 days. Assuming that these sampling days are representative and extrapolating to the 69-day sampling period, the total number of fish caught would be (13,570 fish/11 days) x 69 days = 85,121 fish and the total biomass would be 311,973 g (699 lb). The fish were generally small, with an overall average weight of 3.7 g (0.13 oz) per fish, calculated as 50,532 g collected divided by 13,570 individuals collected. Threadfin shad was again the numerically dominant species, with 13,160 individuals comprising 97 percent of the total number of individuals collected (74 percent of the total weight). The next most common species was bluegill (0.80 percent of the total number of individuals, 0.64 percent of the weight), freshwater drum (0.77 percent of the total number of individuals, 15 percent of the weight), and gizzard shad (0.43 percent of the total number of individuals, 1.3 percent of the weight). All other species contributed less than 1 percent of the total number and weight.

TVA researchers conducted weekly impingement studies from January 25, 2005, through January 15, 2007 (TVA2007c), again collecting fish after 24 hours of operation. TVA reported 22 species from 9 families during this impingement study. The estimated annual impingement (extrapolated from weekly impingement rates) was 20,233 fish during the first year and 40,362 fish during the second year, as shown in Table 4–10. Threadfin shad comprised 91 percent of the total individuals during the entire impingement study, followed by bluegill (3 percent), freshwater drum (2 percent), and channel and blue catfish (1 percent each). All other species contributed less than 1 percent of the total. The largest contributors to biomass were the blue catfish (22 percent), threadfin shad (21 percent), channel catfish (17 percent), and freshwater drum (15 percent).

Table 4–10. List of Fish Species by Family, Scientific, and Common Name and Numbers Collected in Impingement Samples From 2005 Through 2007 at the SQN Intake

			Total Number of Fish in Impingement Samples[(a)]		Calculated Annual Impingement[(b)]	
Family	Scientific Name	Common Name	Year 1	Year 2	Year 1	Year 2
Atherinidae	*Labidesthes sicculus*	unidentified sunfish	0	1	0	7
Centrarchidae	*Lepomis* spp.	unidentified sunfish	0	1	0	7
	Lepomis auritus	redbreast sunfish	2	1	14	7
	Lepomis macrochirus	bluegill	122	120	854	840
	Lepomis microlophus	redear sunfish	1	0	7	0
	Micropterus punctulatus	spotted bass	1	13	7	91
	Micropterus salmoides	largemouth bass	5	5	35	35
	Pomoxis annularis	white crappie	3	3	21	21
	Pomoxis nigromaculatus	black crappie	0	47	0	329
Clupeidae	*Alosa chrysochloris*	skipjack herring	10	10	70	70
	Alosa pseudoharengus	Alewife	10	4	70	28
	Dorosoma cepedianum	gizzard shad	17	25	119	175
	Dorosoma petenense	threadfin shad	2,529	5,373	17,703	37,611
Cyprinidae	*Moxostoma* spp.	unidentified redhorse	0	1	0	7
	Notropis atherinoides	emerald shiner	1	0	7	0
	Pimephales notatus	bluntnose minnow	0	2	0	14
	Pimephales vigilax	bullhead minnow	1	3	7	21
Ictaluridae	*Ameiurus natalis*	yellow bullhead	1	0	7	0
	Ictalurus furcatus	blue catfish	25	40	175	280
	Ictalurus punctatus	channel catfish	50	32	350	224
	Pylodictis ofivaris	flathead catfish	3	11	21	77

Family	Scientific Name	Common Name	Total Number of Fish in Impingement Samples[a]		Calculated Annual Impingement[b]	
			Year 1	Year 2	Year 1	Year 2
Moronidae	*Morone chrysops*	white bass	2	4	14	28
	Morone mississippiensis	yellow bass	24	10	168	70
	Morone saxatilis	striped bass	4	0	28	0
Percidae	*Sander canadensis*	Sauger	1	0	7	0
Poeciliidae	*Gambusia affinis*	western mosquitofish	1	0	7	0
Sciaenidae	*Aplodinotus grunniens*	freshwater drum	76	60	532	420
Total fish			**2,889**	**5,766**	**20,223**	**40,362**

[a] Total collected from once a week, 24-hr impingement samples.

[b] Calculated as the total number of fish in weekly impingement samples multiplied by 7 days per week.

Source: TVA 2007c

Entrainment

TVA conducted entrainment studies of ichthyoplankton (fish eggs and larvae) from 1981 through 1985 (Dycus 1986) and in 2004 (Baxter and Buchanan 2010). Entrainment rates of ichthyoplankton are influenced by the timing of the study, which usually occurs during the spring spawning season, by the fraction of the water withdrawn (which in turn is influenced by the river flow), and by the life history of the species being entrained. Table 4–11 provides the hydraulic, egg, and larval entrainment rates for the 6 years of entrainment studies.

Hydraulic entrainment (the fraction of the water flowing past the SQN site that is withdrawn for cooling) varies depending on the plant operations and the flow past the site. Mean hydraulic entrainment ranged from 5.7 percent in 1983 and 1984 (Dycus 1986) to 24.2 percent in 2004 (TVA2013g), although in 1985 both units were shut down for the last 4 months of the year. The average hydraulic entrainment between 1981 and 1985 was 8.6 percent. According to TVA (2013g), the higher hydraulic entrainment in 2004 may have been the result of lower reservoir flow rates. The peak hydraulic entrainment of 111.1 percent occurred as a result of zero release at Chickamauga Dam and an average release from Watts Bar Dam (Baxter and Buchanan 2010). Entrainment rates of over 100 percent occur during periods when the flow of water past the plant is smaller than the withdrawal from the reservoir (TVA2013a). This is most likely due to upstream flow. For reference, Hopping et al. (2009) discuss the various mechanisms that influence upstream flow, including flow advection as a result of reservoir sloshing from peaking operations, the entrainment of ambient flow by the high velocity diffuser jets, and velocity gradients created by boundary resistance, shoreline irregularities, and bends in the river.

Eggs

Dycus (1986) reports that freshwater drum comprised 99.5 percent of all fish eggs collected during entrainment sampling conducted in 1985. Freshwater drum spawn large numbers of eggs (40,000 to 60,000 per female), broadcasting them into the open water to float until hatching occurs, typically in one or two days (Etnier and Starnes 1993). Results from studies conducted in 1981 and 1982 estimated the percentage of freshwater drum eggs entrained as 6.7 percent and 41.4 percent, respectively (Baxter and Buchanan 2010). Results from the 2004 sampling study show freshwater drum eggs comprised 98.8 percent of the fish eggs collected (Baxter and Buchanan 2010). The percent entrained was estimated to be 11.2 percent of the 5.4 billion eggs transported past SQN or about 600 million fish eggs per year lost to entrainment.

Larvae

Table 4–11 shows the estimated percentages of all larvae passing SQN that were entrained during studies conducted from 1981 through 1985 and in 2004. For the total number of larvae entrained in 2004, 15.6 percent of those passing were entrained, compared to 2.2 to 4.7 percent for previous sampling years. Clupeid (shad) larvae comprised 87.9 percent of the total fish larvae entrained. *Morone* larvae (white, yellow, and striped bass) comprised 5.5 percent, freshwater drum comprised 3.2 percent, and centrarchids (sunfish, such as bluegill) accounted for 3.1 percent (Baxter and Buchanan 2010).

The large number of entrained clupeids (shad) greatly influenced the overall estimated entrainment rate for larvae in 2004. Clupeids were found in the intake samples at average densities lower than in the reservoir and were entrained at a rate of 15.6 percent (the fraction of the clupeids passing the plant that were entrained). Clupeid entrainment rates were lower for 1981 through 1985 (ranging from 1.1 to 2.7 percent), as would be expected from the lower hydraulic entrainment during that time period (Baxter and Buchanan 2010).

Although centrarchids (sunfish) represented only 3.1 percent of the entrained larvae, they were entrained at a higher rate than clupeids. TVA's entrainment analysis from the 2004 study indicated that 24.2 percent of the centrarchid larvae that passed the plant were entrained. Lower entrainment rates, ranging from 0.6 to 1.8 percent, were seen in the entrainment studies between 1981 and 1985 (Baxter and Buchanan 2010).

Morone larvae comprised 5.5 percent of the entrained larvae during the 2004 study and were entrained at a rate of 5 percent of the larvae passing by the plant (Baxter and Buchanan 2010). Entrainment rate estimates from the studies in the 1980s range from 1.7 to 4.8 percent (Baxter and Buchanan 2010).

Although cyprinids (carp) made up 0.2 percent of the larvae sampled, the entrainment rate was over 72 percent. This is based on very low densities of carp larvae in either the intake samples (7 per 1000 m^3 of water) or in the reservoir samples (2 per 1000 m^3 of water). The estimated percentage of carp entrained in the studies that were done in the 1980s ranged from 2.3 to 5.9 percent (Baxter and Buchanan 2010). As discussed in Section 3.7, carp are nonnative, introduced species and a female carp may produce over two million eggs in a given season (Etnier and Starnes 1993).

Freshwater drum comprised only 3.2 percent of the larvae collected during the 2004 study period, and the entrainment rate was 45.4 percent, which is within the range of the entrainment rates observed from the studies conducted in the 1980s (5.5 to 57.8 percent).

Table 4–11. Entrainment Percentages for Fish Eggs and Larvae at Sequoyah Nuclear Plant 1981–1985 and 2004

	1981	1982	1983	1984	1985	2004
Mean percent hydraulic entrainment	13.4	12.6	5.7	5.7	12.2	24.2
Sampling period						
Beginning	4/6/81	3/18/82	3/9/83	3/7/84	3/11/85	5/20/04
End	8/27/81	8/17/82	8/22/83	8/21/84	8/27/85	7/12/04
Eggs						
freshwater drum	6.7	41.4	22.6	9.7	16.6	11.2
Larvae						
Clupeidae (shad)	2.1	1.5	2.7	1.8	1.1	15.4
Cyprinidae (carp)	4.3	4.2	5.9	2.3	3.1	72.6
Catostomidae (suckers)	0.0	0.0	6.1	2.6	0.0	0.0
Ictaluridae (catfish)	8.4	7.7	9.1	45.9	27.8	0.0
Moronidae (white/yellow bass)	1.7	2.7	4.8	2.2	2.46	5.0
Centrarchidae (sunfish)	1.0	1.8	1.1	0.6	0.7	24.2
Percidae (perch)	3.6	1.6	10.7	1.6	3.5	0.0
Sciaenidae (drums)	5.5	25.6	57.8	22.7	30.2	45.4
Total	**2.3**	**2.2**	**4.7**	**2.3**	**2.6**	**15.6**

Sources: Baxter and Buchanan 2010; Dycus 1986

Discussion of Impingement and Entrainment

Of the planktonic fish eggs and larvae that pass SQN and are not entrained, most probably pass through the Chicamauga Dam and are lost to the Chicamauga Reservoir ecosystem. Their contribution to the ecosystem below the dam is unclear. Although the NRC staff considers the entrainment mortality rate to be 100 percent, the entrained organisms appear to be mostly destined to go through the dam not to contribute to the Chicamauga Reservoir ecosystem in any event. Because some fish eggs and larvae may survive passage through the dam, the total mortality due to the dam and SQN together will be greater than that due to the dam alone. The NRC staff found insufficient information to quantify these mortality rates, however.

Impingement studies conducted within a 26-year time span indicate the highest rates of impingement were for four species: threadfin shad, bluegill, freshwater drum, and gizzard shad. In electrofishing and gillnet data from sampling sites upstream (Tennessee RM 490.5) and downstream (Tennessee RM 482) of the SQN site, collected during studies between 1999 and 2011, TVA (2012c) did not observe trends in either the abundance or the distribution of these four species. The NRC staff notes that the high variation inherent in such sampling makes any pattern recognition difficult. Further, impingement of threadfin shad in large numbers occurs frequently in the southeastern United States. A study of 32 southeastern United States power plants found threadfin shad accounted for more than 90 percent of all fish impinged (Loar et al. 1978). EPA (2001) reported similar findings in its compilation of impingement data. The study was not limited to facilities in the southeast and the percentage of threadfin shad impinged was not as high, although threadfin shad was the most frequently impinged species. EPA found the typical annual impingement rate per facility for all reservoirs and lakes (excluding the Great Lakes) to be 678,000 fish per year, ranging from 203,000 to 1,370,000 depending on the facility. Shad are intolerant of cold water temperatures, which often results in high winter mortality, such as that observed at SQN and discussed in Section 3.7. Shad are less susceptible to impingement at higher temperatures when they are able to swim away from the intake.

At SQN, the same species are being impinged across years at approximately the same rates, with the largest number being threadfin shad, followed by gizzard shad, bluegill, and freshwater drum. The consistency in impingement of these species over the years suggests that impingement is having little effect on fish populations in the Chickamauga Reservoir. Further, sampling studies conducted between 1999 and 2011 upstream and downstream of SQN have not shown obvious and sustained declines in fish populations that can be attributed specifically to entrainment or impingement during the operation of SQN (see Section 3.7). In past SEISs, NRC has investigated sustained declines in fish populations as an indication of instability for assessing level of impact (e.g., NRC2013f).

TVA (2007c) used two types of models, an equivalent adult (EA) model and a production foregone model with information from 2006 and 2007, to express the impact of fish impingement at SQN. Equivalent adult losses, which TVA applied for harvestable fish species, are modeled estimates of the number of fish impinged that would have survived to harvestable (adult) age. Production foregone, which TVA applied to non-harvestable species assumed to be prey for harvestable species, is the modeled reduction in prey biomass available to predators due to the loss of prey, including the expected future growth of the prey prior to consumption by the predators. Many fish impinged at SQN are immature or small, and these models assume a natural mortality rate such that not all would have survived to become adults, and so the modeled number of equivalent (adult) fish affected is much lower than the actual number of immature fish actually affected. TVA (2007c) considers the modeled numbers that would have survived to be the "biological liability," which is a representation of the effect the plant's operation has on the aquatic organisms. The total modeled numbers of fish that would have survived had they not been impinged are 1,868 and 821 fish for studies conducted in 2005–2006 and 2006–2007, respectively. Table 4–12 shows the estimated total numbers of impinged fish per year for each full year of impingement sampling at the SQN site and TVA's modeled numbers after application of the EA and production foregone models. Modeled equivalent impingement numbers range from 821 fish in 2006–2007 to 5,843 fish in 1981–1982. Because of the many uncertainties in assumptions incorporated into these models, much uncertainty is associated with the results.

Entrainment and impingement studies show that the species most affected by operation of SQN (freshwater drum, threadfin and gizzard shad, and bluegill) are some of the most common species in the reservoir and that the operation of the SQN site has not destabilized or noticeably altered the populations of these species. Assuming that the past effects predict future effects, the impact of entrainment and impingement on these aquatic resources from the proposed license renewal for the SQN plant would be SMALL.

Table 4–12. Total Estimated Numbers of Fish Impinged by Year at SQN and TVA's Modeled Numbers Using Equivalent Adult (EA) and Production Foregone (PF) Models

	1980–81	1981–82	1982–83	1983–84	1984–85	2005–06	2006–07
Extrapolated annual number for all species impinged	94,528	81,158	20,685	41,076	27,195	20,223	40,362
Modeled annual number after EA and PF reduction	4,851	5,843	2,256	4,162	2,761	1,868	821
Percent of shad (threadfin and gizzard) by number	87%	81%	71%	72%	73%	88%	93%
Percent of shad after EA and PF modeling	66%	52%	36%	45%	47%	59%	77%

Source: TVA 2007c

4.7.1.3 Thermal Impacts on Aquatic Organisms

Thermal discharges can increase the ambient water temperature in sections of the Chickamauga Reservoir. Section 3.1.3 discusses the operation of the SQN cooling system and the design of the diffuser used for discharges. SQN uses once-through cooling during most of the year. When the river temperature approaches the NPDES limit, TVA uses the helper cooling towers to help prevent the plant from exceeding the NPDES limits. Use of the helper towers can reduce not only potential thermal impacts, but also entrainment and impingement impacts because of reduced water withdrawal. The number of helper tower operation hours, reported as equivalent days, varies from year to year, but has averaged 125 equivalent days per year between 2007 and 2013. In 2009, helper towers operated less than 34 equivalent days, and, in 2008, they operated 197 equivalent days (TVA2013g). TVA calculates equivalent days of cooling tower operation based on a summation of the number of hours that at least one CTLP is in service (TVA 2013g).

As discussed in Section 3.1.3, the NPDES permit specifies a mixing zone that is 750 ft (230 m) wide and extends 275 ft (84 m) upstream of the diffusers and 1,500 ft (460 m) downstream of the diffusers. The diffusers are placed such that they span almost the entire width of the main channel (TVA2011b). TVA (2013g) indicates that the main channel is approximately 900 ft (270 m) wide adjacent to the plant, and that the entire reservoir width (including the main channel and the overbank areas) is approximately 2,000 ft (610 m) wide in the vicinity of the diffuser, thus allowing room for fish to avoid the plume in the mixing zone.

Temperature limits set by the permit include a 24-hour downstream temperature of 30.5 °C (86.9 °F), and, if the ambient temperature of the reservoir water exceeds 29.4 °C (84.9 °F), the 24-hour downstream temperature cannot exceed 33.9 °C (93 °F). The NPDES permit also specifies a maximum 24-hour average temperature increase of no more than 5.0 °C (9.0 °F) for November through March (when the reservoir is coldest), and 3.0 °C (5.4 °F) for April through October. The maximum hourly average temperature rate-of-change is limited to 2.0 °C (3.6 °F) per hour (TVA2013a). Temperature criteria are based on 24-hour averaging. TVA (2012) measured temperature profiles in the summer (August 25, 2011) and autumn

(September 14, 2011). The thermal plume was the longest in the summer measurement period and extended approximately 4.1 mi (6.6 km) downstream of the discharge point to Tennessee RM 479.5. The ambient surface temperature (measured at Tennessee RM 486.7) was 81.9 °F (27.7 °C) and the highest temperature measured downstream of the discharge was 86.85 °F (30.5 °C) (at Tennessee RM 481.1).

Water temperatures of 97 °F (36 °C) are considered the upper thermal limit for mortality of warm-water fish species such as gizzard shad, common carp, largemouth bass, and sunfish (NRC 2013d). The upper lethal temperatures for cool water species such as freshwater drum, yellow perch, smallmouth bass, walleye, and sauger are similar or slightly lower than those for the warm-water species, although cool-water species need cooler average temperatures for growing and reproducing (NRC 2013). The thermal limits specified by the NPDES permit do not exceed the upper temperature limit for mortality of warm- or cool-water fish species.

TVA conducted studies on certain species to determine if plant operations, including thermal discharges, affected the fish, including sauger (Hickman and Buchanan 1995), white crappie (Buchanan and McDonough 1990), white bass (Buchanan 1994), and channel catfish (Peck and Buchanan 1991). The studies report no instances of attraction or avoidance of the thermal plume for fish species within the Chickamauga Reservoir.

Between November 1993 and March 1994, TVA (Kay and Buchanan 1995) conducted field investigations including gillnetting, creel census, and estimates of the number of persons fishing and number of fishing boats in the vicinity of the diffuser to determine whether fish were attracted to or unable to avoid the thermal plume. TVA conducted gillnetting at two sites: Tennessee RM 483.4, in the thermal plume, and Tennessee RM 483.8, upstream from the underwater dam. Catfish, bass, and centrarchids were collected in similar numbers at both sampling sites, and the studies report no indication that fish were avoiding the thermal plume or were attracted to the plume. Sauger, a cool-water species, was collected in comparable numbers at both sampling stations, indicating to the investigators that the thermal effluent did not preclude them from moving past the site.

The diffuser discharge plume is buoyant relative to the ambient water in the river. In general, however, the buoyancy is less at lower ambient water temperatures and, thus, the mixing and dilution of the thermal plume is less during months when the river is coolest. In addition, stratification of the river occurs in the warmer months (April through September) at which time the water at a depth of 5 ft (1.5 m) (the basis for the NPDES permit criteria) is warmer than the water at the bottom of the river. According to TVA (2013b), the diffuser jets cause an upwelling that can cool the surface water around the diffuser mixing zone. The river flow over the underwater dam also contributes to the upwelling, which in extreme cases of stratification produces neutral buoyancy in the effluent, causing it to remain submerged.

Ecological monitoring studies did not find a measurable or discernible effect on aquatic organisms in the vicinity of the SQN discharge. Further, TVA has a valid NPDES permit from the State of Tennessee that limits the discharge temperatures. The NRC staff relies on the State's permitting process to ensure the health of the aquatic organisms in the reservoir. In view of all these observations, the NRC staff concludes that the thermal impact on aquatic organisms as a result of the proposed license renewal would be SMALL.

4.7.1.4 Water Use Conflicts with Aquatic Resources

Water use conflicts occur when the amount of water needed to support aquatic resources is diminished as a result of demand for agricultural, municipal, or industrial use or decreased water availability due to droughts, or a combination of these factors.

As discussed in Sections 3.1.3 and 4.5.1.1, the total SQN peak water demand is 1,680 mgd (2,600 cfs, or 73.5 m^3/sec). This is approximately 8 percent of the annual average flow of the Tennessee River at the Chickamauga Dam (21,000 mgd (32,500 cfs or 920 m^3/s)). As mentioned in Section 3.5.1, for once-through cooling system operation at SQN, the condenser flow rate is nearly equal to the surface water withdrawal rate, giving a negligible consumptive use rate.

Between 2008 and 2012, the SQN plant withdrew an average of 1,580 mgd (2,445 cfs, or 69.1 m^3/s) of water, which is also about 8 percent of the Tennessee River's average flow past the SQN site (31,100 cfs (881 m^3/s)). When it occurs, the majority of the consumptive loss occurs on days when the plant operates the cooling towers in helper mode. The amount of water consumed from the river (during the cooling tower operations) on a daily average basis can approach about 45 mgd (70 cfs, or 2 m^3/s)) (see Section 4.5.1.1). On a daily average basis, the net consumptive loss is likely to be roughly 1.2 percent of the river flow past the SQN site. During 2011, the cooling towers were operated fewer than 90 equivalent days (TVA 2013g). Additional information on water use conflicts can be found in Section 4.5.1.1.

The amount of water consumed by the operation of SQNs is minor in comparison to the flow past the plant and even smaller in comparison to the volume of water in the Chickamauga Reservoir. Changes in surface water elevation and aquatic habitat due to water consumption by SQN are very small in comparison to those due to TVA's use of dams to regulate the river. The fish species described in Section 3.7 as present in the Chickamauga Reservoir in the vicinity of the SQN site do not appear to be affected by the consumption of water from the reservoir. The NRC staff concludes that the impact of water use conflicts on aquatic species from the proposed license renewal would be SMALL.

4.7.2 No-Action Alternative – Aquatic Resources

This section describes environmental effects to aquatic organisms if the NRC takes no action. No action, in this case, means that the NRC would not renew the operating licenses for SQN, the SQN units would shut down, and TVA would initiate decommissioning in accordance with 10 CFR Part 50.82. The environmental impacts from decommissioning and related activities are discussed in the Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities (NRC 2002) and in Section 2.1.3 of this SEIS.

If SQN were to shut down, any existing impacts to aquatic ecology would decrease. Some withdrawal of water from the Chickamauga Reservoir would continue during the shutdown period as the fuel is cooled, although the amount of water withdrawn would decrease over time. The aquatic organisms would be subject to lower rates of impingement, entrainment, and heat shock. Impacts on aquatic resources from the no-action alternative would be SMALL.

4.7.3 NGCC Alternative – Aquatic Resources

The NRC staff assumes that construction activities for the NGCC alternative would occur at an existing power plant site (other than SQN) or a brownfield site with available infrastructure and could affect drainage areas or other onsite aquatic features. Also, the NRC staff assumes TVA will implement BMPs to minimize erosion and sedimentation in nearby streams, ponds, or rivers. Stormwater control measures would be required to comply with the State's NPDES permitting. Any dredging or in-water work at sites other than on the Tennessee River or its tributaries, which are controlled by TVA, could require permits from the U.S. Army Corps of Engineers (USACE) pursuant to Section 404 of the Federal Water Pollution Control Act (FWPCA) (Clean Water Act (CWA)) as amended (33 U.S.C. 1251 et seq.). Other USACE permits could be required, depending on the location of the site. Dredging activities would also require BMPs for in-water work to minimize sedimentation and erosion. Due to the short-term nature of the dredging activities, the effect on the aquatic habitats would likely be relatively localized and temporary (recovery time for aquatic communities typically takes several years).

The NGCC plant would typically require less cooling water be withdrawn from the environment than SQN. The lower withdrawal rates would reduce the numbers of fish and other aquatic resources affected by the operation of the intake and decrease the heat released from the discharge as compared to the SQN units. Chemical discharges from operation of the NGCC alternative cooling system would be similar to SQN. Air emissions from the NGCC alternative would emit particulates (as discussed in Section 4.3.3.1) that could be introduced into the water from erosion of soil or from settling on the surface of the water. The particulates would result in minimal exposure to aquatic organisms. Overall aquatic impacts from operation of an NGCC plant would likely be less than for the continued operation of SQN. Impacts on aquatic organisms from construction and operation of an NGCC alternative would be SMALL.

4.7.4 SCPC Alternative – Aquatic Resources

The NRC staff assumes that construction activities for the SCPC alternative would occur at an existing power plant site (other than SQN) or a brownfield site with available infrastructure, and could affect drainage areas or other onsite aquatic features. Also, the NRC staff assumes TVA will implement BMPs to minimize erosion and sedimentation in nearby streams, ponds, or rivers. Stormwater control measures would be required to comply with the State's NPDES permitting. Any dredging or in-water work at sites other than on the Tennessee River or its tributaries, which are controlled by TVA, could require permits from USACE pursuant to Section 404 of the CWA as amended (33 U.S.C. 1251 et seq.). Other USACE permits could be required depending on the location of the site. Dredging activities would also require BMPs for in-water work to minimize sedimentation and erosion. Due to the short-term nature of the dredging activities, the effect on the aquatic habitats would likely be relatively localized and temporary (recovery time for aquatic communities typically takes several years).

The SCPC plant would typically require slightly less cooling water be withdrawn from the environment than SQN. The lower withdrawal rates would reduce the numbers of fish and other aquatic resources affected by the operation of the intake and the heat released from the discharge would be less than that for the SQN units. The actual impact to the aquatic organisms would depend on the ecosystem and biological interactions among the organisms. The SCPC plant would have similar chemical discharges to those from the SQN units as a result of operation of the cooling system. Air emissions from the SCPC units would include small amounts of ash (as discussed in Section 4.3.4.1) that would settle on water bodies or be introduced into the water from soil erosion. Overall, the aquatic impacts from operation of an SCPC plant would be less than for the continued operation of the SQN units if the SCPC plant were located on Chickamauga Reservoir in the vicinity of the SQN site. Without knowing the location of the SCPC unit and the aquatic species and their interactions within the ecosystem, the NRC staff cannot assume that overall impacts of operation of an SCPC plant would be less than those for the license renewal term at the SQN site. Impacts on aquatic organisms from construction and operation of an SCPC alternative would likely be SMALL to MODERATE.

4.7.5 New Nuclear Alternative – Aquatic Resources

The NRC staff assumes that construction activities for the new nuclear alternative would occur at a site other than the SQN site and could affect drainage areas or other onsite aquatic features. Also, the NRC staff assumes TVA will implement BMPs to minimize erosion and sedimentation in nearby streams, ponds, or rivers. Stormwater control measures would be required to comply with the State's NPDES permitting. If the site selected is a greenfield site, a new intake and discharge system would be required. If it is located at an existing nuclear site, such as the Bellefonte site in Alabama, the available infrastructure could be used in its current configuration or be modified or expanded. Any dredging or in-water work at sites other than on the Tennessee River or its tributaries, which are controlled by TVA, could require permits from USACE pursuant to Section 404 of the CWA as amended (33 U.S.C. 1251 et seq.). Other USACE permits could be required, depending on the location of the site. Dredging activities would also require BMPs for in-water work to minimize sedimentation and erosion. Due to the short-term nature of the dredging activities, the effect on the aquatic habitats would likely be relatively localized and temporary (recovery time for aquatic communities typically takes several years).

The new nuclear units would use a closed-cycle cooling system so that water consumption would be less than for the SQN units, which operate in open-cycle and helper modes. As a result, the withdrawal of water and the thermal input from the discharge would be less than for the SQN units. This in turn would reduce entrainment, impingement, and thermal impacts to aquatic organisms. Without knowing the location of the new nuclear units and the aquatic species and their ecosystem interactions, NRC staff cannot assume that the overall impacts of operation of a new nuclear unit would be less than those for the license renewal term at the SQN site. Impacts on aquatic organisms from construction and operation of a new nuclear facility would be SMALL to MODERATE.

4.7.6 Combination Alternative - Aquatic Resources

The staff assumes that construction activities for the combination alternative would occur at another site, other than the SQN site, and could affect drainage areas or other onsite aquatic features. The NRC staff assumes TVA will implement BMPs to minimize erosion and sedimentation in nearby streams, ponds, or rivers. The State's NPDES permitting would require stormwater control measures. During operations, the land-based wind and solar alternative would not require withdrawal of water or consumptive water use. Thus, the impacts on aquatic ecology from the land-based wind and solar combination alternative would be SMALL.

4.8 Special Status Species and Habitats

This section describes the potential impacts of the proposed action (license renewal) and alternatives to the proposed action on special status species and habitats.

4.8.1 Proposed Action

The special status species and habitats issue applicable to SQN during the license renewal term is listed in Table 4–13. Section 3.8 of this SEIS describes the special status species and habitats that have the potential to be affected by the proposed action. The discussion of species and habitats protected under the Endangered Species Act of 1973, as amended (ESA), includes a description of the action area as defined by the ESA section 7 regulations at 50 CFR Part 402.02. The action area encompasses all areas that would be directly or indirectly affected by the proposed SQN license renewal.

Appendix C.1 contains information on the NRC staff's section 7 consultation with the U.S. Fish and Wildlife Service (FWS) for the proposed action. The NRC did not consult with the National Marine Fisheries Service (NMFS) as part of the SQN license renewal review because (as described in Section 3.8 and 4.8.1.1) no species or habitats under NMFS's jurisdiction occur within the action area.

Table 4–13. Special Status Species and Habitats

Issue	GEIS Section	Category
Threatened, endangered, and protected species, critical habitat, and essential fish habitat	4.6.1.3	2

Source: Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51

4.8.1.1 Species and Habitats Protected under the Endangered Species Act

Species and Habitats under FWS Jurisdiction

Section 3.8 considers whether the 11 Federally listed and proposed species identified in Table 4–14 occur in the action area based on each species' habitat requirements, life history, scientific surveys and studies, and other available information. In that section, the NRC staff concludes that none of these species are likely to occur in the action area. The NRC staff also concludes that no candidate species (CS) or proposed or designated critical habitat occur in the action area. Thus, the NRC staff concludes that the proposed action would have no effect on Federally listed species or habitats under FWS's jurisdiction.

Table 4–14. Effect Determinations for Federally Listed Species

Species	Common Name	Federal Status[a]	Effect Determination
Mammals			
Myotis grisescens	gray bat	E	no effect
Myotis septentrionalis	northern long-eared bat	P	no effect
Myotis sodalis	Indiana bat	E	no effect
Fish			
Percuba tanasi	snail darter	T	no effect
Freshwater Mussels			
Dromus dromas	dromedary pearlymussel	E	no effect
Lampsilis abrupta	pink mucket	E	no effect
Plethobasus cooperianus	orangefoot pimpleback	E	no effect
Pleurobema plenum	rough pigtoe	E	no effect
Plants			
Isotria medeoloides	small whorled pogonia	T	no effect
Scutellaria montana	large-flowered skullcap	T	no effect
Spiraea virginiana	Virginia spiraea	T	no effect

[a] E = endangered; T = threatened; P = proposed

If in the future a Federally listed species is observed on the SQN site, the NRC has measures in place to ensure that NRC staff would be appropriately notified. SQN's operating licenses, Appendix B, "Environmental Protection Plan," Section 4.1.1 (NRC 1980, 1981) require TVA to report to the NRC within 24 hours any occurrence of a species protected by the ESA on the SQN site. Additionally, the NRC's regulations containing notification requirements require that operating nuclear power reactors report to the NRC within 4 hours "any event or situation, related to…protection of the environment, for which a news release is planned or notification to other government agencies has been or will be made" (10 CFR Part 50.72(b)(2)(xi)). Such notifications include reports regarding Federally listed species, as described in Section 3.2.12 of NUREG-1022 (NRC 2013b). Further, as a Federal agency, TVA has the responsibility to comply with section 7 of the ESA if listed species or effects of the action are identified that were not previously considered.

<u>Species and Habitats under NMFS's Jurisdiction</u>

As discussed in Section 3.8, no species or habitats under NMFS's jurisdiction occur within the action area. Thus, the NRC staff concludes that the proposed action would have no effect on Federally listed species or habitats under NMFS's jurisdiction.

<u>Cumulative Effects</u>

The ESA regulations at 50 CFR Part 402.12(f)(4) direct Federal agencies to consider cumulative effects as part of the proposed action effects analysis. Under the ESA, cumulative effects are defined as "those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation" (50 CFR Part 402.02). Unlike the NEPA definition of cumulative impacts (see Section 4.16), cumulative effects under the ESA do not include past actions or other Federal actions requiring separate ESA section 7 consultation. When formulating biological opinions under formal section 7 consultation, the FWS and NMFS (1998) consider cumulative effects when determining the likelihood of jeopardy or adverse modification. Therefore, consideration of cumulative effects under the ESA is necessary only if listed species will be adversely affected by the proposed action (FWS 2014).

In the case of SQN, because the NRC staff concluded earlier in this section that the proposed license renewal would have no effect on listed, proposed, or CS or on designated or proposed critical habitat, consideration of cumulative effects is not necessary.

4.8.1.2 Species and Habitats Protected under the Magnuson–Stevens Act

As discussed in Section 3.8, NMFS has not designated essential fish habitat (EFH) pursuant to the Magnuson–Stevens Fishery Conservation and Management Act, as amended (Magnuson–Stevens Act) in the Chickamauga Reservoir. Thus, the NRC staff concludes that the proposed action would have no effect on EFH.

4.8.2 No-Action Alternative – Special Status Species and Habitats

Under the no-action alternative, SQN would shut down. Federally listed species and designated critical habitat can be affected not only by operation of nuclear power plants but also by activities during shutdown. The ESA action area for the no-action alternative would most likely be the same or similar to the action area described in Section 3.8. Because the plant would require substantially less cooling water, potential impacts to aquatic species and habitats would be reduced, although the plant would still require some cooling water for some time. Changes in land use and other shutdown activities might affect terrestrial species differently than under continued operation.

Because no Federally listed species or habitats occur in the action area, the no-action alternative would likely have no effect on any such species or habitats. However, NRC would assess the need for ESA consultation upon plant shutdown. The ESA forbids the taking of a listed species, where to "take" means "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct." In the case of a take, ESA section 7 requires that NRC initiate consultation with the FWS or NMFS. The implementing regulations at 50 CFR Part 402.16 also direct Federal agencies to reinitiate consultation in circumstances where (a) the incidental take limit in a biological opinion is exceeded, (b) new information reveals effects to Federally listed species or designated critical habitats that were not previously considered, (c) the action is modified in a manner that causes effects not previously considered, or (d) new species are listed or new critical habitat is designated that may be affected by the action. An ESA Section 7 consultation could identify impacts on Federally listed species or critical habitat, require monitoring and mitigation to minimize such impacts, and provide a level of exempted takes. Regulations and guidance regarding the ESA Section 7 consultation process are provided in 50 CFR Part 402 and in the *Endangered Species Consultation Handbook* (FWS and NMFS 1998). Upon shutdown, if the NRC determined that the no-action alternative would result in take of listed species or that one or more of the reinitiation criteria at 50 CFR Part 402.16 would be met, the NRC would reinitiate consultation, as appropriate, with FWS at that time. TVA, as a Federal agency, would also have responsibilities under section 7 of the ESA upon SQN shutdown.

The effects on ESA-listed aquatic species would likely be smaller than the effects under continued operation but would depend on the listed species and habitats present when the alternative is implemented. The types and magnitudes of adverse impacts to terrestrial ESA-listed species would depend on the shutdown activities and the listed species and habitats present when the alternative is implemented, and thus, the NRC cannot forecast a particular level of impact for this alternative.

The no-action alternative would not affect EFH because NMFS has not designated EFH in the Chickamauga Reservoir.

4.8.3 NGCC Alternative – Special Status Species and Habitats

This alternative entails shutdown and decommissioning of SQN and construction of a new NGCC alternative at an existing power plant site other than the SQN site or at a brownfield site with available infrastructure in the TVA region. Section 4.8.2 discusses ESA considerations for the shutdown of SQN.

Unlike the proposed action, no-action alternative, and new nuclear alternative, the NRC does not license NGCC facilities, and the NRC would not be responsible for initiating section 7 consultation if listed species or habitats might be adversely affected under this alternative. The facilities themselves would be responsible for protecting listed species because the ESA forbids the taking of a listed species. If TVA were to implement the NGCC alternative, as a Federal agency, TVA would be required to consult with FWS or NMFS under section 7. Similarly, TVA, and not NRC, would be responsible for engaging in EFH consultation with NMFS under the Magnuson–Stevens Act if EFH could be affected by construction or operation of the NGCC alternative.

Because the NGCC alternative would be built on an existing power plant site other than the SQN site, the special status species and habitats affected by the action would be different than those considered under the proposed action. The types and magnitudes of adverse impacts to ESA-listed species and EFH would depend on the proposed site, plant design, operation, and listed species and habitats present when the alternative is implemented. Therefore, the NRC cannot forecast a particular level of impact for this alternative.

4.8.4 SCPC Alternative – Special Status Species and Habitats

This alternative entails shutdown and decommissioning of SQN and construction of a new SCPC alternative at an existing power plant site other than the SQN site or at a brownfield site with available infrastructure in the TVA region. Section 4.8.2 discusses ESA considerations for the shutdown of SQN.

Unlike the proposed action, no-action alternative, and new nuclear alternative, the NRC does not license SCPC facilities, and the NRC would not be responsible for initiating section 7 consultation if listed species or habitats might be adversely affected under this alternative. The facilities themselves would be responsible for protecting listed species because the ESA forbids the taking of a listed species. If TVA were to implement the NGCC alternative, as a Federal agency, TVA would be required to consult with FWS or NMFS under section 7. Similarly, TVA, and not NRC, would be responsible for engaging in EFH consultation with NMFS under the Magnuson–Stevens Act if EFH could be affected by construction or operation of the NGCC alternative.

Because the SCPC alternative would be built on an existing power plant site other than the SQN site, the special status species and habitats affected by the action would be different than those considered under the proposed action. The types and magnitudes of adverse impacts to ESA-listed species and EFH would depend on the proposed site, plant design, operation, and listed species and habitats present when the alternative is implemented. Therefore, the NRC cannot forecast a particular level of impact for this alternative.

4.8.5 New Nuclear Alternative – Special Status Species and Habitats

This alternative entails shutdown and decommissioning of SQN and construction of a new nuclear alternative at an existing power plant site other than the SQN site in the TVA region. Section 4.8.2 discusses ESA considerations for the shutdown of SQN.

The NRC would remain the licensing agency under this alternative, and thus, the ESA would require NRC to initiate consultation with the FWS and NMFS, as applicable, prior to construction to ensure that the construction and operation of the new nuclear plant would not adversely affect any Federally listed species or adversely modify or destroy designated critical habitat. If the new nuclear plant is sited in an area that could affect water bodies with designated EFH, the Magnuson–Stevens Act would require the NRC to consult with NMFS to evaluate potential impacts to that habitat. TVA, as a Federal agency, would have consultation responsibilities under the ESA and Magnuson–Stevens Act.

Because the new nuclear alternative would be built on an existing power plant site other than the SQN site, the special status species and habitats affected by the action would be different than those considered under the proposed action. The types and magnitudes of adverse impacts to ESA-listed species and EFH would depend on the proposed site, plant design, operation, and listed species and habitats present when the alternative is implemented. Therefore, the NRC cannot forecast a particular level of impact for this alternative.

4.8.6 Combination Alternative – Special Status Species and Habitats

This alternative entails shutdown and decommissioning of SQN and construction and operation of wind turbines, possibly outside of the TVA region through purchased power agreements, and solar photovoltaic systems throughout the TVA region. Section 4.8.2 discusses ESA considerations for the shutdown of SQN.

Unlike the proposed action, no-action alternative, and new nuclear alternative, the NRC does not license wind turbines or solar photovoltaic systems, and the NRC would not be responsible for initiating section 7 consultation if listed species or habitats might be adversely affected under this alternative. The facilities themselves would be responsible for protecting listed species because the ESA forbids the taking of a listed species. If TVA were to implement this alternative, as a Federal agency, TVA would be required to consult with FWS or NMFS under section 7. Similarly, TVA, and not NRC, would be responsible for engaging in EFH consultation with NMFS under the Magnuson–Stevens Act if EFH could be affected by any component of this alternative.

Because this alternative would involve several sites throughout the TVA region, the special status species and habitats affected by the action would be different than those considered under the proposed action. The types and magnitudes of adverse impacts to ESA-listed species and EFH would depend on the proposed sites, alternative design, operation, and listed species and habitats present when the alternative is implemented. Therefore, the NRC cannot forecast a particular level of impact for this alternative.

4.9 Historic and Cultural Resources

This section describes the potential impacts of the proposed action (license renewal) and alternatives to the proposed action on historic and cultural resources.

4.9.1 Proposed Action

The historic and cultural resource issue applicable to SQN during the license renewal term is listed in Table 4–15. Section 3.9 of this SEIS describes the historic and cultural resources that have the potential to be affected by the proposed action.

Table 4–15. Historic and Cultural Resources

Issue	GEIS Section	Category
Historic and Cultural Resources	4.7.1	2

Source: Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51

The National Historic Preservation Act of 1966, as amended (NHPA) requires Federal agencies to consider the effects of their undertakings on historic properties, and renewing the operating license of a nuclear power plant is an undertaking that could potentially affect historic properties. Historic properties are defined as resources eligible for listing in the National Register of Historic Places (NRHP). The criteria for eligibility are listed in 36 CFR Part 60.4, “Criteria for evaluation,” and include (1) association with significant events in history, (2) association with the lives of persons significant in the past, (3) embodiment of distinctive characteristics of type, period, or construction, and (4) sites or places that have yielded, or are likely to yield, important information.

The historic preservation review process (Section 106 of the NHPA) is outlined in regulations issued by the Advisory Council on Historic Preservation (ACHP) in 36 CFR Part 800, “Protection of historic properties.”

In accordance with the provisions of the NHPA, the NRC is required to make a reasonable effort to identify historic properties included in or eligible for inclusion in the NRHP in the area of potential effect (APE). The APE for a license renewal action the nuclear power plant site, its immediate environs including viewshed, and inscope transmission lines that may be affected by the license renewal decision, and land-disturbing activities associated with continued reactor operations.

If historic properties are present within the APE, the NRC is required to contact the State Historic Preservation Office, assess the potential impact, and resolve any possible adverse effects of the undertaking (license renewal) on historic properties. In addition, the NRC is required to notify the State Historic Preservation Office if historic properties would not be affected by license renewal or if no historic properties are present. The State Historic Preservation Office is part of the Tennessee Historical Commission in the State of Tennessee.

4.9.1.1 Consultation

In accordance with 36 CFR Part 800.8(c), on March 14, 2013, the NRC initiated consultations on the proposed action by writing to the ACHP and Tennessee Historical Commission (NRC 2013e, 2013g). Also on March 14, 2013, the NRC initiated consultations with the following 14 Federally recognized tribes (NRC 2013e) (see Appendix C for a discussion of these letters):

- Cherokee Nation,
- Chickasaw Nation,
- Alabama Quassarte Tribal Town,
- Muscogee (Creek) Nation,
- Alabama-Coushatta Tribe of Texas,
- Thlopthlocco Tribal Town,
- Eastern Shawnee Tribe of Oklahoma,
- Kialegee Tribal Town,
- Eastern Band of the Cherokee Indians,
- Absentee Shawnee Tribe of Oklahoma,
- United Keetoowah Band of Cherokee Indians in Oklahoma,
- Seminole Tribe of Florida,
- Seminole Nation of Oklahoma, and
- Shawnee Tribe.

In its letters, the NRC provided information about the proposed action, defined the APE, and indicated that the NHPA review would be integrated with the NEPA process, in accordance with 36 CFR Part 800.8. Also in its letters, the NRC invited participation in the identification and possible decisions concerning historic properties and also invited participation in the scoping process.

In February 2013, the NRC contacted the Tennessee Historical Commission concerning the license renewal of SQN and scheduled a meeting to discuss the potential impacts to cultural resources at SQN. The NRC met with the staff of the Tennessee Historical Commission in April 2013. During this meeting, the Tennessee Historical Commission representative did not express any concerns about the proposed license renewal (NRC 2013j). The Tennessee Historical Commission representative also suggested that the NRC consult with the Eastern Tennessee Historical Society and the Tennessee Historical Society as interested parties. In May 2013, the NRC sent letters to these historical societies offering them an opportunity to consult in the environmental review (NRC 2013f, 2013h). The NRC did not receive a response before the publication of this draft SEIS.

The NRC received scoping comments from one tribe, the United Keetoowah Band of Cherokee Indians in Oklahoma, in March 2013 (UKB 2013) (see Appendix C). The United Keetoowah Band of Cherokee Indians in Oklahoma did not raise any concerns and indicated there are no religious or culturally significant sites in the project area but said it would like to be contacted if any inadvertent discoveries of human remains are made as a result of the proposed Federal action (license renewal).

Currently, TVA has no planned physical changes or ground-disturbing activities related to license renewal at the SQN site (TVA 2013g). As described in Section 3.9, there are no known historic properties or NRHP-eligible cultural resources located within the SQN site. However, Site 40HA22 is located near the SQN boundary, but not within the SQN site, and was previously impacted by the construction of SQN. Since Site 40HA22 is located on TVA controlled lands, TVA has the responsibility, under Section 110 of the NHPA, to address site preservation and possible effects to the site from TVA actions such as reservoir operations (TVA 2013c). In addition, as a Federal agency, TVA will also have to comply with Section 106 of the NHPA for any future undertakings in the vicinity of Site 40HA22. TVA has reopened Section 106 consultation with the Tennessee State Historic Preservation Office and submitted revisions to its previous 2010 cultural resource survey of TVA lands, and updated information about this site with the Tennessee Division of Archaeology (TVA 2013a, 2013e). In addition, TVA reinitiated consultation with tribes, including the United Keetoowah Band of Cherokee Indians in Oklahoma (TVA 2013h). There has been no formal eligibility determination of the site for the NRHP at the time of publishing of this draft SEIS, although TVA believes the site is eligible and will treat it as such (TVA 2013a).

The Igou Cemetery is located in the southern area of the SQN site and is protected by several State statutes. The Tennessee Code Annotated (T.C.A.) 39-17-311 is the primary statute providing protection for the historic cemetery, which is maintained by TVA. NRC staff contacted the Tennessee Historical Commission to discuss the historic cemeteries associated with SQN (Igou and McGill). The Tennessee Historical Commission did not express any concerns regarding the management or protection of these historic cemeteries (NRC 2013k).

TVA has established procedures to ensure cultural resources are considered in project planning at SQN. These are the same procedures used throughout TVA properties. In addition, TVA has established procedures for consulting with the State Historic Preservation Office, Federally recognized Indian tribes, and any other interested parties. These procedures describe how TVA will comply with Section 106 of the NHPA for identifying, evaluating, and resolving any adverse effects to historic properties. In addition, TVA has procedures in place for the inadvertent discovery of cultural resources during project activities which include a description of the process for consulting with the Tennessee Historical Commission and Indian tribes (TVA 2013c). Also, TVA provides NEPA Overview and Categorical Exclusion training; 100 percent of the TVA environmental personnel working at SQN have completed this training (TVA 2013c).

Based on the following factors and considerations, the NRC staff concludes that license renewal would cause no adverse effect on historic properties (36 CFR Part 800.4(d)(1)) for the following reasons:

- there are currently no NRHP-eligible historic properties on the SQN site,
- TVA will continue to protect the Igou Cemetery and Site 40HA22,
- input has been received from tribes,
- TVA has continued to adhere to its cultural resources protection procedures,
- the NRC has received assurance that no license renewal-related physical changes or ground-disturbing activities will occur,
- the Tennessee Historical Commission has offered its input, and
- the NRC has received findings from the cultural resource assessment and consultations.

4.9.2 No-Action Alternative – Historic and Cultural Resources

Not renewing the operating licenses and terminating reactor operations would have no effect on historic properties and cultural resources on or in the immediate vicinity of SQN. A separate environmental review would be conducted to determine the impacts of decommissioning activities on historic properties and cultural resources. Therefore, the impacts on historic and cultural resources from plant shutdown would be SMALL.

4.9.3 NGCC Alternative – Historic and Cultural Resources

Land areas affected by the construction and operation of an NGCC alternative would be surveyed to identify and record historic and cultural resources, including land required for a new gas pipeline, roads, transmission corridors, and other ROWs. Former industrial (brownfield) sites would need to be surveyed to verify the level of previous disturbance and to evaluate the potential for cultural resources to be present. Any cultural resources found during these surveys would need to be recorded and evaluated for eligibility for listing on the National Register of Historic Properties (NRHP). Mitigation of adverse effects would be considered if eligible properties were encountered. Areas with the most significant cultural resources should be avoided. Visual impacts, such as historic property viewsheds near the proposed power plant site, should also be evaluated.

The potential impacts to historic properties and cultural resources would vary depending on the site selected for the proposed NGCC alternative. Assuming the NGCC alternative is located at an existing power plant site (other than SQN) or brownfield site in the region, TVA could further reduce the potential impacts to historic and cultural resources if effectively managed under current laws and regulations. However, historic and cultural resources could be affected by the construction of a new or upgraded gas pipeline. Therefore, the impacts to historic and cultural resources from the construction and operation of a NGCC alternative at an existing or brownfield site could range from SMALL to MODERATE assuming that existing gas pipelines are used or that existing gas pipelines are upgraded.

4.9.4 SCPC Alternative – Historic and Cultural Resources

Land areas affected by the construction of the SCPC alternative would need to be surveyed to identify and record historic and cultural resources—all potentially affected land areas, including land required for new roads, railroads, transmission corridors, and other right-of-ways (ROWs). Former industrial (brownfield) sites would need to be surveyed to verify the level of previous disturbance and to evaluate the potential for cultural resources to be present. Power plant developers would need to survey cultural resources. Any resources found would need to be recorded and evaluated for eligibility for listing on the NRHP. Mitigation of adverse effects would need to be considered if eligible properties were encountered. Areas with the most significant cultural resources should be avoided. Visual impacts, such as historic property viewsheds near the proposed power plant site, should also be evaluated.

The potential impacts to historic properties and cultural resources would vary depending on the site selected for the proposed SCPC alternative. The 500-ft (150-m) cooling towers could impact the viewshed of historic properties. However, selecting a previously disturbed former power plant or brownfield site in the TVA region could reduce the potential impacts to historic and cultural resources if effectively managed under current laws and regulations. Therefore, the impacts to historic and cultural resources from the construction and operation of a SCPC power plant would be SMALL.

4.9.5 New Nuclear Alternative – Historic and Cultural Resources

Land areas affected by the construction of the new nuclear alternative would need to be surveyed to identify and record historic and cultural resources—all potentially affected land areas, including land required for new roads, transmission corridors, other ROWs. Former plant sites would need to be surveyed to verify the level of previous disturbance and to evaluate the potential for cultural resources to be present. Any cultural resources found during these surveys would need to be recorded and evaluated for eligibility for listing on the NRHP. Mitigation of adverse effects would need to be considered if eligible properties were encountered. Areas with the most significant cultural resources should be avoided. Visual impacts, such as historic property viewsheds near the proposed power plant site, should also be evaluated.

The potential impacts to historic properties and cultural resources would vary depending on the site selected for the proposed new nuclear alternative. The 500-ft (150-m) cooling towers could impact the viewshed of historic properties. However, selecting an existing nuclear plant site (other than SQN) in the TVA Region could further reduce the potential impacts to historic and cultural resources if effectively managed under current laws and regulations. Therefore, the impacts to historic and cultural resources from the construction and operation of a new nuclear power plant would be SMALL.

4.9.6 Combination Alternative – Historic and Cultural Resources

Land areas would also need to be surveyed that could be potentially affected by the construction and operation of new wind or solar power generation to identify and record historic and cultural resources, including land required for new roads, transmission corridors, or other ROWs. Any historic properties found during these surveys would need to be recorded and evaluated for eligibility for listing on the NRHP. Mitigation of adverse effects would need to be considered if eligible properties were encountered. Areas with the most significant cultural resources should be avoided. Visual impacts, such as historic property viewsheds near the power generating sites, also should be evaluated.

The potential impacts on historic properties and cultural resources would vary, depending on the sites selected for the proposed power generating components of this combination alternative. Construction of wind farms and their support infrastructure could impact historic and cultural resources because of ground-disturbing activities (e.g., grading and digging). Land-based solar PV installations would require more land than rooftop installations and would have a greater potential impact on historic and cultural resources because of ground-disturbing activities. New solar PV installations on rooftops would minimize any land disturbances, thereby reducing impacts to historic and cultural resources. Aesthetic changes caused by the installation of new wind turbines and solar PV systems would have a noticeable effect on historic property viewsheds. However, construction of additional wind turbines and solar PV systems within existing developed solar installations and wind farms could lessen visual impacts to historic properties. Therefore, the impacts to historic and cultural resources from the construction and operation of the wind and solar power generation components of this combination alternative could range from SMALL to LARGE.

4.10 Socioeconomics

This section describes the potential impacts of the proposed action (license renewal) and alternatives to the proposed action on socioeconomic resources.

4.10.1 Proposed Action

The socioeconomic issues applicable to SQN during the license renewal term are listed in Table 4–16. Section 3.10 describes the socioeconomic resources.

Table 4–16. Socioeconomic Issues

Issues	GEIS Section	Category
Employment and income, recreation and tourism	4.8.1.1	1
Tax revenues	4.8.1.2	1
Community services and education	4.8.1.3	1
Population and housing	4.8.1.4	1
Transportation	4.8.1.5	1

Source: Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51

Socioeconomic effects of ongoing reactor operations at SQN have become well-established as regional socioeconomic conditions have adjusted to the presence of the nuclear power plant. These conditions are described in Section 3.10. Any changes in employment and tax payments caused by license renewal and any associated refurbishment activities could have a direct and indirect impact on community services and housing demand, as well as traffic volumes in the communities around a nuclear power plant.

The supplemental site-specific socioeconomic impact analysis for the SQN license renewal, included a review of the TVA ER, scoping comments, other information records, and a data gathering site visit to SQN. The NRC staff did not identify any new and significant information during the review that would result in impacts that would exceed the predicted socioeconomic impacts evaluated in the GEIS, and no additional socioeconomic issues were identified beyond those listed in Table B–1 of Appendix B, Subpart A, to 10 CFR Part 51.

In addition, TVA indicated in their ER that they have no planned refurbishment activities, and do not plan to add non-outage workers during the license renewal term and that increased maintenance and inspection activities could be managed using the current workforce. Consequently, people living in the vicinity of SQN are not likely to experience any changes in socioeconomic conditions during the license renewal term beyond what is currently being experienced. Therefore, the impact of continued reactor operations during the license renewal term would not exceed the socioeconomic impacts predicted in the GEIS. For these issues, the GEIS predicted that the impacts would be SMALL for all nuclear plants.

4.10.2 No-Action Alternative – Socioeconomics

4.10.2.1 Socioeconomic Issues Other than Transportation

Not renewing the operating licenses and terminating reactor operations would have a noticeable impact on socioeconomic conditions in the communities located near SQN. The loss of jobs and income would have an immediate socioeconomic impact. Some, but not all, of the 1,141 SQN employees would begin to leave after reactor operations are terminated; and overall tax revenue and purchasing activity generated by plant operations would be reduced. As explained in Chapter 3, TVA payments in lieu of taxes each year are based upon the gross revenues TVA receives from electricity sales from within the service area, regardless of where the power is generated (TVA 2013a). However, terminating reactor operations at SQN would reduce the percentage of power sales and book value of TVA property in Tennessee and, in turn, the amount of money allocated to the State's counties and municipalities. Therefore, tax-equivalent payments to the State of Tennessee would continue, but at a reduced amount. TVA will still be responsible for producing and distributing electricity (and tax-equivalent payments), even if the operating licenses for SQN are not renewed (TVA 2013a). The loss of tax revenue could reduce or eliminate some public and educational services. Indirect employment and income generated by plant operations would also be reduced.

Former SQN workers and their families could leave in search of employment elsewhere. The increase in available housing along with decreased demand could cause housing prices to fall. Since the majority of SQN employees reside in Hamilton and Rhea counties, socioeconomic impacts from the termination of reactor operations would be concentrated in these counties, with a corresponding reduction in purchasing activity and tax revenue in the regional economy. Income and revenue losses from the termination of reactor operations at SQN would directly affect Hamilton County and nearby communities most reliant on income from power plant operations. However, the reduction in jobs at SQN would most likely occur gradually as TVA transitions from reactor operations to decommissioning. Socioeconomic impacts may not be noticeable in local communities, because this transition may occur over a long period of time. The socioeconomic impacts from the termination of nuclear plant operations (which may not entirely cease until after decommissioning) would, depending on the jurisdiction, range from SMALL to LARGE.

4.10.2.2 Transportation

Traffic congestion caused by commuting workers and truck deliveries on roads in the vicinity of SQN would be reduced after power plant shutdown. Most of the reduction in traffic volume would be associated with the loss of jobs. The number of truck deliveries to SQN would be reduced until decommissioning. Traffic-related transportation impacts would be SMALL as a result of the shutdown of the nuclear power plant.

4.10.3 NGCC Alternative – Socioeconomics

4.10.3.1 Socioeconomic Issues Other than Transportation

Socioeconomic impacts are defined in terms of changes to the demographic and economic characteristics and social conditions of a region. For example, the number of jobs created by the construction and operation of a power plant could affect regional employment, income, and expenditures.

Two types of jobs would be created by this alternative: (1) construction jobs, which are transient, short in duration, and less likely to have a long-term socioeconomic impact and (2) power plant operations jobs, which have the greater potential for permanent, long-term socioeconomic impacts. Workforce requirements for the construction and operation of the NGCC alternative were evaluated to measure their possible effects on current socioeconomic conditions.

Scaling from GEIS estimates, the construction workforce would peak at 2,880 workers (TVA 2013a). The relative economic effect of this many workers on the local economy and tax base would vary with the greatest impacts occurring in the communities where the majority of construction workers would reside and spend their income. As a result, local communities could experience a short term economic “boom” from increased tax revenue and income generated by construction expenditures and the increased demand for temporary (rental) housing and public services as well as commercial services.

After construction, local communities could experience a return to pre-construction economic conditions. Based on this information and given the number of workers required for this alternative, socioeconomic impacts during construction in communities near the SQN site could range from MODERATE to LARGE.

The workforce during power plant operations likely would be 120 to 180 operations workers. Local communities would experience the economic benefits from increased tax revenue and income generated by operational expenditures and demand for housing and public services as well as commercial services. The amount of property tax payments under the NGCC alternative may also increase if additional land is required to support this alternative.

This alternative would also result in the loss of jobs at SQN and a corresponding reduction in purchasing activity and revenue contributions to the regional economy. However, the reduction in jobs at SQN would most likely occur gradually as TVA transitions from reactor operations to decommissioning. Socioeconomic impacts may not be noticeable in local communities, because this transition may occur over a long period of time. The socioeconomic impacts of terminating reactor operations are described in Section 4.10.2.1. Based on this information and given the number of operations workers required for this alternative, socioeconomic impacts during NGCC power plant operations on local communities could range from SMALL to MODERATE.

4.10.3.2 Transportation

Transportation impacts associated with construction and operation of a six-unit, NGCC power plant would consist of commuting workers and truck deliveries of construction materials to the power plant site. During periods of peak construction activity, up to 2,880 workers could be commuting daily to the construction site. Workers commuting to the construction site would arrive via site access roads and the volume of traffic on nearby roads could increase substantially during shift changes. In addition to commuting workers, trucks would be transporting construction materials and equipment to the work site, thus increasing the amount of traffic on local roads. The increase in vehicular traffic would peak during shift changes, resulting in temporary levels of service impacts and delays at intersections. Pipeline construction and modification of existing natural gas pipeline systems could also have a temporary impact. Materials also could be delivered by barge or rail, depending on location of the NGCC alternative. Traffic-related transportation impacts during construction would likely range from MODERATE to LARGE.

Traffic-related transportation impacts would be greatly reduced after construction of the NGCC alternative. Transportation impacts would include daily commuting by the operating workforce, equipment and materials deliveries, and the removal of commercial waste material to offsite disposal or recycling facilities by truck. The operations workforce of 120 to 180 likely would not be noticeable relative to total traffic volumes on local roadways. Since fuel is transported by pipeline, the transportation infrastructure would experience little to no increased traffic from plant operations. Overall, given the relatively small operations workforce of 120 to 180 workers, transportation impacts would be SMALL during power plant operations.

4.10.4 SCPC Alternative – Socioeconomics

4.10.4.1 Socioeconomic Issues Other than Transportation

As explained in Section 4.10.2.2, two types of jobs would be created by this alternative: (1) construction jobs, which are transient, short in duration, and less likely to have a long-term socioeconomic impact and (2) power plant operations jobs, which have the greater potential for permanent, long-term socioeconomic impacts. Workforce requirements for the construction and operation of the SCPC alternative were evaluated to measure their possible effects on current socioeconomic conditions.

Scaling from GEIS estimates, the construction workforce would peak at 2,880 to 6,000 workers (TVA 2013a). The relative economic effect of this many workers on the local economy and tax base would vary with the greatest impacts occurring in the communities where the majority of construction workers would reside and spend their income. As a result, local communities could experience a short term economic “boom” from increased tax revenue and income generated by construction expenditures and the increased demand for temporary (rental) housing and public services as well as commercial services.

After construction, local communities could experience a return to pre-construction economic conditions. Based on this information and given the number of workers required for this alternative, socioeconomic impacts during construction in communities near the site could range from MODERATE to LARGE.

The workforce during power plant operations likely would range between 360 and 480 operations workers. Local communities would experience the economic benefits from increased tax revenue and income generated by operational expenditures and demand for housing and public as well as commercial services. The amount of property tax payments under the SCPC alternative may also increase if additional land is required to support this alternative.

This alternative would also result in the loss of jobs at SQN and a corresponding reduction in purchasing activity and revenue contributions to the regional economy. However, the reduction in jobs at SQN would most likely occur gradually as TVA transitions from reactor operations to decommissioning. Socioeconomic impacts may not be noticeable in local communities, because this transition may occur over a long period of time. The socioeconomic impacts of terminating reactor operations are described in Section 4.10.2.1. Based on this information and given the number of operations workers, socioeconomic impacts during SCPC power plant operations on local communities could range from SMALL to MODERATE.

4.10.4.2 Transportation

Transportation impacts associated with construction and operation of an SCPC power plant would consist of commuting workers and truck deliveries of construction materials to the power plant site. During periods of peak construction activity, up to 2,880 to 6,000 workers could be commuting daily to the construction site. Workers commuting to the construction site would arrive via site access roads and the volume of traffic on nearby roads could increase substantially during shift changes. In addition to commuting workers, trucks would be transporting construction materials and equipment to the work site, thereby increasing the amount of traffic on local roads. The increase in vehicular traffic would peak during shift changes, resulting in temporary levels of service impacts and delays at intersections. Materials could also be delivered by rail or barge, depending on location of the SCPC alternative. Traffic-related transportation impacts during construction would likely range from MODERATE to LARGE.

Traffic-related transportation impacts on local roads would be greatly reduced after the completion of the power plant. The estimated maximum number of operations workers commuting daily to the power plant site could be 480. Frequent coal and limestone deliveries and ash removal by rail would add to the overall transportation impact. The increase in traffic on roadways would peak during shift changes, resulting in temporary levels of service impacts and delays at intersections. Onsite coal storage would make it possible to receive several trains per day at a site with rail access. If the SCPC power plant is located on navigable waters, coal and other materials could be delivered by barge. Coal and limestone delivery and ash removal via rail would cause levels of service impacts because of delays at railroad crossings. Overall, transportation impacts would be SMALL to MODERATE during SCPC power plant operations.

4.10.5 New Nuclear Alternative – Socioeconomics

4.10.5.1 Socioeconomic Issues Other than Transportation

As explained in Section 4.10.2.2, two types of jobs would be created by this alternative: (1) construction jobs, which are transient, short in duration, and less likely to have a long-term socioeconomic impact and (2) power plant operations jobs, which have the greater potential for permanent, long-term socioeconomic impacts. Workforce requirements for the construction and operation of a new nuclear power plant were evaluated to measure their possible effects on current socioeconomic conditions.

TVA estimated the construction workforce would peak at 5,000 workers (TVA 2013a). The relative economic effect of this many workers on the local economy and tax base would vary with the greatest impacts occurring in the communities where the majority of construction workers would reside and spend their income. As a result, local communities could experience a short term economic “boom” from increased tax revenue and income generated by construction expenditures and the increased demand for temporary (rental) housing and public as well as commercial services.

After construction, local communities could experience a return to pre-construction economic conditions. Based on this information and given the number of workers required for this alternative, socioeconomic impacts during construction in communities near the site could range from MODERATE to LARGE.

The workforce during power plant operations likely would range between 540 and 720 operations workers. Some SQN operations workers likely would transfer to the new nuclear power plant. Local communities would experience the economic benefits from increased tax revenue and income generated by operational expenditures and demand for housing and public as well as commercial services. The amount of property tax payments under the new nuclear alternative may also increase if additional land is required to support this alternative.

This alternative would also result in the loss of jobs at SQN and a corresponding reduction in purchasing activity and revenue contributions to the regional economy. However, the reduction in jobs at SQN would most likely occur gradually as TVA transitions from reactor operations to decommissioning. Socioeconomic impacts may not be noticeable in local communities, because this transition may occur over a long period of time. The socioeconomic impacts of terminating reactor operations are described in Section 4.10.2.1. Based on this information and given the number of operations workers required for this alternative, socioeconomic impacts during nuclear power plant operations on local communities could range from SMALL to MODERATE.

4.10.5.2 Transportation

Transportation impacts associated with construction and operation of a new nuclear power plant would consist of commuting workers and truck deliveries of construction materials to the power plant site. During periods of peak construction activity, up to 5,000 workers could be commuting daily to the construction site (TVA 2013a). Workers commuting to the construction site would arrive via site access roads and the volume of traffic on nearby roads could increase substantially during shift changes. In addition to commuting workers, trucks would be transporting construction materials and equipment to the work site, thereby increasing the amount of traffic on local roads. The increase in vehicular traffic would peak during shift changes, resulting in temporary levels of service impacts and delays at intersections. Materials could also be delivered by rail or barge, depending on the location. Traffic-related transportation impacts during construction would likely range from MODERATE to LARGE.

Traffic-related transportation impacts on local roads would be greatly reduced after the completion of the power plant. Transportation impacts would include daily commuting by the operating workforce, equipment and materials deliveries, and the removal of commercial waste material to offsite disposal or recycling facilities by truck. Traffic on roadways would peak during shift changes, resulting in temporary levels of service impacts and delays at intersections. Overall, at the new nuclear power plant site, transportation impacts would be SMALL to MODERATE during operations.

4.10.6 Combination Alternative – Socioeconomics

4.10.6.1 Socioeconomic Issues Other than Transportation

As explained in Section 4.10.2.2, two types of jobs would be created by this alternative: (1) construction jobs, which are transient, short in duration, and less likely to have a long-term socioeconomic impact and (2) operations jobs, which have the greater potential for permanent, long-term socioeconomic impacts. Workforce requirements for the construction and operation of wind and solar generation components of this combination alternative were evaluated to estimate their possible effects on current socioeconomic conditions.

Installation of 2,350-3,150 wind turbines would likely be done in stages and could employ up to 200 construction workers. Additional workers would be required to install solar photovoltaic systems on existing buildings or structures at already-developed residential, commercial, or industrial sites. Similar to the wind farms, installation would likely be done in stages and could also employ up to 200 construction workers.

Conversely, a relatively small number of operations workers (about 50) would be needed to maintain the wind farm while a similar amount of operations workers (about 50) would be needed to maintain the photovoltaic systems. Local communities would experience the economic benefits from increased tax revenue and income generated by operational expenditures and demand for housing and public as well as commercial services. The amount of property tax payments under the wind and solar photovoltaic components may also increase if additional land is required to support this combination alternative.

This combination alternative would also result in the loss of jobs at SQN and a corresponding reduction in purchasing activity, tax payments, and revenue contributions would occur in the surrounding regional economy. However, the reduction in jobs at SQN would most likely occur gradually as TVA transitions from reactor operations to decommissioning. Socioeconomic impacts may not be noticeable in local communities, because this transition may occur over a long period of time. The socioeconomic impacts of terminating reactor operations are described in Section 4.10.2.1. Based on this information and given the small numbers of construction and operations workers required for this alternative, socioeconomic impacts during construction and operations on local communities would be SMALL.

4.10.6.2 Transportation

Transportation impacts during the construction and operation of the wind and solar components of this combination alternative would be less than the impacts for any of the previous alternatives discussed. This is because the construction workforce for each component and the volume of materials and equipment needing to be transported to the respective construction site would be smaller than for the individual alternative. In other words, the transportation impacts would not be concentrated as in the other alternatives, but spread out over a wider area.

Workers commuting to the construction site would arrive via site access roads and the volume of traffic on nearby roads could increase during shift changes. In addition to commuting workers, trucks would be transporting construction materials and equipment to the work site, thereby increasing the amount of traffic on local roads. The increase in vehicular traffic would peak during shift changes, resulting in temporary levels of service impacts and delays at intersections. Transporting heavy and oversized components on local roads could have a noticeable impact over a large area. Some components and materials could also be delivered by rail or barge, depending on location. Traffic-related transportation impacts during construction could range from SMALL to MODERATE at the wind farms and solar installations; depending on current road capacities and average daily traffic volumes.

During operations, transportation impacts would be less noticeable during shift changes and maintenance activities. Given the small numbers of operations workers, the levels of service traffic impacts on local roads from wind farm and solar photovoltaic operations would be SMALL.

4.11 Human Health

This section describes the potential impacts of the proposed action (license renewal) and alternatives to the proposed action on human health resources.

4.11.1 Proposed Action

The human health resource issues applicable to SQN during the license renewal term are listed in Table 4–17. Section 3.11 describes the human health resources.

Table 4–17. Human Health Issues

Issues	GEIS Section	Category
Radiation exposures to the public	4.9.1.1.1	1
Radiation exposures to plant workers	4.9.1.1.1	1
Human health impact from chemicals	4.9.1.1.2	1
Microbiological hazards to the public	4.9.1.1.3	2
Microbiological hazards to plant workers	4.9.1.1.3	1
Chronic effects of electromagnetic fields (EMFs)	4.9.1.1.4	[a] N/A
Physical occupational hazards	4.9.1.1.5	1
Electric shock hazards	4.9.1.1.5	2

[a] N/A (not applicable)—The categorization and impact finding definition does not apply to this issue.

Source: Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51

4.11.1.1 Normal Operating Conditions

<u>Generic Human Health Issues (Category 1)</u>

The NRC staff did not identify any new and significant information during its review of TVA's ER, the site audit, or the scoping process for the Category 1 issues listed in Table 4–17. Therefore, there are no impacts related to these issues beyond those discussed in the GEIS. For these Category 1 issues, the GEIS concluded that the impacts are SMALL.

Chronic Effects of Electromagnetic Fields

In the GEIS, the chronic effects of 60-Hz electromagnetic fields (EMFs) from power lines were not designated as Category 1 or 2, and will not be until a scientific consensus is reached on the health implications of these fields.

The potential for chronic effects from these fields continues to be studied and is not known at this time. The National Institute of Environmental Health Sciences (NIEHS) directs related research through the U.S. Department of Energy (DOE).

The report by NIEHS (NIEHS 1999) contains the following conclusion:

> The NIEHS concludes that ELF-EMF (extremely low frequency-electromagnetic field) 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 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.

This statement is not sufficient to cause the NRC staff to change its position with respect to the chronic effects of EMFs. The NRC staff considers the GEIS finding of "UNCERTAIN" still appropriate and will continue to follow developments on this issue.

Site-Specific Human Health Issues (Category 2)

Microbiological Hazards to the Public

The 2013 GEIS (NRC 2013e) categorizes microbiological hazard to the public as a site-specific (Category 2) issue that requires an assessment of potential health effects to the public from microorganisms associated with nuclear power plants with cooling ponds, lakes, canals, or discharge into rivers. During the license renewal term, members of the public might be exposed to microbiological hazards just as they might be during operation during the original license term.

Microbiological hazards to the public are discussed in Section 3.11.3. Potential public exposure to thermophilic microorganisms from cooling tower or thermal discharge to Chickamauga Reservoir is limited at SQN. SQN maintains an NPDES permit administered by the State of Tennessee that limits thermal discharge to a 24-hour downstream temperature of no greater than 86.9 °F (30.5 °C) during summer months. When the ambient temperature is greater than 84.9 °F (29.4 °C), this restriction can be exceeded, but the permit states that SQN may not have an hourly average downstream temperature greater than 93.0 °F (33.9 °C) (TVA 2013g). These temperatures are below the stated optimal growing temperature of approximately 95 °F (35 °C) for *Legionella* spp. and 98.6 °F (37 °C) for *Pseudomonas aeruginosa. Naegleria fowleri* is rarely found in water temperatures below 95 °F (35 °C). In addition, thermal effluent from SQN is discharged to Chickamauga Reservoir through two diffuser pipes and mixed with ambient water, preventing the stagnant water habitat needed for optimal growth of these microorganisms (TVA 2013g). Further, public boating access to Chickamauga Reservoir is located downstream and opposite of SQN, and public swimming access occurs more than 3 mi (5 km) downstream from SQN (NRC 2013e; TVA 2013g).

The NRC staff concludes that Chickamauga Reservoir water conditions and SQN operation are not likely to encourage the growth of the microbiological organisms of concern and present an exposure hazard to the public. The NRC staff concludes that impacts on public health from thermophilic microbiological organisms from continued operation of SQN in the license renewal period would be SMALL.

Electric Shock Hazards

Based on the GEIS, the Commission found that electric shock resulting from direct access to energized conductors or from induced charges in metallic structures has not been found to be a problem at most operating plants and generally is not expected to be a problem during the license renewal term. However, a site-specific review is required to determine the significance of the electric shock potential along the portions of the transmission lines that are within the scope of this SEIS.

As discussed in Section 3.11.4, TVA performed an evaluation of its transmission lines to determine whether the lines conform to the National Electrical Safety Code (NESC) criteria for induced electric shock. The TVA evaluation concluded that nine spans of its transmission lines exceeded the NESC criteria.

In accordance with 10 CFR Part 51.53(c)(3)(iii), TVA has provided information on actions it is considering to reduce the potential impacts from those transmission lines that exceed the NESC standard. TVA has a 500-kV transmission line uprate program with defined projects in the planning and design stage which will correct the deficiencies. These projects are all scheduled for completion by June 2017, before the end of SQN's current operating license (TVA 2013g).

Based on TVA's stated plans to correct the deficiencies with the affected transmission line spans to achieve conformance with the NESC criteria during its current license term and its expected conformance with the standard during the license renewal term, the NRC staff concludes that the potential impacts from acute electric shock during the license renewal term would be SMALL.

4.11.1.2 Environmental Impacts of Postulated Accidents

This section describes environmental impacts from postulated accidents that might occur during the period of extended operation at SQN. The term "accident" refers to any unintentional event outside the normal plant operational envelope that results in a release or the potential for release of radioactive materials into the environment. Two classes of postulated accidents are evaluated in the GEIS. These are DBAs and severe accidents.

Design-Basis Accidents

To receive U.S. Nuclear Regulatory Commission (NRC) approval to operate a nuclear power facility, an applicant for an initial operating license must submit a safety analysis report (SAR) as part of its application. The SAR presents the design criteria and design information for the proposed reactor and comprehensive data on the proposed site. The SAR also discusses various hypothetical accident situations and the safety features that are provided to prevent and mitigate accidents. The NRC staff reviews the application to determine whether the plant design meets the Commission's regulations and requirements and includes, in part, the nuclear plant design and its anticipated response to an accident.

Design-basis accidents are those accidents that both the licensee and NRC staff evaluate to ensure that the plant can withstand normal and abnormal transients, and a broad spectrum of postulated accidents, without undue hazard to the health and safety of the public. A number of these postulated accidents are not expected to occur during the life of the plant, but are evaluated to establish the design basis for the preventive and mitigative safety systems of the facility. The acceptance criteria for DBAs are described in 10 CFR Part 50 and 10 CFR Part 100.

The environmental impacts of DBAs are evaluated during the initial licensing process, and the ability of the plant to withstand these accidents is demonstrated to be acceptable before issuance of the operating license. The results of these evaluations are found in licensee documentation such as the applicant's final safety analysis report, the safety evaluation report, the final environmental statement (FES), and this section of the supplemental environmental impact statement (SEIS). A licensee is required to maintain the acceptable design and performance criteria throughout the life of the plant, including any extended-life operation. The consequences for these events are evaluated for the hypothetical maximum exposed individual; as such, changes in the plant environment will not affect these evaluations. Because licensees are required to assess operational consequences and maintain aging management programs for the period of extended operation, the environmental impacts as calculated for DBAs should not differ significantly from initial licensing assessments over the life of the plant, including the period of extended operation. Accordingly, the design of the plant relative to DBAs during the period of extended operation is considered to remain acceptable and the environmental impacts of those accidents were not examined further in the GEIS.

Based on information in the GEIS, the Commission found that:

> The environmental impacts of design-basis accidents are SMALL for all nuclear plants. Due to the requirements for nuclear plants to maintain their licensing basis and implement aging management programs during the license renewal term, the environmental impacts during a license renewal term should not differ significantly from those calculated for the design-basis accident assessments conducted as part of the initial plant licensing process.

For the purposes of license renewal, DBAs are designated as a Category 1 issue (Table 4–18). The early resolution of the DBAs makes them a part of the current licensing basis (CLB) of the plant; the CLB of the plant is to be maintained by the licensee under its current license and, therefore, under the provisions of 10 CFR Part 54.30, is not subject to review under license renewal.

Table 4–18. Issues Related to Postulated Accident

Issue	GEIS Section	Category
Design-basis accidents	4.8.1.2	1
Severe accidents	4.8.1.2	2

Source: Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51

Severe Accidents

Severe nuclear accidents are those that are more severe than DBAs because they could result in substantial damage to the reactor core, whether or not there are serious offsite consequences. In the GEIS, the staff assessed the impacts of severe accidents during the license renewal period, using the results of existing analyses and site-specific information to conservatively predict the environmental impacts of severe accidents for each plant during the renewal period.

Severe accidents initiated by external phenomena such as tornadoes, floods, earthquakes, fires, and sabotage have not traditionally been discussed in quantitative terms in FESs and were not specifically considered for SQN in the GEIS (NRC 2013e). In Section 1.7.6 of the GEIS (NRC 2013), NRC states that neither decisions nor recommendations will be made in the GEIS regarding earthquakes (seismicity) or flooding at nuclear power plants. Described in Section 1.7.4 of the GEIS, the risk from intruders (which includes terrorist-related activities) against nuclear power plants is not unique to facilities requesting license renewal. As discussed in the Statements of Consideration for the 10 CFR Part 54 rulemaking, the Commission has determined that there is no need for a special review of security issues in the context of an environmental review for license renewal. The NRC routinely assesses threats and other information provided by other Federal agencies and sources. The NRC also ensures that licensees meet their security requirements through its ongoing regulatory process (routine inspections) as a current and generic regulatory issue that affects all nuclear power plants.

Based on information in the GEIS, the Commission found that:

> The probability-weighted consequences of atmospheric releases, fallout onto open bodies of water, releases to groundwater, and societal and economic impacts from severe accidents are small for all plants. However, alternatives to mitigate severe accidents must be considered for all plants that have not considered such alternatives.

As described in the Design Basis Events section, information related to external flooding does not affect the impacts discussed in the GEIS. The NRC's assessment of flood hazards for existing nuclear power plants is a separate and distinct process from license renewal reviews. As indicated in the GEIS (NRC 2013e), seismic and flood hazard issues are addressed by the NRC on an ongoing basis at all licensed nuclear facilities. However, in accordance with 10 CFR Part 51.53(c)(3)(ii)(L), the NRC staff has reviewed severe accident mitigation alternatives (SAMAs) analysis provided by TVA for SQN. The results of the review are discussed in the Severe Accident Mitigation Alternatives section below.

Severe Accident Mitigation Alternatives

If the NRC staff has not previously evaluated SAMAs for the applicant's plant in an environmental impact statement (EIS) or related supplement or in an environmental assessment, 10 CFR Part 51.53(c)(3)(ii)(L) requires a consideration of alternatives to mitigate severe accidents. SAMAs have not been previously considered for SQN; therefore, the remainder of Section 4.11.1.2 addresses SAMAs. The purpose of this consideration of SAMAs is to ensure that plant changes (i.e., hardware, procedures, and training) with the potential for improving severe accident safety performance are identified and evaluated. Pursuant to 10 CFR Part 54, the only changes that must be implemented by the applicant as part of the license renewal process are those that are identified as being cost beneficial, that provide a significant reduction in total risk, and that are related to adequately managing the effects of aging during the period of extended operation.

Overview of SAMA Process

This section presents a summary of the SAMA evaluation for SQN as described in the TVA's ER (TVA 2013a), additional requested information (TVA 2013c), and the review of those evaluations. The entire evaluation is presented in Appendix F. The NRC staff performed its review with contract assistance from the Center for Nuclear Waste Regulatory Analyses. The NRC staff review is available in full in Appendix F; the complete SAMA evaluation is available in Attachment E of TVA's ER.

The SAMA evaluation for SQN was conducted with a four-step approach. In the first step, TVA quantified the level of risk associated with potential reactor accidents using the plant-specific probabilistic risk assessment (PRA) and other risk models. In the second step, TVA examined the major risk contributors and identified possible ways (SAMAs) of reducing that risk. Common ways of reducing risk are changes to components, systems, procedures, and training. In the third step, TVA estimated the benefits and the costs associated with each of the candidate SAMAs. Estimates were made of how much each SAMA could reduce risk. Those estimates were developed in terms of dollars in accordance with NRC guidance for performing regulatory analyses. The costs of implementing the candidate SAMAs were also estimated. In the fourth step, TVA compared the cost and benefit of each of the remaining SAMAs to determine whether each SAMA was cost beneficial, meaning the benefits of the SAMA exceeded its cost.

Estimate of Risk

TVA submitted an assessment of SAMAs for SQN as part of the ER (TVA 2013d). The assessment was based on the most recent revision to the PRA for each unit, including an internal events model and a plant-specific offsite consequence analysis performed using the WinMACCS Version 3.6.0 computer code, and insights from the SQN individual plant examination (IPE) submittals (TVA 1992, 1998) and individual plant examination of external events (IPEEE) submittals (TVA 1995, 1999).

TVA's determination of offsite risk at SQN is based on the following three major analysis elements: (1) essentially new Level 1 and 2 risk models that replace the original 1992 and revised 1998 IPE submittals (TVA 1992, 1998), (2) analyses of the 1995 and 1999 IPEEE submittals (TVA 1995, 1999), and (3) the combination of offsite consequence measures from WinMACCS analyses with release frequencies and radionuclide source terms from the Level 2 PRA model.

The SQN Unit 1 core damage frequency (CDF) is approximately 3.0×10^{-5} per reactor-year while the Unit 2 CDF is approximately 3.5×10^{-5} per reactor-year. These values were used as the baseline CDF in the SAMA evaluations (TVA 2013d). The CDF is based on the risk assessment for internally initiated events, which includes internal flooding. TVA did not explicitly include the contribution from external events within the SQN risk estimates; however, it did account for the potential risk reduction benefits for individual SAMAs associated with external events by multiplying the estimated benefits for internal events by a factor of 2.9 for Unit 1 and 2.6 for Unit 2. This is discussed further in Appendix F, Sections F.2.2 and F.6.2. Using the calculated risk reduction as a quantitative measure of the potential benefit from SAMA implementation, TVA performed a cost-benefit comparison, as described in the Cost-Benefit Comparison section.

The breakdown of CDF by initiating event is provided in Table 4–19. As shown in this table, Internal Flooding, Loss of All Component Cooling Water and Stuck Open Safety/Relief Valve are the dominant contributors to the CDF in both units. Station blackout (SBO) and anticipated transients without scram (ATWS) are not listed in Table 4–19 because multiple initiators contribute to their occurrence. Station blackout contributes about 13 percent and 10 percent to the occurrence of severe accidents for Units 1 and 2, respectively (3.9×10^{-6} per reactor-year and 3.6×10^{-6} per reactor-year) of the total CDF while ATWS contribute about 14 percent and 12 percent for Units 1 and 2, respectively, (4.1×10^{-6} per reactor-year for each unit) to the total CDF. In a subsequent correction to the ATWS model, TVA indicated that ATWS contributes about 2 percent and 2.3 percent to the total CDF for Units 1 and 2, respectively (TVA 2013c).

The Level 2 SQN PRA model that forms the basis for the SAMA evaluation is essentially a new model for SQN. The Level 2 model was developed with a focus on the quantification of Large Early Release Frequency (LERF) but does include the development of other end states. The Level 2 model utilizes containment event trees (CETs) containing both phenomenological and systemic events. The core damage sequences from the Level 1 PRA are binned into plant damage states based on similar characteristics that influence the accident progression following core damage. These bins provide the interface between the Level 1 and Level 2 CET analyses. The CETs are linked directly to the Level 1 event trees and CET nodes based on the plant damage states.

The CET considers the influence of physical and chemical processes on the integrity of the containment and on the release of fission products once core damage has occurred. Each CET sequence was assigned to one of seven end state categories. Four of these categories represent LERF with the remaining representing late and small early releases and an intact containment. These end states were subsequently grouped into 12 release categories (or release modes) that provide the input to the Level 3 consequence analysis. The frequency of each release category was obtained by summing the frequency of the individual accident progression CET endpoints binned into the release category. The determination of the characteristics for each release category was based on representative accident scenarios that reflect the core damage and containment behavior for the dominant sequence or sequences within a plant damage state and the dominant Level 2 sequence within the release category. The source terms for the representative scenarios were based on a SEQSOR emulation spreadsheet methodology. The results of this analysis for SQN are provided in Table E.1-15 of ER Attachment E (TVA 2013d).

Table 4–19. SQN Units 1 and 2 CDF for Internal Events

Initiating Event	Unit 1 CDF (per year)	Unit 1 Percent CDF Contribution[1]	Unit 2 CDF (per year)	Unit 2 Percent CDF Contribution[1]
Internal Flooding	1.7×10^{-5}	56	2.3×10^{-5}	66
Loss of All Component Cooling Water	3.6×10^{-6}	12	3.2×10^{-6}	9
Stuck Open Safety/Relief Valve	2.3×10^{-6}	8	2.5×10^{-6}	7
Secondary Side Break Outside of Containment	1.3×10^{-6}	4	1.4×10^{-6}	4
Losses of Main Feedwater	9.3×10^{-7}	3	6.9×10^{-7}	2
Reactor Trip	9.2×10^{-7}	3	9.1×10^{-7}	3
Loss of Train A Component Cooling Water[2]	9.0×10^{-7}	3	7.6×10^{-7}	2
Loss of Instrument Boards	7.4×10^{-7}	2	5.7×10^{-7}	2
Other Initiating Events[3]	6.8×10^{-7}	2	5.6×10^{-7}	2
Loss of Offsite Power	6.5×10^{-7}	2	3.9×10^{-7}	1
Turbine Trip	5.1×10^{-7}	2	5.1×10^{-7}	1
Small Loss of Coolant Accident	3.9×10^{-7}	1	4.5×10^{-7}	1
Total CDF (Internal Events)	**3.0×10^{-5}**	**100**	**3.5×10^{-5}**	**100**

[1] Percentages were rounded to the nearest whole percent for reporting and may not sum to 100 percent because of round off error.
[2] Train A is listed as Train 1A for Unit 1 and Train 2A for Unit 2.
[3] Multiple initiating events with each contributing less than 1 percent.

TVA computed offsite consequences for potential releases of radiological material using the WinMACCS Version 3.6.0 code and analyzed exposure and economic impacts from its determination of offsite and onsite risks. Inputs for these analyses include plant-specific and site-specific input values for core radionuclide inventory, source term and release characteristics, site meteorological data, projected population distribution and growth within a 50-mile radius, emergency response evacuation modeling, and economic data. Because of the similarity of the reactor cores at Watts Bar Unit 1, SQN Unit 1, and SQN Unit 2, the radionuclide inventory for the SQN SAMA analysis is based on the core inventory for Watts Bar Unit 1 multiplied by the power ratio of the SQN Unit 1 power of 1,148 MWe to the Watts Bar Unit 1 power of 1,123 MWe (TVA 2013d, Attachment E). Although the SQN Unit 2 power was slightly lower at 1,126 MWe, the same core inventory for SQN Unit 1 was conservatively used for the SQN Unit 2 consequence analysis. The estimation of onsite impacts (in terms of cleanup and decontamination costs and occupational dose) is based on guidance in NUREG/BR–0184 (NRC 1997).

In the ER, the applicant estimated the dose risk to the population within 80 km (50 mi) of the SQN site to be 0.450 person-sievert (Sv) per year (45.0 person-rem per year) for Unit 1 and 0.439 person-Sv per year (43.9 person-rem per year) for Unit 2 (TVA 2013a, Tables E.1-20 and E.1-21). The breakdown of the population dose risk by containment release mode is summarized in Table 4–20. Late containment failure releases and large early releases caused by containment isolation failures accounted for approximately 79 and 75 percent of the population dose risk at Units 1 and 2, respectively. Late containment failure releases alone contributed approximately 47 and 45 percent of the population dose risk at Units 1 and 2. Late containment failure releases and large early releases caused by containment isolation failures accounted for approximately 85 and 83 percent of the offsite economic cost risk at Units 1 and 2, respectively. Late containment failure releases alone contributed approximately 58 and 56 percent of the offsite economic cost risk at Units 1 and 2.

The NRC staff has reviewed TVA's data and evaluation methods and concludes that the quality of the risk analyses is adequate to support an assessment of the risk reduction potential for candidate SAMAs. Accordingly, the staff based its assessment of offsite risk on the CDFs and offsite doses reported by TVA.

Table 4–20. Base Case Mean Population Dose Risk and Offsite Economic Cost Risk for Internal Events

Release Mode			Population Dose Risk [1]				Offsite Economic Cost Risk			
ID [2]	Frequency (per year)		Person-rem/yr		Percent Contribution [3]		$/yr		Percent Contribution [3]	
	Unit 1	Unit 2	Unit 1	Unit 2	Unit 1	Unit 2	Unit 1	Unit 2	Unit 1	Unit 2
Ia	4.1×10^{-8}	4.6×10^{-8}	1.2×10^{-1}	1.3×10^{-1}	<1	<1	$2.3\times10^{+2}$	$2.6\times10^{+2}$	<1	<1
Ib	9.7×10^{-7}	9.5×10^{-7}	$2.5\times10^{+0}$	$2.5\times10^{+0}$	6	6	$5.2\times10^{+3}$	$5.1\times10^{+3}$	5	5
Ic	2.7×10^{-7}	3.9×10^{-7}	7.0×10^{-1}	$1.0\times10^{+0}$	2	2	$1.4\times10^{+3}$	$2.1\times10^{+3}$	1	2
IIa	3.3×10^{-6}	3.3×10^{-6}	$1.2\times10^{+1}$	$1.2\times10^{+1}$	26	27	$2.2\times10^{+4}$	$2.2\times10^{+4}$	23	24
IIb	6.3×10^{-7}	3.3×10^{-7}	$2.2\times10^{+0}$	$1.1\times10^{+0}$	5	3	$4.2\times10^{+3}$	$2.2\times10^{+3}$	4	2
IIc	6.5×10^{-8}	6.3×10^{-8}	1.3×10^{-1}	1.2×10^{-1}	<1	<1	$2.9\times10^{+2}$	$2.8\times10^{+2}$	<1	<1
IId	4.8×10^{-8}	6.8×10^{-8}	1.1×10^{-1}	1.5×10^{-1}	<1	<1	$2.4\times10^{+2}$	$3.4\times10^{+2}$	<1	<1
III	6.4×10^{-7}	7.4×10^{-7}	$5.9\times10^{+0}$	$6.7\times10^{+0}$	13	15	$7.0\times10^{+3}$	$8.1\times10^{+3}$	7	9
IVa	1.8×10^{-5}	1.7×10^{-5}	$1.9\times10^{+1}$	$1.9\times10^{+1}$	42	43	$5.0\times10^{+4}$	$4.9\times10^{+4}$	52	53
IVb	2.2×10^{-6}	1.2×10^{-6}	$2.2\times10^{+0}$	$1.2\times10^{+0}$	5	3	$5.7\times10^{+3}$	$3.2\times10^{+3}$	6	3
Va	2.1×10^{-6}	2.0×10^{-6}	2.8×10^{-1}	2.7×10^{-1}	1	1	$2.6\times10^{+2}$	$2.5\times10^{+2}$	<1	<1
Vb	1.1×10^{-6}	1.9×10^{-6}	1.5×10^{-1}	2.5×10^{-1}	<1	1	$1.3\times10^{+2}$	$2.3\times10^{+2}$	<1	<1
Totals			**$4.5\times10^{+1}$**	**$4.4\times10^{+1}$**	**100**	**100**	**$9.7\times10^{+4}$**	**$9.3\times10^{+4}$**	**100**	**100**

[1] Unit Conversion Factor: 1 Sv = 100 rem

[2] Release Category Descriptions

- I – Large early releases with containment failures
- II – Large early releases with containment isolation failures
- III – Large early releases with containment bypass
- IV – Late containment failure release
- V – Small early release with some mitigation

[3] Percentages are rounded to the nearest whole percent for reporting and may not sum to 100 percent because of roundoff error.

Potential Plant Improvements

The TVA's process for identifying potential plant improvements (SAMAs) consisted of the following elements:

- review of industry documents including NEI 05-01 (NEI 2005) and 12 other plant SAMA analyses for potential cost-beneficial SAMA candidates,
- review of potential plant improvements identified in the SQN IPE and IPEEE, and
- review of the risk significant events in the current SQN PRA Levels 1 and 2 models for modifications to include in the comprehensive list of SAMA candidates.

Based on this process, an initial set of 309 candidate SAMAs, referred to as Phase I SAMAs, were identified. In Phase I of the evaluation, TVA performed a qualitative screening of the initial list of SAMAs and eliminated SAMAs from further consideration using the following criteria:

- The SAMA is not applicable to SQN.
- The SAMA has already been implemented at SQN.
- The SAMA is similar in nature and could be combined with another SAMA candidate.
- The SAMA has an estimated implementation cost in excess of the Modified Maximum Averted Cost Risk (MMACR).
- The SAMA is related to non-risk significant systems.
- A plant improvement that addresses the intent of the SAMA is already in progress.

Based on this screening, a total of 262 SAMAs were eliminated leaving 47 for further evaluation. The remaining SAMAs, referred to as Phase II SAMAs, are listed in Tables E.2-1 and E.2-2 of Attachment E to the ER (TVA 2013a). In Phase II, a detailed evaluation was performed for each of the 47 remaining SAMA candidates.

The NRC staff concludes that TVA used a systematic and comprehensive process for identifying potential plant improvements for SQN, and that the set of SAMAs evaluated in the ER, together with those evaluated in response to NRC staff inquiries, is reasonably comprehensive and, therefore, acceptable. The NRC staff evaluation included reviewing insights from the SQN plant-specific risk studies that included internal initiating events as well as fire, seismic, and other external initiated events, and reviewing plant improvements considered in previous SAMA analyses.

Evaluation of Risk Reduction and Costs of Improvements

In the ER, the applicant evaluated the risk-reduction potential of the 47 SAMAs that were not screened out in the Phase I analysis and retained for the Phase II evaluation. The SAMA evaluations were performed using generally conservative assumptions.

Except for one SAMA associated with internal fires, TVA used model requantification to determine the potential benefits for each SAMA. The CDF, population dose, and offsite economic cost reductions were estimated using the SQN SAMA PRA model for the SAMAs not associated with fire events. The changes made to the model to quantify the impact of SAMAs are detailed in Section E.2.3 of Attachment E to the ER (TVA 2013a). Bounding evaluations were performed to address specific SAMA candidates or groups of similar SAMA candidates.

For the fire related SAMA 287, the benefit was determined by assuming the conditional core damage probability and the associated CDF for the four fire compartments involved was reduced by a factor of 10. The evaluation assumed that all release category frequencies were reduced by the same percentage as CDF. The reduced CDF and release category frequencies were then used to determine the reduction in population dose and offsite economic cost in a manner similar to all other SAMAs (TVA 2013c). The NRC staff notes that the above, as applied by TVA, included increasing the benefit by the external event multiplier which is a significant conservatism because the SAMAs would only impact the fire CDF.

For the SAMAs determined to be potentially cost beneficial, Table 4–22 lists the assumptions made to estimate the risk reduction for each of the evaluated SAMAs, the estimated risk reduction in terms of percent reduction in CDF, population dose risk and offsite economic cost risk, and the estimated total benefit (present value) of the averted risk. The estimated benefits reported in Table 4–22 reflect the combined benefit in both internal and external events. The determination of the benefits for the various SAMAs is further discussed in Appendix F, Section F.6.

TVA estimated the costs of implementing the 47 Phase II SAMAs through the use of other licensees' estimates for similar improvements and the development of site-specific cost estimates where appropriate.

In Table 4–21 below, TVA indicated the following cost ranges were utilized based on the review of previous SAMA applications and an evaluation of expected implementation costs at SQN.

Table 4–21. Estimated Cost Ranges of SAMA Implementation Costs at SQN

Type of Change	Estimated Cost Range
Procedural only	$50K
Procedural change with engineering or training required	$50K to $200K
Procedural change with engineering and testing or training required	$200K to $300K
Hardware modification	$100K to >$1,000K

TVA stated that the SQN site-specific cost estimates were based on the engineering judgment of project engineers experienced in performing design changes at the facility and were compared, where possible, to estimates developed and used at plants of similar design and vintage.

In response to an NRC staff RAI to provide further information as to what was included in the SQN cost estimates, TVA indicated that the cost estimates were done in 2012 dollars and included contingency costs and capital overhead. Cost estimates from past projects were used when applicable. For cost estimates that were not based directly on past projects, itemized cost estimates were developed where applicable and appropriate. Specific hardware costs from recent projects such as piping, valves, electrical cable, and switchgear were used when applicable. Engineering estimates were based on typical man-hours costs for design changes. Training costs were developed based on the man-hours needed to prepare operator training materials. Cost input was received from the electrical, mechanical, and civil disciplines as required. The cost estimates were reviewed by the project manager and/or the discipline engineering managers when warranted. Replacement power, lifetime maintenance, escalation and inflation were not considered in the estimate (TVA 2013c).

Table 4–22. Potentially Cost-Beneficial SAMAs for Units 1 and 2 of the SQN

Percentage Risk Reductions Are Presented for CDF, Population Dose Risk (PDR), and Offsite Economic Cost Risk (OECR)

Individual SAMA and Assumption	Cost Estimate	Unit 1 Percent Risk Reduction			Unit 1 Internal and External Benefit	Unit 2 Percent Risk Reduction			Unit 2 Internal and External Benefit
		CDF	PDR	OECR		CDF	PDR	OECR	
8—Increase training on response to loss of two 120V AC buses	**$50,000**	**<0.1%**	**0.0%**	**0.0%**	**>$50,000[‖] $573 ($1,430)[#]**	**<0.1%**	**0.0%**	**0.0%**	**>$50,000[‖] $226 ($566)[#]**
Assumption: To assess the benefit of increased training on loss of two 120V AC buses causing inadvertent actuation signals, the inadvertent actuation of safety injection was removed from the model. In response to an RAI, determined by TVA to be potentially cost beneficial.									
32—Automatically align emergency core cooling system to recirculation[†]	**$2,100,000**	**13.4%**	**4.2%**	**2.9%**	**$458,00 ($1,144,000)[#]**	**31.8%**	**8.9%**	**6.8%**	**$1,026,000 ($2,564,000)[#]**
Assumption: A bounding analysis was performed by eliminating the failure of the manual action required to align high-pressure recirculation (HARR1) by setting the event to false.									
45—Enhance procedural guidance for use of cross-tied component cooling pumps	**$50,000**	**0.8%**	**1.1%**	**1.2%**	**$83,700 ($209,000)[#]**	**0.6%**	**1.1%**	**1.2%**	**$71,500 ($179,000)[#]**
Assumption: The fault trees for the component cooling water system were modified to reflect that failure of multiple pumps was required to cease flow to the respective heat exchanger train.									
70—Install accumulators for turbine driven auxiliary feedwater pump flow control valves	**$256,000**	**6.1%**	**4.9%**	**3.2%**	**$348,000 ($870,000)[#]**	**5.12%**	**5.01%**	**3.33%**	**$311,000 ($779,000)[#]**
Assumption: A bounding analysis was performed by eliminating the failure of the existing flow control valves.									
87—Replace service and instrument air compressors with more reliable compressors	**$886,000***	**6.5%**	**4.2%**	**2.8%**	**$326,000 ($815,000)[#]**	**5.6%**	**4.3%**	**2.9%**	**$293,000 ($732,000)[#]**
Assumption: A bounding analysis was performed by eliminating the failure of cooling to the compressors. This includes compressors for the auxiliary compressed air system and the compressed air system. In response to an RAI, determined by TVA to be potentially cost beneficial.									

Individual SAMA and Assumption	Cost Estimate	Unit 1 Percent Risk Reduction			Unit 1 Internal and External Benefit	Unit 2 Percent Risk Reduction			Unit 2 Internal and External Benefit
		CDF	PDR	OECR		CDF	PDR	OECR	
88—Install nitrogen bottles as backup gas supply for safety relief valves†	**$100,000**	**3.5%**	**0.2%**	**0.2%**	**$78,100 ($195,000)#**	**3.1%**	**0.5%**	**0.2%**	**$79,000 ($198,000)#**
Assumption: A bounding analysis was performed by modifying the atmospheric relief valve fault tree logic for all four valves to remove their dependence on compressed air.									
105—Delay containment spray actuation after a large loss of coolant accident	**$100,000**	**6.8%**	**2.7%**	**1.8%**	**$257,000 ($641,000)#**	**16.0%**	**5.0%**	**3.8%**	**$539,000 ($1,348,000)#**
106—Install automatic containment spray pump header throttle valves	**$100,000**	**6.8%**	**2.7%**	**1.8%**	**$257,000 ($641,000)#**	**16.0%**	**5.0%**	**3.8%**	**$539,000 ($1,348,000)#**
249—High volume makeup to the refueling water storage tank†	**$565,000**	**6.8%**	**2.7%**	**1.8%**	**$257,000 ($641,000)#**	**16.0%**	**5.0%**	**3.8%**	**$539,000 ($1,348,000)#**
Assumption: A bounding analysis was performed by changing the model so that the refueling water storage tank was always available. This included removing refueling water storage tank rupture, as well as failure to deliver flow from the refueling water storage tank to containment spray pumps A and B. In addition, the failure probability of the human action to align high-pressure recirculation (HARR1) was decreased by half to account for the increased time that the operator would have to perform this action.									
160—Implement procedures for temporary heating, ventilation, and air conditioning‡	**$300,000**	**9.1%**	**7.8%**	**9.1%**	**$665,000 ($1,661,000)#**	**5.0%**	**2.3%**	**2.5%**	**$220,000 ($550,000)#**
Assumption: The analysis was performed by adding a human action to provide temporary cooling (failure frequency of 10^{-1}) for the following areas given cooler/ventilation failure: turbine-driven auxiliary feedwater pump room; residual heat removal pump rooms A and B; safety injection pump rooms A and B, containment spray room; centrifugal charging pump cooler rooms A and B; and space coolers A and B for boric acid transfer pump and auxiliary feedwater (AFW) pumps.									

Individual SAMA and Assumption	Cost Estimate	Unit 1 Percent Risk Reduction			Unit 1 Internal and External Benefit	Unit 2 Percent Risk Reduction			Unit 2 Internal and External Benefit
		CDF	PDR	OECR		CDF	PDR	OECR	
215—Provide a means to ensure reactor coolant pump seal cooling so that reactor coolant pump seal loss of coolant accidents are precluded for station blackout events	**$1,500,000**	**47.5%**	**46.2%**	**54.1%**	**$3,832,000 ($9,580,000)[#]**	**38.5%**	**44.2%**	**53.2%**	**$3,234,000 ($8,085,000)[#]**
Assumption: This analysis was used to evaluate the change in plant risk from providing a means to ensure reactor coolant pump seal cooling so that reactor coolant pump seal loss of coolant accidents are precluded for station backout events. The analysis was performed by adding an additional seal cooling system to the logic "anded" with the existing reactor coolant pump thermal barrier cooling logic. The new seal cooling system with independent power source was given an unavailability of 0.05, which is representative of a single pump train system.									
268—Perform an evaluation of the component cooling water system/AFW area cooling requirements	**$313,000**	**29.5%**	**26.9%**	**31.7%**	**$2,269,000 ($5,673,000)[#]**	**21.3%**	**26.0%**	**31.5%**	**$1,881,000 ($4,704,000)[#]**
Assumption: The analysis was performed by eliminating the failure of the component cooling water system and AFW space coolers.									
275—Install spray protection on motor-driven auxiliary feedwater pumps and pump space coolers[†]	**$800,000**	**8.0%**	**6.9%**	**8.0%**	**$587,000 ($1,467,000)[#]**	**17.8%**	**8.4%**	**8.9%**	**$792,000 ($1,979,000)[#]**
Assumption: A bounding analysis was performed by eliminating spray initiators from the motor-driven auxiliary feedwater pumps, and space coolers used to cool motor-driven auxiliary feedwater pumps.									
279—Improve internal flooding response procedures and training to improve the response to internal flooding events	**$400,000**	**5.3%**	**7.3%**	**7.1%**	**$520,000 ($1,301,000)[#]**	**14.9%**	**10.0%**	**9.8%**	**$796,000 ($1,990,000)[#]**
Assumption: The analysis was performed by reducing the overall failure probability of important flooding human actions, with the flood multiplier for important human actions reduced by a factor of two.									

Individual SAMA and Assumption	Cost Estimate	Unit 1 Percent Risk Reduction			Unit 1 Internal and External Benefit	Unit 2 Percent Risk Reduction			Unit 2 Internal and External Benefit
		CDF	PDR	OECR		CDF	PDR	OECR	
283—Provide frequent awareness training to plant staff on important human actions	**$345,000**	**5.3%**	**4.4%**	**4.9%**	**$372,000 ($930,000)[#]**	**6.6%**	**5.0%**	**5.5%**	**$397,000 ($993,000)[#]**
Assumption: A bounding analysis was performed by reducing the failure probability of important human actions by 10 percent. The human error probability dependency factors for important human actions were also improved by 10 percent.									
285—Protect important equipment in the turbine building from internal flooding[†]	**$955,000***	**8.8%**	**5.8%**	**5.0%**	**$478,000 ($1,196,000)[#]**	**7.6%**	**6.2%**	**5.3%**	**$439,000 ($1,099,000)[#]**
Assumption: The analysis was performed by adding a factor to the flooding initiators that resulted in reduced spray damage to the turbine building distribution boards and the raw cooling water pumps to simulate addition of spray shields. The spray shield was given a failure probability of 10^{-3}.									
286—Install flood doors to prevent water propagation in the electric board room[†,§]	**$4,695,000***	**10.8%**	**26.0%**	**22.4%**	**$1,611,000 ($4,028,000)[#]**	**9.1%**	**26.9%**	**23.5%**	**$1,454,000 ($3,634,000)[#]**
Assumption: The analysis was performed by removing the failure of important equipment from certain floods to simulate watertight doors.									
288—Install spray protection on component cooling water system pumps and component cooling water system/AFW space coolers[†,§]	**$1,809,000***	**8.9%**	**9.8%**	**11.6%**	**$793,000 ($1,982,000)[#]**	**6.9%**	**9.6%**	**11.4%**	**$669,000 ($1,674,000)[#]**
Assumption: A bounding analysis was performed by eliminating spray initiator events from the component cooling water system pumps and component cooling water system/AFW space coolers fault tree logic.									

Individual SAMA and Assumption	Cost Estimate	Unit 1 Percent Risk Reduction			Unit 1 Internal and External Benefit	Unit 2 Percent Risk Reduction			Unit 2 Internal and External Benefit
		CDF	PDR	OECR		CDF	PDR	OECR	
289—Install backup cooling system for component cooling water system/AFW space coolers†	**$2,219,000***	**21.7%**	**19.1%**	**22.6%**	**$1,629,000 ($4,072,000)#**	**13.7%**	**16.0%**	**19.2%**	**$1,164,000 ($2,909,000)#**
Assumption: The analysis was performed by adding a backup space cooler to the fault tree logic, such that failure of the existing and backup coolers is required for failure of the component cooling water system and AFW space coolers.									

\# Value in parentheses represents the larger benefit calculated in the sensitivity analysis (TVA 2013d, Attachment E, Tables E.2-3 and E.2-4).

* TVA identified that implementation costs could be shared between Units 1 and 2 for this SAMA and considered the combined total averted cost risk from both Units 1 and 2 in the cost-benefit evaluation.

† By assessing the sensitivity analysis and the resulting increases in estimated benefits (shown in parentheses), TVA considered the following additional SAMAs to be potentially cost beneficial for either one or both of the units: SAMA 32 (Unit 2), SAMA 88 (Units 1 and 2), SAMA 160 (Unit 2), SAMA 249 (Units 1 and 2), SAMA 275 (Units 1 and 2), SAMA 285 (Units 1 and 2), SAMA 286 (Units 1 and 2), SAMA 288 (Units 1 and 2), and SAMA 289 (Units 1 and 2).

‡ For the baseline results presented in this table, SAMA 160 was considered potentially cost beneficial for Unit 1 only. However, TVA considered SAMA 160 to be potentially cost beneficial for Unit 2 based on the sensitivity results (shown in parentheses).

§ SAMAs 286 and 288 were considered to be potentially cost beneficial, because implementation costs could be shared between Units 1 and 2 and the sensitivity analysis results for the combined total averted cost risk from both units (shown in parentheses) exceeded the SAMA implementation cost.

‖ Additional analyses performed by TVA for the loss of two busses indicated that averted cost risk could exceed $50,000 (TVA 2013c).

The NRC staff reviewed the applicant's cost estimates, presented in Tables E.2-1 and E.2-2 of Attachment E to the ER (TVA 2013a). For certain improvements, the NRC staff also compared the cost estimates to estimates developed elsewhere for similar improvements, including estimates developed as part of other licensees' analyses of SAMAs for operating reactors. With requested clarifications for a few SAMAs (TVA 2013c), NRC staff concludes that the cost estimates provided by TVA are sufficient and appropriate for use in the SAMA evaluation.

Cost-Benefit Comparison

If the implementation costs for a candidate SAMA exceeded the calculated benefit, the SAMA was determined to be not cost beneficial. If the benefit exceeded the estimated cost, the SAMA candidate was considered to be cost beneficial. Sensitivity analyses performed by the applicant can lead to increases in the calculated benefits. Two sensitivity cases were developed by TVA: one used a discount rate of 3 percent and the other used an alternative value for failure probability to explicitly account for uncertainty and include margin into cost-benefit evaluation. Additional details on the sensitivity analysis are presented in Appendix F, Section F.6.2.

The TVA's baseline cost-benefit analysis identified nine and eight candidate SAMAs as potentially cost beneficial for Units 1 and 2, respectively. From a sensitivity analysis, TVA identified an additional seven and nine candidate SAMAs as potentially cost beneficial for Units 1 and 2, respectively. Results of the cost-benefit evaluation are presented in Table 4–22 for these potentially cost-beneficial SAMAs.

In response to NRC RAI, TVA identified 4 additional SAMA candidates as potentially cost beneficial for both units. These additional cost-beneficial SAMAs arose from the NRC evaluation of the baseline SAMA analysis and questioning on potentially lower cost alternatives. In response to NRC staff RAI on the SAMA analyses, TVA indicated that SAMA 8—to increase training on response to loss of two 120V AC busses—and SAMA 87—to replace service and instrument air compressors with more reliable compressors—will be retained as potentially cost beneficial for both units (TVA 2013c).

In its response to questions on potentially lower cost alternatives, TVA identified two additional SAMA candidates as potentially cost beneficial for (1) human actions to automatically trip the RCP on loss of CCW and (2) manufacturing a gagging device for a steam generator safety valve and developing a procedure or work order for closing a stuck-open valve (TVA 2013c). These two potentially cost-beneficial SAMAs are not listed in Table 4–22.

TVA indicated that the potentially cost-beneficial SAMAs will be considered in the design process.

Conclusions

TVA considered 309 candidate SAMAs based on risk-significant contributors at SQN from updated probabilistic safety assessment models, SAMA-related industry documentation, plant-specific enhancements not in published industry documentations, and its review of SAMA candidates from potential improvements at twelve other plants. Phase I screening reduced the list to 47 unique SAMA candidates by eliminating SAMAs that were not applicable to SQN, had already been implemented at SQN, were combined into a more comprehensive or plant-specific SAMA, had excessive implementation cost, had a very low benefit, or relate to in-progress implementation of plant improvements that address the intent of the SAMA.

For the remaining SAMA candidates, TVA performed a cost-benefit analysis. The baseline cost-benefit analysis identified nine and eight candidate SAMAs as potentially cost-beneficial for Units 1 and 2, respectively. From a sensitivity analysis, TVA identified an additional seven and nine candidate SAMAs as potentially cost beneficial for Units 1 and 2, respectively. In response to NRC staff RAI, TVA identified 4 additional SAMA candidates as potentially cost beneficial for both units. These additional cost-beneficial SAMAs arose from the NRC evaluation of the baseline SAMA analysis and questioning on potentially lower cost alternatives. In response to NRC staff RAI on the SAMA analyses, TVA indicated that SAMA 8—to increase training on response to loss of two 120V AC busses—and SAMA 87—to replace service and instrument air compressors with more reliable compressors—will be retained as potentially cost beneficial for both units. In its response to questions on potentially lower cost alternatives, TVA identified two additional SAMA candidates as potentially cost beneficial for (1) human actions to automatically trip the RCP on loss of CCW and (2) manufacturing a gagging device for a steam generator safety valve and developing a procedure or work order for closing a stuck-open valve.

The NRC staff reviewed TVA's SAMA analysis and concludes that, subject to the discussion in this section and Appendix F, the methods used and implementation of the methods were sound. As mentioned in Section F.3.2, the new improved flood mitigation systems to be installed at SQN Units 1 and 2 would be expected to reduce the risk from all external events and possibly some internal events. These new systems are additional plant improvements to which TVA has committed. On the basis of the applicant's treatment of SAMA benefits and costs, NRC staff finds that the SAMA evaluations performed by TVA are reasonable and sufficient for the license renewal submittal.

The staff concurs with TVA's conclusion that 20 candidate SAMAs are potentially cost beneficial for SQN Unit 1 and 21 candidate SAMAs are potentially cost beneficial for SQN Unit 2, which was based on generally conservative treatment of costs, benefits, and uncertainties. This conclusion of a moderate number of potentially cost-beneficial SAMAs is consistent with a moderately large population within 50 mi (80 km) of SQN and moderate level of residual risk indicated in the SQN PRA.

Additionally, the NRC staff evaluated the identified potentially cost-beneficial SAMAs to determine if they are in the scope of license renewal, i.e., they are subject to aging management. This evaluation considers whether the systems, structures, and components (SSCs) associated with these SAMAs: (1) perform their intended function without moving parts or without a change in configuration or properties and (2) that these SSCs are not subject to replacement based on qualified life or specified time period. The NRC staff determined that these SAMAs do not relate to adequately managing the effects of aging during the period of extended operation. Therefore, they need not be implemented as part of license renewal in accordance with 10 CFR Part 54, "Requirements for renewal of operating licenses for nuclear power plants."

4.11.2 No-Action Alternative

Human health risks would be smaller following plant shutdown. The two reactor units, which are currently operating within regulatory limits, would emit less radioactive gaseous, liquid, and solid material to the environment. In addition, following shutdown, the variety of potential accidents at the plant (radiological or industrial) would be reduced to a limited set associated with shutdown events and fuel handling and storage. In Section 4.11.1.1, the NRC staff concluded that the impacts of continued plant operation on human health would be SMALL, except for "[c]hronic effects of electromagnetic fields (EMFs)," for which the impacts are UNCERTAIN. In Section 4.11.1.2, the NRC staff concluded that the impacts of accidents during operation were SMALL. Therefore, as radioactive emissions to the environment decrease, and as likelihood and variety of accidents decrease following shutdown, the NRC staff concludes that the risk to human health following plant shutdown would be SMALL.

4.11.3 NGCC Alternative – Human Health

4.11.3.1 Construction

Impacts on human health from construction of the natural gas-fired alternative, including the possible construction of a new pipeline, would be similar to effects associated with the construction of any major industrial facility. Compliance with worker protection rules would control those impacts on workers at acceptable levels. Impacts from construction on the general public would be minimal since crews would limit active construction area access to authorized individuals. Based on the above, the NRC staff concludes that the impacts on human health from the construction of the natural gas-fired alternative would be SMALL.

4.11.3.2 Operation

Impacts from the operation of a natural gas-fired facility introduces public risk from inhalation of gaseous emissions. The risk may be attributable to nitrogen oxide emissions that contribute to ozone formation, which in turn contribute to health risk. Regulatory agencies, including the EPA and State agencies, base air emission standards and requirements on human health impacts. These agencies also impose site-specific emission limits as needed to protect human health. Given the regulatory oversight exercised by the EPA and State agencies, the NRC staff concludes that the human health impacts from natural gas-fired power generation would be SMALL.

4.11.4 SCPC Alternative – Human Health

4.11.4.1 Construction

Impacts on workers are expected to be similar to those experienced during construction of any major industrial facility. Impacts from construction of combustion-based energy facilities are expected to be the same as those for construction of fossil-fuel facilities. Construction would increase traffic on local roads, which could affect the health of the general public. Human health impacts would be the same for all facilities whether located on greenfield sites, brownfield sites, or at an existing nuclear plant. Personal protective equipment, training, and engineered barriers would protect the workforce (NRC 2013e). Based on the above, the NRC staff concludes that the impacts on human health from the construction of the supercritical pulverized coal alternative would be SMALL.

4.11.4.2 Operation

Coal-fired power generation introduces worker risks from coal and limestone mining, worker and public risk from coal, lime, and limestone transportation, worker and public risk from disposal of coal-combustion waste, and public risk from inhalation of stack emissions. In addition, human health risks are associated with the management and disposal of coal combustion waste. Coal combustion generates waste in the form of ash, and equipment for controlling air pollution generates additional ash and scrubber sludge. Human health risks may extend beyond the facility workforce to the public depending on their proximity to the coal combustion waste disposal facility. The character and the constituents of coal-combustion waste depend on both the chemical composition of the source coal and the technology used to combust it. Generally, the primary sources of adverse consequences from coal-combustion waste are from exposure to sulfur oxide and nitrogen oxide in air emissions and radioactive elements such as uranium and thorium, as well as the heavy metals and hydrocarbon compounds contained in fly ash and bottom ash, and scrubber sludge (NRC 2013e).

Regulatory agencies, including the EPA and state agencies, base air emission standards and requirements on human health impacts. These agencies also impose site-specific emission limits as needed to protect human health. Given the regulatory oversight exercised by the EPA and State agencies, the NRC staff concludes that the human health impacts from radiological doses and inhaled toxins and particulates generated from coal-fired generation would be SMALL (NRC 2013e).

4.11.5 New Nuclear Alternative – Human Health

4.11.5.1 Construction

Impacts on human health from construction of two new nuclear units would be similar to impacts associated with the construction of any major industrial facility. Compliance with worker protection rules would control those impacts on workers at acceptable levels. Impacts from construction on the general public would be minimal since limiting active construction area access to authorized individuals is expected. Impacts on human health from the construction of two new nuclear units would be SMALL.

4.11.5.2 Operation

The human health effects from the operation of two new nuclear power plants would be similar to those of the existing SQN. As presented in Section 4.11.1.1, impacts on human health from the operation of SQN would be SMALL. Therefore, the impacts on human health from the operation of two new nuclear plants would be SMALL.

4.11.6 Combination Alternative – Human Health

4.11.6.1 Construction

Impacts on human health from construction of a combination wind and solar photovoltaic alternative would be similar to effects associated with the construction of any major industrial facility. Compliance with worker protection rules would control those impacts on workers at acceptable levels. Impacts from construction on the general public would be minimal since crews would limit active construction area access to authorized individuals. Based on the above, the NRC staff concludes that the impacts on human health from the construction of a wind and solar alternative would be SMALL.

4.11.6.2 Operation

Operational hazards at a wind facility for the workforce include working at heights, working near rotating mechanical or electrically energized equipment, and working in extreme weather. Potential impacts to workers and the public include ice thrown from rotor blades and broken blades thrown because of mechanical failure. Potential impacts also include EMF exposure, aviation safety, and exposure to noise and vibration from the rotating blades.

Operational hazards at a solar photovoltaic facility may involve exposure to airborne toxic metals (e.g., cadmium) and silicon if a photovoltaic cell were to lose its integrity from a fire. Workers could also inhale silicon dust if the photovoltaic cells were smashed by an object or from a fall to the ground.

However, given the expected compliance with worker protection rules and remediation efforts to contain the toxic material, the potential impacts to workers at the facility and offsite exposure to the public, the impacts would be SMALL.

4.12 Environmental Justice

This section describes the potential human health and environmental effects of the proposed action (license renewal) and alternatives to the proposed action on minority and low-income populations and special pathway receptors.

4.12.1 Proposed Action

The environmental justice issue applicable to SQN during the license renewal term is listed in Table 4–23. Section 3.12 of this SEIS describes the environmental justice matters with respect to SQN.

Table 4–23. Environmental Justice

Issue	GEIS Section	Category
Minority and low-income populations	4.10.1	2
Source: Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51		

The NRC addresses environmental justice matters for license renewal by (1) identifying the location of minority and low-income populations that may be affected by the continued operation of the nuclear power plant during the license renewal term, (2) determining whether there would be any potential human health or environmental effects to these populations and special pathway receptors, and (3) determining if any of the effects may be disproportionately high and adverse. Adverse health effects are measured in terms of the risk and rate of fatal or nonfatal adverse impacts on human health. Disproportionately high and adverse human health effects occur when the risk or rate of exposure to an environmental hazard for a minority or low-income population is significant and exceeds the risk or exposure rate for the general population or for another appropriate comparison group. Disproportionately high environmental effects refer to impacts or risks of impacts on the natural or physical environment in a minority or low-income community that are significant and appreciably exceed the environmental impact on the larger community. Such effects may include biological, cultural, economic, or social impacts.

Figures 3–9 and 3–10 in this SEIS show the location of predominantly minority and low-income population block groups residing within a 50-mi (80-km) radius of SQN. This area of impact is consistent with the impact analysis for public and occupational health and safety, which also focuses on populations within a 50-mi (80-km) radius of the plant. Chapter 4 presents the assessment of environmental and human health impacts for each resource area. The analyses of impacts for all environmental resource areas indicated that the impact from license renewal would be SMALL.

Potential impacts on minority and low-income populations (including migrant workers or Native Americans) would mostly consist of socioeconomic and radiological effects; however, radiation doses from continued operations during the license renewal term are expected to continue at current levels, and they would remain within regulatory limits. Section 4.11.1.2 of this SEIS discusses the environmental impacts from postulated accidents that might occur during the license renewal term, which include both design basis and severe accidents. In both cases, the Commission has generically determined that impacts associated with DBAs are small because nuclear plants are designed and operated to successfully withstand such accidents, and the probability weighted consequences of severe accidents are small.

Therefore, based on this information and the analysis of human health and environmental impacts presented in Chapter 4 of this SEIS, there would be no disproportionately high and adverse human health and environmental effects on minority and low-income populations from the continued operation of SQN during the license renewal term.

As part of addressing environmental justice concerns associated with license renewal, the NRC also assessed the potential radiological risk to special population groups (such as migrant workers or Native Americans) from exposure to radioactive material received through their unique consumption practices and interaction with the environment, including subsistence consumption of fish, native vegetation, surface waters, sediments, and local produce; absorption of contaminants in sediments through the skin; and inhalation of airborne radioactive material released from the plant during routine operation. This analysis is presented below.

4.12.1.1 Subsistence Consumption of Fish and Wildlife

The special pathway receptors analysis is an important part of the environmental justice analysis because consumption patterns may reflect the traditional or cultural practices of minority and low-income populations in the area, such as migrant workers or Native Americans.

Section 4-4 of Executive Order (E.O.) 12898 (59 FR 7629) directs Federal agencies, whenever practical and appropriate, to collect and analyze information about the consumption patterns of populations that rely principally on fish and/or wildlife for subsistence and to communicate the risks of these consumption patterns to the public. In this SEIS, the NRC considered whether there were any means for minority or low-income populations to be disproportionately affected by examining impacts on American Indian, Hispanics, migrant workers, and other traditional lifestyle special pathway receptors. The assessment of special pathways considered the levels of radiological and nonradiological contaminants in native vegetation, crops, soils and sediments, GW, surface water, fish, and game animals on or near SQN.

The following is a summary discussion of TVA's radiological environmental monitoring programs that assess the potential impacts from the subsistence consumption of fish and wildlife near the SQN site.

TVA has an ongoing comprehensive Radiological Environmental Monitoring Program (REMP) to assess the impact of SQN operations on the environment. To assess the impact of nuclear power plant operations, samples are collected annually from the environment and analyzed for radioactivity. A plant effect would be indicated if the radioactive material detected in a sample was significantly larger than background levels. Two types of samples are collected. The first type, a control sample, is collected from areas that are beyond the measurable influence of the nuclear power plant or any other nuclear facility. These samples are used as reference data to determine normal background levels of radiation in the environment. These samples are then compared with the second type of samples, indicator samples, collected near the nuclear power plant. Indicator samples are collected from areas where any contribution from the nuclear power plant will be at its highest concentration. These samples are then used to evaluate the contribution of nuclear power plant operations to radiation or radioactivity levels in the environment. An effect would be indicated if the radioactivity levels detected in an indicator sample was significantly larger than the control sample or background levels.

Samples of environmental media are collected from the aquatic and terrestrial pathways in the vicinity of SQN. The aquatic pathways include GW, surface water, drinking water, fish, and shoreline sediment. The terrestrial pathways include airborne particulates and food products (i.e., broad leaf vegetation). During 2011, analyses performed on samples of environmental media at SQN showed no significant or measurable radiological impact above background levels from site operations (TVA 2012b).

4.12.1.2 Conclusion

Based on the radiological environmental monitoring data from SQN, the NRC staff concludes that no disproportionately high and adverse human health impacts would be expected in special pathway receptor populations in the region as a result of subsistence consumption of water, local food, fish, and wildlife. Continued operation of SQN would not have disproportionately high and adverse human health and environmental effects on these populations.

4.12.2 No-Action Alternative – Environmental Justice

This section evaluates the potential for disproportionately high and adverse human health and environmental effects on minority and low-income populations that could result from the no action alternative. Impacts on minority and low-income populations would depend on the number of jobs and the amount of tax revenues lost by communities in the immediate vicinity of the power plant after SQN ceases operations. Not renewing the operating licenses and terminating reactor operations would have a noticeable impact on socioeconomic conditions in the communities located near SQN. The loss of jobs and income would have an immediate socioeconomic impact. Some, but not all, of the 1,141 SQN employees would begin to leave after reactor operations are terminated; and overall tax revenue generated by plant operations would be reduced. The reduction in tax revenue would decrease the availability of public services in Hamilton County. This could disproportionately affect minority and low-income populations that may have become dependent on these services. See also Appendix J of NUREG-0586, Supplement 1 (NRC 2002), for additional discussion of these impacts.

4.12.3 NGCC Alternative – Environmental Justice

This section evaluates the potential for disproportionately high and adverse human health, environmental, and socioeconomic effects on minority and low-income populations that could result from the construction and operation of a new NGCC plant. Some of these potential effects have been identified in resource areas discussed in this SEIS. For example, increased demand for rental housing during replacement power plant construction could disproportionately affect low-income populations.

Potential impacts to minority and low-income populations from the construction and operation of a new NGCC plant at an existing power plant site would mostly consist of environmental and socioeconomic effects (e.g., noise, dust, traffic, employment, and housing impacts). Noise and dust impacts from construction would be short-term and primarily limited to onsite activities. Minority and low-income populations residing along site access roads would be affected by increased commuter vehicle traffic during shift changes and truck traffic. However, these effects would be temporary during certain hours of the day and would not likely be high and adverse. Increased demand for rental housing during construction could affect low-income populations in the vicinity of the existing power plant site. However, given that power plant sites are generally located near metropolitan areas, construction workers could commute to the site, thereby reducing the potential demand for rental housing.

Emissions from the operation of an NGCC plant could affect minority and low income populations living in the vicinity of the new power plant. However, permitted air emissions are expected to remain within regulatory standards.

Based on this information and the analysis of human health and environmental impacts presented in this SEIS, the construction and operation of a new NGCC plant would not likely have disproportionately high and adverse human health and environmental effects on minority and low-income populations in the vicinity of the existing power plant site. However, a definitive determination of the potential for disproportionately high and adverse human health and environmental effects on minority and low-income populations would depend on the alternative's location, plant design, and expected operational characteristics. Therefore, the NRC cannot definitively forecast the effects on minority and low-income populations for this alternative.

4.12.4 SCPC Alternative – Environmental Justice

This section evaluates the potential for disproportionately high and adverse human health and environmental effects on minority and low-income populations that could result from the construction and operation of a new SCPC power plant. Some of these potential effects have been identified in resource areas discussed in this SEIS. For example, increased demand for rental housing during replacement power plant construction could disproportionately affect low-income populations.

Potential impacts to minority and low-income populations from the construction and operation of a new SCPC plant at the existing power plant site would consist of environmental and socioeconomic effects (e.g., noise, dust, traffic, employment, and housing impacts). Noise and dust impacts from construction would be short-term and primarily limited to onsite activities. Minority and low-income populations residing along site access roads would be affected by increased commuter vehicle traffic during shift changes and truck traffic. However, these effects would be temporary during certain hours of the day and would not likely be high and adverse. Increased demand for rental housing during construction could affect low-income populations. However, given the proximity of some existing power plant sites to metropolitan areas, many construction workers could commute to the site, thereby reducing the potential demand for rental housing.

Emissions from the operation of a SCPC plant could affect minority and low income populations living in the vicinity of the new power plant. However, permitted air emissions are expected to remain within regulatory standards.

Based on this information and the analysis of human health and environmental impacts presented in this SEIS, the construction and operation of a new SCPC plant would not likely have disproportionately high and adverse human health and environmental effects on minority and low-income populations. However, a definitive determination of the potential for disproportionately high and adverse human health and environmental effects on minority and low-income populations would depend on the alternative's location, plant design, and expected operational characteristics. Therefore, the NRC cannot definitively forecast the effects on minority and low-income populations for this alternative.

4.12.5 New Nuclear Alternative – Environmental Justice

This section evaluates the potential for disproportionately high and adverse human health and environmental effects on minority and low-income populations that could result from the construction and operation of a new nuclear power plant. Some of these potential effects have been identified in resource areas discussed in this SEIS. For example, increased demand for rental housing during replacement power plant construction could disproportionately affect low-income populations.

Potential impacts to minority and low-income populations from the construction and operation of a new nuclear power plant would mostly consist of environmental and socioeconomic effects (e.g., noise, dust, traffic, employment, and housing impacts). Noise and dust impacts from construction would be short-term and primarily limited to onsite activities. Minority and low-income populations residing along site access roads would be affected by increased commuter vehicle traffic during shift changes and truck traffic. However, these effects would be temporary during certain hours of the day and would not likely be high and adverse. Increased demand for rental housing during construction could affect low-income populations. However, given the proximity of some existing nuclear power plant sites to metropolitan areas, many construction workers could commute to the site, thereby reducing the potential demand for rental housing.

Potential impacts to minority and low income populations from new nuclear power plant operations would mostly consist of radiological effects; however, radiation doses are expected to be well below regulatory limits andpermitted air emissions are expected to remain within regulatory standards.

Based on this information and the analysis of human health and environmental impacts presented in this SEIS, the construction and operation of a new nuclear power plant would not likely have disproportionately high and adverse human health and environmental effects on minority and low-income populations. However, a definitive determination of the potential for disproportionately high and adverse human health and environmental effects on minority and low-income populations would depend on the alternative's location, plant design, and expected operational characteristics. Therefore, the NRC cannot definitively forecast the effects on minority and low-income populations for this alternative.

4.12.6 Combination Alternative – Environmental Justice

This section evaluates the potential for disproportionately high and adverse human health and environmental effects on minority and low-income populations that could result from the construction and operation of a combination of wind and solar photovoltaic electrical power generating activities. Some of these potential effects have been identified in resource areas discussed in this SEIS. For example, increased demand for rental housing during construction could disproportionately affect low-income populations.

Potential impacts to minority and low-income populations from the construction and operation of new wind turbines and solar photovoltaic installations would mostly consist of environmental and socioeconomic effects (e.g., noise, dust, traffic, employment, and housing impacts). Noise and dust impacts from construction would be short-term and primarily limited to onsite activities. Minority and low-income populations residing along site access roads would be affected by increased commuter vehicle traffic during shift changes and truck traffic. However, these effects would be temporary during certain hours of the day and would not likely be high and adverse. Increased demand for rental housing during construction could affect low-income populations. However, given the small number of construction workers and the possibility that many workers could commute to these construction sites, the potential need for rental housing would not be significant.

Minority and low income populations living in close proximity to wind farm and solar photovoltaic power generating installations could be disproportionately affected by maintenance and operations activities. However,operational impacts from the wind turbines and solar photovoltaic installations would mostly be limited to noise and aesthetic effects.

Based on this information and the analysis of human health and environmental impacts presented in this SEIS, the construction and operation of new wind farm and solar photovoltaic installations would not likely have disproportionately high and adverse human health and environmental effects on minority and low-income populations. However, a definitive determination of the potential for disproportionately high and adverse human health and environmental effects on minority and low-income populations would depend on the alternative's location, plant design, and expected operational characteristics. Therefore, the NRC cannot definitively forecast the effects on minority and low-income populations for this alternative.

4.13 Waste Management

This section describes the potential impacts of the proposed action (license renewal) and alternatives to the proposed action on waste management and pollution prevention.

4.13.1 Proposed Action

The waste management issues applicable to SQN during the license renewal term are listed in Table 4–24. Section 3.13 of this SEIS describes SQN waste management.

Table 4–24. Waste Management

Issues	GEIS Section	Category
Low-level waste storage and disposal	4.11.1.1	1
Onsite storage of spent nuclear fuel	4.11.1.2	[a] 1
Offsite radiological impacts of spent nuclear fuel and high-level waste disposal	4.11.1.3	[b] N/A
Mixed-waste storage and disposal	4.11.1.4	1
Nonradioactive waste storage	4.11.1.4	1

[a] The impacts of this issue only apply for the license renewal term.

[b] N/A (not applicable)—The categorization and impact finding definition do not apply to this issue.

Source: Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51

The NRC staff's evaluation of the environmental impacts associated with spent nuclear fuel is addressed in two issues in Table 4–24, "Offsite radiological impacts (spent fuel and high-level waste disposal)" and "Onsite spent fuel." The issue, "Offsite radiological impacts (spent fuel and high-level waste disposal)," is not evaluated in this SEIS. In addition, the issue, "Onsite spent fuel" only evaluates the environmental impacts during the licensed life for operation of the reactor, i.e. the license renewal term. As discussed below, the Waste Confidence Continued Storage of Spent Nuclear Fuel Rule and supporting generic EIS are expected to provide the necessary NEPA analyses of the environmental impacts at an onsite or offsite spent nuclear fuel storage facility.

For the term of license renewal, the staff did not find any new and significant information related to "Onsite spent fuel" and the remaining waste management issues listed in Table 4–24 during its review of the TVA's ER (TVA 2013g), the site visit, and the scoping process. Therefore, there are no impacts related to these issues beyond those discussed in the GEIS. For these Category 1 issues, the GEIS concludes that the impacts are SMALL.

Historically, the NRC's Waste Confidence Decision and Rule represented the Commission's generic determination that spent fuel can continue to be stored safely and without significant environmental impacts for a period of time after the end of a reactor's licensed life for operation. This generic determination meant that the NRC did not need to consider the storage of spent fuel after the end of a reactor's licensed life for operation in NEPA documents that supported its reactor and spent fuel storage application reviews. The NRC first adopted the Waste Confidence Decision and Rule in 1984. The NRC amended the Decision and Rule in 1990, reviewed it in 1999, and amended it again in 2010 (49 FR 34658 and 34694; 55 FR 38474;

64 FR 68005; and 75 FR 81032 and 81037). The Waste Confidence Decision provided a regulatory basis and NEPA analysis to support the Waste Confidence Rule (10 CFR 51.23).

On December 23, 2010, the Commission published in the *Federal Register* a revision of the Waste Confidence Rule, supported again by a Waste Confidence Decision, to reflect information gained from experience in the storage of spent fuel and the increased uncertainty in the siting and construction of a permanent geologic repository for the disposal of spent nuclear fuel and high-level waste (75 FR 81032 and 81037). In response to the 2010 Waste Confidence Rule, the States of New York, New Jersey, Connecticut, and Vermont—along with several other parties—challenged the Commission's NEPA analysis in the decision, which provided the regulatory basis for the rule. On June 8, 2012, the United States Court of Appeals, District of Columbia Circuit in *New York* v. *NRC*, 681 F. 3d 471 (D.C. Cir., 2012) vacated the NRC's Waste Confidence Rule, after finding that it did not comply with NEPA.

In response to the court's ruling, the Commission, in CLI-12-16 (NRC 2012a), determined that it would not make final decisions for licensing actions that depend upon the Waste Confidence Rule until the court's remand is appropriately addressed. The Commission also noted that all licensing reviews and proceedings should continue to move forward. In addition, the Commission directed in SRM-COMSECY-12-0016 (NRC 2012b) that the NRC staff proceed with a rulemaking that includes the development of a generic EIS.

The generic EIS, which provides a regulatory basis for the revised rule, would provide NEPA analyses of the environmental impacts of spent fuel storage at a reactor site or at an away-from-reactor storage facility after the end of a reactor's licensed life for operation ("continued storage"). As directed by the Commission, the NRC will not make final decisions regarding renewed license applications until the court's remand is appropriately addressed. This will ensure that there would be no irretrievable or irreversible resource commitments or potential harm to the environment before the impacts of continued storage have been appropriately considered.

On September 13, 2013, the NRC published a proposed revision of 10 CFR Part 51.23 (i.e., the Waste Confidence Rule), which, if adopted as a final rule, would generically address the environmental impacts of continued storage (78 FR 56776). The NRC also prepared a draft generic EIS to support this proposed rule (NRC 2013c) (78 FR 56621). The final rule is scheduled to be published by October 2014. Upon issuance of the final rule and generic EIS for waste confidence, the NRC staff will consider whether additional NEPA analysis of continued storage is warranted before taking any action on the SQN license renewal application.

4.13.2 No-Action Alternative – Waste Management

If the no-action alternative were implemented, SQN would cease operation at the end of its initial operating licenses, or sooner, and enter decommissioning. The generation of spent nuclear fuel high-level waste would stop and generation of low-level, mixed waste and nonradioactive waste would decrease. The impacts of decommissioning are discussed in Section 4.15.2. Impacts from implementation of the no-action alternative are expected to be SMALL.

4.13.3 NGCC Alternative – Waste Management

4.13.3.1 Construction

Construction-related debris would be generated during plant construction activities, and would be recycled or disposed of in approved landfills.

4.13.3.2 Operation

Waste generation from natural gas-fired technology would be minimal. The only significant waste generated at a natural gas-fired power plant would be spent selective catalytic reduction (SCR) catalyst, which is used to control nitrous oxide emissions.

The spent catalyst would be regenerated or disposed of offsite. Other than spent SCR catalyst, waste generation at an operating natural gas-fired plant would be limited to nonhazardous waste and trash resulting from operations and maintenance activities. Overall, the NRC staff concludes that waste impacts from natural gas-fired power generation would be SMALL.

4.13.4 SCPC Alternative – Waste Management

4.13.4.1 Construction

Construction-related debris would be generated during plant construction activities, and would be recycled or disposed of in approved landfills.

4.13.4.2 Operation

Coal combustion generates waste in the form of fly ash and bottom ash. In addition, equipment for controlling air pollution generates additional ash, spent SCR catalyst, and scrubber sludge. The management and disposal of the large amounts of coal combustion waste is a significant part of the operation of a coal-fired power generating facility.

Although a coal-fired power generating facility is likely to use offsite disposal of coal combustion waste, some short-term storage of coal combustion waste (either in open piles or in surface impoundments) is likely to take place on site, thus establishing the potential for leaching of toxic chemicals into the local environment.

Based on the large volume, as well as the toxicity of waste generated by coal combustion, the NRC staff concludes that the impacts from waste generated at a coal-fired plant would be MODERATE.

4.13.5 New Nuclear Alternative – Waste Management

4.13.5.1 Construction

Construction-related debris would be generated during construction activities, and would be recycled or disposed of in approved landfills.

4.13.5.2 Operation

During normal plant operations, routine plant maintenance, and cleaning activities would generate radioactive low-level waste, spent nuclear fuel, and high-level waste as well as nonradioactive waste. Sections 3.1.4 and 3.1.5 discuss radioactive and nonradioactive waste management at SQN. Quantities of radioactive and nonradioactive waste generated by SQN would be comparable to that generated by the two new nuclear plants.

According to the GEIS (NRC 1996, 2013c), the generation and management of solid radioactive and nonradioactive waste during the license renewal term are not expected to result in significant environmental impacts. Based on this information, the waste impacts would be SMALL for the new nuclear alternative.

4.13.6 Combination Alternative – Waste Management

4.13.6.1 Construction

Construction-related debris would be generated during construction activities, and would be recycled or disposed of in approved landfills.

4.13.6.2 Operation

Waste generation from a combination wind and solar photovoltaic alternative would be minimal, consisting of debris from routine maintenance and the disposal of worn or broken parts. Based on this information, the NRC staff concludes that waste impacts from the construction and operation of a combination wind and solar photovoltaic alternative would be SMALL.

4.14 Evaluation of New and Potentially Significant Information

New and significant information must be both new and bear on the proposed action or its impacts, presenting a seriously different picture of the impacts from those envisioned in the GEIS (i.e., impacts of greater severity than impacts considered in the GEIS, considering their intensity and context).

In accordance with 10 CFR 51.53(c), the ER that the applicant submits must provide an analysis of the Category 2 issues in Table B–1 of 10 CFR Part 51, Subpart A, Appendix B. Additionally, it must discuss actions to mitigate any adverse impacts associated with the proposed action and environmental impacts of alternatives to the proposed action. In accordance with 10 CFR 51.53(c)(3), the ER does not need to contain an analysis of any Category 1 issue unless there is new and significant information on a specific issue.

The NRC process for identifying new and significant information is described in NUREG–1555, Supplement 1, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants, Supplement 1: Operating License Renewal* (NRC 1999a, 2013i). The search for new information includes:

- review of an applicant's ER and the process for discovering and evaluating the significance of new information,
- review of public comments,
- review of environmental quality standards and regulations,
- coordination with Federal, state, and local environmental protection and resource agencies, and
- review of technical literature.

New information that the staff discovers is evaluated for significance using the criteria set forth in the GEIS. For Category 1 issues in which new and significant information is identified, reconsideration of the conclusions for those issues is limited in scope to assessment of the relevant new and significant information; the scope of the assessment does not include other facets of an issue that the new information does not affect.

The NRC staff reviewed the discussion of environmental impacts associated with operation during the renewal term in the GEIS and has conducted its own independent review, including a public involvement process (e.g., public meetings) to identify new and significant issues for the SQN license renewal application environmental review. The NRC staff has not identified new and significant information on environmental issues related to operation of SQN during the renewal term. The NRC staff also determined that information provided during the public comment period did not identify any new issue that requires site-specific assessment.

4.15 Impacts Common to All Alternatives

This section describes the impacts that are considered common to all alternatives discussed in this SEIS, including the proposed action and replacement power alternatives. The continued operation of a nuclear power plant and replacement fossil fuel power plants both involve mining, processing, and the consumption of fuel, which results in comparative impacts (NRC 2013e). The termination of operations and the decommissioning of both a nuclear power plant and replacement fossil fueled power plants are also discussed in the following sections, as well as GHG emissions.

4.15.1 Fuel Cycles

This section describes the environmental impacts associated with the fuel cycles of the proposed action and replacement power alternatives. Most replacement power alternatives employ a set of steps in the utilization of their fuel sources, which can include extraction, transformation, transportation, and combustion. Emissions generally occur at each stage of the fuel cycle (NRC 2013e).

4.15.1.1 Uranium Fuel Cycle

The uranium fuel cycle issues applicable to SQN are discussed below and listed in Table 4–25.

Table 4–25. Issues Related to the Uranium Fuel Cycle

Issues	GEIS Section	Category
Offsite radiological impacts—individual impacts from other than the disposal of spent fuel and high-level waste	4.12.1.1	1
Offsite radiological impacts—collective impacts from other than the disposal of spent fuel and high-level waste	4.12.1.1	1
Nonradiological impacts of the uranium fuel cycle	4.12.1.1	1
Transportation	4.12.1.1	1

Source: Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51

The uranium fuel cycle includes uranium mining and milling, the production of uranium hexafluoride, isotopic enrichment, fuel fabrication, reprocessing of irradiated fuel, transportation of radioactive materials, and management of low-level wastes and high-level wastes related to uranium fuel cycle activities. The generic potential impacts of the radiological and nonradiological environmental impacts of the uranium fuel cycle and transportation of nuclear fuel and wastes are described in detail in NUREG–1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (NRC 1996, 1999b, 2013c).

The NRC staff did not identify any new and significant information related to the uranium fuel cycle issues listed in Table 4–25 during its review of the applicant's ER (TVA 2013g), the site visit, and the scoping process. Therefore, there are no impacts related to these issues beyond those discussed in the GEIS. For these Category 1 issues, the GEIS concludes that the impacts are SMALL, except for the issue, "Offsite radiological impacts (collective effects)," to which the NRC has not assigned an impact level. This issue assesses the 100-year radiation dose to the U.S. population (i.e., collective effects or collective dose) from radioactive effluents released as part of the uranium fuel cycle for nuclear power plant during the license renewal term compared to the radiation dose from natural background exposure. There are no regulatory limits applicable to collective doses to the public from fuel-cycle facilities. The Commission has determined that the practice of estimating health effects on the basis of collective doses may not be meaningful. Fuel-cycle facilities are designed and operated to meet regulatory limits and standards. Therefore, the Commission has concluded that the collective impacts are acceptable and would not be sufficiently large to require the NEPA conclusion that the option of extended operation should be eliminated (78 FR 37282).

4.15.1.2 Replacement Power Plant Fuel Cycles

<u>Fossil Fuel Energy Alternatives</u>

Fuel cycle impacts for a fossil-fuel-fired plant result from the initial extraction of fuel, cleaning and processing of fuel, transport of fuel to the facility, and management and ultimate disposal of solid wastes from fuel combustion. These impacts are discussed in more detail in section 4.12.1.2 of the GEIS (NRC 2013e) and can generally include:

- significant changes to land use and visual resources;
- impacts to air quality, including release of criteria pollutants, fugitive dust, VOCs, and coalbed methane in the atmosphere;
- noise impacts;
- geology and soil impacts due to land disturbances and mining;
- water resource impacts, including degradation of surface water and GW quality;
- ecological impacts, including loss of habitat and wildlife disturbances;
- historic and cultural resources impacts within the mine footprint;
- socioeconomic impacts from employment of both the mining workforce and service and support industries;
- environmental justice impacts;
- health impacts to workers from exposure to airborne dust and methane gases; and
- generation of coal and industrial wastes.

<u>New Nuclear Energy Alternatives</u>

Fuel cycle impacts for a nuclear plant result from the initial extraction of fuel, transport of fuel to the facility, and management and ultimate disposal of spent fuel. The environmental impacts of the uranium fuel cycle are discussed above in Section 4.15.1.1.

<u>Renewable Energy Alternatives</u>

The “fuel cycle” for renewable energy facilities is difficult to define for technologies such as wind and solar because these natural resources exist regardless of any effort to harvest them for electricity production. Impacts from the presence or absence of these renewable energy technologies are oftendifficult to determine (NRC 2013e).

4.15.2 Terminating Power Plant Operations and Decommissioning

This section describes the environmental impacts associated with the termination of operations and the decommissioning of a nuclear power plant and replacement power alternatives. All operating power plants will terminate operations and be decommissioned at some point after the end of their operating life or after a decision is made to cease operations. For the proposed action, license renewal would delay this eventuality for an additional 20 years beyond the current license periods, which ends in 2020 and 2021 for SQN Units 1 and 2, respectively.

4.15.2.1 Existing Nuclear Power Plant

Environmental impacts from the activities associated with the decommissioning of any reactor before or at the end of an initial or renewed license are evaluated in Supplement 1 of NUREG–0586, *Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities Regarding the Decommissioning of Nuclear Power Reactors* (NRC 2002a). Additionally, the incremental environmental impacts associated with decommissioning activities resulting from continued plant operation during the renewal term are discussed in the GEIS.

Table 4–26 lists the Category 1 issues in Table B–1 of 10 CFR Part 51, Subpart A, Appendix B that are applicable to SQN decommissioning following the license renewal term.

Table 4–26. Issues Related to Decommissioning

Issues	GEIS Section	Category
Radiation doses	4.12.2.1	1
Waste management	4.12.2.1	1
Air quality	4.12.2.1	1
Water quality	4.12.2.1	1
Ecological resources	4.12.2.1	1
Socioeconomic impacts	4.12.2.1	1

Decommissioning would occur whether SQN were shut down at the end of its current operating license or at the end of the period of the license renewal term. TVA stated in its ER (TVA 2013a) that it is not aware of any new and significant information on the environmental impacts of SQN during the license renewal term. The staff has not found any new and significant information during its independent review of TVA's ER, the site visit, or the scoping process. Therefore, the NRC staff concludes that there are no impacts related to these issues, beyond those discussed in the GEIS. For all of these issues, the NRC staff concluded in the GEIS that the impacts are SMALL.

4.15.2.2 Replacement Power Plants

<u>Fossil Fuel Energy Alternatives</u>

The environmental impacts from the termination of power plant operations and decommissioning of a fossil-fuel-fired plant are dependent on the facility's decommissioning plan. General elements and requirements for a fossil fuel plant decommissioning plan are discussed in section 4.12.2 of the GEIS and can include the removal of structures to at least 3 ft (1 m) below grade; removal of all coal, combustion waste, and accumulated sludge; removal of intake and discharge structures; and the cleanup and remediation of incidental spills and leaks at the facility. The decommissioning plan outlines the actions necessary to restore the site to a condition equivalent in character and value to the greenfield or brownfield site on which the facility was first constructed (NRC 2013e).

The environmental consequences of decommissioning are discussed in section 4.12.2 of the GEIS and can generally include:

- short-term impacts on air quality and noise from the deconstruction of facility structures,
- short-term impacts on land use and visual resources,
- long-term reestablishment of vegetation and wildlife communities,
- socioeconomic impacts due to the decommissioning workforce and the long-term loss of jobs, and
- elimination of health and safety impacts on operating personnel and the general public.

New Nuclear Alternative

Termination of operations and decommissioning impacts for a nuclear plant include all activities related to the safe removal of the facility from service and the reduction of residual radioactivity to a level that permits release of the property under restricted conditions or unrestricted use and termination of a license (NRC 2013e). The environmental impacts of the uranium fuel cycle are discussed above in Section 4.15.1.

Renewable Alternative

Termination of power plant operation and decommissioning for renewable energy facilities would be similar to the impacts discussed for fossil-fuel-fired plants above. Decommissioning would involve the removal of facility components and operational wastes and residues in order to restore the site to a condition equivalent in character and value to the greenfield or brownfield site on which the facility was first constructed (NRC 2013e).

4.15.3 Greenhouse Gas Emissions and Climate Change

The following sections discuss GHG emissions released from operation of SQN and the environmental impacts that could occur from changes in climate conditions. The cumulative impacts of GHG emissions on climate are discussed in Section 4.16.12, Global Climate Change.

4.15.3.1 Greenhouse Gas Emissions From the Proposed Project and Alternatives

Gases found in the Earth's atmosphere that trap heat and play a role in Earth's climate are collectively termed GHGs. GHG include, but are not limited to, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), water vapor (H_2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC), and sulfur hexafluoride (SF_6). Earth's climate responds to changes in concentration of GHG in the atmosphere as GHGs affect the amount of energy absorbed and heat trapped by the atmosphere. Increasing GHG concentration in the atmosphere generally increases Earth's surface temperature. Atmospheric concentrations of CO_2, CH_4, and N_2O have significantly increased since 1750 (IPCC 2007c). CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6 (termed long-lived GHGs) are well mixed throughout Earth's atmosphere and their impact on climate is long lasting as a result of their long atmospheric lifetime (EPA 2009b). CO_2 is of primary concern for global climate change because of its long atmospheric lifetime and it is the primary gas emitted as a result of human activities (USGCRP 2009). Climate change research indicates that the cause of the Earth's warming over the last 50 years is due to the buildup of GHGs in atmosphere resulting from human activities (USGCRP 2014).

Proposed Action

Operations at SQN emit GHG directly and indirectly. In accordance with E.O. 13514 (Federal Leadership in Environmental, Energy, and Economic Performance), the Tennessee Valley Authority (TVA), a Federal agency and owner of SQN, is required to measure and report GHG emissions resulting from SQN's direct and indirect activities.[5] SQN's direct GHG emissions result from stationary combustion sources (auxiliary boilers and diesel generators), mobile combustion sources (fleet vehicles), and fugitive fluorinated gases (electrical and refrigerant equipment). Indirect GHG emissions originate from mobile combustion sources (workforce commuting and official travel), off-site municipal solid waste disposal, contracted wastewater treatment, purchased electricity, and transmission and distribution losses of the consumed purchased electricity.

Annual GHG emissions are presented in Table 4–27 for 2008-2012. These quantified GHG emission estimates include the direct and indirect sources discussed above that emit long-lived GHGs, presented as CO_2 equivalents (CO_2e).[6] The GHG emission estimates presented do not include potential emissions as result of leakage, servicing, repair, and disposal of refrigerant equipment at SQN (CEQ 2012). Ozone depleting substances, such as chlorofluorocarbons and hydrochlorofluorocarbons (HCFC), are present at SQN and can potentially be emitted (TVA 2013i). However, estimating GHG emissions from these substances is complicated due their ability to deplete ozone, which is also a GHG, making their global warming potentials (GWPs) difficult to quantify. These ozone depleting substances are regulated by the CAA under Title VI. TVA maintains a program to manage stationary refrigeration appliances at SQN to recycle, recapture, and reduce emissions of ozone depleting substances and is in compliance with Section 608 of the CAA (TVA 2013a).

In response to the NRC's order (Order Number: EA-12-049) titled "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," TVA will install one large blackout diesel generator and up to three EDGs at each unit in 2016 to mitigate and cope with an extended station blackout event (TVA 2013i). The diesel generators are expected to be operated only in the event of loss of AC power to the site and during periodic routine testing. Periodic testing of the diesel generators is estimated to emit 200 MT CO_2e/year (TVA 2013i, 2013d).

The additional GHG emissions from routine testing of the diesel generators will be minor. As there are no plans for refurbishment at SQN for license renewal, GHG emissions are not expected beyond those direct and indirect sources discussed above. Table 4–27 provides emissions indicative of those expected during the extended period of operation.

[5] GHG direct and indirect emission categories are defined in the 2012 Federal Greenhouse Gas Accounting and Reporting Guidance Technical Support Document. The direct and indirect emission classification was retained for SQN's GHG emissions inventory and GHG emission discussions in this EIS. http://www.whitehouse.gov/sites/default/files/microsites/ceq/revised_federal_greenhouse_gas_accounting_and_reporting_guidance_060412.pdf.

[6] Carbon dioxide equivalents (CO_2e) is a metric used to compare the emissions of GHG based on their global warming potential (GWP). GWP is a measure used to compare how much heat a GHG traps in the atmosphere. GWP is the total energy that a gas absorbs over a period of time, compared to carbon dioxide. Carbon dioxide equivalents is obtained by multiplying the amount of the GHG by the associated GWP. For example, the GWP of CH_4 is estimated to be 21; therefore, 1 ton of CH_4 emission is equivalent to 21 tons of CO_2 emissions.

Table 4–27. Estimated GHG emissions[(a)] from Operations at SQN

Year	CO_2e[(b)] (MT/year)
2008	23,250
2009	24,640
2010	24,250
2011	28,720
2012	25,000

(a) GHG emission estimates presented include indirect and direct GHG emissions. Direct GHG emission from stationary combustion sources at SQN reported to the U.S. Environmental Protection Agency were added to the GHG inventory provided by TVA 2013d.

(b) Values rounded to the nearest tens.

Source: TVA 2013i, 2013t

No-Action Alternative

When the plant stops operating, there will be a reduction in GHG emissions from activities related to plant operation, such as use of diesel generators and employee vehicles. GHG emissions are anticipated to be less than that presented in Table 4–27.

NGCC Alternative

As discussed in the Section 2.3, the NRC staff evaluated an NGCC alternative that consists of six 400 MW units. The 2013 GEIS (NRC 2013e) presents lifecycle[7] GHG emissions associated with natural gas power generation. As presented in Table 4.12-5 of the GEIS, lifecycle GHG emissions from natural gas can range from 120 to 930 g carbon equivalent per kilowatt-hour (C_{eq}/kWh). The EPA has developed standard emission factors that relate the quantity of released pollutants to a variety of regulated activities (EPA 2000). Using these emission factors, the NRC staff estimates that operation of six 400-MW NGCC units will directly emit 9.7 MMT of CO_2e per year.

SCPC Alternative

As discussed in Section 2.4 of this SEIS, the NRC staff evaluated an SCPC alternative that consists of two to four SCPC units with a total output of 2,400 MW. The 2013 revised GEIS presents lifecycle GHG emissions associated with coal power generation. As presented in Table 4.12-4 of the GEIS, lifecycle GHG emissions from coal power generation can range from 264 to 1689 grams of carbon equivalent per kilowatt-hour (g C_{eq}/kWh). The NRC staff estimates that operation of two to four SCPC units will directly emit 17.5 MMT of CO_2e per year.

New Nuclear Alternative

As discussed in Section 2.5, the NRC staff evaluated the new nuclear plant alternative that would consist of two units with approximate generating capacity of 1,200 MW each. The 2013 revised GEIS presents lifecycle GHG emissions associated with nuclear power generation. As presented in Table 4.12-4 through 4.12-6 of the GEIS, lifecycle GHG emissions from nuclear

[7] Lifecycle carbon emissions analyses consider construction, operation, decommissioning and associated processing of fuel (gas, coal, etc.).

power generation can range from 1 to 288 g C_{eq}/kWh. GHG emissions from operation of the new nuclear power plant alternative would be similar to the GHG emissions from operation of SQN presented in Table 4–27.

Combination Alternative

As discussed in Section 2.6, the NRC staff evaluated a combination alternative that relies on wind and solar capacity to replace SQN. The total installed solar photo voltaic (PV) capacity would be 2,000 to 2,900 MW and total installed wind capacity would be 4,700 to 6,300 MW. The 2013 revised GEIS presents lifecycle GHG emissions associated with renewable power generation. As presented in Table 4.12-6 of the GEIS, lifecycle GHG emissions from wind power range from 2 to 81 g C_{eq}/kWh and solar PV from 5 to 217 g C_{eq}/kWh. Beyond maintenance of the wind turbines and solar PV (e.g. serving equipment or repairs), there would be no direct emissions associated with operations from wind generation or from solar PV.

Summary of GHG emissions from the proposed action and alternatives

Table 4–28 presents the direct GHG emissions from operation of the proposed action (license renewal) and alternatives. As quantified in the table, nuclear power plants emit a substantially lower amount of GHG emissions than electrical generation based on fossil fuels. The NGCC and SCPC direct GHG emissions estimates do not consider carbon capture technologies that could capture and remove CO_2. In 2012, the EPA issued a final GHG Tailoring Rule to address GHG emissions from stationary sources under the CAA permitting requirements; the GHG Tailoring Rule establishes when an emission source will be subject to permitting requirements and control technology to reduce GHG emissions. The National Energy Technology Laboratory (NETL) estimates that carbon capture technologies can remove as much as 90 percent of CO_2 (NETL 2010a); if carbon capture technologies were to be installed for the NGCC and SCPC alternatives, GHG emissions would still be substantially greater than the proposed action, the new nuclear alternative, and the combination alternative.

Table 4–28. Direct[(a)] GHG Emissions from Operation of the Proposed Action and Alternatives

Technology	CO_2e (MT/year)
SQN continued operation[(b)]	700
NGCC	9,743,500
SCPC	17,538,400
New Nuclear	700
Combination Alternative	0

(a) GHG emissions presented include only direct emissions from operation of the electricity generating technology. For the NGCC and SCPC alternatives, GHG emission result from direct combustion of the gas and coal. For the proposed action and new nuclear alternative; direct GHG emissions are a result of combustion sources such as diesel generators, auxiliary boilers, etc.

(b) Direct emissions from continued operation include emissions from stationary sources (diesel generators and auxiliary boilers). Data provided reflect the highest direct GHG emissions from the most recent 5 years of SQN operation (Table 3.3.2-1, TVA 2013i, 2013d).

Source: TVA 2013i, 2013d

4.15.3.2 Climate Change Impacts to Resource Areas

Climate change is the decades or longer change in climate measurements (temperature, precipitation, etc.) that has been observed on a global, national, and regional level (EPA 2012; IPCC 2007c; USGCRP 2014). Climate change can vary regionally, locally, and seasonally depending on local, regional, and global factors. Just as the regional climate differs throughout the world, the impacts of climate change can vary between locations.

On a global level, from 1901 to 2011, average surface temperatures have risen at a rate of 0.14 ˚F per decade (0.08 °C per decade), and total annual precipitation has increased at an average rate of 2.3 percent per decade (EPA 2012). The observed global change in average surface temperature and precipitation has been accompanied by an increase in sea surface temperatures, a decrease in global glacier ice, increase in sea level, and changes in extreme weather events. Such extreme events include an increase in frequency of heat waves, heavy precipitation, and minimum and maximum temperatures (EPA 2012; IPCC 2007c; USGCRP 2009).

In the United States, the U.S Global Change Research Program (USGCRP) reports that from 1895 to 2012, average surface temperature has increased by 1.3 °F to 1.9 °F (0.72 to 1.06 °C) and since 1900, average annual precipitation has increased by 5 percent (USGCRP 2014). On a seasonal basis, warming has been the greatest in winter and spring. Since the 1980s, an increase in the length of the freeze-free season, the period between the last occurrence of 32 ˚F (0 °C) in the spring and first occurrence of 32 ˚F (0 °C) in the fall, has been observed for the contiguous United States; between 1991 and 2011 the average freeze-free season was 10 days longer than between 1901 and 1960 (USGCRP 2014). Since the 1970s, the United States has warmed at a faster rate as the average surface temperature rose at an average rate of 0.31 to 0.45 ˚F (0.17 to 0.25 °C) per decade. In addition, the year 2012 was the warmest on record (USGCRP 2014). Observed climate related changes in the United States include increases in the frequency and intensity of heavy precipitation, earlier onset of spring snowmelt and runoff, rise of sea level in coastal areas, increase in occurrence of heat waves, and a decrease in occurrence of cold waves (EPA 2012; NOAA 2013; USGCRP 2009, 2014).

Temperature data indicates that the Southeast region, where SQN is located, did not experience significant warming overall for the time period from 1900 to 2012 (USGCRP 2014). The lack of warming in the Southeast has been termed the "warming hole" (NOAA 2013). However, since 1970, average annual temperatures in the Southeast have risen by 2 ˚F (1.1 °C) and accompanied by an increase in the number of days with daytime maximum temperatures above 90 °F (32.2 °C) and nights above 75 °F (23.9 °C) (IPCC 2007c; NOAA 2013; USGCRP 2009, 2014). This atmospheric warming trend is also evident for the SQN site and vicinity. Based on data from the SQN meteorological station spanning the period of 1972 through 2012, linear regression analysis indicates that the average daily minimum temperature has increased about 3.4°F (1.9°C), whereas the average daily maximum temperature has increased about 2.5°F (1.4°C) (TVA 2013i). Average annual precipitation data for the Southeast does not exhibit an increasing or decreasing trend for the long term period (1895-2011) or a trend in the length of the freeze-free season (NOAA 2013). Nevertheless, since the mid-1970s, the number of freezing days has declined by four to seven days in the region (USGCRP 2009). On the other hand, average precipitation in the region has increased in the fall and decreased in the summer (NOAA 2013 and USGCRP 2009). The number of tornadoes in the Southeast region has increased since the 1950s; however, the observed increasing tornado trend is not statistically significant and may be a result of better reporting of tornadoes (USGCRP 2014).

GHG emission concentration and climate models are commonly used to project possible climate change. Climate models indicate that over the next few decades, temperature increases will continue due to current GHG emissions concentrations in the atmosphere (USGCRP 2014) Over the longer term, the magnitude of temperature increases and climate change effects will depend on both past and future GHG emission scenarios (IPCC 2007c; USGCRP 2009, 2014). Climate models project a continued increase in global surface temperatures, more frequent and long-lasting heat waves, continued increase in sea level, continued decline in arctic sea ice, an increase in heavy precipitation events, and an increased frequency of severe droughts.

For the license renewal period of SQN, climate model simulations (between 2021-2050 relative to the reference period (1971-1999)) indicate an increase in annual mean temperature in the Southeast region from 1.5-3.5 ˚F (0.83-1.9 °C) (NOAA 2013). The predicted increase in temperature during this time period occurs for all seasons with the largest increase occurring in the summertime (June, July, and August). Climate model simulations (for the time period 2021-2050) suggest spatial differences in annual mean precipitation changes with some areas experiencing an increase and others a decrease in precipitation (for Tennessee, a 0 to 3 percent increase in annual mean precipitation is predicted); however, these changes in precipitation were not significant and the models indicate changes that are less than normal year to year variations (NOAA 2013). While future regional changes in precipitation are difficult to predict, the USGCRP reports that storm tracks are expected to shift northward, increases in heavy precipitation events will continue, the number of dry days between rainfalls will increase, and an increase in drought are expected (USGCRP 2014). Higher temperatures increase evaporation that contributes to dry conditions and a warmer climate allows more moisture to be held in the atmosphere because of warmer air's ability to hold more water vapor (USGCRP 2009).

Changes in climate have broader implications for public health, water resources, land use and development, and ecosystems. For instance, changes in precipitation patterns and increase in air temperature can affect water availability and quality, distribution of plant and animal species, and land-use patterns and land-cover, which can in turn affect terrestrial and aquatic habitats. The sections below discuss how future climate change may impact air quality, water resources, land-use, terrestrial resources, aquatic resources, and human health in the region of interest for SQN. Although there is uncertainty in the exact future climate change scenario, the discussions provided below demonstrate the potential implications of climate change on resources.

Air Quality

Air pollutant concentrations result from complex interactions between physical and dynamic properties of the atmosphere, land, and ocean. The formation, transport, dispersion, and deposition of air pollutants depend in part on weather conditions (IPCC 2007a). Air pollutant concentrations are sensitive to winds, temperature, humidity, and precipitation (EPA 2009b). Hence, climate change can impact air quality as a result of the changes in meteorological conditions.

Ozone has been found to be particularly sensitive to climate change (EPA 2009a; IPCC 2007a; USGCRP 2014). Ozone is formed as a result of the chemical reaction of nitrogen oxides (NO_x) and volatile organic compounds (VOCs) in the presence of heat and sunlight. Sunshine, high temperatures, and air stagnation are favorable meteorological conditions to higher levels of ozone (EPA 2009, IPCC 2007a). The emission of ozone precursors also depends on temperature, wind, and solar radiation (IPCC 2007a); both NO_x and biogenic VOC emissions are expected to be higher in a warmer climate (EPA 2009a). Warmer climate and weaker air circulation is conducive to higher ozone levels. Although surface temperatures are expected to increase in the Southeast region, ozone levels will not necessarily increase since ozone formation is also dependent on the relative amount of precursors available (NASA 2004). Regional air quality modeling indicates that the Southern regions of the U.S. can experience an increase in ozone concentration by the year 2050 (Tagaris, 2009). However, air quality projections (particularly ozone and $PM_{2.5}$) are uncertain and indicate that concentrations are driven primarily by emissions rather than by physical climate change (IPCC 2013).

Land Use

Changes or fluctuations in river and lake water levels could result in land use changes along affected water bodies as well as the possible loss of man-made infrastructure. This could necessitate infrastructure redesign and replacement, or its relocation. The Southeast region has experienced an expanding population and regional land-use changes faster than any other region in the U.S., which has resulted in reduced land available for agriculture and forests (USGCRP 2014). As noted by the U.S. Global Change Research Program (USGCRP 2009), the projected rapid rate and large amount of climate change over the next century will challenge the ability of society and natural systems to adapt. For example, it is difficult and expensive to alter or replace infrastructure designed to last for decades (such as buildings, bridges, roads, and reservoirs) in response to continuous and/or abrupt climate change. Energy and transportation infrastructure and other property could also be adversely affected. Projections in land-use changes, between 2010 and 2050, indicate that the Southeast region will experience a continued increase in exurban and suburban development and a decrease in forests and cropland land cover (USGCRP 2014). However, the limited extent of climate change that may occur during the 20-year license renewal term would not likely cause land use conditions to change in the vicinity of SQN.

Water Resources

Predicted changes in the timing, intensity, and distribution of precipitation would be likely to result in changes in surface water runoff affecting water availability across the Southeast. Specifically, while average precipitation during the fall has increased by 30 percent since about 1900, summer and winter precipitation has declined by about 10 percent across the eastern portion of the region including eastern Tennessee (USGCRP 2009). A continuation of this trend coupled with predicted higher temperatures during all seasons (particularly the summer months), would reduce GW recharge during the winter, produce less runoff and lower stream flows during the spring, and potentially lower GW base flow to rivers during the drier portions of the year (when stream flows are already lower). As cited by the USGCRP, the loss of moisture from soils because of higher temperatures along with evapotranspiration from vegetation is likely to increase the frequency, duration, and intensity of droughts across the region into the future (USGCRP 2009, USGCRP 2014). Changes in runoff in a watershed along with reduced stream flows and higher air temperatures all contribute to an increase in the ambient temperature of receiving waters. Annual runoff and river-flow are projected to decline in the Southeast region (USGCRP 2014). Land use changes, particularly those involving the conversion of natural areas to impervious surface, exacerbate these effects. These factors combine to affect the availability of water throughout a watershed, such as that of the Tennessee River, for aquatic life, recreation, and industrial uses. Additionally, Tennessee is a karst rich state and the aquifers are a significant source of domestic water to residents; changes in precipitation patterns and drought conditions can impact this GW resource (TWRA 2009). While changes in projected precipitation for the Southeast region are uncertain, the USGCRP has reasonable expectation that there will be reduced water availability due to the increased evaporative losses from rising temperatures alone (USGCRP 2014). For the 2010 to 2060 period, net water supply availability in the Southeast region is projected to decrease; specifically water availability in eastern Tennessee is expected to decrease by 2.5 to 5 percent (USGCRP 2014).

Terrestrial Resources

As described above, an increase in annual mean temperature combined with less rainfall will increase the frequency, duration, and intensity of drought in the Southeast. As the climate changes, terrestrial resources will either be able to tolerate the new physical conditions, such as less water availability, or shift their population range to new areas with a more suitable climate, or decline and perhaps be extirpated from the area. Some species may be more susceptible to changes in climate. For example, migratory birds that travel long distances may not be able to pick up on environmental clues that a warmer, earlier spring is occurring in the United States while the birds are still overwintering in the tropics. Fraser et al. (2013) found that songbirds overwintering in the Amazon did not leave their winter sites earlier, even when spring sites in the eastern United States experienced a warmer spring. As a result, the song birds missed periods of “peak food” availability. Special status species and habitats, such as those that are Federally protected by the ESA, would likely be more sensitive to climate changes because these species’ populations are already experiencing threats that are endangering their continued existence throughout all or a significant portion of their ranges. Because of this, these species populations are already experiencing reduced genetic variability that could prohibit them from adapting to and surviving amidst habitat and climate changes. Climate changes could also favor non-native invasive species and promote population increases of insect pests and plant pathogens, which may be more tolerant to a wider range of climate conditions or have range limits that are set by extreme cold temperatures or ice cover (Bradley et al. 2010; Hellman et al. 2008). Physiological stressors associated with climate change may also exacerbate the effects of other existing stressors in the natural environment, such as those caused by habitat fragmentation, nitrogen deposition and runoff from agriculture, and air emissions.

Aquatic Resources

The potential effects of climate change described above for water resources, whether from natural cycles or man-made activities, could result in changes that would affect aquatic resources in the Tennessee River. Raised air temperatures could result in higher water temperatures in the Tennessee River reservoirs. For instance, TVA found that a 1 °F (0.5 °C) increase in air temperature resulted in an average water temperature increase between 0.25 °F and 0.5 °F (0.14 °C and 0.28 °C) in the Chickamauga Reservoir (TVA 2013i). Higher water temperatures would increase the potential for thermal effects on aquatic biota and, along with altered river flows, could exacerbate existing environmental stressors, such as excess nutrients and lowered dissolved oxygen associated with eutrophication (NCADAC 2013). Even slight changes could alter the structure of the aquatic communities in the reservoir. As discussed above under “terrestrial resources,” special status species, such as those that are Federally protected under the ESA, would be more sensitive to climate changes. Invasions of non-native species that thrive under a wide range of environmental conditions could further disrupt the current structure and function of aquatic communities (NRC 2013).

Historic and Cultural Resources

Changes or fluctuations in river and lake water levels because of climate change could result in the disturbance or loss of historic and cultural resources from flooding, erosion, inundation, or drying out. Because of water-level changes, some resources could be lost before they could be documented or otherwise studied. However, the limited extent of climate change that may occur during the 20-year license renewal term would not likely result in any significant loss of historic and cultural resources at SQN.

Socioeconomics

Rapid changes in climate conditions could have an impact on the availability of jobs in certain industries. For example, tourism and recreation are major job creators in some regions, bringing significant revenue to regional economies. Across the nation, fishing, hunting, and other outdoor activities make important economic contributions to rural economies and are also a part of the cultural tradition. A changing climate would mean reduced opportunities for some activities in some locations and expanded opportunities for others. Hunting and fishing opportunities could also change as animals' habitats shift and as relationships among species are disrupted by their different responses to climate change (USGCRP 2014). Water-dependent recreation could also be affected (USGCRP 2009). The USGCRP reports that climate change in the Southeast region by the year 2050 could create unfavorable conditions for summertime outdoor recreation and tourism activity (USGCRP 2014). However, the limited extent of climate change that may occur during the 20-year license renewal term would not likely cause any significant changes in socioeconomic conditions in the vicinity of SQN.

Human Health

Increasing temperatures because of changes in climate conditions could have an impact on human health. The limited extent of changes in climate conditions that may occur during the license renewal term would not likely result in any change to the impacts discussed in Section 4.11 from SQN's radioactive and non-radioactive effluents. Increased water temperatures may increase the potential for adverse effects of thermophilic organisms that can be a threat to human health.

Environmental Justice

Rapid changes in climate conditions could disproportionately affect minority and low-income populations. The USGCRP (2009) indicates that "infants and children, pregnant women, the elderly, people with chronic medical conditions, outdoor workers, and people living in poverty are especially at risk from a variety of climate-related health effects." Examples of these effects include increased heat stress, air pollution, extreme weather events, and diseases carried by food, water, and insects. The greatest health burdens related to climate change are likely to fall on the poor, especially those lacking adequate shelter and access to other resources such as air conditioning. Elderly poor people on fixed incomes are more likely to have debilitating chronic diseases or limited mobility. In addition, the elderly have a reduced ability to regulate their own body temperature or sense when they are too hot. According to the USGCRP (2009), they "are at greater risk of heart failure, which is further exacerbated when cardiac demand increases in order to cool the body during a heat wave." The USGCRP study also found that people taking medications, such as diuretics for high blood pressure, have a higher risk of dehydration (USGCRP 2009). The USGCRP (2014) study reconfirmed the previous report findings regarding the risks of climate change on low-income populations, and also warns that climate change could affect the availability and access to local plant and animal species thus impacting the people that have historically depended on them for food or medicine (USGCRP 2014). However, due to the limited amount of expected changes in the environment during the 20-year license renewal term, minority and low-income populations at SQN are not likely to experience disproportionately high and adverse impacts from climate change.

4.16 Cumulative Impacts of the Proposed Action

As described in Section 1.4 of this SEIS, the NRC has approved a revision to its environmental protection regulation, 10 CFR Part 51, "Environmental protection regulations for domestic licensing and related regulatory functions." This revision amends Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51 by adding a new Category 2 issue, “Cumulative impacts,” to evaluate the potential cumulative impacts of license renewal.

The NRC staff considered potential cumulative impacts in the environmental analysis of continued operation of the SQN during the 20-year license renewal period. Cumulative impacts may result when the environmental effects associated with the proposed action are overlaid or added to temporary or permanent effects associated with other past, present, and reasonably foreseeable actions. Cumulative impacts can result from individually minor, but collectively 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.

For the purposes of this cumulative analysis, past actions are those before the receipt of the license renewal application. Present actions are those related to the resources at the time of current operation of the power plant, and future actions are those that are reasonably foreseeable through the end of plant operation, including the period of extended operation. Therefore, the analysis considers potential impacts through the end of the current license terms, as well as the 20-year renewal license terms. The geographic area over which past, present, and reasonably foreseeable actions would occur depends on the type of action considered and is described below for each resource area.

To evaluate cumulative impacts, the incremental impacts of the proposed action, as described in Sections 4.1 to 4.13, are combined with other past, present, and reasonably foreseeable future actions regardless of which agency (Federal or non-Federal) or person undertakes such actions. The NRC staff used the information provided in the TVA’s ER; responses to requests for additional information; information from other Federal, State, and local agencies; scoping comments; and information gathered during the visits to the SQN site to identify other past, present, and reasonably foreseeable actions. To be considered in the cumulative analysis, the NRC staff determined if the project would occur within the noted geographic areas of interest and within the period of extended operation, was reasonably foreseeable, and if there would be potential overlapping effect with the proposed project. For past actions, consideration within the cumulative impacts assessment is resource- and project-specific. In general, the effects of past actions are included in the description of the affected environment in Chapter 3, which serves as the baseline for the cumulative impacts analysis. However, past actions that continue to have an overlapping effect on a resource potentially affected by the proposed action are considered in the cumulative analysis.

Other actions and projects identified during this review and considered in the NRC staff’s analysis of the potential cumulative effects are described in Appendix E. Not all actions or projects listed in Appendix E are considered in each resource area because of the uniqueness of the resource and its geographic area of consideration.

4.16.1 Air Quality and Noise

This section addresses the direct and indirect effects of license renewal on air quality and noise when added to the aggregate effects of other past, present, and reasonably foreseeable future actions. As described in Section 4.3, the incremental impacts on air quality and noise levels from the proposed license renewal would be SMALL. The geographic area considered in the cumulative air quality analysis is the county of the proposed action, as air quality designations for criteria air pollutants are generally made at the county level. Counties are further grouped together based on a common airshed—known as an air quality control region (AQCR)—to provide for the attainment and maintenance of the National Ambient Air Quality Standards (NAAQS). The SQN site is located in Hamilton County, Tennessee, which is part of the Chattanooga Interstate AQCR (40 CFR 81.42, "Chattanooga Interstate Air Quality Control Region"); this AQCR also includes several counties in Georgia.

4.16.1.1 Air Quality

Section 3.3.2 presents a summary of the air quality designation status for Hamilton County. As noted in Section 3.3.2, the EPA regulates six criteria pollutants under the NAAQS, including carbon monoxide, lead, nitrogen dioxide, ozone, sulfur dioxide, and particulate matter (PM). Hamilton County is designated as unclassified or in attainment with respect to carbon monoxide, lead, sulfur dioxide, ozone, and PM, ≤ 10 micrometers (μm) (PM_{10}) (40 CFR 81.343). Hamilton County is a non-attainment area with respect to the 1997 annual PM, ≤ 2.5 μm ($PM_{2.5}$) standard (40 CFR Part 81.343, "Tennessee").

Criteria pollutant air emissions from the SQN site are presented in Section 3.3.2. These emissions are from permitted sources, including two cooling towers, a carpenter shop, as well as emissions from blasting operations, insulator saws, auxiliary boilers, and several emergency or blackout diesel generators (TVA 2013a). Section 4.3.1.1 noted that, except for limited emissions associated with new diesel generators being installed in response to lessons learned from the Fukushima incident, there would be no additional air emissions associated with the SQN license renewal because there is no planned site refurbishment. Therefore, cumulative changes to air quality in Hamilton County would be the result of changes to present-day emissions, as well as future projects and actions within the county.

Appendix E provides a list of present and reasonably foreseeable projects that could contribute to cumulative impacts to air quality. For example, the listed coal-fired energy projects and manufacturing facilities are presently operational and are sources of criteria air pollutants. Continued air emissions from existing projects and actions listed in Appendix E as well as proposed new source activities would contribute to air emissions in Hamilton County. Development and construction activities associated with regional growth of housing, business, and industry, as well as associated vehicular traffic, will also result in additional air emissions. Project timing and location, which are difficult to predict, affect cumulative impacts to air quality. However, permitting and licensing requirements, efficiencies in equipment, cleaner fuels, and various mitigation measures can be used to minimize cumulative air quality impacts.

Climate change can affect air quality as a result of changes in meteorological conditions. Air pollutant concentrations are sensitive to winds, temperature, humidity, and precipitation (EPA 2009b). As discussed in Section 4.14.3.2, ozone levels have been found to be particularly sensitive to climate change influences (EPA 2009a, IPCC 2007b). Sunshine, high temperatures, and air stagnation are favorable meteorological conditions leading to higher levels of ozone (EPA 2009a, IPCC 2007b). Although surface temperatures are expected to increase in the Southeast region, ozone levels will not necessarily increase since ozone formation is also dependent on the relative amount of precursors available (NASA 2004). The combination of higher temperatures, stagnant air masses, sunlight, and emissions of precursors may make it difficult to meet ozone NAAQS (USGCRP 2009). States, however, must continue to comply with the CAA and ensure air quality standards are met.

4.16.1.2 Noise

Section 3.3.3 presents a summary of noise sources at SQN and site vicinity. Noise emission sources from SQN include fans, turbine generators, transformers, cooling towers, compressors, emergency generators, main steam-safety relief valves, and emergency sirens. With the exception of emergency sirens, most of the noise sources are not audible at the site boundary or are intermittent and considered a minor nuisance. As a major industrial facility, SQN noise emissions can reach 65–75 A-weighted decibels (dBA) levels on site, which attenuates with distance. Within the last 5 years, SQN has not received any noise-related complaints from operation (TVA 2013i). Additionally, future residents of the recreational vehicle (RV) park near the SQN site boundary, as identified in Appendix E, are not anticipated to be affected since most noise sources from SQN are not audible at the SQN site boundary. Occupants of the RV park will be the nearest residents to SQN. Beyond any local ordinances, there are no Federal regulations for public exposures to noise. As there are no planned refurbishment activities associated with license renewal, cumulative impacts to noise levels would be the result of continued operation sources from SQN and around the site, as well as future projects and actions in the vicinity of SQN.

Appendix E provides a list of present and reasonably foreseeable projects that could contribute to cumulative noise impacts. Development and construction activities associated with regional growth of housing, business, and industry, as well as associated vehicular traffic, will result in additional noise generation. Construction equipment, for instance, can result in noise levels in the range of 85–95 dBA; however, noise levels attenuate rapidly with distance such that at half a mile distance from construction equipment noise levels can drop to 51–61 dBA (NRC 2002). Therefore, contributions to noise levels from future actions are limited by projects in the vicinity of the SQN site. While the timing of these future activities is difficult to predict, noise emissions are expected to occur for short periods of time. Additionally, future residents of the RV park near the SQN property boundary are not anticipated to be affected since noise sources from SQN are not audible at the SQN site boundary.

Conclusion

Given that there is no planned site refurbishment associated with the SQN license renewal and, therefore, no expected changes in air emissions or noise levels beyond those noted for the operation of new diesel generators, cumulative air quality and noise impacts would be the result of changes to present-day and reasonably foreseeable projects and actions. As noted above, the timing and location of new projects, which are difficult to predict, affect cumulative impacts on air quality and noise levels. However, various strategies and techniques are available to limit air quality impacts. Also, noise abatement and controls can be incorporated to reduce noise impacts (HUD 2013, FHWA 2013). Therefore, the NRC staff concludes that the cumulative impacts from past, present, and reasonably foreseeable future actions on air quality and noise levels during the license renewal term would be SMALL.

4.16.2 Geology and Soils

This section addresses the direct and indirect effects of license renewal on geology and soils when added to the aggregate effects of other past, present, and reasonably foreseeable future actions. As noted in Section 4.4.1, the TVA has no plans to conduct refurbishment or replacement actions. Ongoing operation and maintenance activities at the SQN site are expected to be confined to previously disturbed areas. Any geologic materials, such as aggregates used to support operation and maintenance activities, would be procured from local and regional sources. These materials are abundant in the region. Geologic conditions are not expected to change during the license renewal term. Thus, activities associated with continued operations are not expected to affect the geologic environment. Considering ongoing activities and reasonably foreseeable actions, the NRC staff concludes that the cumulative impacts on geology and soils during the SQN license renewal term would be SMALL.

4.16.3 Water Resources

This section addresses the direct and indirect effects of license renewal on water resources when added to the aggregate effects of other past, present, and reasonably foreseeable future actions. As described in Sections 4.5.1.1 and 4.5.1.2, the incremental impacts on water resources from continued operations of SQN, during the license renewal term would be SMALL. The NRC staff also conducted an assessment of other projects and actions for consideration in determining their cumulative impacts on water resources (see Appendix E). The geographic area considered for the surface water resources component of the cumulative impacts analysis spans the Tennessee River Basin (watershed) but focuses on the catchment area (i.e., the Chickamauga Reservoir Catchment Area) for the reach of the Tennessee River from Watts Bar Dam to Chickamauga Dam and the potential for impacts to downstream users. As such, this review focused on those projects and activities that would withdraw water from or discharge effluent to the Tennessee River or its tributaries (e.g., the Hiwassee River). For GW, the geographic area of interest comprises the local GW basin relative to the SQN site and Chickamauga Reservoir in which GW flows to discharge points, or is withdrawn through wells including residential and public water supply wells (e.g., Hixson Utility District). As such, this review focused on those projects and activities that would (1) withdraw water from or discharge waste water to the local GW basin relative to the SQN site and Chickamauga Reservoir or (2) use GW from the Hixson Utility District.

4.16.3.1 Surface Water Resources

Water resource managers must balance multiple conflicting water management objectives. Within the Tennessee River Basin, this includes demands for power generation, public water supply, industrial use, irrigation, recreation, flood protection, and instream flow requirements to sustain aquatic life (TVA 2011b). Specifically, Section 26a of the TVA Act requires that TVA approval be obtained before any construction activities can be carried out that affect navigation, flood control, or public lands along the shoreline of TVA-managed reservoirs or in the Tennessee River or its tributaries. TVA requires permits for intake structures and withdrawals from the Tennessee River, which enables system-wide tracking of water usage. As the operator of Chickamauga Reservoir and upstream and downstream dams, TVA controls the reservoir to maintain adequate water resources and manage water use conflicts and competing objectives under variable interannual and intraannual flow conditions (TVA 2013a, 2013q). These competing issues and their associated regulatory considerations are discussed in Section 3.5 of this SEIS.

The U.S. Geological Survey (USGS) and TVA have extensively studied water use in the Tennessee Valley (Hutson et al. 2004, TVA 2012g). The study, *Water Use in the Tennessee Valley for 2010 and Projected Use in 2035* (TVA 2012g), considers present and reasonably foreseeable uses of water in the Tennessee River Basin. Projections are based on increasing resource demands for a growing population; changes in economics, manufacturing, technology, environmental regulations; and reservoir operations. Climate change was not included in this study but climate change implications have been considered by NRC staff as discussed later in this section.

Specifically, the largest use of surface water in the Tennessee River Basin is for thermoelectric power generation. According to TVA (2012g), tabulated surface water withdrawals for thermoelectric, industrial, public-supply, and irrigation water use in the basin’s Chickamauga Reservoir Catchment Area in 2010 were 1,591.37, 66.24, 31.33, and 0.53 mgd, respectively. Corresponding return flows, which includes pumped GW, were 1,724.21, 64.19, 16.34, and 0.0 mgd, respectively. Return flows include effluent discharges from such sources as power plants, other industrial facilities, and municipal wastewater treatment plants.

Thermoelectric power generation accounts for more than 90 percent of all withdrawals from the Chickamauga Reservoir Catchment Area. In 2010, cumulative surface water withdrawals from the Tennessee River Basin above Chickamauga Dam totaled 4,899 mgd. This volume is about 15 percent of the mean annual flow (i.e., 21,000 mgd) through Chickamauga Dam. Corresponding consumptive use was 252 mgd, which is 5 percent of total withdrawn and approximately 1 percent of the mean annual flow through the dam. During the same period, the combined consumptive water use in the Watts Bar and Chickamauga Reservoir catchment areas, encompassing Watts Bar Nuclear Power Plant (WBN) Unit 1 and SQN, was estimated to total 22.93 mgd, which was 9 percent of all upstream consumptive uses (TVA 2012g).

By 2035, it is projected that water use will decrease by 21 percent overall from 2010 levels in the Tennessee River Basin. This is mostly attributable to declines in water demand for power generation based on the expected shut-down of coal-fired power plants with high withdrawal rates for once-through cooling systems. However, net (consumptive) water use is projected to increase by 51 percent due in part to future power plants switching to closed-cycle cooling systems (TVA 2012g). Although once-through systems return most of their withdrawn water to the source (minus evaporative losses of less than 3 percent), surface water withdrawals for closed-cycle cooling systems entail consumptive losses of greater than 50 percent, resulting in the return of less water (see Section 4.5.1.1). These impacts may be greater during times of drought, especially when temperatures are high. As there are no other power generation facilities in the Chickamauga Reservoir Catchment Area of the river basin, NRC staff would expect no decline in water use over the license renewal period for SQN. In fact, Watts Bar Unit 2 (WBN 2) is scheduled for completion in December 2015. Once full operations are achieved, water use for WBN Units 1 and 2 is projected to be 284 mgd, of which 40 mgd will be consumptive use (NRC 2013c). Combined with SQN's annualized surface water consumptive use of 6 mgd (see Section 4.5.1.1), the total combined consumptive use in the Watts Bar and Chickamauga Reservoir Catchment Area could be as much as 46 mgd. Nevertheless, these combined, consumptive losses would still be a very small fraction of the mean annual flow of the Tennessee River as measured near the WBN site, which is equivalent to 17,800 mgd (NRC 2013c).

In contrast to water demand for thermoelectric power generation, demands for other uses are projected to increase throughout the whole of the river basin by 2035 because of population growth. Demands for public supply, other industrial, and irrigation water use are projected to increase by 215, 354, and 12 mgd, respectively. Total consumptive water use in the Tennessee River watershed is expected to increase by 241 mgd to 712 mgd by 2035. This consumptive use is approximately 8 percent of the total forecasted withdrawals within the watershed, and approximately 1.7 percent of the current mean annual discharge of the Tennessee River (i.e., 65,600 cfs (1,853 m^3/s), or 42,400 mgd) (NRC 2013c; TVA 2012g).

<u>Water Quality Considerations</u>

The concentration of chemical constituents in water samples collected in Chickamauga Reservoir adjacent to the SQN site are indicative of the cumulative impact of all upstream activities including industrial, agricultural, and municipal discharges. As presented in Section 3.5.1.3, the water quality of the reservoir is generally good. Nevertheless, the Hiwassee River embayment of Chickamauga Reservoir is identified by the Tennessee Department of Environment and Conservation (TDEC) as having an impaired use for fish consumption because of mercury, primarily attributable to atmospheric deposition and industrial sources. Upstream of SQN, Watts Bar Reservoir is listed as impaired for fish consumption because of polychlorinated biphenyls (PCBs) from industrial sources. Portions of the reservoir are also identified as impaired for fish consumption because of mercury and chlordane in contaminated sediments. The Emory River Arm of Watts Bar Reservoir is identified as impaired because of arsenic, coal ash deposits, and aluminum, as well as mercury, PCBs, and chlordane (TDEC 2010, 2012). The Emory River Arm is the area of the reservoir most affected by the ash spill that occurred at TVA's Kingston Fossil Plant in 2008.

As noted previously, further development in the basin and associated population growth is expected. Upstream development could lead to discharges to Chickamauga Reservoir that affect water quality. Development projects can result in water quality impacts if they increase sediment loading to nearby surface water bodies. The magnitude of cumulative impacts would depend on the nature and location of the actions relative to surface water bodies, the number of actions (facilities or projects), and whether facilities comply with regulating agency requirements (e.g., permitted discharge limits). However, the potential for unchecked development, particularly industrial development, would be limited during SQN's license renewal term by TVA's authority to regulate land use and development along the shoreline of the Tennessee River system (TVA 2013p). Moreover, new and modified industrial and large commercial facilities would be subject to regulation under the FWPCA. This would include TDEC-administered National Pollutant Discharge Elimination System (NPDES) permit limits on stormwater and point source discharges designed to be protective of surface water resources. Likewise, it is this regulatory framework that presently governs wastewater effluent and thermal discharges from SQN, WBN, and other major industrial facilities in the Tennessee River Basin.

Climate Change Considerations With Respect to Water Resources

The NRC staff considered the U.S. Global Change Research Program's (USGCRP's) most recent compilation of the state of knowledge relative to global climate change effects (USGCRP 2009, 2014). For the Southeastern United States, the area of moderate to severe spring and summer drought increased by 12 percent and 14 percent, respectively, from 1975 to 2008. Average temperatures have increased by 1.6 °F (0.9 °C) while annual precipitation has declined by about 8 percent. As part of its analysis, the NRC staff specifically considered the potential for climate change-related impacts on water resources and its implications specific to the Tennessee River Basin over the course of the SQN license renewal term. The operation of the dams and reservoirs by TVA on the river and its tributaries provide many benefits, but has resulted in increased water temperature and thermal stratification of some reservoirs during summer months. Water temperature in the Tennessee River above and below the SQN site fluctuates throughout the year in response to many factors. Air temperature and solar radiation are the dominant meteorological variables influencing river system water temperatures. For example, during July 1993, maximum air temperatures recorded in Chattanooga were above 90 °F (32 °C) each day, with temperatures reaching as high as 104 °F (40 °C). During this period, all nine mainstem Tennessee River reservoirs had surface water temperatures that exceeded 86 °F (30 °C), and some had water temperatures as high as 90 °F (32 °C) (NRC 2013c). Relative to the Tennessee River system, historical records encompassing the Watts Bar–Chickamauga Reservoir Catchment Areas show a trend of increasing temperature over the last 40 years. Observations from TVA's Sequoyah Meteorological Station for the years 1972 through 2012 indicate an atmospheric warming trend. In general, the average daily minimum temperature has warmed slightly faster than the average daily mean and the average daily maximum. Since 1972 , linear regressions suggest that the average daily minimum temperature has increased about 3.4°F (1.9°C), whereas the average daily maximum has increased about 2.5°F (1.4°C) (TVA 2013i).

TVA has further analyzed the relationship between historical air temperature and river flow at Chattanooga, which is centrally located in the Tennessee River Basin. The analysis required the estimation of "natural" flow (i.e., the flow rate that would have occurred without dams and flow regulation, based on observed rainfall and runoff). The natural flow at the location of Chickamauga Dam on the Tennessee River provides a measure of the magnitude of drought in the eastern part of the Tennessee River Basin. To obtain a measure of conditions when the river temperature is most likely to be extreme, TVA analyzed measured air temperature and natural flow for the warmest months of the year (i.e., June, July, and August from 1948 to 2012). Figure 4–1 shows the plot of the deviation in mean air temperature at the Chattanooga airport and the deviation in mean natural flow at Chickamauga Dam. While there is considerable scatter in the points, there is a general inverse relationship between the percent deviation from mean air temperature and the percent deviation from mean natural river flow (i.e., the highest air temperatures are associated with the lowest flow rates). Five of the most recent six data points (2007, 2008, 2010, 2011, and 2012) are in the quadrant of higher temperature and lower flow (TVA 2013i).

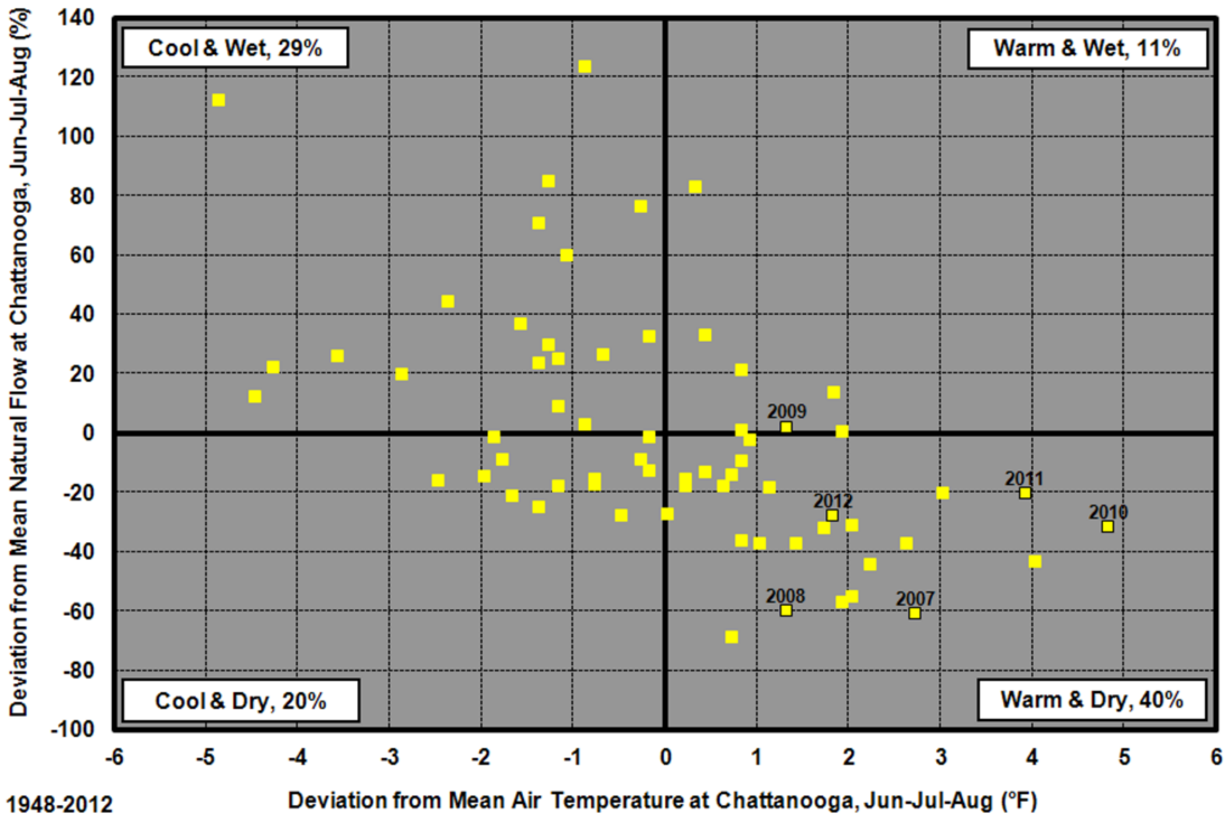
As part of the cumulative impacts analysis, the NRC staff evaluated the potential for rising river water temperatures. River water temperature is a complex function of many contributions including SQN operations, Tennessee River operating policy, land use, regulated withdrawals and effluent discharges, seasonality, regional meteorology, and the global climate system. Potential cumulative impacts with respect to elevated Tennessee River temperatures and the incremental addition of SQN thermal discharges was assessed using historical data and TVA climate change scenario modeling.

TVA performed a modeling study to simulate the potential effect of climate change on the performance of SQN encompassing the proposed period of extended operations (2012 to 2041). The principal model input data were: (1) 20 years of historical (1992-2011) river discharge, stage, temperature, and meteorology data; 2) an estimate of the potential future increase in air temperature and humidity in the Tennessee Valley due to climate change based on research by the Electric Power Research Institute (EPRI); and (3) a relationship between air temperature and water temperature during the warmest months of the year. The latter element reflects the results of a recent TVA study of extreme meteorology in the TVA reservoir system that found for a waterbody such as Chickamauga Reservoir, each 1°F (0.55°C) increase in air temperature generally increased the average water temperature in the reservoir by an amount between 0.25°F and 0.5°F (0.13 to 0.25°C). TVA's model incorporates the thermal discharge (mixing zone) compliance model developed for managing SQN operations. It also incorporates an algorithm to make plant operational decisions to include cooling tower operation and generation load reductions necessary to comply with thermal discharge and ambient river temperature limits specified in SQN's NPDES permit (TVA 2013i).

TVA's modeling results indicate that by 2041, SQN helper cooling tower use may increase in certain years by about 70 percent compared to recent operational experience. The results identified the potential for plant derates (power reductions) and shutdown events to occur in 4 of the 30 modeled years, although the duration of the simulated events was very small compared to the extent of the license renewal period. TVA noted that the model does not account for TVA's ability to forecast and respond to extreme hydrothermal conditions in managing SQN operations. Therefore, TVA believes that the modeling results suggest that SQN's cooling capacity will be adequate during the license renewal period (TVA 2013i).

Ultimately, elevated intake river water temperature can decrease the efficiency of the generators, increase helper cooling tower operations, and increase receiving water temperatures. If these occur during drought-induced low flow periods, decreases in SQN withdrawals (such as through plant derates) may be necessary to maintain Chickamauga Reservoir temperatures in accordance with SQN's NPDES permit.

Figure 4–1. Analysis of Hydrothermal Conditions for the Tennessee Valley Reflecting Observed Air Temperature and Estimated Natural River Flow at Chattanooga, Tennessee



Source: TVA 2013i

Consumptive water use from continued SQN operations will continue to be a very small percentage of the overall flow of the Tennessee River through Chickamauga Reservoir. Criteria imposed by TDEC, through SQN's NPDES permit, will continue to limit SQN's water withdrawals and thermal discharges. Potential cumulative impacts to surface water resources include prolonged drought and temperature increases. The magnitude of such future impacts within the Tennessee River System associated with climate change remains speculative. However, long-term warming could potentially affect navigation, power production, and municipal and industrial users, although the magnitude of the impact is uncertain. Therefore, the NRC staff concludes that the cumulative impacts from past, present, and reasonably foreseeable future actions on surface water resources during the license renewal term would be SMALL to MODERATE. This conclusion is based in part on the regulatory framework established by the State of Tennessee in managing surface water use and quality and the operation of the Tennessee River System by TVA to manage flows and to regulate water quality for designated uses.

4.16.3.2 Groundwater Resources

This section addresses the direct and indirect effects of license renewal on GW use and quality when added to the aggregate effects of other past, present, and reasonably foreseeable future actions. Groundwater is not used at the SQN site. As described in Section 3.5.2.2 of this SEIS, TVA obtains water for SQN industrial and potable uses from the Hixson Utility District, a municipal supplier of water (TVA 2013a). The Hixson Utility District currently has an estimated excess capacity of 12 mgd (45 million Lpd) (CHCRPA 2011). Potable water supplies around the SQN plant area are abundant and are expected to remain so over the period of extended operations (TVA 2013a, Table 2.10-1).

Historical releases of liquids containing tritium have not affected GW quality beyond the site boundary. A GW pathway has not been identified for tritium-contaminated GW to reach other drinking water users. As described in Sections 3.5.2.3 and 4.5.1.2 of this SEIS, a program is in place to safeguard GW quality. SQN operations have not affected and are not expected to affect the quality of GW in any aquifers that are a current or potential future source of water for offsite users. Considering ongoing activities and reasonably foreseeable actions, the NRC staff concludes that the cumulative impacts on GW use and quality during the SQN license renewal term would be SMALL.

4.16.4 Terrestrial Ecology

This section addresses past, present, and future actions that could result in cumulative impacts on the terrestrial species and habitats described in Sections 3.6 and 3.8, including protected terrestrial species. For purposes of this analysis, the geographic area considered in the evaluation includes the SQN site and surrounding region.

Historic Conditions

Section 3.6 discusses the ecoregion in which the SQN site lies—the Ridge and Valley ecoregion. Over the past 40 years, the amount of area developed into residential, commercial, or industrial uses has increased, and the amount of forested area has decreased. For example, forests declined from 57.3 percent in 1973 to 55.8 percent in 2000, whereas developed areas increased from 7.9 percent to 9.3 percent. The amount of agricultural land also decreased, from 31.2 percent to 30.5 percent from 1973 to 2000. USGS (2012) determined that strong economic growth, especially near large urban centers such as Chattanooga, contributed to the increase in developed areas. Development is likely to continue in the reasonably foreseeable future as a result of new transmission lines, power plants, and residential and commercial activities.

Development, Urbanization, and Habitat Fragmentation

As the region surrounding the SQN site becomes more developed, habitat fragmentation will increase and the amount of forested and wetland areas are likely to decline. Transmission line corridors established for SQN transmission lines represent past habitat fragmentation because some of the corridors split otherwise continuous tracts of forested, scrub-shrub, or wetland habitats. Construction of transmission lines associated with new energy projects may also result in habitat fragmentation if the corridors are not collocated with existing right-of-ways or sited within previously developed areas. Edge species that prefer open or partially open habitats (similar to the area within and near a right-of-way corridor) will likely benefit from the fragmentation, while species that require interior forest or wetland habitat will likely decline.

Increased development will likely decrease the overall availability and quality of forested, scrub-shrub, and wetland habitats. Species that require larger ranges, especially predators, will likely suffer reductions in their populations. Similarly, species with threatened, endangered, or declining populations are likely to be more sensitive to declines in habitat availability and quality.

Parks and Wildlife Preserves

State parks and wildlife refuges located near SQN provide valuable habitat to native wildlife and migratory birds during the proposed license renewal period. As development and urbanization increase habitat conversion and fragmentation, these protected areas will become ecologically more important as they provide large, continuous areas of minimally disturbed habitat.

Conclusion

Section 4.6 of this SEIS concludes that the impact from the proposed license renewal would not noticeably alter the terrestrial environment and, thus, would be SMALL. However, as environmental stressors, such as construction of new transmission lines, power plants, or residential areas, continue over the proposed license renewal term, certain attributes of the terrestrial environment (such as species abundance) are likely to change noticeably. The NRC staff does not expect these impacts to destabilize any important attributes of the terrestrial environment because such impacts will cause gradual change, which should allow the terrestrial environment to appropriately adapt. The NRC staff concludes that the cumulative impacts of the proposed license renewal of SQN plus other past, present, and reasonably foreseeable future projects or actions would result in MODERATE impacts to terrestrial resources.

4.16.5 Aquatic Ecology

This section addresses the direct and indirect effects of license renewal on aquatic resources when added to the aggregate effects of other past, present, and reasonably foreseeable future actions. Section 4.7 of this document finds that the direct and indirect impacts on aquatic resources from the proposed license renewal, when considered in the absence of the aggregate effects, would be SMALL. The cumulative impact is the total effect on the aquatic resources of all actions taken, no matter who has taken the actions (the second principle of cumulative effects analysis in CEQ (1997)).

The geographic area of interest considered in the cumulative aquatic resource analysis depends on the particular cumulative impacts being discussed. Direct and indirect impacts from the SQN site are largely limited to the Chickamauga Reservoir because dams on the Tennessee River and its tributaries largely segment the biological communities. The direct and indirect effects of the continued operation of SQN would not be communicated in a discernible manner beyond Chickamauga Dam. The geographic area considered for cumulative impacts from closely sited power plants, as well as from activities such as dams, agriculture, and urban and industrial development, includes the entire Chickamauga Reservoir, as well as one reservoir above the site (Watts Bar Reservoir) and one below (Nickajack Reservoir). This area is largely defined by water use.

Actions other than relicensing that can affect aquatic resources can be placed into two groups. The first is those caused by closely sited power plants. The NRC staff considers other power facilities within the geographic area of interest as “closely sited” for the purposes of cumulative impact analyses if these plants can affect the aquatic resources at SQN. The second group includes multiple other activities that affect Chickamauga Reservoir, such as dams, agriculture, and urban and industrial development.

Closely Sited Power Plants

The analysis of effects from other power-producing facilities on the aquatic resources in the vicinity of the SQN site is limited to facilities in Chickamauga Reservoir, as well as one reservoir upstream (Watts Bar Reservoir) and one reservoir downstream (Nickajack Reservoir). These power-producing facilities are listed in Appendix G and include Watts Bar Nuclear Plant Unit 1 (operating) and Unit 2 (pursuing a license), located 2 mi (3 km) downstream of Watts Bar Dam and approximately 44 mi (71 km) upstream of the SQN site; the Kingston Fossil Plant at the junction of Emory River and Clinch River, approximately 94 mi (151 km) upstream of the SQN site; and Raccoon Mountain Pumped-Storage Plant near Chattanooga. The two dams on either end of Chickamauga Reservoir (Watts Bar and Chickamauga dams) are considered with the effects of other activities including impoundment of the river.

Raccoon Mountain pumped-storage plant withdraws water from Nickajack Reservoir, downstream of Chickamauga Dam, during periods of low water demand. The water is pumped to a reservoir on the top of Raccoon Mountain. TVA indicates that it takes 28 hours to fill the upper reservoir. Water is released through tunnels to Nickajack Reservoir when demand is high. The water running through the tunnels drives generators that produce power (TVA 2013q). The facility was built in the 1970s and the reservoir holds 60 million cubic yards (46 million m^3) of water (TVA2013p).

Watts Bar Nuclear Plant is a source of entrainment, impingement, and thermal stress in the same reservoir as SQN. WBN Unit 1 received an operating license in 1996. It is collocated with WBN 2, which applied for an operating license in 2009. The WBN units are pressurized water reactors designed with a total electrical generating capacity of 2,540 megawatts electric (MWe) and two natural-draft cooling towers. Although the operating license for Unit 2 has not yet been issued, the two units are designed to use the same intake and discharge structures. The original intake pumping station is located on the Chickamauga Reservoir at Tennessee River Mile (RM) 528.0. A supplemental condenser cooling-water intake, originally used for the Watts Bar Fossil Plant, is also used for operation of WBN Unit 1 and will be used for WBN 2. The supplemental condenser cooling-water intake is located above Watts Bar Dam at Tennessee RM 529.9 and pulls water from Watts Bar Reservoir. It operates by gravity flow such that the flow through the intake structure fluctuates in response to changes in the elevation of the water level in Watts Bar Reservoir (NRC2013c).

The total flow through the two operating units (including withdrawals from both the supplemental condenser cooling water intake and the intake pumping station) would be approximately 237 mgd (12 m^3/s or 440 cfs), which is approximately 1.6 percent of the mean annual flow past the WBN site (see Table 3–1 for anticipated water use). When operating together, WBN Units 1 and 2 would consume 33 mgd (1.8 m^3/s or 62 cfs), which is approximately 0.2 percent of the mean annual flow past the WBN site (NRC 2013d).

In compiling the EIS related to the operation of WBN 2 (NRC 2013c), the NRC staff considered cumulative entrainment and impingement from both units based on studies conducted during operation of WBN Unit 1. The total entrainment of fish eggs and larvae, using the most recent estimates available and assuming both intakes were withdrawing water from the same environment, is 2.45 percent for eggs (assuming 2 times the entrainment rate for the Intake Pumping Station (IPS) from the 2010–2011 study (TVA 2012e) combined with the supplemental condenser cooling water (SCCW) system intake entrainment rate) and 2.84 percent for larvae (assuming two times the entrainment rate of 0.43 percent from the 2010–2011 study (TVA2012e) for the IPS, combined with the entrainment rate for the SCCW). Current operation of the SCCW for WBN Unit 1 accounts for the largest portion of the entrainment rates. The NRC staff's determination of impact levels was based on studies of impingement at both intakes, although the intakes draw water from populations in two different reservoirs. TVA researchers conducted two impingement studies at the intake pumping station on Chickamauga Reservoir. The first occurred in 1996 and 1997 (Baxter et al. 2010) and the second from March 2010 to March 2011 (TVA2012c). Small numbers of fish were impinged at the intake pumping station in 1996 and 1997. Larger numbers were impinged in the 2010 through 2011 study, but they were almost entirely composed of gizzard shad and threadfin shad (over 99 percent). TVA researchers conducted three impingement studies on the SCCW: (1) in 1974 through 1975, during operation of the Watts Bar Fossil Plant (TVA 1976), (2) in 1999 and 2000 (Baxter et al. 2001), and (3) in 2005 through 2007, as part of the 316(b) monitoring program (TVA 2007a). In the first study, shad constituted 73 percent of the fish collected. Bluegill was the next most abundant fish species followed by freshwater drum and skipjack herring. In the second study, again the majority of fish impinged were gizzard shad and threadfin shad (75 percent) followed by bluegill (17.6 percent). In the third study over 99 percent of the fish impinged were threadfin and gizzard shad; however, the threadfin shad composed the majority, with estimates of greater than 5.3 million impinged during the first year of the study, and over 211,000 the second year. The staff concluded that this high number of threadfin shad impinged likely resulted from weather conditions and the location of the SCCW system, which is on Watts Bar Dam. Overall, NRC staff concluded that the cumulative impact of operation of both WBN Units 1 and 2 would not destabilize or noticeably alter aquatic resources (NRC 2013d).

The Kingston Fossil Plant, near Kingston, Tennessee, is located on a peninsula at the junction of the Emory River and Clinch River, approximately 88 mi (142 km) upstream from the SQN site. TVA conducted impingement studies in 2004 through 2005 and 2005 through 2006, reporting 30 species impinged during the first year of the study and 33 in the second year. The estimated annual impingement extrapolated from weekly samples was 185,577 fish during the first year and 225,197 fish during the second year. Similar to impingement results for the SCCW, threadfin shad accounted for 95 percent of the 2-year total of fish TVA collected during an impingement study conducted from November 16, 2004, through November 16, 2006 (TVA 2007b).

Historical entrainment studies (Schneider and Tuberville 1981) showed that, although the hydraulic entrainment of the Kingston Fossil Plant averaged 22.7 percent in 1975, the biological entrainment was significantly lower at 0.84 percent. This difference was attributed by TVA, at least partially, to the use of a skimmer wall. The NRC staff does not anticipate cumulative impacts from entrainment and impingement at the Kingston Fossil Plant to affect the fish population observed in the vicinity of the SQN site because the home ranges of most species are less than the migratory distance between the two locations.

A nuclear facility is proposed for the Clinch River site, which is located upstream of the Kingston Fossil Plant, but between Watts Bar Dam and Melton Hills Dam. Although an application has not been submitted, the project is proposed to include up to six Babcock and Wilcox small modular reactor modules. A potential for impacts to aquatic resources exists, the magnitude of which is unknown, although, based on the design of the proposed units, it would be much smaller than that from a conventional nuclear power facility.

Thermal impacts beyond the SQN site may add to aquatic resources cumulative impact. The NRC staff also considered potential cumulative impacts as a result of the addition of thermal discharges from the Kingston Fossil Plant or the Watts Bar Nuclear Plant. All three facilities have NPDES permits that are granted by the State of Tennessee. The NRC relies on the State of Tennessee to protect the health of aquatic organisms by ensuring compliance with the NPDES permit requirements. Furthermore, because of the distances between these three sites, the travel time of water through the reservoirs, and the dissipation of heat from the discharge plumes, the NRC staff considers these impacts to be independent of effects at SQN.

Chemical contamination from power producing facilities can also adversely affect aquatic resources. The chemical releases from Watts Bar Nuclear Plant are similar to those from SQN. The two nuclear plants control water chemistry for various plant water uses by adding biocides, algaecides, corrosion inhibitors, potential of hydrogen (pH) buffering, scale inhibitors, and dispersants. Similar to SQN, the NRC relies on the State of Tennessee to ensure compliance with the NPDES permit requirements at the WBN site (TDEC 2011, TVA2011d) such that aquatic resources of Chickamauga Reservoir would not be affected by chemical discharges resulting from operation of WBN, Units 1 and 2.

Although NRC staff expects little effect on aquatic habitats from anticipated industrial and wastewater discharges if facilities comply with NPDES permit limitations, there is a case within the geographical area of interest where an accident occurred. In December 2008, a coal fly-ash slurry spill occurred at the Kingston Fossil Plant. The Tennessee Department of Health (TDOH) sampled water quality downstream of the Kingston Fossil Plant in response to the spill. It conducted the majority of sampling in the Clinch and Emory rivers. In addition, TDOH also sampled at Tennessee RM 568.2. According to the TDOH, except in the immediate vicinity of the coal ash release, the coal ash or the metals in the coal ash have not affected surface water in the Watts Bar Reservoir, and concentrations of radiation are below the regulatory limits that protect public health. In addition, TDOH sampling and analysis of metals associated with coal ash indicate that metals in all other areas of the Emory River and Clinch River have remained below any health comparison values.

Although the TDEC and the Tennessee Wildlife Resource Agency advise citizens to avoid consuming striped bass and limit consumption of catfish and sauger in the Clinch and Emory rivers, the pollutants of concern in these rivers include PCBs and mercury from historical activities not related to TVA (TDOH 2009). The long-term hazards of PCBs and mercury to aquatic resources are discussed in Section 2.3.2.1. These PCBs can impair reproductive, endocrine, and immune system functions in fish, increase the incidence of lesions and tumors, and cause death. Mercury can adversely affect reproduction and development and cause death. The effects of contamination on the level of individual fish can alter population dynamics and destabilize natural populations and ecosystems.

<u>Other Activities Including Dams, Agriculture, Urban and Industrial Development</u>

Section 3.7 describes some of the changes that were made to the Tennessee River since the early 1900s. These changes include impoundment of the river. Historically, the Tennessee River was free flowing and flooded annually. Before 1936, the few power dams that obstructed streams in Tennessee backed up relatively small impoundments. In 1936, TVA completed its first reservoir on the Tennessee River—Norris Reservoir. Currently, TVA operates nine dams on the mainstem of the Tennessee River. The dams have fragmented the watershed, altered water temperatures, increased sedimentation, reduced dissolved oxygen concentrations, and altered flow regimes. This in turn has caused and will continue to cause extirpation of fish, mussels, and other aquatic resources (Etnier and Starnes 1993, Neves and Angermeier 1990, Neves et al. 1997). Other past actions that have changed and continue to change the aquatic fauna in the geographical region include introduction of nonnative species, overfishing of species such as paddlefish, harvesting of mussels, toxic spills, mining, and agriculture. Section 3.7 describes the introduction and success of nonnative and invasive aquatic fish, invertebrate, and plant species that have clearly destabilized and changed Tennessee River aquatic communities. The aquatic community in Chickamauga Reservoir, like many other aquatic communities, changes slowly in response to stress. This community has been changing for a long time, is changing now, and will probably continue to change for the foreseeable future. In their review of the Tennessee River, White et al. (2005) made the following observation:

> 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.

The dams on the Tennessee River are barriers to fish migration, and the transport of fish, eggs, and larvae through the dams result in some mortality (Cada 1991, Watters 2000). Furthermore, the placement of the dams altered the flow regimes and continues to alter the water quality, including the temperature of the river (as discussed in Section 3.5). For example, increasing the volume of water released from Watts Bar Dam is one of five options TVA can use to keep the thermal discharge from operation of WBN, Units 1 and 2, within the NPDES limits (NRC 2013c) If this option is chosen, the water released from Watts Bar Dam could have slight and indiscernible effects on the water levels in Tennessee River reservoirs and tributaries upstream and downstream of Watts Bar Dam, including in the vicinity of the SQN site, and slight and indiscernible effects on the aquatic resources in those reservoirs and tributaries.

The management of the impounded river as reservoirs, including the management of commercially and recreationally important fish, stocking of fish, and introduction of nonnative fish also serve as a stress on the native aquatic resources. Chapter 3 of this SEIS describes specific impacts on aquatic resources from reservoir impoundment, including the extirpation of aquatic resources, which is detectable and a symptom of ecosystem destabilization.

Operations at industrial sites can affect the chemicals that are released to the aquatic environment. For example, waste disposal activities at the DOE's Oak Ridge Reservation, located on the Clinch River at Clinch RM 17.7, introduced PCBs, metals, organic compounds (including those with mercury), and radionuclides (including cesium-137) into local streams and, ultimately, into the Watts Bar Reservoir system. The highest discharges occurred in the mid-1950s. The mouth of the Clinch River is located at Tennessee RM 567.7, placing the Oak Ridge Reservation at approximately 100 mi (161 km) upstream of the Watts Bar Dam and 140 mi (225 km) upstream of the SQN site. The highest concentrations of chemical and radioactive contaminants lie in the subsurface sediments where 40 to 80 cm (16 to 32 in.) of sediment covers the deposits (ATSDR 1996). Such legacy contaminants can adversely affect resources in the Tennessee River.

Other industrial sites with discharges that could contribute to cumulative impacts include Resolute Forest Products, a paper mill, and Olin Chlor Alkali Products (Olin 2013), a manufacturer of chlorine and caustic soda on the Hiwassee River, a tributary that empties into Chickamauga Reservoir upstream of the SQN site. The NRC staff expects little effect to aquatic habitats from industrial and wastewater discharges if facilities comply with NPDES permit limitations.

A preliminary study has been conducted for a toll bridge that would cross the Tennessee River in the vicinity of the SQN site to connect Highway 58 with Interstate 75 (Chattanoogan 2012). The project would require inwater work that would temporarily affect aquatic resources in the vicinity of the construction site. The study estimated that by 2021 between 9,900 and 10,700 vehicles would cross per day. The staff assumes that the construction firm would use BMPs to minimize the effects of construction on aquatic resources and to minimize effects of runoff into the river during operation of the bridge.

Based on information TVA provided and the NRC staff's independent review, the NRC staff concludes that the cumulative impacts on aquatic resources in Chickamauga Reservoir are LARGE based on past, present, and reasonably foreseeable future actions. The environmental effects are clearly noticeable and have destabilized important attributes of the aquatic resources in the vicinity of the SQN site. The incremental, site-specific impact from the continued operation of SQN during the license renewal period would be minor and not noticeable in comparison to cumulative impact on the aquatic ecology.

4.16.6 Historic and Cultural Resources

This section addresses the direct and indirect effects of license renewal on historic and cultural resources when added to the aggregate effects of other past, present, and reasonably foreseeable future actions. The geographic area considered in this analysis is the APE associated with the proposed undertaking, as described in Section 3.9.

The archaeological record for the region indicates prehistoric and historic occupation of the SQN site and its immediate vicinity. The completion of Chickamauga Reservoir in 1940 and the construction of SQN, Units 1 and 2, in 1970 resulted in destruction of cultural resources within the SQN site and surrounding area. Other historic land development in the vicinity of SQN also resulted in impacts on, and the loss of, cultural resources on the SQN site and its immediate vicinity. However, there remains the possibility for additional historic or cultural resources to be located within the SQN site. The present and reasonably foreseeable projects which could affect these resources reviewed in conjunction with license renewal are noted in Appendix G of this document. Direct impacts would occur if historic and cultural resources in the APE were physically removed or disturbed. Indirect visual or noise impacts could occur from new construction or maintenance. The following projects are located within the geographic area considered for cumulative impacts:

- Chickamauga Dam water level fluctuation,
- independent spent fuel storage installation (ISFSI) expansion,
- tritium production,
- use of highly enriched uranium (HEU) fuel,
- use of mixed-oxide fuel (MOXF),
- decommissioning of SQN, Units 1 and 2,
- transmission lines maintenance or construction, and
- future urbanization in the immediate vicinity of SQN.

As described in Section 4.9, no cultural resources would be adversely affected by SQN, Units 1 and 2, license renewal activities as no associated changes or ground-disturbing activities would occur (TVA 2013a). Cultural resources on the SQN site are being managed through TVA BMPs (e.g., procedures and training) and license renewal would have no contributory incremental effect on historic and cultural resources (TVA 2013b). Expansion of ISFSI, tritium production, use of HEU fuel, use of MOXF, decommissioning of SQN, Units 1 and 2, transmission lines, and future urbanization all have the potential to result in impacts on cultural resources through inadvertent discovery during ground-disturbing activities. The Chickamauga Dam has the potential to affect cultural resources because of the fluctuation of river water levels that may cause erosion impacts to resources located on the river banks. However, TVA has established processes and procedures to ensure cultural resources are considered in project planning during normal operation of SQN, Units 1 and 2, and these same processes and procedures are used throughout the TVA power properties. Therefore, the NRC staff concludes that the cumulative impact of the proposed license renewal when combined with other past, present, and reasonably foreseeable future activities on historic and cultural resources would be SMALL.

4.16.7 Socioeconomics

This section addresses socioeconomic factors that have the potential to be directly or indirectly affected by changes in operations at SQN in addition to the aggregate effects of other past, present, and reasonably foreseeable future actions. The primary geographic area of interest considered in this cumulative analysis is Hamilton and Rhea Counties, where approximately 84 percent of SQN employees reside (see Table 3–22). This is where the economy, tax base, and infrastructure would most likely be affected because SQN workers and their families reside, spend their incomes, and use their benefits within these counties.

As discussed in Section 4.8.10 of this SEIS, continued operation of SQN during the license renewal term would have no impact on socioeconomic conditions in the region beyond those that are already being experienced. Since TVA has no plans to hire additional workers during the license renewal term, overall expenditures and employment levels at SQN would remain relatively constant and unchanged, with no additional demand for permanent housing and public services. In addition, as employment levels and tax payments would not change, there would be no population- or tax revenue-related land-use impacts. Based on this and other information presented in preceding sections of Chapter 4 of this SEIS, there would be no additional contributory effect on socioeconomic conditions in the future from the continued operation of SQN on socioeconomic conditions in the region during the license renewal term beyond what is currently being experienced. Therefore, the only contributory effects would come from reasonably foreseeable future planned activities at SQN, unrelated to the proposed action (license renewal), and other reasonably foreseeable planned offsite activities. For example, residential development is forecast for the SQN area, but not to the point that population densities will be significant. Contributing to projected development is a provision to install sewage lines in part of the area (TVA 2013a).

4.16.7.1 Tritium Production and Use of Highly Enriched Uranium and Mixed-Oxide Fuel at SQN

The applicant stated in its ER that SQN has been selected by DOE for irradiation services for the production of tritium. Tritium production at SQN was studied in DOE's EIS for tritium production in a commercial light water reactor (DOE 1999). Fewer than 10 additional workers per unit and some power plant modifications would be required to provide tritium production irradiation services to DOE. These additional workers and other transportation-related activities would increase traffic volumes on local roads near SQN. During reactor operations, irradiated tritium-producing burnable absorber rod assemblies, nonradioactive waste, and some additional low-level radioactive waste would be transported off site for processing and disposal. Should DOE select SQN for irradiation services, and the NRC approve a license amendment for this activity, the contributory socioeconomic effect of this action would be SMALL in the immediate vicinity of SQN. Furthermore, the use of HEU and MOXF would not create any contributory socioeconomic effects in the immediate vicinity of SQN.

4.16.7.2 Watts Bar Nuclear Power Plant Unit 2

The 1978 operating license FES evaluated the impacts from operating both WBN Units 1 and 2, concluding no significant socioeconomic impacts would occur from combined power plant operations. Since that time, the region around WBN, Units 1 and 2, has experienced economic growth and increases in population and housing.

Currently, TVA expects to employ 200 workers to operate WBN 2, which is the same number of operations workers projected in the 1978 FES (NRC 1978). However, this would be in addition to the 700 TVA personnel and 1,360 construction workers (PNNL 2009) currently employed at the WBN site (TVA 2008, 2010). Should WBN 2 become operational, the overall level of employment at the WBN site would be less than total current employment at the WBN site. The contributory socioeconomic effect of this action would be SMALL in the immediate vicinity of SQN.

4.16.7.3 Small Modular Reactor Modules at the Clinch River Site

The incremental socioeconomic effects of installing and operating small modular reactor (SMR) modules at the Clinch River site cannot be accurately estimated since the NRC has not received an application for a construction and operation license. However, installing and operating SMR modules would create new employment and income opportunities resulting in temporary (during installation) and permanent (during operations) population increases in communities located near the Clinch River site. Employment-driven population growth would cause increased traffic volumes on local roads and increased demand for housing and local commercial and public services near the site. Should SMR modules be installed and operated at the Clinch River site, the contributory socioeconomic effect of this action could be SMALL in the immediate vicinity of SQN.

4.16.7.4 Recreational Vehicle Trailer Park

Construction and operation of an RV trailer park directly across from SQN would both increase traffic volumes on roads near SQN as well as demand for commercial and public services. The RV trailer park will use the same municipal public water supply as SQN. The contributory socioeconomic effect of this action could be SMALL in the immediate vicinity of SQN.

4.16.7.5 Conclusion

When combined with other past, present, and reasonably foreseeable future activities, there will be no additional contributory effect on socioeconomic conditions from the continued operation of SQN during the license renewal period beyond what is currently being experienced. Therefore, the NRC staff concludes that the cumulative socioeconomic impact would be SMALL in the immediate vicinity of SQN.

4.16.8 Human Health

The NRC and EPA established radiological dose limits for protection of the public and workers from both acute and long-term exposure to radiation and radioactive materials. These dose limits are codified in 10 CFR Part 20 and 40 CFR Part 190. As discussed in Section 4.11.1, the doses resulting from operation of SQN are below regulatory limits and the impacts of these exposures are SMALL. For the purposes of this analysis, the geographical area considered is the area included within an 50-mi (80-km) radius of the SQN site. The only other nuclear power plant within the applicable geographical area is TVA's Watts Bar Nuclear Plant (WBN) that is approximately 31 miles south-southwest of the SQN site. The WBN site contains an operating reactor, Unit 1, and Unit 2 that is under construction. In addition to storing its spent nuclear fuel in a storage pool, SQN also stores some of its spent nuclear fuel in an onsite independent spent fuel storage installation (ISFSI).

EPA regulations in 40 CFR Part 190 limit the dose to members of the public from all sources in the nuclear fuel cycle, including nuclear power plants, fuel fabrication facilities, waste disposal facilities, and transportation of fuel and waste. As discussed in Section 3.1.4.5 of this SEIS, SQN has conducted a radiological environmental monitoring program since 1971, well before commercial operation began in 1981. This program measures radiation and radioactive materials in the environment from SQN, its ISFSI, and all other sources, such as WBN. The NRC staff reviewed the radiological environmental monitoring results for the 5-year period from 2008 to 2012 as part of the cumulative impacts assessment. The NRC staff's review of TVA's data showed no indication of an adverse trend in radioactivity levels in the environment from SQN, its ISFSI, or WBN. The data showed that there was no measurable impact to the environment from the operations at SQN and there were no contributory impacts from WBN.

As discussed in Section 3.1.4.6 of this SEIS, TVA may seek NRC approval to produce tritium at SQN for the DOE. In addition, TVA may seek NRC approval to use mixed oxide (MOX) fuel at SQN. Also, as discussed in Section 3.1.4.6, SQN is not producing tritium for the DOE and is not using MOX fuel. In order to conduct either of these actions, TVA is required to submit license amendments to the NRC. The NRC would perform independent safety and environmental reviews of these actions to ensure the adequate protection of the public and the environment.

The NRC and the State of Tennessee will regulate any future development or actions in the vicinity of the SQN site that could contribute to cumulative radiological impacts.

Based on the NRC staff's review of radiological environmental monitoring data, radioactive effluent release data, and the expected continued compliance with Federal radiation protection standards, the cumulative radiological impacts to SQN workers and members of the public from the operation of SQN during the renewal term would be SMALL.

4.16.9 Environmental Justice

The environmental justice cumulative impact analysis assesses the potential for disproportionately high and adverse human health and environmental effects on minority and low-income populations that could result from past, present, and reasonably foreseeable future actions, including SQN operations during the renewal term. Adverse health effects are measured in terms of the risk and rate of fatal or nonfatal adverse impacts on human health. Disproportionately high and adverse human health effects occur when the risk or rate of exposure to an environmental hazard for a minority or low-income population is significant and exceeds the risk or exposure rate for the general population or for another appropriate comparison group. Disproportionately high environmental effects refer to impacts or risks of impacts on the natural or physical environment in a minority or low-income community that are significant and appreciably exceed the environmental impact on the larger community. Such effects may include biological, cultural, economic, or social impacts. Some of these potential effects have been identified in resource areas presented in preceding sections of this SEIS. As previously discussed in this chapter, the impact from license renewal for all resource areas (e.g., land, air, water, ecology, and human health) would be SMALL.

As discussed in Section 4.12 of this SEIS, there would be no disproportionately high and adverse impacts on minority and low-income populations from the continued operation of SQN during the license renewal term. Because TVA has no plans to hire additional workers during the license renewal term, employment levels at SQN would remain relatively constant, and there would be no additional demand for housing or increased traffic. Based on this information and the analysis of human health and environmental impacts presented in the preceding sections, it is not likely there would be any disproportionately high and adverse contributory effect on minority and low-income populations from the continued operation of SQN during the license renewal term. Therefore, the only contributory effects would come from the other reasonably foreseeable future planned activities at SQN, unrelated to the proposed action (license renewal), and other reasonably foreseeable planned offsite activities.

4.16.9.1 Tritium Production and Use of Highly Enriched Uranium and Mixed-Oxide Fuel at SQN

Potential impacts to minority and low-income populations would mostly consist of environmental and socioeconomic effects (e.g., traffic, employment, and housing impacts). Radiation doses from plant operations after power plant modifications for irradiation services or the use of HEU and MOXF are expected to continue to remain well below regulatory limits. Noise and dust impacts from power plant modifications would be temporary and limited to onsite activities. Minority and low-income populations residing along site access roads could experience increased commuter vehicle traffic during shift changes. Increased demand for inexpensive rental housing during irradiation services-related power plant modifications could disproportionately affect low-income populations; however, because of the short duration of the work and the availability of housing, impacts to minority and low-income populations would be of short duration and limited.

Based on this information and the analysis of human health and environmental impacts presented in this section of the SEIS, irradiation services or the use of HEU and MOXF would not have disproportionately high and adverse human health and environmental effects on minority and low-income populations residing in the vicinity of SQN.

4.16.9.2 Watts Bar Unit 2

Potential impacts to minority and low-income populations would mostly consist of environmental and socioeconomic effects (e.g., noise, dust, traffic, employment, and housing impacts). Radiation doses from WBN 2 power plant operations are expected to be similar to WBN Unit 1 and well below regulatory limits. Increased demand for inexpensive rental housing during the completion of WBN 2 could disproportionately affect low-income populations; however, because of the short duration of the work and the availability of housing, impacts to minority and low-income populations would be of short duration and limited.

Based on this information and the analysis of human health and environmental impacts presented in this section of the SEIS, the contributory effects of WBN 2 operations would not cause any disproportionately high and adverse human health and environmental effects on minority and low-income populations residing in the vicinity of SQN.

4.16.9.3 Small Modular Reactor Modules at the Clinch River Site

Potential impacts to minority and low-income populations would mostly consist of environmental and socioeconomic effects (e.g., noise, dust, traffic, employment, and housing impacts). Radiation doses from operating SMR modules at the Clinch River site are expected to be well below regulatory limits. Increased demand for inexpensive rental housing during the installation of SMR modules could disproportionately affect low-income populations; however, because of the short duration of the installation work and the availability of housing, impacts to minority and low-income populations would be of short duration and limited.

Based on this information and the analysis of human health and environmental impacts presented in this section of the SEIS, the contributory effects of SMR module operations at the Clinch River site would not cause any disproportionately high and adverse human health and environmental effects on minority and low-income populations residing in the vicinity of SQN.

4.16.9.4 Recreational Vehicle Trailer Park

Potential impacts to minority and low-income populations would mostly consist of environmental and socioeconomic effects during the construction of the RV trailer park (e.g., noise, dust, and traffic impacts). Noise and dust impacts during construction would be temporary and limited to onsite activities. These adverse effects would also be offset by the availability of low-income housing at the proposed RV trailer park. Minority and low-income populations residing nearby could also experience increased traffic on roads near their houses; however, impacts to minority and low-income populations would be limited to certain hours of the day and would be of short duration.

Based on this information and the analysis of human health and environmental impacts presented in this section of the SEIS, the contributory effects of the RV trailer park would not cause any disproportionately high and adverse human health and environmental effects on minority and low-income populations residing in the vicinity of SQN.

4.16.9.5 Conclusion

The NRC staff concludes that the contributory effects of this action, when combined with other past, present, and reasonably foreseeable future activities considered, would not cause any disproportionately high and adverse human health and environmental effects on minority and low-income populations residing in the vicinity of SQN.

4.16.10 Waste Management

This section describes waste management impacts during the license renewal term when added to the aggregate effects of other past, present, and reasonably foreseeable future actions. For the purpose of this cumulative impacts analysis, the area within a 50-mi (80-km) radius of SQN was considered.

As with any major industrial facility, SQN generates waste as a consequence of normal operations. The expected waste generation rates during the license renewal term would be the same as during current operations, and radioactive waste (low-level, high-level, and spent nuclear fuel) and nonradioactive waste will continue to be generated. Hazardous waste would continue to be packaged and shipped to offsite Resource Conservation and Recovery Act (RCRA)-permitted treatment and disposal facilities. Typically, hazardous waste is not held in long-term storage at SQN. Hazardous wastes from SQN are transferred to TVA's permitted hazardous waste storage facility (HWSF) in Muscle Shoals, Alabama, which serves as a central collection point for all TVA-generated hazardous wastes. It is then shipped to an approved licensed facility for disposition (TVA 2013a).

As discussed in Sections 3.1.4 and 3.1.5 of this SEIS, TVA maintains waste management programs for all radioactive and nonradioactive waste generated at SQN and is required to comply with Federal and State permits and other regulatory requirements for the management of waste material. Current waste management activities at SQN would likely remain unchanged during the license renewal term. The existing onsite independent spent fuel storage installation at SQN may be expanded to handle the additional spent nuclear fuel generated during the license renewal term; however, the impacts of this expansion would be addressed under a separate licensing action and associated NEPA review process (TVA 2013a). Nonradioactive and nonhazardous waste generated during the license renewal term would continue to be shipped off site by commercial haulers to licensed treatment and disposal facilities.

4.16.10.1 Tritium Production and Use of Mixed-Oxide Fuel at SQN

As discussed in Section 3.1.4, if SQN applies for and receives NRC approval to provide tritium production services to DOE, power plant modifications will be required. These modifications would generate small amounts of construction and other nonradioactive waste. This waste material would be shipped off site by commercial haulers to licensed treatment and disposal facilities. During reactor operations, nonradioactive waste, and some additional low-level radioactive waste would be generated and transported off site for processing and disposal. Should SQN provide tritium production services during the license renewal term, the NRC staff concludes that the contributory effect of this action on waste management, would be SMALL in the immediate vicinity of SQN. Additionally, the use of HEU and MOXfuel would not result in any noticeable changes in the types or quantities of nonradioactive or radioactive waste. SQN's waste management program would handle the waste in accordance with Federal and State requirements. The NRC staff concludes that the contributory effect of this action on waste management during the license renewal term would be SMALL.

4.16.10.2 Watts Bar Unit 2

The 1978 operating license FES evaluated the impacts from operating both WBN, Units 1 and 2. Should WBN 2 become operational, waste management activities at the WBN site would be required to comply with Federal and State permits and other regulatory requirements for the management of waste material. The contributory effect of this action would be SMALL.

4.16.10.3 Recreational Vehicle Trailer Park

Construction and operation of an RV trailer park directly across from SQN would generate volumes of commercial waste, but the operator of the park would be required to comply with Federal and State requirements for the management of waste material. The contributory effect of this action would be SMALL in the immediate vicinity of SQN.

4.16.10.4 Conclusion

Since current waste management activities at SQN would continue during the license renewal term, there would be no new or increased contributory effect beyond what is currently being experienced. Therefore, the only new contributory effects would come from reasonably foreseeable future planned activities at SQN, unrelated to the proposed action (license renewal), and other reasonably foreseeable planned offsite activities. All radioactive and nonradioactive waste treatment and disposal facilities within 50 mi (80 km) of SQN would also be required to comply with Federal and State permits and other regulatory requirements. In addition, the waste management activities at other TVA nuclear power reactor sites (e.g., Watts Bar) as well as other industrial facilities generating radioactive and nonradioactive waste would also have to meet the same or similar requirements. Based on this information, the cumulative effect from continued waste management activities at SQN during the license renewal term would be SMALL.

4.16.11 Global Climate Change

This section addresses the impact of GHG emissions resulting from continued operation of SQN on global climate change when added to the aggregate effects of other past, present, and reasonably foreseeable future actions. The impacts of climate change on air, water, and ecological resources are discussed in Section 4.14.3. Climate is influenced by both natural and human-induced factors; the observed global warming (increase in Earth's surface temperature) in the 21st century has been attributed to the increase in GHG emissions resulting from human activities (USGCRP 2009, 2014). Climate model projections indicate that future climate change is dependent on current and future GHG emissions (IPCC 2007b; USGCRP 2009, 2014). As described in Section 4.14.3.1, operations at SQN emit GHG emissions directly and indirectly. Therefore, it is recognized that GHG emissions from continued SQN operation may contribute to climate change.

The cumulative impact of a GHG emission source on climate is global. GHG emissions are transported by wind and become well-mixed in the atmosphere as a result of their long atmospheric lifetime. Therefore, the extent and nature of climate change is not specific to where GHGs are emitted. In April 2013, the EPA published the official U.S. inventory of GHG emissions, which identifies and quantifies the primary anthropogenic sources and sinks of GHGs. The EPA GHG inventory is an essential tool for addressing climate change and participating with the United Nations Framework Convention on Climate Change to compare the relative global contribution of different emission sources and GHGs to climate change. In 2011, the U.S. emitted 6,702.3 teragrams of carbon dioxide equivalents (CO_2e) (6,702 million metric tons (MMT) CO_2e) and since 1990 emissions have increased at an average annual rate of 4 percent (EPA 2013e). In 2010 and 2011, the total amount of carbon dioxide equivalent (CO_2e) emissions related to electricity generation was 2,303 teragrams (2,303 million metric tons (MMT)) and 2,200 teragrams (2,200 MMT), respectively (EPA 2013e). The Energy Information Administration (EIA) reported that, in 2010, electricity production in Tennessee was responsible for 48 MMT CO_2e (EIA 2012). Facilities that emit 25,000 metric tons (MT) CO_2e or more per year are required to report annually their GHG emissions to the EPA. These facilities are known as direct emitters and the data is publicly available in EPA's facility-level information on GHGs tool (FLIGHT). In 2011, FLIGHT identified eight facilities in Hamilton County, where SQN is located, that emitted a total of 818,014 MT CO_2e (EPA 2013a). In 2011, FLIGHT identified 93 facilities in Tennessee that emitted a total of 55.8 MMT CO_2e (EPA 2013b).

Appendix E provides a list of present and reasonably foreseeable projects that could contribute to GHG emissions. Permitting and licensing requirements and other mitigative measures can minimize the impacts of GHG emissions. For instance, in 2012 the EPA issued a final GHG Tailoring Rule to address GHG emissions from stationary sources under the CAA permitting requirements; the GHG Tailoring Rule establishes when an emission source will be subject to permitting requirements and control technology to reduce GHG emissions. Executive Order 13514 (Federal Leadership in Environmental, Energy, and Economic Performance) requires Federal agencies to set GHG emission reduction targets, relative to 2008 GHG emissions, by the year 2020. TVA, in accordance with this E.O. has developed a Strategic Sustainable Performance Plan that identifies the actions and measures that will be taken to reach GHG emission reduction targets by 2020 of its facilities (TVA 2012f). On June 25, 2013, the Executive Office of thePresident set forward a Climate Action Plan. The Climate Action Plan will reduce carbon pollution, prepare the United States for the impacts of climate change, and lead international efforts to combat global climate change. Future actions and steps taken to reduce GHG emissions, such as E.O. 13514 and the Climate Action Plan, will lessen the impacts on climate change.

EPA's U.S. inventory of GHG emissions illustrates the diversity of GHG source emitters, such as electricity generation, industrial processes, and agriculture. GHG emissions resulting from operations at SQN range from 23,250 to 28,720 MT CO_2e (Table 4–27). In comparing SQN's GHG emission contribution to different emissions sources, whether it be total U.S. GHG emissions, emissions from electricity production in Tennessee, or emissions on a county level, GHG emissions from SQN are minor relative to these inventories; this is evident as presented in Table 4–28. Climate models indicate that short-term climate change (through the year 2030) is dependent on past GHG emissions. Therefore, climate change is projected to occur with or without present and future GHG emissions from SQN. The NRC staff concludes that the impact from the contribution of GHG emissions from continued operation of SQN on climate change would be SMALL. As discussed in Section 4.14.3.2, climate change and climate-related changes have been observed on a global level and climate models indicate that future climate change will depend on present and future GHG emissions. Based on continued increases in GHG emission rates, climate models project that Earth's average surface temperature will continue to increase and climate-related changes will persist. Therefore, the cumulative impact of GHG emissions on climate change is noticeable but not destabilizing. The NRC staff concludes that the cumulative impacts from the proposed license renewal and other past, present, and reasonably foreseeable projects would be MODERATE.

4.16.12 Summary of Cumulative Impacts

The NRC staff considered the potential impacts resulting from the operation of SQN during the period of extended operation and other past, present, and reasonably foreseeable future actions near SQN. Potential cumulative impacts would range from SMALL to LARGE, depending on the resource. Table 4–29 summarizes the cumulative impacts on resource areas.

1 **Table 4–29. Comparison of GHG Emission Inventories**

Source	CO_2e MMT/year
Global Fossil Fuel Combustion Emissions[1]	31,865.00
U.S. Emissions[2]	6,702.00
Tennessee[3]	55.80
Hamilton County[4]	0.82
SQN Emissions[5]	0.0029

[1] According to the International Energy Agency in 2011 global CO_2 emissions from fossil fuel combustion was 31.6 Gt (IEA 2012); 31.6 Gt of CO_2 is equivalent to 31,865 CO_2e.

[2] Source: EPA 2013e

[3] GHG emissions account only for direct emitters, those facilities that emit 25,000 MT or more a year (EPA 2013b)

[4] GHG emissions account only for direct emitters, those facilities that emit 25,000 MT or more a year (EPA 2013a)

[5] Emissions include direct and indirect emissions from operation of SQN and the most conservative value is provided (2011 GHG inventory) (TVA 2013d; TVA 2013t).

2 **Table 4–30. Summary of Cumulative Impacts on Resource Areas**

Resource Area	Cumulative Impact
Air Quality and Noise	Because there are no planned site refurbishments with the SQN license renewal, and no expected changes in air emissions, cumulative impacts in Hamilton County would be the result of changes to present-day emissions and emissions from reasonably foreseeable projects and actions. Various strategies and techniques are available to limit air quality impacts. Therefore, the cumulative impacts from the continued operation of SQN would be SMALL.
Water Resources	Consumptive surface water use from continued SQN operations will continue to be a very small percentage of the overall flow of the Tennessee River through Chickamauga Reservoir. Potential impacts to surface water resources include prolonged drought and temperature increases. Long-term warming could potentially affect navigation, power production, and municipal and industrial users, although the magnitude of the impact is uncertain. However, the regulatory framework established by the State of Tennessee in managing surface water use and quality and the operation of the Tennessee River System by TVA to manage flows and to regulate water quality for designated uses will continue to limit water withdrawals from and thermal discharges to the Chickamauga Reservoir. Therefore, the NRC staff concludes that the cumulative impacts from past, present, and reasonably foreseeable future actions on surface water resources during the license renewal term would be SMALL to MODERATE. SQN operations have not affected and are not expected to affect the quality of GW in any aquifers that are a current or potential future source of water for offsite users. Considering ongoing activities and reasonably foreseeable actions, the NRC staff concludes that the cumulative impacts on GW use and quality during the SQN license renewal term would be SMALL. Therefore, overall cumulative impact to water resources from continued operation of SQN would range from SMALL to MODERATE.

Resource Area	Cumulative Impact
Aquatic Ecology	NRC staff concludes that the cumulative impacts on aquatic resources in Chickamauga Reservoir are LARGE based on past, present and reasonably foreseeable future actions. The environmental effects are clearly noticeable and have destabilized important attributes of the aquatic resources in the vicinity of the SQN site. The incremental, site-specific impact from the continued operation of SQN during the license renewal period would be minor and not noticeable in comparison to cumulative impact on the aquatic ecology.
Terrestrial Ecology	Construction of new transmission lines, power plants, or residential areas over the proposed license renewal term have the potential to affect terrestrial resources. Habitat fragmentation will increase as the region surrounding the SQN site becomes more developed. Therefore, the cumulative impacts from the continued operation of SQN would be MODERATE.
Human Health	The NRC staff reviewed SQN's radioactive effluent and environmental monitoring data from 2008 to 2012, and concluded the impacts of radiation exposure to the public from operation of SQN during the renewal term are SMALL. The cumulative radiological impacts from SQN, Units 1 and 2, and their potential production of tritium and use of MOX fuel, as well as its ISFSI, Watts Bar 1, and any future operating nuclear power plants are required to meet the radiation dose limits in 10 CFR Part 20 and EPA's 40 CFR Part 190. Therefore, the cumulative impacts from the continued operation of SQN would be SMALL.
Socioeconomics	As discussed in Section 4.9 of this SEIS, continued operation of SQN during the license renewal term would have no impact on socioeconomic conditions in the region beyond those already experienced. TVA has no plans to hire additional workers during the license renewal term; employment levels at TVA would remain relatively constant with no new demands for housing or increased traffic. Combined with other past, present, and reasonably foreseeable future activities, there will be no additional contributory effect on socioeconomic conditions from the continued operation of SQN during the license renewal period beyond what is currently being experienced. Therefore, the NRC staff concludes that the cumulative socioeconomic impact would be SMALL in the immediate vicinity of SQN.
Cultural Resources	As described in Section 4.9, no cultural resources would be adversely affected by SQN, Units 1 and 2, license renewal activities as no associated changes or ground-disturbing activities will occur (TVA 2013a). Cultural resources on the SQN site are being managed through TVA BMPs (e.g., procedures and training) and license renewal would have no contributory incremental effect on historic and cultural resources. Therefore, combined with other past, present, and reasonably foreseeable future activities, the potential cumulative impacts on historic and cultural resources would be SMALL.
Environmental Justice	There would be no disproportionately high and adverse impacts to minority and low-income populations from the continued operation of SQN during the license renewal term.

Resource Area	Cumulative Impact
Waste Management and Pollution Prevention	Since current waste management activities at SQN would continue during the license renewal term, there would be no new or increased contributory effect beyond what is currently being experienced. Therefore, the only new contributory effects would come from reasonably foreseeable future planned activities at SQN, unrelated to the proposed action (license renewal), and other reasonably foreseeable planned offsite activities. All radioactive and nonradioactive waste treatment and disposal facilities within 50 mi (80 km) of SQN would also be required to comply with Federal and State permits and other regulatory requirements. In addition, the waste management activities at other TVA nuclear power reactor sites (e.g., Watts Bar) as well as other industrial facilities generating radioactive and nonradioactive waste would also have to meet the same or similar requirements. Based on this information, the cumulative effect from continued waste management activities at SQN during the license renewal term would be SMALL.
Global Climate Change	As discussed in Section 4.14.3, the NRC staff concludes that the impact from the contribution of GHG emissions from continued operation of SQN on climate change would be SMALL. As discussed in Section 4.14.3.2, climate change and climate-related changes have been observed on a global level and climate models indicate that future climate change will depend on present and future GHG emissions. Because of continued increases in GHG emission rates, climate models project that Earth's average surface temperature will continue to increase and climate-related changes will persist. Therefore, the cumulative impact of GHG emissions on climate change is noticeable but not destabilizing. The NRC staff concludes that the cumulative impacts from the proposed license renewal and other past, present, and reasonably foreseeable projects would be MODERATE.

4.17 Resource Commitments

4.17.1 Unavoidable Adverse Environmental Impacts

Unavoidable adverse environmental impacts are impacts that would occur after implementation of all workable mitigation measures. Carrying out any of the energy alternatives considered in this SEIS, including the proposed action, would result in some unavoidable adverse environmental impacts.

Minor unavoidable adverse impacts on air quality would occur due to emission and release of various chemical and radiological constituents from power plant operations. Nonradiological emissions resulting from power plant operations are expected to comply with EPA emissions standards, though the alternative of operating a fossil fueled power plant in some areas may worsen existing attainment issues. Chemical and radiological emissions would not exceed the national emission standards for hazardous air pollutants.

During nuclear power plant operations, workers and members of the public would face unavoidable exposure to radiation and hazardous and toxic chemicals. Workers would be exposed to radiation and chemicals associated with routine plant operations and the handling of nuclear fuel and waste material. Workers would have higher levels of exposure than members of the public, but doses would be administratively controlled and would not exceed standards or administrative control limits. In comparison, the alternatives involving the construction and operation of a non nuclear power generating facility would also result in unavoidable exposure to hazardous and toxic chemicals to workers and the public.

The generation of spent nuclear fuel and waste material, including low level radioactive waste, hazardous waste, and nonhazardous waste would be unavoidable. Hazardous and nonhazardous wastes would be generated at non nuclear power generating facilities. Wastes generated during plant operations would be collected, stored, and shipped for suitable treatment, recycling, or disposal in accordance with applicable Federal and state regulations. Due to the costs of handling these materials, power plant operators would be expected to carry out all activities and optimize all operations in a way that generates the smallest amount of waste possible.

4.17.2 Short-Term Versus Long-Term Productivity

The operation of power generating facilities would result in short term uses of the environment, as described in Chapter 4. "Short term" is the period of time that continued power generating activities take place.

Power plant operations require short term use of the environment and commitment of resources (e.g., land and energy), indefinitely or permanently. Certain short term resource commitments are substantially greater under most energy alternatives, including license renewal, than under the no action alternative because of the continued generation of electrical power and the continued use of generating sites and associated infrastructure. During operations, all energy alternatives entail similar relationships between local short term uses of the environment and the maintenance and enhancement of long term productivity.

Air emissions from power plant operations introduce small amounts of radiological and nonradiological constituents to the region around the plant site. Over time, these emissions would result in increased concentrations and exposure, but they are not expected to impact air quality or radiation exposure to the extent that public health and long term productivity of the environment would be impaired.

Continued employment, expenditures, and tax revenues generated during power plant operations directly benefit local, regional, and state economies over the short term. Local governments investing project generated tax revenues into infrastructure and other required services could enhance economic productivity over the long term.

The management and disposal of spent nuclear fuel, low level radioactive waste, hazardous waste, and nonhazardous waste requires an increase in energy and consumes space at treatment, storage, or disposal facilities. Regardless of the location, the use of land to meet waste disposal needs would reduce the long term productivity of the land.

Power plant facilities are committed to electricity production over the short term. After decommissioning these facilities and restoring the area, the land could be available for other future productive uses.

4.17.3 Irreversible and Irretrievable Commitments of Resources

This section describes the irreversible and irretrievable commitment of resources that have been noted in this SEIS. Resources are irreversible when primary or secondary impacts limit the future options for a resource. An irretrievable commitment refers to the use or consumption of resources that are neither renewable nor recoverable for future use. Irreversible and irretrievable commitment of resources for electrical power generation include the commitment of land, water, energy, raw materials, and other natural and man made resources required for power plant operations. In general, the commitment of capital, energy, labor, and material resources are also irreversible.

The implementation of any of the energy alternatives considered in this SEIS would entail the irreversible and irretrievable commitment of energy, water, chemicals, and—in some cases—fossil fuels. These resources would be committed during the license renewal term and over the entire life cycle of the power plant, and they would be unrecoverable.

Energy expended would be in the form of fuel for equipment, vehicles, and power plant operations and electricity for equipment and facility operations. Electricity and fuel would be purchased from offsite commercial sources. Water would be obtained from existing water supply systems. These resources are readily available, and the amounts required are not expected to deplete available supplies or exceed available system capacities.

4.18 References

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5.0 CONCLUSION

This draft supplemental environmental impact statement contains the environmental review of the application for renewed operating licenses for Sequoyah Nuclear Plant, Units 1 and 2 (SQN), submitted by Tennessee Valley Authority (TVA), as required by the *Code of Federal Regulations* (CFR), Part 51 of Title 10 (10 CFR Part 51), the U.S. Nuclear Regulatory Commission's (NRC's) regulations that implement the National Environmental Policy Act (NEPA). This chapter presents conclusions and recommendations from the site-specific environmental review of SQN. Section 5.1 summarizes the environmental impacts of license renewal; Section 5.2 presents a comparison of the environmental impacts of license renewal and energy alternatives; and Section 5.3 presents the NRC staff conclusions and recommendation.

5.1 Environmental Impacts of License Renewal

The NRC staff's review of site-specific environmental issues in this SEIS leads to the conclusion that issuing renewed licenses at SQN would have SMALL impacts for the Category 2 issues applicable to license renewal at SQN. The NRC staff considered mitigation measures for each Category 2 issue, as applicable. The NRC staff concluded that no additional mitigation measure is warranted.

5.2 Comparison of Alternatives

In Chapter 4, the staff considered the following alternatives to SQN license renewal:

- no-action alternative,
- natural gas combined-cycle alternative,
- super-critical pulverized coal alternative,
- new nuclear alternative, and
- combination alternative (wind, solar)

Based on the summary of environmental impacts provided in Table 2–2, the NRC staff concluded that the environmental impacts of renewal of the operating licenses for SQN would be smaller than those of feasible and commercially viable alternatives. The no-action alternative, the act of shutting down SQN on or before its licenses expires, would have SMALL environmental impacts in most areas with the exception of socioeconomic impacts which would have SMALL to LARGE environmental impacts. Continued operations would have SMALL environmental impacts in all areas. The staff concluded that continued operation of the existing SQN is the environmentally preferred alternative.

5.3 Recommendation

The NRC's preliminary recommendation is that the adverse environmental impacts of license renewal for SQN are not great enough to deny the option of license renewal for energy-planning decisionmakers. This recommendation is based on the following:

- the analysis and findings in NUREG-1437, Volumes 1 and 2, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*,
- the Environmental Report submitted by TVA,

- consultation with Federal, state, and local agencies,
- the NRC staff’s environmental review, and
- consideration of public comments received during the scoping process.

6.0 LIST OF PREPARERS

Members of the U.S. Nuclear Regulatory Commission's (NRC's) Office of Nuclear Reactor Regulation (NRR) prepared this supplemental environmental impact statement (SEIS) with assistance from other NRC organizations and contract support from Pacific Northwest National Laboratory (PNNL), the Center for Nuclear Waste Regulatory Analyses (CNWRA) and a private contractor. Table 6–1 identifies each contributor's name, affiliation, and function or expertise.

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[a] PNNL is operated by Battelle for the U.S. Department of Energy.
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APPENDIX A
COMMENTS RECEIVED ON THE SQN ENVIRONMENTAL REVIEW

COMMENTS RECEIVED ON THE SQN ENVIRONMENTAL REVIEW

A.1 Comments Received During the Scoping Period

The scoping process for the environmental review of the license renewal application for Sequoyah Nuclear Plant, Units 1 and 2 (SQN) began on March 8, 2013, with the publication of the U.S. Nuclear Regulatory Commission's (NRC's) Notice of Intent to conduct scoping in the *Federal Register* (78 FR 15055). The scoping process included two public meetings held in Soddy-Daisy, Tennessee, on April 3, 2013. Approximately 80 people attended the meetings. After the NRC's prepared statements pertaining to the license renewal process, the meetings were open for public comments. Attendees provided oral statements that were recorded and transcribed by a certified court reporter. A summary and transcripts of the scoping meetings are available using the NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS Public Electronic Reading Room is accessible at http://www.nrc.gov/reading-rm/adams.html. The scoping meetings summary is listed under ADAMS Accession Number ML13108A146. Transcripts for the afternoon and evening meetings are listed under Accession Numbers ML13108A137 and ML13114A124, respectively. In addition to comments received during the public meetings, comments were also received electronically.

Each commenter was given a unique identifier, so every comment can be traced back to its author. Table A–1 identifies the individuals who provided comments and an accession number to identify the source document of the comments in ADAMS.

Specific comments were categorized and consolidated by topic. Comments with similar specific objectives were combined to capture the common essential issues raised by commenters. Comments fall into one of the following general groups:

- Specific comments that address environmental issues within the purview of the NRC environmental regulations related to license renewal. These comments address Category 1 (generic) or Category 2 (site-specific) issues identified in NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS) or issues not addressed in the GEIS. The comments also address alternatives to license renewal and related Federal actions.

- General comments in support of or opposed to nuclear power or license renewal or comments regarding the renewal process, the NRC's regulations, and the regulatory process.

- Comments that address issues that do not fall within or are specifically excluded from the purview of NRC environmental regulations related to license renewal. These comments typically address issues such as the need for power, emergency preparedness, security, current operational safety issues, and safety issues related to operation during the renewal period.

Comments that are general or outside the scope of the environmental review for SQN license renewal are not included here but can be found in the Scoping Summary Report (ADAMS Accession No. ML14041A118). To maintain consistency with the Scoping Summary Report, the unique identifier used in that report for each comment is retained in this Appendix A. Comments addressed in this Appendix A are identified in the meeting transcripts and written comments provided at the end of the Scoping Summary Report.

Table A–1. Individuals Providing Comments During the Scoping Comment Period

Each commenter is identified along with their affiliation and how their comment was submitted.

Commenter	Affiliation (if stated)	ID	Comment source	ADAMS Number
Jaak Saame		1	Web	ML13091A018
David Lochbaum	Union of Concerned Scientists	2	Web	ML13101A117
Adelle Wood		3	Web	ML13116A292
Jeannie Hacker-Cerulean	University of Tennessee at Chattanooga	4	Web	ML13116A293
Sylvia D. Aldrich		5	Web	ML13116A295
Eric Blevins		6	Web	ML13116A296
Tara Pilkinton		7	Web	ML13116A294
Brian Paddock	Resident	8	Email Evening meeting	ML13119A111 ML13114A124
Tim Anderson		9	Email Evening meeting	ML13142A389 ML13114A124
Gretel Johnston	Bellefonte Efficiency & Sustainability Team Mothers Against Tennessee River Radiation	10	Email Afternoon meeting	ML13119A113 ML13108A137
Sandra Kurtz	Resident	11	Email Afternoon meeting Evening meeting	ML13119A203 ML13108A137 ML13114A124
Unknown name Initials: CS		12	Web	ML13121A158
Yolanda Moyer		13	Web	ML13130A238
Judith Canepa	New York Climate Action Group	14	Web	ML13130A239
Tom Clements	Friends of the Earth	15	Mail	ML13149A008
Hardie Stulce	Resident	16	Afternoon meeting	ML13108A137
Don Safer	Resident	17	Afternoon meeting Evening meeting	ML13108A137 ML13114A124
Kathleen Ferris	Resident	18	Afternoon meeting Evening meeting	ML13108A137 ML13114A124
Jimmy Green	Resident	19	Evening meeting	ML13114A124
Garry Morgan	Non-Resident	20	Evening meeting	ML13114A124
Ann Harris	Resident	21	Evening meeting	ML13114A124
Kristina Lambert	BREDL	22	Mail	ML13130A244

Comments received during the scoping comment period applicable to this environmental review were placed into 1 of 9 categories, which are based on topics contained in the SQN draft supplemental environmental impact statement (DSEIS). These categories and their abbreviation codes are listed in Table A–2.

The following pages contain the comments, identified by the commenter’s ID, comment number, and comment issue category along with the NRC staff response. Comments are presented in the same order as listed in Table A–2.

Table A–2. Issue Categories

Comments were divided into the 9 categories below, each with a unique abbreviation code.

Code	Technical Issue
AL	Alternatives
AE	Aquatic Ecology
CC	Climate Change
GW	Groundwater
HH	Human Health
LR	License Renewal and NEPA Process
PA	Postulated Accidents and SAMA
RW	Radiological Waste
SW	Surface Water

A.1.1 Alternatives

Comments:

8-4-AL: NEPA requires a hard look and that's a very interesting test for a lawyer. What's a hard look? And I've read hundreds of NEPA cases and it varies, but it does not appear here that there has been or so far an active consideration of what would be called the no action option which would be not to issue a license extension and to put the plant into a posture where it would be decommissioned at the termination of the existing license period.

8-6-AL: And secondly, the GAO did a similar study, full consideration of energy efficiency and better capital expense for planning. GAO, when they say we don't think that TVA has really looked at the realistic potential for energy efficiency. So those are yet unoffered.

One other factor you should look at is that the USEC, the United States Enrichment Corporation, which is a shuck and a boondoggle and has been for years, to create nuclear fuel, has announced that it is closing this year. That represents five percent of the entire load and production of electricity. So we're going to have a five percent decline this year apart from any other energy efficiency.

9-7-AL: We also request an evaluation process as to whether this "proposed" increase in demand for energy could not be met with any other form of energy, such as solar or hydro, an energy source that doesn't carry the threat of a 25 mile dead zone for hundreds of years.

9-10-AL: In accordance with NEPA and Section 309 of the Clean Air Act, we ask for an evaluation of alternative modes of facility operations, including answering the question, can a portion or even all of this "proposed" energy demand be met more cost effective with environmentally friendly renewable energy, and ask that you evaluate alternative technologies and mitigation measures, and the environmental impact of these alternatives.

10-1-AL: I come here today, first of all, I'd like to challenge a basic assumption that's in this Environmental Report. And that is that the only alternative to extending this license is either to do nothing and decommission, which I would recommend, or to -- the other option is called, in your own words, as the "reasonable alternative energy sources" as an option. But the only options that are given in this study are nuclear and gas powered power plants.

And many, many studies -- and I've included them in the literature -- have addressed the issue of how to replace -- as we retire coal plants and nuclear plants, how we replace dirty energy with clean energy. And the first and foremost choice that we advocate is energy efficiency.

Energy efficiency cannot only replace all the power that's being generated by Sequoyah at this time and quickly. It does not come on line slowly; it comes on line quickly and creates a lot of jobs and it's less expensive by far than nuclear. But it also will improve the homes of the people of the Tennessee Valley. It will improve your lives by giving you smaller electric bills every month and as well as creating jobs and not fouling our nest and putting dangerous radioactive poisons into our ecosystem or fossil fuels either.

So our first line we recommend is that this basic assumption that the only alternatives are dirty fuels being looked at carefully and examined and that that assumption be renegotiated for the power plant. That, if in fact another option is taken, that that could be renewable energy or the first line we would recommend is energy efficiency.

In a study by Georgia Tech and Duke University a couple of years ago asserted that energy efficiency programs in one decade in the South alone could create 380,000 new jobs. That's between 2010 and 2020, 380,000 new jobs. It would lower electricity bills by 41 billion dollars. And all while eliminating the need for new power plants for two decades and saving 8.6 billion gallons of fresh water. Now that's a major environmental concern. And if this truly is an environmental study, I think that this has to be taken into consideration and considered as a viable modern alternative.

So we call first of all for energy efficiency.

10-14-AL: First, we think it is important to challenge the stated assumption that, "Possible alternatives to the proposed action (license renewal) include no action and reasonable alternative energy sources," given that only nuclear and gas power plants are considered as "reasonable alternative energy sources." We assert that Energy Efficiency and Renewable Energy are "reasonable alternative energy sources" that need to be identified and evaluated in the Supplemental Environmental Impact Statement (SEIS). To support our claim, we enter into the record multiple studies showing that Energy Efficiency Programs are definitively more economically viable and environmentally "reasonable alternative energy sources" than nuclear or gas power plants.

All of the power generated by Sequoyah can be replaced by energy efficiency alone and new power can be generated with renewable sources, such as wind or solar. In fact, Energy Efficiency Programs can readily replace the existing power and provide for future power needs – offering significantly more jobs, coming 'on-line' more quickly, and enhancing the quality of life of TVA rate-payers by improving the efficiency of our homes, reducing monthly electric bills, and improving our environment by not emitting toxic waste. According to a Georgia Tech and Duke University study, assertive energy efficiency programs in one decade in the south alone can create 380,000 new jobs and lower utility bills by $41 billion, while eliminating the need for new power plants for two decades, and saving 8.6 billion gallons of fresh water.

And if more energy does need to be generated, solar is now less expensive than nuclear, and a 2012 federal report on renewable energy states that Tennessee alone has the technical potential of generating well over 2 million GWh of utility scale solar power.

Rather than "reasonable alternative energy sources", we believe this false assumption of limited options is biased toward environmentally unsound choices requiring the use of dirty nuclear and fossil fuels rather than the best replacement of existing power - which is first and foremost that of demand reduction through energy efficiency and heat recycling, and secondly through environmentally sustainable renewable energy such as wind and solar. That the SEIS has not included these options with its nuclear and gas generation alternatives indicates how behind-the times TVA seems determined to remain, no matter what the cost to rate-payers or the environment. The NRC should not accept this assessment of environmental impact without studying and reasonably adjusting these basic assumptions about viable alternatives.

10-21-AL: We know that energy efficiency programs can 'supply' the energy we need at less cost for TVA and at greater benefit to the people of this valley. We also know that renewable electricity can be generated for less money and with significantly less risk to human habitat. What we do not know is why the NRC continually enables an industry that is willing to gamble with human lives and habitats, despite the "reasonable alternative energy sources" of energy efficiency and renewables.

11-19-AL: I know that Gretel had just spoken about the decommissioning plans and the fact that there are only two alternatives mentioned, both of which either say decommission -- and we would recommend that -- or and build a new -- but the alternative also says if you want a new 40-year licensed nuclear plant. But you can't do it on the Sequoyah nuclear site. It's already poisoned actually. So that doesn't sound like a good plan. We wouldn't recommend any more nuclear plants.

The other is the gas fired generators to replace Sequoyah Nuclear Plant, but again not on the Sequoyah Nuclear Plant site because it's sort of no man's land when you get a nuclear plant. People can't go there again. It's kind of like a land grab, it seems to me, kind of giving away your land which can never be entered again because it always -- even in decommissioning, because it always has to be protected from the radiation. So you're giving away to land to think about having nuclear plants. But if they're going to be decommissioned, it has to be certainly safe, too.

There are alternatives and I, too, would suggest that NRC consider other alternatives besides just those two.

11-26-AL: And the idea that we don't need to replace that energy or that it could be replaced with solar alternative or other alternative energies.

11-38-AL: The SEIS states that there are only two feasible alternatives to consider meeting the need for power in the future? Alternatives: 1. Decommission SQN and build a new nuclear plant replacement with a 40-year license somewhere besides the SQN site. 2. Construct new natural gas-fired generators and infrastructure in place of SQN, but not on the SQN site. Can it be that TVA and NRC cannot think of any other alternatives such as shutting SQN down and meeting power demand and even baseload with solar, wind, energy efficiency, demand-side management, and other now-viable energy alternatives to name some? These will be cheaper, healthier and safer. Consider other alternatives.

14-7a-AL: We support the swift transfer to renewable energy technologies. Such a transfer is not only possible, it is possible now, and absolutely essential for the sustainability of human life. If Germany, Denmark, and other countries can do it, so can the United States.

17-8-AL: The other thing that I would like -- next thing I'd like the NRC to consider in this application is the need for the power from this risky type of power. Last year alone in 2012, according to the USA Today there was over 13,000 megawatts of wind power installed in the United States. That's 13 reactors like Sequoyah. In one year without hearings like this, without the need to go through these types of procedures, without the risk to the public, without the evacuation plans, without the radioactive waste.

17-11-AL: So back to the need for it, the wind potential, the solar potential in the valley, at this point TVA is putting a restriction on the amount of solar that can be installed. There's so much more potential to install solar and it won't even cost TVA anything but the feed-in tariff. People are willing to spend their own money, put these solar panels on their roofs. And TVA is putting a limit on how much solar power can go on people's roofs.

17-12-AL: And there are credible sources. The National Renewal Energy Lab in Colorado, it's a Department of Energy funded think tank on renewable energy. It says we can get all of our power in a reliable grid by 2040 -- or 80 percent of our power in a reliable grid by 2040 from all renewable sources. And that's not with -- that's without even evolving the renewable technology like it's going to evolve.

17-22-AL: The lack of need, just this last year 2012, over 13,000 megawatts of wind power was put in place in the United States. It required no scoping hearings about massive releases of radiation. That's 13 nuclear power plants the size of Sequoyah that have gone online in the U.S.

TVA has a proposal in front of them today for 3,500 megawatts of wind power to be brought in from Oklahoma by a private company on a direct current line through Arkansas and put into the TVA grid in Memphis to be used. That's 3,500 megawatts. That's both Sequoyah Plant and the Gallatin Steam Plant. That's just scratching the surface of what wind can do.

Solar energy is -- TVA is putting the brakes on solar every way that it can in every possible situation. Just look it up. There's a budding solar energy industry in the Valley. A lot of jobs, a lot of installers, it's jobs that can't be exported. It's jobs that will continue. And the people who have put solar on their roofs have guaranteed what their cost is going to be for 30 years. TVA needs to encourage that instead of this license renewal.

19-1-AL: The main point I want to make is we wanted to make sure that the NRC is aware that TVA is beginning to enter into the process of developing an updated, integrated resource plan. Probably at the end of this year they're going to get started seriously on that. This will inform the question of whether or not the power generated by this plant is needed.

And so we would recommend that you closely follow the IRP process of TVA to see how that calculation plays out. Clearly not using this energy is going to be the most efficient way to go and the least environmental impact. And that's the thing we're always recommending, energy efficiency and renewable energy as a clean and preferred alternative.

Response: *These comments concern renewable energy replacement power and energy efficiency alternatives to SQN and assert that the environmental impact statement should address the no-action alternative to license renewal at SQN. In evaluating alternatives to license renewal, the NRC staff considered energy technologies or options currently in commercial operation, as well as technologies not currently in commercial operation but likely to be commercially available by the time the current SQN operating licenses expire.*

The NRC staff evaluated 18 alternatives to the proposed action in the SQN DSEIS. Alternatives that could not provide the equivalent of SQN's current generating capacity and, in some cases, those alternatives whose costs or benefits did not justify inclusion in the range of reasonable alternatives, were eliminated from detailed consideration. The NRC staff explained the reasons why each of these alternatives was eliminated from further consideration in section 2.3 of the SQN DSEIS. The 18 alternatives were narrowed to 4 alternatives considered in detail in sections 2.2.2.1–2.2.2.4 of the SQN DSEIS. The NRC staff evaluated the environmental impacts of these four alternatives and the no-action alternative in Chapter 4 of the SQN DSEIS.

8-11-AL: Articles to be considered in the environmental review: GAO Report GAO-12-107 - Tennessee Valley Authority, Full Consideration of Energy and Efficiency and Better Capital Expenditures Planning Are Needed; and, Global Energy Partners' Study Identifies Significant Energy Savings Potential for TVA Customers.

10-10-AL: Article to be considered in the environmental review: Executive Summary Energy Efficiency in the South.

10-11-AL: Article to be considered in the environmental review: GAO Report GAO-12-107 - Tennessee Valley Authority, Full Consideration of Energy and Efficiency and Better Capital Expenditures Planning Are Needed.

14-7b-AL: See the work of Mark Z. Jacobson, professor at Stanford University: Shifting the world to 100% clean, renewable energy by 2030 at http://news.stanford.edu/news/2009/october19/jacobson-energy-study-102009.html.

Response: *The NRC staff read and considered each of the articles and the web-site mentioned in the comments above. Most of the information in these articles is general in nature and was not used in development of the alternatives sections of the SQN DSEIS. However, the Global Energy Partners Study that TVA commissioned on energy efficiency potential was discussed in SQN DSEIS section 2.1.1.3.*

A.1.2 Aquatic Ecology

Comments:

8-1-AE: I happen to also be the Tennessee Local Counsel for a Challenge to the Environmental Impact Statement for the Watch Bar 2 Unit, which is still under construction and for which there are still legal contentions pending as to the impact on water temperature and aquatic resources.

I suggest that the NRC staff take a close look at this because all of the aquatic impacts heretofore in the licensing of these reactors was done, based on modeling and not based on any real world measurements. Since then TVA has gone back and done a considerable amount of real world biological assessment and quite frankly, they have done a pretty good job of it.

And you might look at what they've done in terms of dealing with the Watts Bar 2 litigation contest and see if you don't think they need to do the same thing with respect to the impacts of the cooling water and resulting hot water from the plants under consideration here.

Response: *This comment suggests that the NRC closely consider a legal challenge concerning aquatic resources to construction of Watts Bar Nuclear Power Plant (WBN), Unit 2, for potential implications for the SQN license renewal application environmental review.*

WBN is located in southeastern Tennessee approximately 50 miles northeast of Chattanooga and is owned by TVA. The site has two Westinghouse-designed pressurized water reactors.

WBN Unit 1 received a full power operating license in early 1996, and is presently the last power reactor to be licensed in the U.S. TVA suspended construction of WBN Unit 2 in 1985. In 2007, TVA informed NRC of its plan to resume construction of WBN Unit 2. The NRC staff is working towards supporting an operating license decision in 2015.

In May 2013, the NRC staff published "Final Environmental Statement Related to the Operation of Watts Bar Nuclear Plant, Unit 2, NUREG-0498"*.*

*On November 21, 2013 the NRC issued an Order extending the Watts Bar Unit 2 construction completion date to September 30, 2016 (*78 FR 72120*).*

The contention this comment refers to alleged that the discussion of impacts to aquatic resources in TVA's Final Environmental Statement was insufficient.

The intervener who submitted the contention subsequently withdrew it based on its view that "the Nuclear Regulatory Commission (NRC) Staff's recently-issued Final Environmental Impact Statement is responsive to the majority of concerns raised in Contention 7, and that any *remaining concerns are best addressed outside of the adjudicatory process." This contention, Contention 7, is available at ADAMS Accession Number ML12066A185. The granting of the request to withdraw the contention is available at ADAMS Accession Number ML13198A195.*

The NRC staff discussed the effect of SQN license renewal on water temperature and aquatic resources in SQN DSEIS section 4.7. The NRC staff also discussed the effects of WBN Unit 2 and other possible stressors on ecological resources as part of cumulative impacts in SQN DSEIS section 4.16.

9-11-AE: We need a detailed report as to the entrainment and impingement impacts on marine life; the impacts of the cooling water discharges and thermal backwash operations and fish return systems, we ask that you look at retrofitting the current open loop cooling systems to mitigate these impacts.

11-9-AE: So I'm concerned about the use of that water, two-thirds of which does not go back into the river after it's used to cool. The rest of it is hot and so we worry about the fish and the aquatic community there in that whole ecosystem.

11-11-AE: And the rest goes back into the river and is hot. There are regulations about how hot it can be, but it is hot and it goes back into the river and affects the fish. Although as I've been told, fish can swim around the hot parts. But there are other macro invertebrates and small critters in the water that are called the drift community and they cannot swim around. They are subject to whatever they run into. So that's a problem.

11-34-AE: The water returned to the river is carrying heat that has impacts for the aquatic ecosystem. While fish can move to avoid heated water plumes, the aquatic drift community and certain macroinvertebrates upon which fish feed cannot.

Response: *These comments concern the effects of entrainment, impingement, thermal effluent and water loss on aquatic resources. The NRC staff described and examined the effects of entrainment, impingement, thermal effluent and water use conflicts on aquatic resources in SQN DSEIS sections 3.7 and 4.7. Regarding changes to the cooling water system, the U.S. Environmental Protection Agency and the State of Tennessee, not the NRC, oversee impacts at the cooling water intake structure and of the effluent through the National Pollution Discharge Elimination (NPDES) permitting process. The U.S. EPA and the State of Tennessee are responsible for protection of aquatic resources through the NPDES permitting process.*

A.1.3 Climate Change

Comments:

11-8-CC: And we have climate disruption – more storms, more problems that way.

11-13-CC: We cannot have nuclear plants using all that water that could be used for other uses. And it's just evaporating into the air for the most and that is – that also causes climate change, climate disruptions as well. So I think we need to – I think that we are going to have continued drought conditions in between storms if the predictions are correct about that.

And we are also going to have hotter water and that has caused some shutdowns of nuclear plants already here in the Tennessee Valley. I know that Sequoyah and Watts Bar have both shut down because the water in the river was too hot to take the hot water that the nuclear plants were putting into it. So those shut-downs that are caused by climate should be a significant environmental impact and should be considered as one of the possible things to analyze as to how that's going to work.

11-22-CC: …climate disruption patterns which should be updated.

11-35-CC: In a climate unstable world, water will be THE ultimate constraining resource. We have already seen TVA's nuclear plants shut down because of summer temperatures that prevented proper cooling. With temperatures rising scientists predict periods of excessive rain, severe drought conditions, and hotter temperatures in the summer here. Climate change must be addressed as an environmental impact for this SEIS.

Response: *These comments express concerns over climate change impacts to the environment and to SQN. In SQN DSEIS section 4.15.3, the NRC staff discussed potential impacts from climate change to: air quality; land use; water, terrestrial and aquatic resources; historic and cultural resources; socioeconomics; human health; and, environmental justice. In this section, the NRC staff also discussed greenhouse gas (GHG) emissions from the proposed SQN license renewal and alternatives to license renewal. The impact of GHG emissions resulting from continued operation of SQN during the proposed license renewal term on global climate change when added to the aggregate effects of other past, present, and reasonably foreseeable future actions are discussed in SQN DSEIS section 4.16.12.*

A.1.4 Groundwater

Comments:

3-7-GW: Other concerns include safety of drinking water …

9-15-GW: Any study should include the impact of the more than thirty documented spills of radioactive material into the water and food supply that have already occurred in the Tennessee Valley by this operator.

A local history of radioactive leaks into the groundwater and Tennessee River.

20100407 Browns Ferry Unit 3 Approximately 1,000 gallons of radioactively contaminated water leaked from Condensate Storage Tank No. 5 as workers were transferring water between condensate storage tanks. A worker conducting routine rounds observed water leaking from an open test valve near the top of CST No. 5.

20080105 Browns Ferry Unit 3 The condensate storage tank overflowed due to failed tank level instrumentation. The spilled water flowed into the sump in the condensate piping tunnel, triggering a high level alarm that prompted workers to initiate the search that discovered the overflow condition. Some of the spilled water may have permeated through the pipe tunnel into the ground.

20060700 Sequoyah Unit 1 An investigation to identify sources of tritium in groundwater found detectable levels of tritium in the Unit 1 and Unit 2 refueling water storage tank moat water.

20060700 Sequoyah Unit 2 An investigation to identify sources of tritium in groundwater found detectable levels of tritium in the storage tank moat water.

20060200 Browns Ferry Unit 3 A soil sample taken from underneath the radwaste ball joint vault (located outside the radwaste doors) indicated trace levels of cobalt-60 and cesium-137.

20060200 Browns Ferry Unit 1 A soil sample taken from underneath the radwaste ball joint vault (located outside the radwaste doors) indicated trace levels of cobalt-60 and cesium-137.

20060200 Browns Ferry Unit 2 A soil sample taken from underneath the radwaste ball joint vault (located outside the radwaste doors) indicated trace levels of cobalt-60 and cesium-137.

20051100 Browns Ferry Unit 1 Tritium levels greater than baseline values were detected in an underground cable tunnel between the intake structure and the turbine building. Samples taken in January 2006 identified gamma emitters in addition to tritium (beta emitter).

20051100 Browns Ferry Unit 2 Tritium levels greater than baseline values were detected in an underground cable tunnel between the intake structure and the turbine building. Samples taken in January 2006 identified gamma emitters in addition to tritium (beta emitter).

20051100 Browns Ferry Unit 3 Tritium levels greater than baseline values were detected in an underground cable tunnel between the intake structure and the turbine building. Samples taken in January 2006 identified gamma emitters in addition to tritium (beta emitter).

20050000 Watts Bar Unit 1 The radwaste line was discovered to be leaking.

20050300 Browns Ferry Unit 1 A leak in a pipe elbow on the east side of the cooling tower and an overflow of the cooling tower basin caused by malfunction of the system level indicators resulted in radioactive contamination of the concrete pad and ground around the tower.

20050300 Browns Ferry Unit 2 A leak in a pipe elbow on the east side of the cooling tower and an overflow of the cooling tower basin caused by malfunction of the system level indicators resulted in radioactive contamination of the concrete pad and ground around the tower.

20050300 Browns Ferry Unit 3 A leak in a pipe elbow on the east side of the cooling tower and an overflow of the cooling tower basin caused by malfunction of the system level indicators resulted in radioactive contamination of the concrete pad and ground around the tower.

20040000 Watts Bar Unit 1 The radwaste line was discovered to be leaking.

20030000 Watts Bar Unit 1 Beginning in 2003, tritium leaching into the ground from the plant has been found in site monitoring points.

20020400 Sequoyah Unit 1 Prior to excavation for the steam generator replacement crane foundation, sampling identified contaminated soil surrounding the Unit 1 refueling water storage tank moat drain.

20010100 Browns Ferry Unit 3 Tritium levels greater than baseline values were detected in an onsite monitoring well west of the Unit 3 condenser circulating water conduit in the radwaste loading area.

19981200 Watts Bar Unit 1 Radioactively contaminated soil was discovered beneath the concrete radwaste pad.

19980100 Sequoyah Unit 2 Radioactively contaminated water overflowed the Unit 2 additional equipment building sump and out the doorway to the ground outside.

19970500 Sequoyah Unit I Approximately 3,000 gallons of radioactively contaminated water spilled from the modularized transfer demineralization system when a conductivity probe failed. An estimated 600 to 1,000 gallons flowed through the railroad bay door to the ground outside.

19970500 Sequoyah Unit 2 Approximately 3,000 gallons of radioactively contaminated water spilled from the modularized transfer demineralization system when a conductivity probe failed. An estimated 600 to 1,000 gallons flowed through the railroad bay door to the ground outside.

19950500 Sequoyah Unit 2 Workers identified contaminated soil at the outfall of the Unit 2 refueling water storage tank moat drain pipe.

19850000 Sequoyah Unit 1 Radioactively contaminated water leached through a concrete wall of the condensate demineralizer waste evaporator building into the ground.

19850000 Sequoyah Unit 2 Radioactively contaminated water leached through a concrete wall of the condensate demineralizer waste evaporator building into the ground.

19830116 Browns Ferry Unit 3 A leaking tube in a residual heat removal heat exchanger allowed radioactive water from the reactor coolant system to be released to the river at levels exceeding technical specification limits.

19780715 Browns Ferry Unit 1 After the unit was shut down for maintenance, the residual heat removal system was placed in operation to assist shut down cooling of the reactor vessel water. Workers determined that a residual heat removal heat exchanger had a tube leak and that radioactively contaminated water was being discharged to the Tennessee River "at a rate above permissible limits."

19770104 Browns Ferry Unit 1 A leak in a residual heat removal heat exchanger allowed radioactive water to be released to the river at levels exceeding technical specification limits.

19731019 Browns Ferry Unit 1 About 1,400 gallons of liquid radwaste of unknown, unanalyzed concentration was inadvertently discharge to the river due to personnel error. The liquid radwaste tank was intended to be placed in recirculation mode but was mistakenly placed in discharge mode. *Source; Union of concerned scientist and NRC*

15-16 January 1983 Nearly 208,000 gallons of water with low-level radioactive contamination was accidentally dumped into the Tennessee River at the Browns Ferry power plant.

11-16-GW: So in both 2003 and in 2011, tritium was found in the ground water at Sequoyah.

Response: *These comments concern impacts to groundwater from past actions and from the proposed license renewal of SQN. Documented spills (including tritium spills) are identified in section 3.5.2 and their impact on groundwater is described in section 4.5 of the SQN DSEIS.*

The cumulative effect on groundwater from the aggregate of past, present, and reasonably foreseeable future actions over the proposed license renewal period is evaluated in section 4.16.3.2 of the SQN DSEIS. This section considers the total effect of actions that could impact groundwater (including both direct and indirect effects) no matter who has taken the actions (Federal, State, County, or private).

A.1.5 Human Health

Comments:

3-5-HH: Certainly foremost in the public's mind is the fear of harmful radiation exposure to the public;

4-6-HH: We look forward to a decline in Leukemia rates after all the spent fuel is in casks.

5-6-HH: We look forward to a decline in Leukemia rates after all the spent fuel is in casks.

9-2-HH: Maybe the decision needs to be postponed for five years to reassess the needs and the dangers based upon real time, up-to-date health studies.

9-3-HH: We also ask that the Commission include the following internationally recognized study as a basis for any comprehensive human health impact studies. These reports show a positive link between increased cancer rates and the release of low, mid, and high level releases.

There are many studies regarding the fallout of Chernobyl and the true effects to the population that are not being considered. These reports even by the most conservative estimates state that over one million additional cancer cases have been attributed to that disaster – FOR YOU EIS TO SHOW NO HARMFUL EFFECTS can't even be true due to the fact that even your own reports define an acceptable risk margin, to the population of one in 500 people therefore the fact is there are additional cancer rates that your report uses as a baseline and thus marginalizes. We just want the public to know the truth.

And the studies that should be included are the American Academy of Sciences 2008 Biological Effects of Ionizing Radiation reports there's no safe level of radiation.

European Committee on Radiation Risk argues that the existing risk model used by the NRC does not take internal exposure into account. High rates of internal exposure will mean a dramatic increase in cancer risks for Fukushima residents with as many as 400,000 additional cases predicted by this model by 2061.

The Office of Science and Financial Assistance Program Notice 9914, Low Dose Radiation, says, "Each unit of radiation, no matter how small, can cause cancer and most of the projected radiation exposures associated with human activity over the next 100 years will be low dose and low dose-rate radiation from medical tests, waste clean-up, and environmental isolation of materials associated with nuclear weapons and nuclear power production."

The German Federal Office of Radiation Protection titled Epidemiology Study of Childhood Cancer in the Vicinity of Nuclear Power Plants shows a causative link to young children developing cancer more frequently when they live near nuclear power plants.

The American Cancer Society states that ionizing radiation is a proven human carcinogen. And they go on to say that people living near or down-wind of a plant are known as down-winders.

Any EIS should include a comprehensive study as to the effects on the citizens and the commerce and the environment of having onsite storage, above ground storage of high level nuclear waste. Specifically the dangers of such storage and the fact that the storage site is already three times its designed capacity.

9-5-HH: The American Cancer society states "Ionizing radiation" is a proven human carcinogen (cancer causing agent). The evidence for this comes from many different sources, including studies of atomic bomb survivors in Japan, people exposed during the Chernobyl nuclear accident, people treated with high doses of radiation for cancer and other conditions, and people exposed to radiation at work, such as uranium miners and nuclear plant workers. "They go on to say, "people living near or downwind (also known as down winders) of nuclear facilities may also be exposed to radioactive byproducts. Levels of radiation are likely to be higher near these sites, but some radioactive particles enter the atmosphere and travel great distances, landing thousands of miles away from the facility."

9-16-HH: Any EIS study should include the effects of storing nuclear material and waste on a site that is well over its design capacity, it should include a study as to how much the "background" radiation of the area will be increased based upon the increase in waste material and what is the long term and short effects as for the air, drinking water and food supply. In addition the study should include the health risk of and security risk of transporting the materials to other locations.

10-2-HH: And allowing radionuclides into our environment not only affects the food chain, but it affects our very DNA. It changes the structure of our genetic makeup. That's a long range issue, you know, just one of these radionuclides – the power plant creates 200. When the uranium goes in, it creates 200 poisons that don't exist in nature.

Our body doesn't know what to do with them, so they try and find the things that they most closely resemble, whether it be iodine or potassium or calcium. It tries to find that and it takes it up that way in the bones, in the thyroid, and different parts of the body. That's what it does with these radionuclides.

And they last for a very long time; some of them are short lived. But we're talking about 200. And some of them are extremely long lived. What is it? The iodine 129 lasts for – what is it, 570,000,000 years is the half life? That's 570,000,000 years, you know, that it's dangerous.

11-20-HH: I want to talk about radiation doses and you have – NRC has radiation doses. They have established standards and those standards for radiation tell all the nuclear plants what level of dosages are okay, in their opinion, okay for you to receive. Some small amount that they consider absolutely safe and below that there's no problem. And that's how they figure out what the dosage is going to be and how they say there's no public risk. But we all know that there is no safe dose of radiation because it's cumulative.

11-27-HH: I wanted to talk a little bit here though about radiation doses. Apparently it seems that the statement that the public will continue at current levels associated with normal operations and that these doses also for the occupational doses to employees are going to remain the same when the license is renewed. So we don't need to worry about that, but these doses are all well below the regulatory limits, they say. And so we don't need to worry.

Another 20 years of this is not good because in fact no dose of radiation is safe and it's cumulative. So the additional time there is going to continue to expose us citizens in a growing population, urban population, with more and more of this radiation that is emitted on a daily basis from a nuclear power plant.

The thing that happens is those daily radiation doses levels that they recommend seem to go up if there is more in the air and then they call it background radiation. But at Fukushima that's what happened. When the accident happened, suddenly the people that were supposedly not supposed to receive a dose at a certain level, suddenly it was okay for those people to receive a higher level and that was the standard that they set.

So the radiation standard seemed to change depending on how much is actually in the air. And our radiation background – so called background level – has been rising over these years. So it is cumulative. There is cancer risks even without the accident.

And I think the other thing is that the radiation standard – and maybe NRC can look at this in overall – the standard for how much dosage you could get is based on a what they call, the Reference Man. And the Reference Man is a German white male, about five foot nine and – five foot four and 150, 170 pounds, something like that.

Anybody qualify here?

The truth is that the studies now show that it is women and infants and fetuses that are more subject to radiation dose and cancer events.

So the problem is that the standard themselves are not right. And I think that really needs to be looked at.

11-39-HH: NRC found that radiation doses to the public will continue at current levels associated with normal operations and also for occupational doses to employees. We are told that the range of doses are all well below regulatory limits. Thus, it was concluded that since the range of dosages are well below regulatory limits, there is no significant additional impact if the license is renewed for another 20 years. The idea that we are all safe forever once one sets radiation exposure standards is not true. We know now that there is no safe dose of radiation and that those standards are likely to change as was done after Fukushima to protect the nuclear industry from public outrage. In fact, ionizing radiation is cumulative. There is cancer risk even without an accident. We have enough background radiation as is. A license to add human made radiation for another 20 years should not be granted.

12-6-HH: We look forward to a decline in Leukemia rates after all the spent fuel is in casks.

17-7-HH: The other major issue it's been mentioned about the children. In doing research on this in a Reuter's article from March 15th, 2011, it quoted, it said between 12,000 and 83,000 children were born with congenital deformities according to the German physicians group IPPNW, between 12,000 and 83,000 children born with deformities. Some of the deformities of these children, if you have the stomach for it, they're horrible. They're hardly human.

17-18-HH: It's a nightmare stew of toxic substances that absolutely have to be protected from the biosphere. And we are not doing a good job of that. And that's why the background radiation levels are increasing.

18-1-HH: For many decades we have been warned by physicians and public health officials, people like Helen Caldecott and Dr. John Gofman and Rosalie Bertell have told us the dangers of ionizing radiation to human health. We have been told that it damages DNA and causes mutations and that it is carcinogenic and especially to children. Now there's no debating the issue that nuclear reactors do emit radiation. There are routine emissions; there are spills; there are accidents, some more serious than others.

However, TVA and the NRC, I have yet to see a report that does not say, "No risk to the public," after one of these things occurs. These reactors pollute the environment, the water, the air. The rain rains down radionuclides onto the grass, gets into our plants, into our food chain.

There are many studies that have been done mostly abroad that show that people, especially children, who live near nuclear reactors have a higher incidence of cancer than the national averages or than people who live at a greater distance. Back in the 1980s there was one by at Sellafield in England that found clusters of leukemia and cancer. In Germany around the year 2010 was a government sponsored study that showed that the reactors tested there was almost double the rate of leukemia – well, over double the rate of leukemia and double the amount of other cancers in children. Another study at Chepstow, Wales, a very recent one, shows that three and a half times the risk of cancer to children than the national average.

Now just this past week another study came out from Sacramento. It was done at Sacramento County, California, where there are approximately 1.4 million people living. Rancho Seco is a reactor that has been closed for 23, over 23 years. This study shows – by going through all the cancer records of the state of California, they have shown that there is a drop of cancer incidents in the 20 years since the closing. A very precise number, 4,319 fewer cases over that 20 year period. And many of these are women, Hispanics, and children. Again children are some of the worst victims of radiation poisoning.

18-2-HH: National Academy of Sciences is currently carrying on a study of reactors in this country to see whether the cancer incidence is indeed higher or not. The NRC is sponsoring that study and it's not yet completed. Yet the NRC is going ahead with relicensing before knowing all the facts regarding human health in the vicinity of these plants.

18-4-HH: For decades the public has been warned by physicians and public health officials of the dangers of ionizing radiation. And people like Doctor Helen Caldecott and Doctor Samuel Epstein are continuing to warn us of the dangers.

We know that it causes changes in DNA that cause mutations. We know that it is carcinogenic and especially for children. And I suppose as a grandmother, the children are one of my main concerns. I've got two little daughters who live near Philadelphia, Pennsylvania and they are surrounded by nuclear reactors. So the things I've learned about cancer really are close to my heart.

It doesn't take a major accident for reactors to emit radiation. There are routine emissions that are required just to operate them safely, safer, more safely. There are spills. There are accidents and every time there are these – not catastrophic, but sometimes very close to catastrophic – events, TVA and NRC reassure the public there's no danger. There's no risk to the public. I don't know how many times I've read that on the NRC website.

What these reactors are doing is polluting the environment. They pollute the water. They pollute the air. When rain falls through polluted air, the radiation is washed down into the ground. The plants become radioactive. The cows eat the plants. The radioactive iodine goes into the cows' milk. The children drink the milk. It is not safe. This radiation is getting into our food chain. And since we eat lots of meat at the top of the food chain, we're getting a lot of radiation just without the catastrophic event.

Now there are several studies, as Mr. Anderson pointed out. There was one back in the 1980's in Sellafield, England that showed that clusters of cancers and leukemia. More recently around 2010, the Germany government sponsored a study of the reactors in Germany and they found for children under five years old they had more than doubled the incidents of leukemia and almost double for other types of cancer. Another study more recent from that is from Chepstow in Wales. They found that children were at three and one-half times the risk if they lived close to a nuclear reactor as the national average.

Now these are instances of cancers close to the nuclear reactors, but there's another study that came out; just last week it was released. It's from California, Sacramento County, which has a population of 1.4 million. Rancho Seco Reactor closed over 23 years ago and some scientists have been going through the cancer registry for California trying to determine what has happened to the cancer rate. They used the last two months of the reactor's operation and then they've been studying what's been happening in the intervening 20 years.

And what they found is that a very considerable drop in the cancer incidents since that time. They have found 4,319 fewer cancer cases over a 20 year period. That's more people than died in the Twin Towers. And of the people who are most effected are women, Hispanics, and children.

18-5-HH: An NAS study – there is a National Academy of Science study being sponsored by the NRC right now to try to determine what the cancer incidence is around nuclear reactors. And of that study which is continuing now – I'm sorry, I've lost my train of thought – okay, that study is not yet completed. And it probably won't be for several years.

So in addition to other questions asked about the timing for this relicensing, my question is why not wait until that study is in to determine whether we should be relicensing aging reactors.

Response: *The NRC's mission is to protect the public health and safety and the environment from the effects of radiation from nuclear reactors, materials, and waste facilities. A discussion of these responsibilities beginning with the Atomic Energy Act of 1954 can be found on the NRC website at http://www.nrc.gov/about-nrc/history.html. The NRC's regulatory limits for radiological protection are set to protect workers and the public from the harmful health effects* *(i.e., cancer and other biological impacts) of radiation on humans. The limits are based on the recommendations of standards-setting organizations. Radiation standards reflect extensive scientific study by national and international organizations. The NRC actively participates in and monitors the work of these organizations to keep current on the latest trends in radiation protection. If the NRC determines that there is a need to revise its radiation protection regulations, it will initiate a rulemaking. Members of the public who believe that the NRC should revise or update its regulations may request that the NRC do so by submitting a petition for rulemaking.*

The NRC has based its dose limits and dose calculations on a descriptive model of the human body referred to as "standard man." However, the NRC has always recognized that dose limits and calculations based on "standard man" must be informed and adjusted in some cases for factors such as age and gender. For example, the NRC has different occupational dose limits for pregnant women workers once they have declared (i.e., made known) they are pregnant because the rapidly developing human fetus is more radiosensitive than an adult woman. NRC dose limits are also much lower for members of the public, including children and elderly people, than for adults who receive radiation exposure as part of their occupation. Finally, NRC dose calculation methods have always included age-specific dose factors for each radionuclide in order to consider the varied sensitivity to radiation exposure by infant, child, and teen bodies, which are also generally smaller than adult bodies. In addition, the calculation methods have always recognized that the diets (amounts of different kinds of food) of infants, children, and teens are different from those of adults. NRC is currently updating 10 CFR Part 20 Standards for Radiation Protection and information about this rulemaking can be found at: http://www.nrc.gov/about-nrc/regulatory/rulemaking.html.

BEIR VII is the seventh in a series of publications from the National Academies concerning radiation health effects, referred to as the Biological Effects of Ionizing Radiation (BEIR) reports. The BEIR VII report titled "Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII – Phase 2) (National Research Council 2006), focuses on the health effects of low levels of low linear energy transfer (LET) ionizing radiation. Low-LET radiation deposits less energy in the cell along the radiation path and is considered less destructive per radiation track than high-LET radiation. Examples of low-LET radiation, the subject of this report, include X-rays and γ-rays (gamma rays). Health effects of concern include cancer, hereditary diseases, and other effects, such as heart disease. The NRC accepts the linear, no-threshold (LNT) dose-response model (see additional information at http://www.nrc.gov/about-nrc/radiation/health-effects/rad-exposure-cancer.html). The BEIR VII Committee concluded that the current scientific evidence is consistent with the hypothesis that there is a LNT dose-response relationship between exposure to ionizing radiation and the development of cancer in humans. Having accepted this model, the NRC believes that this model is conservative when applied to workers and members of the public who are exposed to radiation from nuclear facilities. This is based on the fact that numerous epidemiological studies have not shown increased incidences of cancer at low doses. Some of these studies included: (1) the 1990 National Cancer Institute study (NCI 1990) of cancer mortality rates around 52 nuclear power plants, (2) the University of Pittsburgh study that found no link between radiation released during the 1979 accident at the Three-Mile Island nuclear power station and cancer deaths among residents, and (3) the 2001 study performed by the Connecticut Academy of Sciences and Engineering that found no meaningful associations from exposures to radionuclides around the Haddam Neck nuclear power plant in Connecticut to the cancers studied. In addition, a position statement entitled "Radiation Risk in Perspective" by the Health Physics Society (August 2004) made the following points regarding radiological health effects: (1) Radiological health effects (primarily cancer) have been demonstrated in humans through epidemiological studies only at doses exceeding 5-10 rem delivered at high dose rates. Below *this dose, estimation of adverse effect remains speculative; and (2) Epidemiological studies have not demonstrated adverse health effects in individuals exposed to small doses (less than 10 rem delivered over a period of many years).*

One of the SQN public scoping comments stated that, based on the BEIR VII report, there is no safe dose of radiation. The BEIR VII report (National Research Council 2006) makes no such assertion that there is no safe level of exposure to radiation. Rather, the conclusions of the report are specific to estimating cancer risk. The report does not make any statements about "no safe level or threshold." However, the report did note that the "BEIR VII Committee said that the higher the dose, the greater the risk; the lower the dose, the lower the likelihood of harm to human health." Further, the report notes that "[t]he Committee maintains that other health effects, such as heart disease and stroke, occur at high radiation doses but that additional data must be gathered before an assessment of any possible dose response can be made of connections between low doses of radiation and non-cancer health effects." Although the LNT model is still considered valid, the BEIR VII Committee concluded that the current scientific evidence is consistent with the hypothesis that there is a linear dose-response relationship between exposure to ionizing radiation and the development of radiation-induced solid cancers in humans. Further, the Committee concluded "that it is unlikely that a threshold exists for the induction of cancers but notes that the occurrence of radiation-induced cancers at low doses will be small."

Although radiation may cause cancers at high doses, currently there are no reputable scientifically conclusive data that unequivocally establish the occurrence of cancer following exposure to low doses (i.e., below about 10 rem [0.1 Sv]). However, radiation protection experts conservatively 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 adverse impacts such as incidents of cancer. Simply stated, in this model any increase in dose, no matter how small, results in an incremental increase in health risk. This theory is accepted by the NRC as a conservative model for estimating health risks from radiation exposure, recognizing that the model probably over-estimates those risks. Based on this theory, the NRC conservatively establishes limits for radioactive effluents and radiation exposures for workers and members of the public. Although the public dose limit in 10 CFR Part 20 is 100 mrem (1 mSv) for all facilities licensed by the NRC, the NRC has imposed additional constraints on nuclear power reactors. Each nuclear power reactor has enforceable license conditions that limit the total annual whole body dose to a member of the public outside the facility to 25 mrem (0.25 mSv). The amount of radioactive material released from nuclear power facilities is well measured, well monitored, and known to be very small. The doses of radiation that are received by members of the public as a result of exposure to nuclear power facilities are very low (i.e., less than a few millirem) such that resulting cancers attributed to the radiation have not been observed and would not be expected. As stated in the GEIS, the NRC believes the public and occupational impacts during the license renewal term would be SMALL.

Although a number of studies of cancer incidence in the vicinity of nuclear power facilities have been conducted, no studies to date accepted by the scientific community show a correlation between radiation dose from nuclear power facilities and cancer incidence in the general public. The following is a list of some of the most recent radiation health studies that the NRC recognizes:

In 1990, at the request of Congress, the National Cancer Institute conducted a study of cancer mortality rates around 52 nuclear power plants and 10 other nuclear facilities. The study covered the period from 1950 to 1984, and evaluated the change in mortality rates before and *during facility operations. The study concluded there was no evidence that nuclear facilities may be linked causally with excess deaths from leukemia or from other cancers in populations living nearby.*

In June 2000, investigators from the University of Pittsburgh found no link between radiation released during the 1979 accident at Three Mile Island power plant and cancer deaths among nearby residents. Their study followed 32,000 people who lived within 5 miles of the plant at the time of the accident.

The American Cancer Society in 2000 concluded that although reports about cancer clusters in some communities have raised public concern, studies show that clusters do not occur more often near nuclear plants than they do by chance elsewhere in the population. Likewise, there is no evidence that links strontium-90 with increases in breast cancer, prostate cancer, or childhood cancer rates. Radiation emissions from nuclear power plants are closely controlled and involve negligible levels of exposure for nearby communities.

In 2000, the Illinois Public Health Department compared childhood cancer statistics for counties with nuclear power plants to similar counties without nuclear plants and found no statistically significant difference.

The Connecticut Academy of Sciences and Engineering, in January 2001, issued a report on a study around the Haddam Neck nuclear power plant in Connecticut and concluded radiation emissions were so low as to be negligible and found no meaningful associations with the cancers studied.

In 2001, the Florida Bureau of Environmental Epidemiology reviewed claims that there are striking increases in cancer rates in southeastern Florida counties caused by increased radiation exposures from nuclear power plants. However, using the same data to reconstruct the calculations, on which the claims were based, Florida officials were not able to identify unusually high rates of cancers in these counties compared with the rest of the state of Florida and the nation.

On April 7, 2010, the NRC announced that it asked the National Academy of Sciences (NAS) to perform a state-of-the-art study on cancer risk for populations surrounding nuclear power facilities. The NAS has a broad range of medical and scientific experts who can provide the best available analysis of the complex issues involved in discussing cancer risk and commercial nuclear power plants. More information on its methods for performing studies is available at http://www.nationalacademies.org/studycommitteprocess.pdf.

The NAS study will update the 1990 U.S. National Institutes of Health National Cancer Institute (NCI) report, "Cancer in Populations Living Near Nuclear Facilities" (NCI 1990). The study's objectives are to (1) evaluate whether cancer risk is different for populations living near nuclear power facilities; (2) include cancer occurrence; (3) develop an approach to assess cancer risk in geographic areas that are smaller than the county level; and (4) evaluate the study results in the context of offsite doses from normal reactor operations. Phase I of the NAS study report was published on March 29, 2012 and is available on the NAS web site (http://www.nap.edu).

The NRC staff's discussion on the impacts to human health from the operation of SQN during the proposed license renewal term is discussed in SQN DSEIS section 4.11.

9-8-HH: We need a real time public access monitoring systems, surrounding the plant in a concentric grid, showing the actual real time readings of radiation in the area, this needs to be done via the internet, through local government agencies and concerned citizens, in this manner we will not rely on the board or brass of TVA to let us know when there is an event or a release. There should be billboard size signs place on major thoroughfares that shows real time radiation levels for that sign location, so that daily commuters can become aware as to what's the background levels and when there are unsafe levels in the area.

Response: *The NRC considered the need for a review of emergency planning issues in the context of license renewal during its rulemaking proceedings on 10 CFR Part 54, which included public notice and comment. As discussed in the statement of consideration for rulemaking (56 FR 64966), the programs for emergency preparedness at nuclear power facilities apply to all nuclear power facility licensees and require the specified levels of protection from each licensee regardless of plant design, construction, or license date. Requirements related to emergency planning are in the regulations at 10 CFR 50.47 and Appendix E to 10 CFR Part 50. These requirements apply to all operating licenses and will continue to apply to facilities with renewed licenses. Through its standards and required exercises, the NRC reviews existing emergency preparedness plans throughout the life of any facility, keeping up with changing demographics and other site-related factors. Accordingly, the NRC has determined that there is no need for a special review of emergency planning issues in the context of an environmental review for license renewal (NRC 2006). Thus, decisions and recommendations concerning emergency preparedness at nuclear plants are ongoing and outside the regulatory scope of license renewal.*

Because this comment requests changes to the way in which radiation levels surrounding SQN are communicated to the public, the NRC staff has forwarded the comment to the Hamilton County, Tennessee, Office of Emergency Management asking Hamilton County to respond to this comment.

A.1.6 License Renewal & NEPA Process

Comments:

4-1-LR, 5-1-LR, and 12-1-LR: It is important that TVA retire the permits on Sequoyah 1 & 2. The permits are already 10 years past their original (recommended) termination dates.

14-1-LR: The plant has aged ten years past its intended lifespan.

Response: *These comments express concern that TVA should "retire the permits on Sequoyah 1 & 2", that "the permits are already 10 years past their original (recommended) termination dates" and that SQN "has aged ten years past its intended lifespan." This NRC staff response assumes that the "permits" mentioned in the comments above refer to the NRC operating licenses for SQN. The NRC operating licenses for SQN Units 1 and 2 will expire on September 17, 2020, and September 15, 2021, respectively. The Atomic Energy Act of 1954 specifies that licenses for commercial power reactors can be granted for up to 40 years. The initial 40-year licensing period was based on economic and antitrust considerations rather than on technical limitations of the nuclear facility. The initial operating licenses (DPR-77 and DPR-79) for SQN were granted for 40 years.*

8-2-LR: First, I would call to your attention – and I think this has was raised in the questions. We seriously challenge that the assumptions in the Generic EIS are still valid. I think many of them are out of date and I was glad to hear that the GEIS is being revisited. It's not clear to me how that fits in and how well that will be done to provide, in fact, an adequate foundation for the SEIS. And if the GEIS is still in ferment or is out of date, building an SEIS on a site specific basis on top of it, it seems to me, is legally questionable under the National Environmental Policy Act.

9-1-LR: The citizens of the United States have a right under the National Environmental Protection Act of 1969 to request that the Generic Environmental Impact Statement be thrown out and a third party comprehensive risk analysis that takes all elements at such risks to the community, to our commerce, to the environment into account. A report that truly defines the human health effects of low dose exposures and mental stress to the population for living under such risks.

What are the true effects of cancer causing agents reaching into our environment?

What are the true impacts of increased permanent storage or production of high level nuclear waste? Due to the permanent storage issue this proposed action should be considered a major federal action and, therefore, require a new Environmental Impact Statement under Section 102 42 USC 4332.

NEPA, the Environmental Quality Improvement Act of 1970, has amended Section 42 USC 4371 and Section 309 of the Clean Air Act as amended under 42 USC 7609, and we hereby request the study.

Also any study under these rules should also include a comprehensive study to determine if there is this speculative energy demand and whether it could be met through other sources that are now viable, including renewable energy.

And the answer to that is, yes, we can, and, no, we don't have a true need to build more reactors and can certainly phase out these 25 mile evac zones over the next decades.

We demand that Any EIS Studies will include – the long term health effects of low, mid and high level radiation on the surrounding community and the health effects on humans, born and unborn, and the effects to humans on the environment now and in the future – in addition, any action by a federal agency requiring a large burden on the area water supply should provide a comprehensive study as the effects of this massive water usage, including the effects to the marine and human life associated with the "scheduled releases" of various radioactive isotopes, and proposed average water temperature increases on the surrounding water supplies and how that relates back to human consumption, rights and the long term environmental impacts.

9-6-LR: In addition to a comprehensive study of the effects of these reactors to the public health, commerce and environment, I call for a comprehensive action plan to be presented to the public covering risk, and instructions on how to keep our families safe, how to manage our food supply and what we can do in the event of an event – all residents within the 25 Mile Evac Zone should be included in this education process – through all forms of media and psa's.

9-12-LR: We also request an impact statement from the United States Department of the Interior as and the Department of Justice as to the legitimacy of the generic impact study and we consider these actions a major event which would constitute and more through study under Section 102 [42 USC§ 4332]. Of NEPA.

10-20-LR: It appears that the TVA SEIS staff as well as the concerned citizen activists who have focused on this request for a renewal license can only address a percentage of the issues that need to be identified and evaluated for our safety. The very volume of issues necessary to mitigate the hazards and Environmental Impact of extending the Sequoyah Nuclear Power Plant operating license another 50% beyond its design-basis life span, indicates the number of potential and known problems with this inherently dangerous radioactive technology – and its potential and already known deleterious impacts on the human environment.

11-2-LR: The original Environmental Impact Statement was done when the plant was first opened back in the 1980s and it seems like it's time to really start from scratch, not just say that there's been no significant environmental impact at this point because it's operating for all this time and, gosh, we haven't really had an accident yet. So we can just, we can just rely on that same Environmental Impact Statement and we can say that it's going to be the same way for the next 20 years, 20 years starting in 2020, because that's when the first license expires.

So it's questionable to think that there's going to be no significant environmental impact in the future just because – and I don't think it's even reasonable to say there's been no significant environmental impacts in the past 32 years. But still that's what NRC is saying. So I think that we need to really begin from scratch again on that. I know there was one extension in between.

11-29-LR: The Supplemental Environmental Impact Statement should not be supplemental given that the original EIS goes back to the 1980s. I don't think that NRC and TVA can say that in that time there has been 'no significant environmental impact' and not really start from scratch. To say because it's been operating for 32 years without 'significant environmental impact' which is questionable in itself, is enough reason to give it a go-ahead for another 20 years is faulty reasoning.

Response: *These comments voice concerns with the license renewal process and that the GEIS is outdated and not comprehensive enough. The license renewal process is designed to assure safe operation of the nuclear power plant and protection of the environment during the license renewal term. Under the NRC's environmental protection regulations in Title 10, Part 51, of the Code of Federal Regulations (10 CFR Part 51), which implement Section 102(2) of the National Environmental Policy Act (NEPA), renewal of a nuclear power plant operating license requires the preparation of an environmental impact statement (EIS).*

To support the preparation of these EISs, the NRC issued the Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS), NUREG-1437, in 1996. The original 1996 GEIS for license renewal was prepared to assess the environmental impacts associated with the continued operation of nuclear power plants during the license renewal term. The intent was to determine which environmental impacts would result in essentially the same (generic) impact at all nuclear power plants, and which ones could result in different levels of impacts at specific plants and would require a plant-specific analysis to determine the impacts. For those issues that could not be generically addressed, the NRC would prepare plant-specific supplemental EISs (SEISs) to the GEIS.

As stated in the 1996 final rule that incorporated the findings of the GEIS in 10 CFR Part 51, the NRC recognized that environmental impact issues might change over time, and that additional issues may need to be considered.

On June 20, 2013, the NRC published a final rule (78 FR 37282) revising its environmental protection regulation, 10 CFR Part 51, "Environmental protection regulations for domestic licensing and related regulatory functions." Specifically, the final rule updates the potential environmental impacts associated with the renewal of an operating license for a nuclear power reactor for an additional 20 years. A revised GEIS, which updates the 1996 GEIS, provides the technical basis for the final rule. The revised GEIS specifically supports the revised list of NEPA issues and associated environmental impact findings for license renewal contained in Table B–1 in Appendix B to Subpart A of the revised 10 CFR Part 51. The revised GEIS and final rule reflect lessons learned and knowledge gained during previous license renewal environmental reviews. In addition, public comments received on the draft revised GEIS and rule and during previous license renewal environmental reviews were re-examined to validate existing environmental issues and identify new ones.

The NRC has established a license renewal review process that can be completed in a reasonable period with clear requirements to assure safe plant operation for up to an additional 20 years of plant life. The process for the license renewal application environmental review, as *described in the NRC's regulations in 10 CFR Part 51, offers two public comment periods. The process begins when an applicant submits the license renewal application that includes an Environmental Report. After accepting the application, the NRC staff issues a Notice of Intent to prepare a site-specific supplement to the generic environmental impact statement for license renewal (SEIS) and conduct scoping. The Notice of Intent is posted on the NRC website and published in the Federal Register. The NRC staff also schedules public scoping meetings in the vicinity of the facility. Based on the scoping process and the NRC staff's independent review, a draft SEIS for public comment is issued. In addition, the NRC staff holds public meetings to discuss the findings in the draft SEIS and to obtain comments on it from the public and other interested stakeholders. The final SEIS incorporates appropriate comments and changes from the draft SEIS and includes an appendix that presents the comments received and the NRC staff responses to those comments.*

The major milestones of the SQN license renewal application environmental review are discussed in SQN DSEIS section 1.3.

The last sentence of comment 11-2-LR claims there was an "extension in between." To date, there has been no extension of the SQN operating licenses.

9-14-LR: At the end of the day with the expiration of the operating license set to expire in 2020 and 2021, I feel these actions are premature, and are being aggressively pushed upon the citizens without adequate time for discussions, without time to study the health and impacts of Fukushima, and therefore again request additional public hearings on this issue as well as, something other than a generic impact study that hasn't been updated properly since like 1940.

Response: *This comment voices concern that lessons learned from the Fukushima accident be appropriately considered, that there be "additional public hearings on this issue" and that the GEIS is outdated. The immediately preceding response addresses the GEIS portion of this comment.*

On March 11, 2011, a 9.0-magnitude earthquake struck Japan and was followed by a 45-foot tsunami, resulting in extensive damage to the nuclear power reactors at the Fukushima Dai-ichi facility. The NRC has taken significant action to enhance the safety of reactors in the United States based on the lessons learned from this accident. The NRC continues to evaluate and act on the lessons learned from the accident to ensure proper safety enhancements are appropriately considered and implemented at U.S. nuclear power plants. For further information on the NRC's continued response to the Japan Nuclear Accident visit:
http://www.nrc.gov/reactors/operating/ops-experience/japan-info.html

The public meeting at which the commenter made this comment was a scoping meeting to provide the public information about the license renewal process, to provide opportunities for public involvement, and to solicit input on the scope of NRC's environmental review. The NRC staff held two public scoping meetings on TVA's application for renewal of SQN's operating licenses on April 3, 2013, in Soddy-Daisy, Tennessee

Another opportunity for public involvement regarding TVA's application for renewal of SQN's operating licenses will be the SQN DSEIS public comment period. This comment period will include two public meetings. These public meetings, as well as all NRC public meetings, will be posted on the NRC's website at http://www.nrc.gov/public-involve.html*. In addition, these two public meetings will be noticed in the Federal Register and advertised in local news media.*

Under the Atomic Energy Act, Congress established an adjudicatory process that promotes public involvement in hearings on a variety of civilian nuclear matters. Through this hearing process, independent judges on the Atomic Safety and Licensing Board Panel (ASLBP) hear and address concerns of individuals or entities that are directly affected by any licensing or *enforcement action involving a facility that produces or uses nuclear materials. A 60-day opportunity to request a hearing regarding TVA's application for renewal of SQN's operating licenses began on March 5, 2013, and was noticed in the Federal Register (78 FR 14362), posted to the NRC public website and announced in a letter to the applicant made publicly available in ADAMS (ADAMS Accession Number ML13035A214).*

17-20-LR: It is a fact that not one of these renewal applications has been denied. And I have people who have called it rubber stamped. I hope that the rubber stamping stops and this will be a very serious consideration.

21-10-LR: Delay in this extension will serve to show that the NRC has thrown away their rubber stamp.

Response: *The NRC maintains focus on its mission to ensure adequate protection of public health and safety, to promote the common defense and security, and to protect the environment with clearly defined requirements for license renewal. To date, the NRC has approved all of the applications for license renewal for which the review has been completed. Although the NRC can deny a request to renew a license if an applicant does not provide appropriate or adequate information in its initial application, the NRC can and does identify deficiencies in applications and allows applicants to correct and resubmit their applications or provide additional information to support an application. This process can continue until the NRC concludes that the application is sufficient to complete the review.*

A.1.7 Postulated Accidents

Comments:

2-1-PA: Environmental Report Section 4.21 addresses Severe Accident Mitigation Alternatives. As stated in Section 4.21.3, a SAMA analysis is required for license renewal unless one has previously been performed for other reasons. The Limerick nuclear plant in Pennsylvania did a SAMA analysis as part of its initial licensing process. When its owner applied for license renewal, it did not submit another SAMA analysis.

Page 4-65 explains TVA reviewed 309 SAMA candidates. 262 candidates were screened out as either not being applicable to Sequoyah.

47 SAMA candidates underwent further analysis and TVA identified 9 potentially cost-beneficial SAMAs for Unit 1 and 8 on Unit 2. As explained on page 4-66, because none of these potentially cost-beneficial safety upgrades is related to aging management – the focus of license renewal – none are required in TVA's view.

Page 4-67 reports that TVA's analysis of SAMAs 286 and 288 for both units concluded that the "total averted cost risk from the sensitivity analyses is greater than the implementation cost."

But Section 4.21.6 concludes that "None of the SAMAs are related to adequately managing the effects of aging during the period of extended operation. Therefore, they do not need to be implemented as part of license renewal pursuant to 10 CFR Part 54."

As demonstrated by the Limerick case, SAMA analyses are not required for license renewal unless a SAMA analysis has not yet been done. Thus, the SAMA analysis is not linked solely to aging management during a license renewal period.

The SAMA analysis is done for the Environmental Report. The Environmental Report considers alternatives to the proposed activity; namely, operating these reactors for 20 more years.

The Environmental Report's evaluation shows that operating these reactors without these safety upgrades for 20 years is the wrong thing to do from a legal and moral perspective. The Sequoyah licenses should not be renewed without these safety upgrades.

Response: *This comment requests that license renewal not be granted until "safety upgrades" identified in TVA's SQN Severe Accident Mitigation Alternatives (SAMA) analysis are implemented.*

Pursuant to 10 CFR Part 54, the only changes that must be implemented by the applicant as part of the license renewal process are those that are identified as being cost beneficial, that provide a significant reduction in total risk, and that are related to adequately managing the effects of aging during the period of extended operation.

The NRC staff evaluated the identified potentially cost-beneficial SAMAs to determine if they are in the scope of license renewal (i.e. they are subject to aging management). This evaluation considers whether the systems, structures, and components (SSCs) associated with these SAMAs: (1) perform their intended function without moving parts or without a change in configuration or properties and (2) that these SSCs are not subject to replacement based on qualified life or specified time period. The NRC staff determined that these SAMAs do not relate to adequately managing the effects of aging during the period of extended operation. Therefore, they need not be implemented as part of license renewal in accordance with 10 CFR Part 54. Section 4.11.1.2 and Appendix F of the SQN DSEIS provide the NRC staff's review of TVA's SAMA analysis.

10-4-PA: Another deliberately fabricated beyond design basis ongoing event that has been mentioned earlier is this extended use of cooling pools to store the irradiated, spent – it's called spent fuel, but it's actually much more toxic than the uranium that goes into the reactors because it has been enriched in the process, creating these radionuclides I talked about earlier.

In that the Homeland Security and Congress asked the National Academy of Sciences to do a study on this to decide whether it was dangerous, this overloading of the cooling pools, and they recommended that all of the fuel going into these cooling pools be removed after five years and put into dry cask storage which is considerably safer for all of us.

10-5-PA: According to a very well respected Robert Alvarez at the – I'm sorry, I've forgotten where he is – the Policy Institute of some sort. Anyway he wrote a study in 2012 and he quoted something that I think is worth requoting, "A severe pool fire," – they said – first let me preface it that they had known for decades that severe accidents can occur in cooling pools. They've known that for decades. And he said, "A severe pool fire could render about 188 square miles around the nuclear reactor uninhabitable. Could cause as many as 28,000 cancer fatalities and cause 59 billion dollars in damage according to a 1997 report for the NRC by Brookhaven National Laboratory."

Sequoyah has well over 1,000 metric tons of this higher irradiated radioactive trash and it's very, very dangerous stuff. And it's stored in these cooling pools. In fact, 75 percent has been piling up in these cooling pools for 30 years now. They've only moved a quarter of it into dry cask storage. Now that's a better rate than Watts Bar, which is 100 percent in the cooling pools and Browns Ferry, which is 88 percent in the cooling pools.

But basically they're just saving a buck by keeping it in the pools and not putting it in the safer dry cask storage.

10-16-PA: Another deliberately fabricated "beyond-design-basis" ongoing event is the extended use of spent fuel cooling pools as storage tanks, rather than the temporary circulating cooling pools they were designed to be. As originally designed, and as recommended by a National

Academy of Sciences study commissioned for Congress and Homeland Security in 2005, radioactive trash (or spent fuel) should be moved from the cooling pools into dry cask storage after 5 years, not continually packed into the vulnerable cooling pools. As Robert Alvarez states in the 2012 submitted article, "Improving Spent-Fuel Storage at Nuclear Reactors," nuclear safety studies for decades have said severe accidents can occur at spent fuel pools and the consequences could be catastrophic. "A severe pool fire could render about 188 square miles around the nuclear reactor uninhabitable, cause as many as 28,000 cancer fatalities, and cause $59 billion in damage, according to a 1997 report for the NRC by Brookhaven National Laboratory."

Sequoyah has well over a thousand metric tons (about 2.5 million pounds) of highly radioactive waste with a history of improper storage. In 2010, for example, about 75% of 30 years of spent fuel was being stored in cooling pools. While this is better than the 100% pool storage record at Watts Bar and the 88% record at Browns Ferry, this clearly indicates the lack of attention by the corporate culture of TVA to the maintenance and security warranted by a nuclear power utility, which indicates a potential threat to our environment. The concentration of fuel, transfer and storage plans, and scheduled implementation of those plans needs to be identified and evaluated in the Safety Evaluation Report.

11-24-PA: And the crowding of the radioactive fuel rods and the so called spent fuel pool which is actually a higher end radiation than when it started out in the reactor – when the rod started out in the reactor. That is a concern and we would advocate for moving those, the used fuel rods, after they cool and it takes about five years for them to cool. To remove those and put them in hardened cask waste cask storage. This radioactive trash doesn't need to be in the pools where it actually has more chance of exploding.

17-10-PA: At Fukushima Unit 4, which is teetering and if it falls there are concerns by scientists that it will be a global environmental catastrophe if that Unit 4 if all the cesium in there spills and is spread. Well, the amount of cesium – amount of fuel rods in that pool is far less than the 796 metric tons in the pools at Sequoyah right now. There's also 378 metric tons in casks there.

Response: *These comments concern the impacts of a spent nuclear fuel (SNF) accident. SQN stores its SNF in a spent fuel pool and in dry casks. The spent fuel pool is a structure constructed of steel-reinforced concrete walls with a stainless steel liner, and filled with water. The spent fuel pool is located inside the plant's protected area. The NRC regularly inspects SQN's spent fuel storage program to ensure the safety of the SNF stored in the spent fuel pool. For more information on NRC inspections, see the response to the radioactive waste comments later in this same section A.1.*

Following the March 11, 2011, earthquake and tsunami at Japan's Fukushima nuclear power plant, the NRC ordered licensees to: install additional instrumentation to monitor water levels in spent fuel pools, and, develop ways to easily maintain or restore spent fuel pool cooling in an emergency (Order EA-12-051,"ORDER MODIFYING LICENSES WITH REGARD TO RELIABLE SPENT FUEL POOL INSTRUMENTATION", is available online at: http://pbadupws.nrc.gov/docs/ML1205/ML12056A044.pdf).

The NRC is evaluating how a spent fuel pool at a U.S. reactor similar to Fukushima might respond to an earthquake far more powerful than the one that struck Japan. A study published in 2013 found a one-in-10-million-years chance that a severe earthquake could cause a radioactive release from the spent fuel pool at that reactor. In that extremely unlikely case, the study found that existing procedures would keep the population around the plant safe. For further information on the NRC's continued response to the Japan nuclear accident visit: http://www.nrc.gov/reactors/operating/ops-experience/japan-info.html.

10-8-PA: And, okay, I want to show you something here. I notice in the ACRS that tornadoes were mentioned and they talked about their study. Basically they did their statistical work around two major periods. One was a 37-year period from 1950 to 1986 and there were 31 tornadoes during that period in a 34-mile radius. And then the next period was the next 15 years up to 2002 and there were 23 tornadoes during that period. That is nearly doubling the rate in that period time. And this only goes up to 2002.

Okay, well, in 2011, as you can see, this is NOAA track of the tornadoes that came through the Tennessee Valley on April 27th, 2011. And those circles are the 50-mile radius of our nuclear power plant in this valley. And Sequoyah had around 15 of them, it looks like here. Someone else may count it differently, but that's what it looked like to me.

And I noticed in your report that you did mention that and that TVA reported that three of them touched down within 10 miles of Sequoyah. Your statisticians predict unlikely odds of a direct hit on Sequoyah. But I tell you, I'm not real confident with gambling on this. There's a lot of people whose lives are involved in this and I think we need to take it seriously.

Response: *This comment voices concern with the environmental impacts of tornadoes at SQN. The NRC requires U.S. nuclear power plants to be designed, built and maintained to safely withstand a set of unlikely but harmful events such as equipment failure, pipe breaks, and severe weather; these are called design-basis requirements. In some cases, high winds, floods, and tornados may contribute to plant risk; however, these contributions are generally much lower than those from seismic and fire events. Section 4.11.1.2 of the SQN DSEIS discusses design-basis accidents and adopts the GEIS finding that the environmental impacts from externally initiated events such as tornadoes are small.*

As part of the Fukushima lessons learned Tier 2 activities, the NRC plans to perform "other" external hazard reevaluations at NRC licensed power plants. "Other" external hazard reevaluations will reanalyze the potential effects of external hazards other than seismic and flooding events. "Other" external hazard reevaluations include severe weather (including tornadoes). The NRC staff expects to begin work on this topic as soon as significant resources become available, following implementation of Tier 1 actions related to seismic and flooding hazard walkdowns and reevaluations. Current status of this and other Fukushima related lesson learned activities are available at: http://www.nrc.gov/reactors/operating/ops-experience/japan-dashboard/priorities.html.

17-1-PA: The plant safety and security in the TVA document that was sent out back in 2010 says that, "Severe accidents are defined as accidents with substantial damage to the reactor core and degradation of containment systems. Because the probability of a severe accident is very low, the NRC considers them too unlikely to warrant normal design controls to prevent or mitigate the consequences. Severe accident analyses consider both the risk for the severe accident and the offsite consequences."

What that means is that they just dismiss out of hand the possibility of a severe accident and don't consider it at all in the Environmental Impact Statement.

17-21-PA: The plant safety issues do not take into the effects – take into account the effects of serious accidents that's beyond design basic accidents. And they just reject considering those out of hand in all of the Environmental Impact Statements. So it never gets considered what the possibility is in terms of a massive release of radiation. That's not part of this process. It's specifically excluded because it's said to be so unlikely as to happen, but we've already seen it happen twice in our lifetimes.

22-2-PA: Based on historical experience with nuclear reactors, I believe that these facilities are inherently dangerous. An accident at these nuclear reactors so close to my home could pose a grave risk to my property, health and safety. In particular, I am concerned that if an accident involving release of radioactive material were to occur, I could be killed or become very ill.

Response: *These comments express concern for the potential adverse environmental impacts associated with accidents at SQN. The NRC studies potential severe accidents in great detail and develops requirements and guidance to ensure licensed nuclear power plants avoid severe accidents. Further, the NRC inspects against those requirements to ensure adequate protection of public health and safety, to promote the common defense and security, and to protect the environment.*

The term "accident" refers to any unintentional event outside the normal plant operational envelope that results in a release or the potential for release of radioactive materials into the environment. Two classes of postulated accidents are evaluated in the generic environmental impact statement (GEIS). These are design-basis accidents and severe accidents.

Design-basis accidents are those accidents that both the licensee and NRC staff evaluate to ensure that the plant can withstand without undue hazard to the health and safety of the public. A number of these accidents are not expected to occur during the life of the plant, but are evaluated to establish the design basis for the preventive and mitigative safety systems of the facility. The impacts of design-basis accidents were evaluated in the GEIS and determined to be small for all plants.

Severe nuclear accidents are those that are more severe than design-basis accidents because they could result in substantial damage to the reactor core, whether or not there are serious offsite consequences. In the GEIS, the staff assessed the impacts of severe accidents during the license renewal period, using the results of existing analyses and site-specific information to conservatively predict the environmental impacts of severe accidents for each plant during the renewal period. Based on information in the GEIS, the Commission found that "The probability-weighted consequences of atmospheric releases, fallout onto open bodies of water, releases to groundwater, and societal and economic impacts from severe accidents are small for all plants."

Section 4.11.1.2 of the SQN DSEIS provides the NRC staff analysis of postulated accidents.

A.1.8 Radiological Waste

Comments:

4-2-RW, 5-2-RW, and 12-2-RW: We require that all nuclear material be interred in casks and left on site.

11-18-RW: Spent fuel storage, you know, spent fuel is radioactive fuel that uranium that has been used in the reactor and then it becomes actually more radioactive and it is taken out of the reactor and put into this fuel pool. And the rods that where the uranium fuel is – this is highly radioactive rods – are put into the fuel pool. And what's happening is it's getting more and more crowded because they don't know what to do with the waste.

Where shall we put the radioactive waste since there's no place to ship it to? There's no setup for that. And besides why have two places that are radioactive when you can just leave it on site here at Sequoyah? But how much more should we be making? So the crowding of the rods is a problem.

And when they take the rod density, there's more opportunity for accidents when the rods are so much closer together and fission can happen. So where do we put it? These are the things that I think that the scoping should include. Where are we going to put those rods and keep the crowding smaller? And is the Watts Bar radioactive waste also going to be supported to Sequoyah, which has – I think is true.

And has the proposed independent spent fuel storage building been put in place and is it secure enough?

Further, are there plans to put things into hardened cask storage so that they are safer than they are in the fuel pool?

11-37-RW: Spent fuel storage is inadequately protected as rod density in the fuel pool increases. This rod crowding is a serious safety concern. Why have 20 more years of radioactive spent fuel? There are many questions that should be adequately analyzed and answered: Where do we put it and how will it be monitored and managed? Is the Watts Bar radioactive waste going to be transported to SQN as well? Has the proposed Independent Spent Fuel Storage Building been put in place and is it secure enough?

17-9-RW: At Sequoyah there's currently 1,174 metric tons of this high level radioactive waste. It's easily one to three million times more radioactive than when the fuel went into the reactors. This is not just spent fuel; this stuff is a nightmare.

Response: *These comments concern the impacts of spent nuclear fuel (SNF) on the environment and human health. SQN stores its SNF in its spent fuel pool and in dry casks.*

The spent fuel pool is a structure constructed of steel-reinforced concrete walls with a stainless steel liner, and filled with water. The spent fuel pool is located inside the plant's protected area. The NRC regularly inspects SQN's spent fuel storage program to ensure the safety of the SNF stored in the spent fuel pool. The NRC's safety requirements for the storage of SNF during licensed operations, including requirements related to the spacing of spent fuel rods in the pool, ensure that the expected increase in the volume of SNF during the license renewal term can be safely stored on site.

The latest NRC inspection of activities associated with the SQN spent fuel pool was performed in January 2014. As reported on page 14 of the SEQUOYAH NUCLEAR PLANT – NRC INTEGRATED INSPECTION REPORT 05000327/2013005 AND 05000328/2013005 (ADAMS Accession No. ML14038A346) dated February 7, 2014: No findings associated with the SQN spent fuel pool were identified.

SQN also stores SNF in NRC approved dry cask canisters made of leak-tight welded and bolted steel at the SQN Independent Spent Fuel Storage Installation (ISFSI). A typical dry cask storage system is detailed at the following website: http://www.nrc.gov/waste/spent-fuel-storage/diagram-typical-dry-cask-system.html*.*

The NRC regularly inspects SQN's dry cask storage system to ensure it complies with NRC requirements. The latest NRC inspection of the SQN ISFSI was performed in January 2014.

As reported on page 27 of the SEQUOYAH NUCLEAR PLANT – NRC INTEGRATED INSPECTION REPORT 05000327/2013005 AND 05000328/2013005 (ADAMS Accession No. ML14038A346) dated February 7, 2014: No findings associated with the SQN ISFSI were identified.

TVA plans to construct and operate an ISFSI at Watts Bar Nuclear Plant (WBN) to store WBN SNF. A detailed description of the proposed ISFSI is contained in the "Independent Spent Fuel Storage Installation, Watts Bar Nuclear Plant, Draft Environmental Assessment, dated April 7, 2014, available on line at: http://www.tva.gov/environment/reports/spent_fuel_storage/Draft%20EA%20WBN%20ISFSI%20Public%20Review%20April%207%202014.pdf*. TVA has not informed the NRC staff of any plans to transfer spent fuel from WBN to SQN.*

Spent nuclear fuel is discussed in SQN DSEIS section 3.1.4. The NRC's evaluation of impacts from the onsite storage of SNF, offsite radiological impacts of SNF and high-level waste disposal, and, the uranium fuel cycle are addressed in Chapter 4 of the SQN DSEIS.

10-12-RW: Article to be considered during the environmental review: "Improving Spent-Fuel Storage at Nuclear Reactors."

Response: *The NRC staff read and considered the article in the comment above. The information in this article is not within the scope of the license renewal application environmental review and therefore was not used in development of the SQN DSEIS.*

A.1.9 Surface Water

Comments:

11-7-SW: It's also I'm especially concerned about water use. And we have climate disruption -- more storms, more problems that way. And we also have growing industry, business people that use the water in addition to the drinking water, most of which comes from the Tennessee River for Chattanooga.

And a nuclear plant uses seven -- if it's a 1,000 megawatt and Sequoyah is a little bigger than seven thousand fourteen hundred -- 714,740 gallons per minute. So I'm concerned about the use of that water, two-thirds of which does not go back into the river after it's used to cool.

11-10-SW: I was talking to you earlier about the water usage and how much water comes out of the river, every minute, 714,740 gallons per minute when the plant is operating. And two thirds of that goes up into the air through the cooling towers that we're all so familiar with.

11-12-SW: And in fact, it's water that's going to be the constraining resource in the future. We cannot have nuclear plants using all that water that could be used for other uses. And it's just evaporating into the air for the most …

11-33-SW: In this age of climate disruption, water quality and quantity is of prime importance. Nuclear Plants use inordinate amounts of water each day when operating and about two-thirds is evaporated through the cooling towers and is not returned to the river. The Union of Concerned Scientists tells us that the typical 1,000 MW-electric nuclear power reactor can use up to a whopping 714,740 gallons per minute. This is water that could be used by other businesses, industries, and for drinking water.

19-2-SW: There's some other environmental issues I just wanted to mention that are tied specifically to the Sequoyah Plant. One is the water requirements. That's been a big issue recently, the amount of water that these plants take in and the temperature rise. I'm sure you're looking at that.

Response: *These comments concern the impact on surface water from SQN. SQN DSEIS sections 3.1.3 and 3.5.1 contain a description of the consumptive use of surface water at SQN. Consumptive water use during the proposed license renewal term of SQN will continue to be a very small percentage of the overall flow of the Tennessee River through the Chickamauga Reservoir. The potential impact of SQN license renewal activities on surface water resources is described in section 4.5.1.1 of the SQN DSEIS.*

The cumulative effect on surface water resources by the aggregate of past, present, and reasonably foreseeable future actions over the proposed license renewal term is evaluated in section 4.16.3.1 of the SQN DSEIS. This section considers the total effect of actions that could impact the surface water (including both direct and indirect effects) no matter who has taken the actions (Federal, State, County, or private).

APPENDIX B
APPLICABLE LAWS, REGULATIONS, AND OTHER REQUIREMENTS

APPLICABLE LAWS, REGULATIONS, AND OTHER REQUIREMENTS

The Atomic Energy Act of 1954 (AEA), as amended (42 USC § 2011 et seq.), authorizes the U.S. Nuclear Regulatory Commission (NRC) to enter into agreement with any State to assume regulatory authority for certain activities (see 42 USC § 2012 et seq.). For example, through the Agreement State Program, Tennessee assumed regulatory responsibility over certain byproduct, source, and quantities of special nuclear materials not sufficient to form a critical mass. The Division of Radiological Health, Tennessee Department of Environment and Conservation (TDEC), administers the Tennessee Agreement State Program.

In addition to carrying out some Federal programs, state legislatures develop their own laws. State statutes supplement, as well as implement, Federal laws for protection of air, water quality, and groundwater (GW). State legislation may address solid waste management programs, locally rare and endangered species, and historic and cultural resources.

The Clean Water Act (33 USC § 1251 et seq., herein referred to as CWA) allows for primary enforcement and administration through state agencies, given that the state program is at least as stringent as the Federal program. The state program must conform to the CWA and to the delegation of authority for the Federal National Pollutant Discharge Elimination System (NPDES) program from the U.S. Environmental Protection Agency (EPA) to the state. The primary mechanism to control water pollution is the requirement for direct dischargers to obtain an NPDES permit, or in the case of states where the authority has been delegated from the EPA, a State Pollutant Discharge Elimination System permit, under the CWA. In Tennessee, TDEC issues and enforces NPDES permits.

One important difference between Federal regulations and certain state regulations is the definition of waters that the state regulates. Certain state regulations may include underground waters, whereas the CWA only regulates surface waters. In Tennessee, TDEC is charged with conserving, managing and protecting surface water and GW resources (TDEC 2014).

B.1 Federal and State Environmental Requirements

Sequoyah Nuclear Plant (SQN) is subject to Federal and State requirements for its environmental program.

Table B–1 lists the principle Federal and State environmental regulations and laws associated with the environmental review of the SQN license renewal application.

1 **Table B–1. Federal and State Environmental Requirements**

Law/regulation	Requirements
Current operating license and license renewal	
Atomic Energy Act (42 U.S.C. § 2011 et seq.)	This Act is the fundamental U.S. law on both the civilian and the military uses of nuclear materials. On the civilian side, it provides for both the development and the regulation of the uses of nuclear materials and facilities in the United States. The Act requires that civilian uses of nuclear materials and facilities be licensed, and it empowers the NRC to establish by rule or order, and to enforce, such standards to govern these uses as “the Commission may deem necessary or desirable in order to protect health and safety and minimize danger to life or property.”
10 CFR Part 51. Title 10 *Code of Federal Regulations* (10 CFR) Part 51, Energy	“Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions.” This part contains environmental protection regulations applicable to the NRC’s domestic licensing and related regulatory functions.
10 CFR Part 54	“Requirements for Renewal of Operating Licenses for Nuclear Power Plants.” This part focuses on managing adverse effects of aging rather than noting all aging mechanisms. The rule is intended to ensure that important systems, structures, and components will maintain their intended function during the period of extended operation.
10 CFR Part 50	“Domestic Licensing of Production and Utilization Facilities.” Regulations that the NRC issues under the AEA, as amended (68 Stat. 919), and Title II of the Energy Reorganization Act of 1974 (88 Stat. 1242), provide for the licensing of production and utilization facilities. This part also gives notice to all persons who knowingly supply—to any licensee, applicant, contractor, or subcontractor—components, equipment, materials, or other goods or services that relate to a licensee’s or applicant’s activities subject to this part, that they may be individually subject to NRC enforcement action for violation of § 50.5.
Air quality protection	
Clean Air Act (CAA) (42 USC § 7401 et seq.)	The CAA is a comprehensive Federal law that regulates air emissions. Among other things, this law authorizes EPA to establish National Ambient Air Quality Standards (NAAQS) to protect public health and public welfare and to regulate emissions of hazardous air pollutants. EPA has promulgated NAAQS for six criteria pollutants: sulfur dioxide, nitrogen dioxide, carbon monoxide (CO), ozone, lead, and particulate matter. All areas of the United States must maintain ambient levels of these pollutants below the ceilings established by the NAAQS.
Tennessee Air Quality Act (Tennessee Code Title 68, Chapter 201)	The Tennessee Air Quality Act authorizes the setting of ambient air quality standards as necessary to protect the public health and welfare and emission standards for the purpose of controlling air contamination, air pollution, and the sources of air pollution.

Law/regulation	Requirements
Water resources protection	
Clean Water Act (CWA) (33 USC § 1251 et seq.) and the NPDES (40 CFR 122)	The CWA establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters.
Wild and Scenic River Act (16 USC § 1271 et seq.)	The Wild and Scenic River Act created the National Wild and Scenic Rivers System, which was established to protect the environmental values of free flowing streams from degradation by affecting activities, including water resources projects.
Safe Drinking Water Act (SDWA) (42 USC § 300f et seq.)	The SDWA is the principal Federal law that ensures safe drinking water for the public. Under the SDWA, EPA is required to set standards for drinking water quality and oversees all states, localities, and water suppliers that implement these standards.
Tennessee Water Quality Control Act (Tennessee Code Chapter 69, Chapter 3, Part 1)	Water quality regulations for National Pollutant Discharge Elimination System (NPDES) Permits, State Permits, Water Quality Based Effluent Limitations and Water Quality Certification.
Waste management and pollution prevention	
Resource Conservation and Recovery Act (RCRA) (42 USC § 6901 et seq.)	RCRA gives EPA authority to control hazardous waste. Before a material can be classified as a hazardous waste, it first must be a solid waste as defined under the Resource Conservation and Recovery Act (RCRA). Hazardous waste is classified under Subtitle C of the RCRA. Parts 261, "Identification and Listing of Hazardous Waste," and 262, "Standards Applicable to Generators of Hazardous Waste," of 40 CFR contain all applicable generators of hazardous waste regulations.
Pollution Prevention Act (42 USC § 13101 et seq.)	The Pollution Prevention Act formally established a national policy to prevent or reduce pollution at its source whenever feasible. The Act supplies funds for state and local pollution prevention programs through a grant program to promote the use of pollution prevention techniques by business.
Protected species	
Endangered Species Act (ESA) (16 USC § 1531 et seq.)	The ESA forbids any government agency, corporation, or citizen from taking (e.g., harming or killing) endangered animals without an Endangered Species Permit. The ESA also requires Federal agencies to consult with the U.S. Fish and Wildlife Service or National Marine Fisheries Service if any Federal action may adversely affect any listed species or designated critical habitat.
Magnuson–Stevens Fishery Conservation and Management Act (MSA) (P.L. 94-265), as amended through January 12, 2007	The Magnuson–Stevens Fishery Conservation and Management Act (MSA) includes requirements for Federal agencies to consider the impact of Federal actions on essential fish habitat (EFH) and to consult with the National Marine Fisheries Service if any activities may adversely affect EFH.
Fish and Wildlife Coordination Act (16 USC § 661 et seq.)	To minimize adverse impacts of proposed actions on fish and wildlife resources and habitat, the Fish and Wildlife Coordination Act requires that Federal agencies consult Government agencies regarding activities that affect, control, or modify waters of any stream or bodies of water. It also requires that justifiable means and measures be used in modifying plans to protect fish and wildlife in these waters.

Law/regulation	Requirements
Historic preservation	
National Historic Preservation Act (NHPA) (16 USC § 470 et seq.)	The National Historic Preservation Act (NHPA) directs Federal agencies to consider the impact of their actions on historic properties. To comply with NHPA, Federal agencies must consult with State Historic Preservation Officers and, when applicable, tribal historic preservations officers. NHPA also encourages state and local preservation societies.

B.2 Operating Permits and Other Requirements

Table B–2 lists the permits and licenses issued by Federal, State, and local authorities for activities at SQN.

Table B–2. Licenses and Permits

Permit	Number	Dates	Responsible Agency
Operating license	DPR-77	Issued: 9/17/1980 Expires: 9/17/2020	NRC
Operating license	DPR-79	Issued: 9/15/1981 Expires: 9/15/2021	NRC
NPDES Permit	TN0026450	Expires: 10/31/2013 Permit administratively continued - renewal application pending.	TDEC
401 Water Quality Certification	None – part of the NPDES permit	Expires: 10/31/2013 Permit administratively continued - renewal application pending.	TDEC
Discharge of stormwater to waters of the State	TNR 050015	Expires: 05/14/14 Permit administratively continued - renewal application pending.	TDEC
Air Permit - Operation of emergency generators	4150-20200102-11C	Expires: 07/17/17	Chattanooga–Hamilton County Air Pollution Control Bureau (CHCAPCB)
Air Permit - Operation of Unit 1 cooling tower	4150-30600701-01C	Expires: 07/17/17	CHCAPCB
Air Permit - Operation of Unit 2 cooling tower	4150-30600701-03C	Expires: 07/17/17	CHCAPCB
Air Permit - Operation of insulation saws A and B	4150-30700804-06C	Expires: 07/17/17	CHCAPCB
Air Permit - Operation of auxiliary boilers A and B	4150-10200501-08C	Expires: 07/17/17	CHCAPCB
Air Permit - Operation of carpenter shop	4150-30703099-09C	Expires: 07/17/17	CHCAPCB
Air Permit - Operation of abrasive blasting operation	4150-30900203-10C	Expires: 07/17/17	CHCAPCB
Asbestos removal for individual, non-scheduled renovations	3034	Expires: 12/31/14	CHCAPCB
Hazardous waste generator identification	TN5640020504	Expires: None	TDEC
Disposal of solid waste	DML 331050021	Expires: None	TDEC
Shipment of radioactive material to a Tennessee disposal/processing facility	T-TN002-L13	Expires: 12/31/2014	TDEC

Source: TVA 2013

B.3 References

[TDEC] Tennessee Department of Environment and Conservation. 2014. *Water Resources* home page. Available at <http://www.tennessee.gov/environment/water/> (accessed 13 May 2014).

[TVA] Tennessee Valley Authority. 2013. Sequoyah Nuclear Plant, Units 1 and 2, License Renewal Application, Appendix E, Applicant's Environmental Report, Operating License Renewal Stage. Chattanooga, TN: TVA. January 7, 2013. 783 p. Agencywide Documents Access and Management System No. ML130240007, Parts 2 through 8 of 8.

APPENDIX C
CONSULTATION CORRESPONDENCE

CONSULTATION CORRESPONDENCE

C.1 Endangered Species Act (ESA) Section 7 Consultation

C.1.1 Federal Agency Obligations Under ESA Section 7

As a Federal agency, the U.S. Nuclear Regulatory Commission (NRC) must comply with the Endangered Species Act of 1973, as amended (16 *United States Code* (U.S.C.) 1531 et seq.; herein referred to as ESA), as part of any action authorized, funded, or carried out by the agency, such as the proposed agency action that this supplemental environmental impact statement (SEIS) evaluates: whether to issue renewed licenses for the continued operation of Sequoyah Nuclear Plant, Units 1 and 2 (SQN) for an additional 20 years beyond the current license terms. Under section 7 of the ESA, the NRC must consult with the U.S. Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS) (referred to jointly as "the Services" and individually as "Service"), as appropriate, to ensure that the proposed agency action is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of designated critical habitat.

The ESA and the regulations that implement ESA section 7 (Title 50 of the *Code of Federal Regulations* (50 CFR) Part 402, "Interagency cooperation—Endangered Species Act of 1973, as amended") describe the consultation process that Federal agencies must follow in support of agency actions. As part of this process, the Federal agency shall either request that the Services provide a list of any listed or proposed species or designated or proposed critical habitats that may be present in the action area or request that the Services concur with a list of species and critical habitats that the Federal agency has created (50 CFR 402.12(c)). If it is determined that any such species or critical habitats may be present, the Federal agency is to prepare a biological assessment to evaluate the potential effects of the action and determine whether the species or critical habitat are likely to be adversely affected by the action (16 U.S.C. 1536(c); 50 CFR 402.12(a)). Further, biological assessments are required for any agency action that is a "major construction activity" (50 CFR 402.12(b)), which the ESA regulations define to include major Federal actions significantly affecting the quality of the human environment under the National Environmental Policy Act of 1969, as amended (42 U.S.C. 4321 et seq.; herein referred to as NEPA) (50 CFR 402.02).

Federal agencies may fulfill their obligations to consult with the Services under ESA section 7 and to prepare a biological assessment in conjunction with the interagency cooperation procedures required by other statutes, including NEPA (50 CFR 402.06(a)). In such cases, the Federal agency should include the results of the ESA section 7 consultation in the NEPA document (50 CFR 402.06(b)). Accordingly, Section C.1.2 describes the biological assessment prepared for the proposed agency action evaluated in this SEIS, and Section C.1.3 describes the chronology and results of the ESA section 7 consultation.

C.1.2 Biological Assessment

The NRC considers this SEIS to fulfill its obligation to prepare a biological assessment under ESA section 7. Accordingly, the NRC did not prepare a separate biological assessment for the proposed SQN license renewal.

Although the contents of a biological assessment are at the discretion of the Federal agency (50 CFR 402.12(f)), the ESA regulations suggest information that agencies may consider for inclusion. The NRC has considered this information in the following sections.

Section 3.8 describes the action area and the Federally listed and proposed species and designated and proposed critical habitat that have the potential to be present in the action area. This section includes information pursuant to 50 CFR 402.12(f)(1), (2), and (3).

Section 4.8 provides an assessment of the potential effects of the proposed SQN license renewal on the species and critical habitat present and the NRC's effect determinations, which are consistent with those identified in Section 3.5 of the *Endangered Species Consultation Handbook* (FWS and NMFS 1998). The NRC also addresses cumulative effects and alternatives to the proposed action. This section includes information pursuant to 50 CFR 402.12(f)(4) and (5).

C.1.3 Chronology of ESA Section 7 Consultation

Upon receipt of Tennessee Valley Authority's license renewal application, the NRC staff considered whether any Federally listed or proposed species or designated or proposed critical habitats may be present in the action area (as defined at 50 CFR 402.02) for the proposed SQN license renewal. No species under the NMFS's jurisdiction occur within the action area. Therefore, the NRC staff did not consult with the NMFS. With respect to species under the FWS's jurisdiction, the NRC staff compiled a list of ESA-protected species and critical habitats within the vicinity of the facility and requested the FWS's concurrence with this list in accordance with the ESA section 7 regulations at 50 CFR 402.12(c) in a letter dated March 20, 2013. The FWS concurred with the NRC staff's list in its letter dated July 3, 2013. The NRC staff used this list as a starting point for its analysis of effects to Federally listed species and critical habitat, which appears in Sections 3.8 and 4.8 of this SEIS. In Section 3.8, the NRC staff concludes that no ESA-protected species or critical habitat occur in the action area. In Section 4.8, the NRC staff concludes that the proposed agency action would have no effect on any ESA-protected species or critical habitat. FWS (2013) does not typically provide its concurrence with "no effect" determinations by Federal agencies. Thus, the ESA does not require further informal consultation or the initiation of formal consultation with the FWS for the proposed SQN license renewal. Nonetheless, because this SEIS constitutes the NRC's biological assessment, the NRC staff will submit a copy of this SEIS, upon its issuance, to the FWS for review in accordance with 50 CFR 402.12(j).

Table C–1 lists the letters, e-mails, and other correspondence related to the NRC's ESA obligations with respect to its review of the SQN license renewal application. This table will be updated in the final SEIS, as applicable, to include correspondence transpiring between the issuance of the draft and final SEIS.

Table C–1. ESA Section 7 Consultation Correspondence

Date	Sender and Recipient	Description	ADAMS Accession No. [(a)]
March 20, 2013	M. Wong (NRC) to C. Dohner (FWS)	Request for concurrence with list of Federally listed species and habitats for the proposed SQN license renewal	ML13079A186
June 5, 2013	B. Grange (NRC) to M. Jennings (FWS)	Request for update on the status of FWS's review of the NRC's list of Federally listed species and habitats	ML13177A193
July 3, 2013	M. Jennings (FWS) to M. Wong (NRC)	Concurrence with NRC's list of Federally listed species and habitats	ML13184A228
July 15, 2013	B. Grange (NRC) to R. Sykes (FWS)	Request for clarification on whether to include white fringeless orchid in the NRC's analysis of effects to Federally listed species and habitats	ML13197A395
July 15, 2013	R. Sykes (FWS) to B. Grange (NRC)	Reply to request for clarification on whether to include white fringeless orchid in the NRC's analysis of effects to Federally listed species and habitats	ML13197A395

[(a)] These documents can be accessed through the NRC's Agencywide Documents Access and Management System (ADAMS) at http://adams.nrc.gov/wba/.

C.2 Essential Fish Habitat Consultation

The NRC must comply with the Magnuson–Stevens Fishery Conservation and Management Act, as amended, (16 U.S.C. §1801–1884, herein referred to as Magnuson–Stevens Act) for any actions authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken that may adversely affect essential fish habitat (EFH).

In Sections 3.8 and 4.8 of this SEIS, the NRC staff concludes that NMFS has not designated EFH under the Magnuson–Stevens Act in the Chickamauga Reservoir, and that the proposed SQN license renewal would have no effect on EFH. Thus, the Magnuson–Stevens Act does not require the NRC to consult with NMFS for the proposed SQN license renewal.

C.3 National Historic Preservation Act of 1966 Consultation

The National Historic Preservation Act (NHPA) requires Federal agencies to consider the effects of their undertakings on historic properties and consult with applicable state and Federal agencies, tribal groups, and individuals and organizations with a demonstrated interest in the undertaking before taking action. Historic properties are defined as resources that are eligible for listing on the National Register of Historic Places. The historic preservation review process (Section 106 of the National Historic Preservation Act of 1966, as amended) is outlined in regulations issued by the Advisory Council on Historic Preservation (ACHP) in 36 CFR Part 800. In accordance with 36 CFR 800.8(c), the NRC has elected to use the NEPA process to comply with its obligations under Section 106 of the NHPA.

Table C–2 lists the chronology of consultations and consultation documents related to the NRC Section 106 review. The NRC staff is required to consult with the noted agencies and organizations in accordance with the statutes listed above.

Table C–2. NHPA Correspondence

Date	Sender and Recipient	Description	ADAMS Accession No. [(a)]
March 14, 2013	M. Wong (NRC) to R. Nelson (ACHP)	Request for scoping comments/notification of Section 106 review	ML13058A315
March 14, 2013	M. Wong (NRC) to E.P. McIntyre, Jr., Tennessee Historical Commission	Request for scoping comments/notification of Section 106 review	ML13058A180
March 15, 2013	M. Wong (NRC) to B. John Baker, Cherokee Nation	Request for scoping comments/notification of Section 106 review	ML13058A243
March 15, 2013	M. Wong (NRC) to B. Anoatubby, The Chickasaw Nation	Request for scoping comments/notification of Section 106 review	ML13058A243
March 15, 2013	M. Wong (NRC) to T. Yargee, Alabama Quassarte Tribal Town	Request for scoping comments/notification of Section 106 review	ML13058A243
March 15, 2013	M. Wong (NRC) to G. Tiger, Muscogee (Creek) Nation	Request for scoping comments/notification of Section 106 review	ML13058A243
March 15, 2013	M. Wong (NRC) to O.C. Sylestine, Alabama–Coushatta Tribe of Texas	Request for scoping comments/notification of Section 106 review	ML13058A243
March 15, 2013	M. Wong (NRC) to G. Scott, Thlopthlocco Tribal Town	Request for scoping comments/notification of Section 106 review	ML13058A243
March 15, 2013	M. Wong (NRC) to G.J. Wallace, Eastern Shawnee Tribe of Oklahoma	Request for scoping comments/notification of Section 106 review	ML13058A243
March 15, 2013	M. Wong (NRC) to T. Hobia, Kialegee Tribal Town	Request for scoping comments/notification of Section 106 review	ML13058A243
March 15, 2013	M. Wong (NRC) to M. Hicks, Eastern Band of the Cherokee Indians	Request for scoping comments/notification of Section 106 review	ML13058A243
March 15, 2013	M. Wong (NRC) to G. Blanchard, Absentee Shawnee Tribe of Oklahoma	Request for scoping comments/notification of Section 106 review	ML13058A243
March 15, 2013	M. Wong (NRC) to G.G. Wickliffe, United Keetoowah Band of Cherokee Indians in Oklahoma	Request for scoping comments/notification of Section 106 review	ML13058A243
March 15, 2013	M. Wong (NRC) to J. E. Billie, Seminole Tribe of Florida	Request for scoping comments/notification of Section 106 review	ML13058A243

Date	Sender and Recipient	Description	ADAMS Accession No. [(a)]
March 15, 2013	M. Wong (NRC) to L. M. Harjo, Seminole Nation of Oklahoma	Request for scoping comments/notification of Section 106 review	ML13058A243
March 25, 2013	L. LaRue-Baker, United Keetoowah band of Cherokee Indians in Oklahoma to E. Larson (NRC)	Response to request for scoping comments	ML13084A357
April 30, 2013	M. Wong (NRC) to the Eastern Tennessee Historical Society	Request for scoping comments/notification of Section 106 review	ML13112A141
May 6, 2013	M. Wong (NRC) to The Tennessee Historical Society	Request for scoping comments/notification of Section 106 review	ML13113A301

[(a)]These documents can be accessed through the NRC's ADAMS at http://adams.nrc.gov/wba/.

C.4 References

50 CFR Part 402. *Code of Federal Regulations*, Title 50, *Wildlife and Fisheries*, Part 402, "Interagency cooperation—Endangered Species Act of 1973, as amended."

Endangered Species Act of 1973, as amended. 16 U.S.C. §1531 et seq.

[FWS] U.S. Fish and Wildlife Service. 2013. "Consultations: Frequently Asked Questions." Available at <http://www.fws.gov/endangered/what-we-do/faq.html#8> (accessed 20 June 2014).

[FWS and NMFS] U.S. Fish and Wildlife Service and National Marine Fisheries Service. 1998. *Endangered Species Consultation Handbook: Procedures for Conducting Consultation and Conference Activities Under Section 7 of the Endangered Species Act*. March 1998. 315 p. Available at <http://www.fws.gov/endangered/esa-library/pdf/esa_section7_handbook.pdf> (accessed 8 July 2013).

Magnuson–Stevens Fishery Conservation and Management Act, as amended. 16 U.S.C. §1801–1884.

National Environmental Policy Act of 1969, as amended. 42 U.S.C. §4321 et seq.

APPENDIX D
CHRONOLOGY OF ENVIRONMENTAL REVIEW CORRESPONDENCE

CHRONOLOGY OF ENVIRONMENTAL REVIEW CORRESPONDENCE

This appendix contains a chronological listing of correspondence between the U.S. Nuclear Regulatory Commission (NRC) and external parties as part of its license renewal application (LRA) environmental review for Sequoyah Nuclear Plant, Units 1 and 2 (SQN) other than consultation correspondence and comments received during the scoping process. Consultation correspondence is listed and discussed in Appendix C of this supplemental environmental impact statement (SEIS). Scoping comments are provided and addressed in Appendix A of this SEIS and in the Scoping Summary Report (see Table D–1 below). All documents are available electronically from the NRC's Public Electronic Reading Room found on the Internet at the following Web address: http://www.nrc.gov/reading-rm.html. From this site, the public can gain access to the NRC's Agencywide Documents Access and Management System (ADAMS), which provides text and image files of the NRC's public documents in ADAMS. The ADAMS accession number for each document is included in the following table.

D.1 Environmental Review Correspondence

Table D–1 lists the environmental review correspondence, by date, beginning with the request by Tennessee Valley Authority (TVA) to renew the operating license for SQN.

Table D–1. Environmental Review Correspondence

Date	Correspondence Description	ADAMS No.
January 7, 2013	Transmittal of SQN LRA from TVA to NRC	ML13024A004
February 8, 2013	Receipt and availability of SQN LRA	ML13016A489
February 26, 2013	Determination of acceptability and sufficiency for docketing, proposed review schedule, and opportunity for a hearing regarding the application from TVA, for renewal of the operating licenses for SQN	ML13035A214
March 12, 2013	Notice of intent to prepare an environmental impact statement and conduct scoping process for license renewal for SQN	ML13056A161
March 20, 2013	Forthcoming meeting to discuss the license renewal process and environmental scoping for SQN	ML13067A331
April 3, 2013	Transcript from afternoon public scoping meeting	ML13108A137
April 3, 2013	Transcript from evening public scoping meeting	ML13108A138
March 26, 2013	Transmittal of environmental audit plan to TVA	ML13067A244
May 23, 2013	Transmittal of environmental and severe accident mitigation alterative (SAMA) requests for additional information (RAIs)	ML13119A083
June 7, 2013	Transmittal of revised environmental and SAMA RAIs	ML13136A358
July 17, 2013	TVA response to SAMA RAIs	ML13227A003
July 23, 2013	TVA response to environmental RAIs	ML13206A385
August 7, 2013	Environmental audit summary	ML13120A198
September 20, 2013	TVA transmittal of documents in support of environmental review	ML13289A108
September 20, 2013	TVA transmittal of documents regarding archaeological, protected species and habitats and terrestrial ecology resources in support of environmental review	ML13282A585
February 10, 2014	Schedule change letter	ML14007A470
March 4, 2014	Schedule change letter	ML14059A347
April 24, 2014	Scoping Summary Report	ML14041A118

APPENDIX E
ACTIONS AND PROJECTS CONSIDERED IN CUMULATIVE ANALYSIS

ACTIONS AND PROJECTS CONSIDERED IN CUMULATIVE ANALYSIS

E.1 Actions and Projects Considered in Cumulative Analysis

Table E–1 identifies actions and projects considered in the U.S. Nuclear Regulatory Commission (NRC) staff's analysis of cumulative impacts related to the environmental analysis of the continued operation of Sequoyah Nuclear Plant, Units 1 and 2 (SQN). Not all actions or projects listed in this appendix are considered in each resource area because of the uniqueness of the resource and its geographic area of consideration.

1 **Table E–1. Actions and Projects Considered in Cumulative Analysis**

Project Name	Summary of Project	Location With Respect to SQN	Status
Nuclear projects			
WBN Units 1 and 2	Nuclear power plant Two 1,123-MWe Westinghouse four-loop reactors	Soddy Daisy, TN Approximately 45 mi (72 km) northeast	Operational WBN Unit 1 is currently licensed to continue operations through November 11, 2035 (NRC 2014a). WBN Unit 2 construction 80% complete; completion projected for December 2015 (TVA 2014j). Major NPDES permit No. TN0020168
Clinch River Site	Up to six Babcock & Wilcox mPower design small modular reactor (SMR) modules	Roane County, TN Approximately 65 mi (104 km) northeast	Proposed Application not yet submitted, but construction permit expected in December 2015 (TVA 2013b)
Oak Ridge Reservation	Research and manufacturing park including Oak Ridge National Laboratory, the East Tennessee Technology Park, the Y-12 National Security Complex, and the TRU Waste Processing Facility	Oak Ridge, TN Approximately 35 mi (56 km) northeast	Operational (DOE 2012)
Bellefonte Nuclear Plant, Units 1 and 2	Nuclear power plant Two 1,260-MWe Babcock and Wilcox-designed pressurized light water reactors	Scottsboro, AL Approximately 89 mi (143 km) southwest	Deferred Bellefonte Units 1 and 2 construction permits were issued December 24, 1974. The construction permit for Unit 1 has been extended to October 1, 2020 (AP 2011; TVA 2013a).
Bellefonte Nuclear Plant, Units 3 and 4	Nuclear power plant Two 1,148-MWe Westinghouse four-loop reactors	Scottsboro, AL Approximately 89 mi (143 km) southwest	Deferred Application for two new nuclear units submitted October 30, 2007 (NRC 2014b)

Project Name	Summary of Project	Location With Respect to SQN	Status
Coal-fired energy projects			
Kingston Fossil Plant	Nine-unit coal-fired plant 1,398 MW	Kingston, TN Approximately 25 mi (40 km) northeast	Operational NPDES permit No. TN0005452 (TVA 2014e)
Bull Run Fossil Plant	Single-generator coal-fired plant 870 MW	Oak Ridge, TN Approximately 46 mi (74 km) northeast	Operational NPDES permit No. TN0005410 (TVA 2014b)
Dams and hydroelectric energy projects			
Watts Bar Dam	Hydroelectric power plant on the Tennessee River Five units totaling 182 MW	Spring City, TN Approximately 31 mi (51 km) northeast	Operational (TVA 2014i)
Apalachia Dam	Hydroelectric power plant on the Hiwassee River Two units totaling 82 MW	Murphy, NC Approximately 45 mi (73 km) east	Operational (TVA 2014a)
Chickamauga Dam	Hydroelectric power plant on the Tennessee River Four units totaling 119 MW Flood control for the city of Chattanooga, TN Future Chickamauga Lock replacement (stalled because of funding issues; some construction complete)	Chattanooga, TN Approximately 11 mi (19 km) southwest	Operational (TVA 2014c) Proposed lock replacement, but stalled because of funding issues Some preconstruction complete (USACE 2014)
Nickajack Dam	Hydroelectric power plant on the Little Tennessee River Four units totaling 106 MW	Marion County, TN Approximately 34 mi (55 km) southwest	Operational (TVA 2014f)
Raccoon Mountain Pumped-Storage Plant	Hydroelectric power plant Four units totaling 1,616 MW	Chattanooga, TN Approximately 20 mi (32 km) southwest	Operational (TVA 2014h)
Ocoee Dam #1	Hydroelectric power plant on the Ocoee River Five generating units totaling 24 MW	Benton, TN Approximately 27 mi (43 km) south-southeast	Operational Minor NPDES permit No. TN0027499 (TVA 2014g)

Project Name	Summary of Project	Location With Respect to SQN	Status
Dams and hydroelectric energy projects (continued)			
Watts Bar Dam Safety Modifications	Installation of permanent measures for safety deficiencies related to maximum flood events May include removing temporary barriers, installing permanent modifications in the form of a combination of concrete floodwalls, raised earthen embankments or berms and gap closure barriers	Upstream from Watts Bar Dam in the vicinity of the Watts Bar Dam Recreation Area Potential construction staging area downstream of dam and adjacent to the lock canal	Final EIS published May 2013 (TVA 2014d) Current status of TVA Watts Bar Dam safety modifications is provided in Enclosure 3 of a letter from TVA to NRC dated 4/25/14, available at http://pbadupws.nrc.gov/docs/ML1412/ML14122A219.pdf.
Water supply and treatment facilities			
Dayton, TN, sewage treatment plant	Wastewater treatment facility on Chickamauga Lake	Approximately 17 mi (27 km) southwest	Operational Major NPDES permit No. TN0020478 (EPA 2014a)
Dayton, TN, water supply	Withdraws water from Chickamauga Lake Reservoir	Approximately 19 mi (30 km) northeast	Operational (City of Dayton 2014)
Loudon Utilities Board	Withdraws water from the Tennessee River	Approximately 53 mi (85 km) northeast	Operational Planning to expand capacity (LUB 2014)
Kingston sewage treatment plant	Sewage treatment facilities on the Lower Clinch River	Roane County, TN Approximately 53 mi (84 km) northeast	Operational Major NPDES permit No. TN0061701 (EPA 2014a)
Roane County wastewater plant	Sewage treatment facilities on the Lower Clinch River	Roane County, TN Approximately 54 mi (87 km) northeast	Operational Major NPDES permit No. TN0024473 (EPA 2014a)
Watts Bar Utility District	Withdraws groundwater and purchases surface water	Approximately 61 mi (99 km) northeast	Operational (WBUD 2013)
Moccasin Bend wastewater treatment plant	Wastewater treatment facility on Chickamauga Lake	Chattanooga, TN Approximately 19 mi (30 km) southwest	Operational Major NPDES permit No. TN0024210 (EPA 2014a)
Tennessee American Water	Withdraws water from the Tennessee River	Chattanooga, TN Approximately 17 mi (28 km) southwest	Operational (TAW 2014)
Cleveland Utilities sewage treatment plant	Wastewater treatment facility on the Hiwassee River	Cleveland, TN Approximately 17 mi (28 km) northeast	Operational Major NPDES permit No. TN0024121 (EPA 2014a)

Project Name	Summary of Project	Location With Respect to SQN	Status
Manufacturing facilities			
General Shale Brick, Inc., Plant 42	Brick and structural clay tile manufacturing	Spring City, TN Approximately 35 mi (57 km) northeast	Operational Major air permit No. 4714300116; minor NPDES permit Nos. TN0079839 and TN0079863 (EPA 2014a, 2014b)
Resolute Forest Products (formerly AbiBow)	Integrated pulp and paper mill on the Hiwassee River	Calhoun, TN Approximately 20 mi (32 km) east	Operational Major NPDES permit No. TN0002356 (EPA 2014a, 2014b)
Olin Chemical Corporation	Manufacturer of chlorine and caustic soda on the Hiwassee River	Charleston, TN Approximately 18 mi (29 km) east	Operational Major NPDES permit No. TN0002461 (EPA 2014a)
Various minor NPDES wastewater discharges	Various businesses with smaller wastewater discharges	Within 10 mi (16 km)	Operational (EPA 2014a)
Transportation			
Tennessee Toll Bridge	Proposed bridge and highway linking U.S. Highway 27 at Sequoyah Access Road to Interstate 75	Within 15 mi (24 km)	In planning stages by Tennessee Department of Transportation (CHCRPA 2011)
Parks and recreation sites			
Harrison Bay State Park	485 ha (1,200 ac) on 40 mi (60 km) of Chickamauga Lake shoreline with various parks, trails, boat launches, campgrounds, swimming areas	Approximately 3 mi (5 km) southwest	Managed by Tennessee Department of Environment and Conservation (TDEC) (TSP 2013c)
Booker T. Washington State Park	142 ha (353 ac) near Chattanooga with a bike trail, boat launches, and swimming area	Approximately 9 mi (14 km) southwest	Managed by TDEC (TSP 2013a)
Yuchi Wildlife Refuge	957 ha (2,364 ac) with small game hunting	Approximately 28 mi (45 km) northeast	Managed by the Tennessee Wildlife Resources Agency (TWRA) (TWRA 2014a)
Watts Bar Wildlife Management Area	1,570 ha (3,880 ac) with big and small game hunting	Includes both Thief Neck Island and Long Island Approximately 46 and 54 mi (75 and 87 km) northeast	Managed by the TWRA (TWRA 2014b)

Project Name	Summary of Project	Location With Respect to SQN	Status
Parks and recreation sites (continued)			
Recreational Areas	Various parks, boat launches, campgrounds, swimming areas on Chickamauga Lake	Within 10 mi (16 km)	Operational
Chickamauga Wildlife Management Area	1,620 ha (4,000 ac) in Bradley, Hamilton, McMinn, Meigs, and Rhea Counties Big and small game hunting	Throughout the region, includes Yellow Creek, Washington Ferry, McKinley Branch, Goodfield Creek, Cottonport, Shelton Bottoms, Moon Island, Gillespie Bend, Mud Creek, New Bethel, Sale Creek, and Soddy Creek wildlife management areas	Managed by the TWRA (TWRA 2014c)
Cumberland Trail State Scenic Trail	A 300-mi (480-km) backcountry hiking trail from Cumberland Gap National Park, KY, to Chickamauga Chattanooga National Military Park	Throughout region	Approximately 175 mi (280 km) of the trail has been constructed. Managed by the Cumberland Trail Conference (TSP 2013b)
Sequoyah projects			
ISFSI expansion	ISFSI currently licensed on SQN plant site; may require expansion in the future	SQN site	No immediate plans (TVA 2013a)
Production of tritium	SQN plant selected by DOE for purchase of irradiation services. Addition of employees (fewer than 10 employees per unit) and plant modifications. Irradiated tritium-producing burnable absorber rod assemblies, nonradioactive waste, and some additional low-level radioactive waste would be transported off site for processing and disposal.	SQN site	Notice of intent to prepare and EIS published in 2011, with accompanying scoping meetings held in October 2011. Draft EIS not yet published for public comment (NNSA 2012; TVA 2013a)

Project Name	Summary of Project	Location With Respect to SQN	Status
Sequoyah projects (continued)			
Use of highly enriched uranium (HEU) fuel	TVA plans to acquire 28 metric tons of HEU from the DOE for downblending to BLEU and use as reactor fuel at SQN through 2022.	SQN site	EA with finding of no significant impact finished in 2011 (TVA 2013a)
Use of mixed-oxide fuel (MOXF)	SQN is a potential site for DOE's surplus Pu dispositioning. Fabricating MOXF entails mixing Pu with depleted UO, manufacturing the fuel into pellets, and loading the pellets into fuel assemblies for use in nuclear reactors.	SQN site	TVA is coordinating with the DOE on the EIS. Draft closed for comment in October 2012 Currently preparing final EIS (NNSA 2014; TVA 2013a)
Other projects			
Future Urbanization	Construction of housing units and associated commercial buildings; roads, bridges, and rail; and water and wastewater treatment and distribution facilities and associated pipelines as described in local land-use planning documents. Industrial parks in Chattanooga, the fastest growing city in TN.	Throughout region	Construction would occur in the future, as described in State and local land-use planning documents (CHCRPA 2014)
RV Park	RV park directly across from SQN site. Land was previously undeveloped. Is on same municipal water supply as SQN.	Directly across from SQN	Operational (Allstays 2014)

Key: ac = acres; BLEU = blended low-enriched uranium; CHCRPA = Chattanooga–Hamilton County Regional Planning Agency; DOE = Department of Energy; EA = environmental assessment; EIS = environmental impact statement; EPA = U.S. Environmental Protection Agency; ha = hectares; HEU = highly enriched uranium; ISFSI = independent spent fuel storage installation; LUB = Loudon Utilities Board; MOXF = mixed-oxide fuel; MW = megawatts; MWe = megawatts electric; NNSA = National Nuclear Security Administration; NPDES = National Pollutant Discharge Elimination System; NRC = U.S. Nuclear Regulatory Commission; Pu = plutonium; RV = recreational vehicle; SMR = small modular reactor; SQN = Sequoyah Nuclear Plant, Units 1 and 2; TAW = Tennessee American Water; TRU = transuranic; TSP = Tennessee State Parks; TVA = Tennessee Valley Authority; TWRA = Tennessee Wildlife Resources Agency; UO = uranium oxide; USACE = United States Army Corps of Engineers; WBN = Watts Bar Nuclear Power Plant; WBUD = Watts Bar Utility District

Sources: Allstays 2014; AP 2011; CHCRPA 2011, 2014; City of Dayton 2014; DOE 2012; EPA 2014a. 2014b; LUB 2014; NNSA 2012, 2014; NRC 2014a, 2014b; TAW 2014; TSP 2013a, 2013b, 2013c; TVA 2013a, 2013b, 2014a, 2014b, 2014c, 2014d, 2014e, 2014f, 2014g, 2014h, 2014i, 2014j; TWRA 2014a, 2014b, 2014c; USACE 2014; WBUD 2013

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APPENDIX F
NRC STAFF EVALUATION OF SEVERE ACCIDENT MITIGATION ALTERNATIVES

U.S. NUCLEAR REGULATORY COMMISSION STAFF EVALUATION OF SEVERE ACCIDENT MITIGATION ALTERNATIVES FOR SEQUOYAH NUCLEAR STATION IN SUPPORT OF LICENSE RENEWAL APPLICATION REVIEW

F.1 Introduction

Tennessee Valley Authority (TVA) submitted an assessment of severe accident mitigation alternatives (SAMAs) for the Sequoyah Nuclear Station (SQN) Units 1 and 2 in Section 4.21 and Attachment E of the Environmental Report (ER) (TVA 2013d). This assessment was based on the most recent revision to SQN probabilistic risk assessment (PRA) for each unit, including an internal events model and a plant-specific offsite consequence analysis performed using the WinMACCS Version 3.6.0 computer code, and insights from the SQN individual plant examination (IPE) submittals (TVA 1992, 1998) and individual plant examination of external events (IPEEE) submittals (TVA 1995, 1999). In identifying and evaluating potential SAMAs, TVA considered SAMAs that addressed the major contributors to core damage frequency (CDF) and population dose at SQN, SAMA-related industry documentation, plant-specific enhancements not in published industry documentations, as well as insights and SAMA candidates from potential improvements at twelve other plants. TVA initially identified a list of 309 potential SAMAs. This list was reduced to 47 unique SAMA candidates by eliminating SAMAs that: were not applicable to SQN; had already been implemented at SQN; were combined into a more comprehensive or plant-specific SAMA; had excessive implementation cost; is related to a non-risk significant system; or related to in-progress implementation of plant improvements that address the intent of the SAMA. From the baseline analysis, TVA concluded in the ER that nine and eight candidate SAMAs are potentially cost-beneficial for Units 1 and 2, respectively. From a sensitivity analysis (TVA 2013d, Attachment E), TVA identified an additional seven and nine candidate SAMAs as potentially cost beneficial for Units 1 and 2, respectively.

As a result of the review of the SAMA assessment, the U.S. Nuclear Regulatory Commission (NRC) staff issued requests for additional information (RAIs) to TVA by letter dated June 7, 2013 (NRC 2013). Key questions concerned: changes and updates to Level 1 and Level 2 PRA models that most affected CDF; differences in CDF values and importance measures; systems shared between both units and influences from events at one unit on the other unit; the impact of open items and issues from the peer review of the PRA; the assignment of representative accident scenarios and release categories considering the set of containment event tree (CET) end states; the impact of recent external flooding developments on external event conclusions; potential effects of weaknesses in the fire analysis; new information on fire-initiated events; and further information on the cost-benefit analysis of several specific candidate SAMAs and low-cost alternatives. In response to the NRC staff RAI, TVA submitted additional information by a letter dated July 17, 2013 (TVA 2013c), and provided further information on the key questions. The TVA's responses addressed the NRC staff's concerns and resulted in the identification of four additional potentially cost-beneficial SAMAs that apply to both units.

An assessment of the SAMAs for SQN is presented below.

F.2 Estimate of Risk for SQN

The TVA's estimates of offsite risk at SQN are summarized in Section F.2.1. The summary is followed by the NRC staff's review of TVA's risk estimates in Section F.2.2.

F.2.1 TVA's Risk Estimates

Two distinct analyses are combined to form the basis for the risk estimates used in the SAMA analysis: (1) the SQN Level 1 and 2 PRA models, which are essentially new models and (2) a supplemental analysis of offsite consequences and economic impacts (essentially a Level 3 PRA model) developed specifically for the SAMA analysis. The SAMA analysis is based on the most recent SQN Level 1 and Level 2 PRA models available at the time of the ER, referred to as the SQN SAMA model (TVA 2013d). The scope of this SQN PRA does not include external events.

The SQN Unit 1 CDF is approximately 3.0×10^{-5} per reactor-year while the Unit 2 CDF is approximately 3.5×10^{-5} per reactor-year. These values were used as the baseline CDF in the SAMA evaluations (TVA 2013d). The CDF is based on the risk assessment for internally initiated events, which includes internal flooding. TVA did not explicitly include the contribution from external events within the SQN risk estimates; however, it did account for the potential risk reduction benefits for individual SAMAs associated with external events by multiplying the estimated benefits for internal events by a factor of 2.9 for Unit 1 and 2.6 for Unit 2. This is discussed further in Sections F.2.2 and F.6.2.

The breakdown of CDF by initiating event is provided in Table F–1. As shown in these tables, Internal Flooding, Loss of All Component Cooling Water (CCW) and Stuck Open Safety/Relief Valve are the dominant contributors to the CDF in both units. Station blackout (SBO) and anticipated transients without scram (ATWS) are not listed explicitly in Table F–1 because multiple initiators contribute to their occurrence. SBO contributes about 13 percent and 10 percent to the total CDF for Units 1 and 2, respectively (3.9×10^{-6} per reactor-year and 3.6×10^{-6} per reactor-year), while ATWS contribute about 14 percent and 12 percent to the total CDF for Units 1 and 2, respectively (4.1×10^{-6} per reactor-year for each unit). Note that in a subsequent correction to the ATWS model, TVA indicated that ATWS contribute about 2 percent and 2.3 percent to the total CDF for Units 1 and 2, respectively (TVA 2013c). This is discussed in more detail in Section F.2.2.1.

The Level 2 SQN PRA model that forms the basis for the SAMA evaluation is essentially a new model for SQN. The Level 2 model was developed with a focus on the quantification of large early release frequency (LERF) but does include the development of other end states. The Level 2 model utilizes CETs containing both phenomenological and systemic events. The core damage sequences from the Level 1 PRA are binned into plant damage states (PDSs) based on similar characteristics that influence the accident progression following core damage. These bins provide the interface between the Level 1 and Level 2 CET analyses. The CETs are linked directly to the Level 1 event trees and CET nodes based on the PDS.

Table F–1. SQN Units 1 and 2 CDF for Internal Events

Initiating Event	Unit 1 CDF (per year)	Unit 1 Percent CDF Contribution[1]	Unit 2 CDF (per year)	Unit 2 Percent CDF Contribution[1]
Internal Flooding	1.7×10^{-5}	56	2.3×10^{-5}	66
Loss of All CCW	3.6×10^{-6}	12	3.2×10^{-6}	9
Stuck Open Safety/Relief Valve	2.3×10^{-6}	8	2.5×10^{-6}	7
Secondary Side Break Outside of Containment	1.3×10^{-6}	4	1.4×10^{-6}	4
Losses of Main Feedwater	9.3×10^{-7}	3	6.9×10^{-7}	2
Reactor Trip	9.2×10^{-7}	3	9.1×10^{-7}	3
Loss of Train A CCW[2]	9.0×10^{-7}	3	7.6×10^{-7}	2
Loss of Instrument Boards	7.4×10^{-7}	2	5.7×10^{-7}	2
Other Initiating Events[3]	6.8×10^{-7}	2	5.6×10^{-7}	2
Loss of Offsite Power	6.5×10^{-7}	2	3.9×10^{-7}	1
Turbine Trip	5.1×10^{-7}	2	5.1×10^{-7}	1
Small Loss of Coolant Accident (LOCA)	3.9×10^{-7}	1	4.5×10^{-7}	1
Total CDF (Internal Events)	**3.0×10^{-5}**	**100**	**3.5×10^{-5}**	**100**

[1] Percentages were rounded to the nearest whole percent for reporting and may not sum to 100 percent because of round off error.

[2] Train A is listed as Train 1A for Unit 1 and Train 2A for Unit 2.

[3] Multiple initiating events with each contributing less than 1 percent.

The CET considers the influence of physical and chemical processes on the integrity of the containment and on the release of fission products once core damage has occurred. Each CET sequence was assigned to one of seven end state categories. Four of these categories represent LERF with the remaining representing late and small early releases and an intact containment. These end states were subsequently grouped into 12 release categories (or release modes) that provide the input to the Level 3 consequence analysis. The frequency of each release category was obtained by summing the frequency of the individual accident progression CET endpoints binned into the release category. The determination of the characteristics for each release category was based on representative accident scenarios that reflect the core damage and containment behavior for the dominant sequence or sequences within a PDS and the dominant Level 2 sequence within the release category. The source terms for the representative scenarios were based on a SEQSOR emulation spreadsheet methodology. The results of this analysis for SQN are provided in Table E.1–15 of ER Attachment E (TVA 2013d).

TVA computed offsite consequences for potential releases of radiological material using the WinMACCS Version 3.6.0 code and analyzed exposure and economic impacts from its determination of offsite and onsite risks. Inputs for these analyses include plant-specific and site-specific input values for core radionuclide inventory, source term and release characteristics, site meteorological data, projected population distribution and growth within a 50-mile radius, emergency response evacuation modeling, and economic data. Because of the similarity of the reactor cores at Watts Bar Unit 1, SQN Unit 1, and SQN Unit 2, the radionuclide inventory for the SQN SAMA analysis is based on the core inventory for Watts Bar Unit 1 multiplied by the power ratio of the SQN Unit 1 power of 1,148 MWe to the Watts Bar Unit 1 power of 1,123 MWe (TVA 2013d, Attachment E). Although the SQN Unit 2 power was slightly lower at 1,126 MWe, the same core inventory for SQN Unit 1 was used for the SQN Unit 2 consequence analysis. The estimation of onsite impacts (in terms of cleanup and decontamination costs and occupational dose) is based on guidance in NUREG/BR–0184 (NRC 1997b).

In the ER, the applicant estimated the dose risk to the population within 80 km (50 mi) of the SQN site to be 0.450 person-sievert (Sv) per year (45.0 person-rem per year) for Unit 1 and 0.439 person-Sv per year (43.9 person-rem per year) for Unit 2 (TVA 2013d, Tables E.1-20 and E.1-21). The breakdown of the population dose risk by containment release mode is summarized in Table F–2. Late containment failure releases and large early releases caused by containment isolation failures accounted for approximately 79 and 75 percent of the population dose risk at Units 1 and 2, respectively. Late containment failure releases alone contributed approximately 47 and 45 percent of the population dose risk at Units 1 and 2. Late containment failure releases and large early releases caused by containment isolation failures accounted for approximately 85 and 83 percent of the offsite economic cost risk (OECR) at Units 1 and 2, respectively. Late containment failure releases alone contributed approximately 58 and 56 percent of the OECR at Units 1 and 2.

Table F–2. Base Case Mean Population Dose Risk and Offsite Economic Cost Risk for Internal Events

	Release Mode		Population Dose Risk[1]				Offsite Economic Cost Risk			
	Frequency (per year)		Person-rem/yr		Percent Contribution[3]		$/yr		Percent Contribution[3]	
ID[2]	Unit 1	Unit 2	Unit 1	Unit 2	Unit 1	Unit 2	Unit 1	Unit 2	Unit 1	Unit 2
Ia	4.1×10^{-8}	4.6×10^{-8}	1.2×10^{-1}	1.3×10^{-1}	<1	<1	$2.3\times10^{+2}$	$2.6\times10^{+2}$	<1	<1
Ib	9.7×10^{-7}	9.5×10^{-7}	$2.5\times10^{+0}$	$2.5\times10^{+0}$	6	6	$5.2\times10^{+3}$	$5.1\times10^{+3}$	5	5
Ic	2.7×10^{-7}	3.9×10^{-7}	7.0×10^{-1}	$1.0\times10^{+0}$	2	2	$1.4\times10^{+3}$	$2.1\times10^{+3}$	1	2
IIa	3.3×10^{-6}	3.3×10^{-6}	$1.2\times10^{+1}$	$1.2\times10^{+1}$	26	27	$2.2\times10^{+4}$	$2.2\times10^{+4}$	23	24
IIb	6.3×10^{-7}	3.3×10^{-7}	$2.2\times10^{+0}$	$1.1\times10^{+0}$	5	3	$4.2\times10^{+3}$	$2.2\times10^{+3}$	4	2
IIc	6.5×10^{-8}	6.3×10^{-8}	1.3×10^{-1}	1.2×10^{-1}	<1	<1	$2.9\times10^{+2}$	$2.8\times10^{+2}$	<1	<1
IId	4.8×10^{-8}	6.8×10^{-8}	1.1×10^{-1}	1.5×10^{-1}	<1	<1	$2.4\times10^{+2}$	$3.4\times10^{+2}$	<1	<1
III	6.4×10^{-7}	7.4×10^{-7}	$5.9\times10^{+0}$	$6.7\times10^{+0}$	13	15	$7.0\times10^{+3}$	$8.1\times10^{+3}$	7	9
IVa	1.8×10^{-5}	1.7×10^{-5}	$1.9\times10^{+1}$	$1.9\times10^{+1}$	42	43	$5.0\times10^{+4}$	$4.9\times10^{+4}$	52	53
IVb	2.2×10^{-6}	1.2×10^{-6}	$2.2\times10^{+0}$	$1.2\times10^{+0}$	5	3	$5.7\times10^{+3}$	$3.2\times10^{+3}$	6	3
Va	2.1×10^{-6}	2.0×10^{-6}	2.8×10^{-1}	2.7×10^{-1}	1	1	$2.6\times10^{+2}$	$2.5\times10^{+2}$	<1	<1
Vb	1.1×10^{-6}	1.9×10^{-6}	1.5×10^{-1}	2.5×10^{-1}	<1	1	$1.3\times10^{+2}$	$2.3\times10^{+2}$	<1	<1
Totals			$\mathbf{4.5\times10^{+1}}$	$\mathbf{4.4\times10^{+1}}$	**100**	**100**	$\mathbf{9.7\times10^{+4}}$	$\mathbf{9.3\times10^{+4}}$	**100**	**100**

[1] Unit Conversion Factor: 1 Sv = 100 rem

[2] Release Category Descriptions

- I – Large early releases with containment failures
- II – Large early releases with containment isolation failures
- III – Large early releases with containment bypass
- IV – Late containment failure release
- V – Small early release with some mitigation

[3] Percentages are rounded to the nearest whole percent for reporting and may not sum to 100 percent because of roundoff error.

F.2.2 Review of TVA's Risk Estimates

The TVA's determination of offsite risk at SQN is based on the following three major elements of analysis:

- essentially new Level 1 and 2 risk models that replace the original 1992 and revised 1998 IPE submittals (TVA 1992, 1998),
- the external event analyses of the 1995 and 1999 IPEEE submittals (TVA 1995, 1999), and
- the combination of offsite consequence measures from WinMACCS analyses with release frequencies and radionuclide source terms from the Level 2 PRA model.

Each analysis element was reviewed to determine the acceptability of TVA's risk estimates for the SAMA analysis, as summarized further in this section.

F.2.2.1 Internal Events CDF Model

The NRC staff's review of the SQN IPE is described in an NRC letter dated May 15, 1995 (NRC 1995). From its review of the IPE submittal, NRC staff concluded that the IPE process was acceptable in meeting the intent of Generic Letter (GL) 88-20 (NRC 1988). Although no vulnerabilities were identified in the IPE, 11 enhancements or improvements were identified. Based on the disposition of the Phase I SAMA candidates discussed in ER Section E.2.2, nine of these improvements have been implemented and two were retained as potential SAMAs for further analysis.

The internal events CDF value from the 1992 IPE (1.7×10^{-4} per reactor-year) is above the average and near the maximum of the values reported for other Westinghouse 4-loop plants. Figure 11.6 of NUREG–1560 (NRC 1997a) shows that the IPE-based total internal events CDF for Westinghouse 4-loop plants range from 3×10^{-6} per year to 2×10^{-4} per year, with an average CDF for the group of 6×10^{-5} per year. It is recognized that other plants have updated the values for CDF subsequent to the IPE submittals to reflect modeling and hardware changes. The internal events CDF result for SQN used for the SAMA analysis (3.0×10^{-5} per year and 3.5×10^{-5} per year for Units 1 and 2, respectively) is near the average for other plants of similar vintage.

It is noted that the SQN was one of the units analyzed in considerable detail in the NUREG–1150 analysis of the risk of five nuclear power plants (NRC 1990b). NUREG–1150 indicated the mean internal events CDF for SQN was 4×10^{-6} per year, which is very similar to the current TVA estimate. It should be noted, however, that the NUREG–1150 value does not include internal flooding, which, as seen above, accounts for about 50 percent of the current CDF estimates.

There have been seven (six plus the draft of the initial cutset and fault tree analysis (CAFTA) model) revisions to the SQN Level 1 model since the 1992 IPE submittal. A listing of the changes made to the SQN PRA since the original IPE submittal was provided in the ER and in response to an NRC staff RAI (TVA 2013c, 2013d), as summarized in Table F–3. A comparison of internal events CDF between the 1992 IPE and the current PRA model indicates a decrease of about a factor of five in the total CDF (from 1.7×10^{-4} per reactor-year to 3.0×10^{-5} and 3.5×10^{-5} per reactor-year for Units 1 and 2 respectively). This reduction can be attributed to incorporation of plant-specific data, improved modeling details, and removal of conservatism.

Table F–3. Summary of Major PRA Models and Corresponding CDF and LERF Results

RA Model	Summary of Significant Changes from Prior Model	CDF (per year) Unit 1	CDF (per year) Unit 2	LERF (per year) Unit 1	LERF (per year) Unit 2
1992 (IPE)		1.7×10^{-4} (same model)		2.7×10^{-6} (same model)	
1995 (R1)	Incorporation of a crosstie line from the 480-V Board Room 1A to the 480-V Board Room 1B and a crosstie line from 480-V Board Room 2A to the 480-V Board Room 2B for 120-V alternating current inverters room cooling Requantification of operator action “Align High-Pressure Recirculation, Given Auto Swapover Succeeds” because of revision of the procedures and training programs applicable to this operator action Revision of the success criteria for component cooling system (CCS) Train A Removal of CCS mechanical seal cooling requirement for successful operation of the safety injection, residual heat removal (RHR), and centrifugal charging pumps	3.8×10^{-5} (same model)		6.1×10^{-7} (same model)	
2000 (R2)	Modification of steam generator level control valves for the turbine-driven auxiliary feedwater pump (TDAFWP) fail open on a loss of plant air Revision of success criteria for bleed and feed cooling to require one power operated relief valve (PORV) Reviewed reactor coolant pump (RCP) seal failure and electric power recovery models against current plant and industry data Review and revision of emergency raw cooling water (ERCW) strainer maintenance Lowering of model quantification cutoff value from 10^{-9} to 10^{-12}	6.3×10^{-6} (same model)[1]		1.1×10^{-7} (same model)[1]	
2003 (R3)	Update to human action analysis and error rates Separation of reactor trip failure (ATWS) and steam generator tube rupture into individual event tree modules Review of various systems analyses to confirm current system installation and operation, included necessary changes to system modeling or success criteria Revision of plant compressed air fault trees to address replacement of C and D air compressors with new, higher-capacity units	1.3×10^{-5} (same model)[1]		2.6×10^{-7} (same model)[1]	
2006 (R4)	Incorporation of plant-specific data collected by the Maintenance Rule program and comments made by the plant system engineers Model changes to permit calculation of Fussel-Vesely importance values Verification, update, and reevaluation of human actions	1.8×10^{-5} (same model)[1]		3.9×10^{-7} (same model)[1]	
2011 Draft CAFTA[2]	Complete revision of the Revision 4 model including conversion from the RISKMAN software platform into CAFTA–peer reviewed February 2011	6.5×10^{-5}	6.3×10^{-5}	2.5×10^{-6}	3.1×10^{-6}

RA Model	Summary of Significant Changes from Prior Model	CDF (per year)		LERF (per year)	
		Unit 1	Unit 2	Unit 1	Unit 2
2011 (PRA CAFTA R0)[2]	Created new core damage sequences to account for pressure relief for transients Performed Bayesian update of basic event probabilities that were significant contributors to risk Reclassified 480 gpm (gallon-per-minute) seal loss-of-coolant accidents (LOCAs) as small-break LOCAs Added requirement for cold-leg accumulators for certain LOCAs Human-error probabilities were recalculated to account for dependency on recovery actions for both cognitive and execution steps Incorporated shutdown board crosstie logic Revised ERCW success criteria Added mutually exclusive logic for operator actions to trip RCP on a loss of offsite power, eliminating erroneous block valve isolation events and prohibited CCS test and maintenance events Refined analysis of internal flooding to eliminate overly conservative effects and incorporated new Electric Power Research Institute standard for pipe rupture frequencies	3.0×10^{-5}	3.6×10^{-5}	4.4×10^{-6}	4.6×10^{-6}
SAMA Model[3]	Relatively minor revision to the Level 2 model to (1) ensure proper accounting for Level 1 sequences with large containment isolation failures in isolation LERF Level 2 sequences and (2) add success logic of the Level 2 sequences and additional top logic to group sequences for the quantification of release categories No changes made to the Level 1 model logic Higher truncation limit used for both the Level 1 and LERF quantification	3.0×10^{-5}	3.5×10^{-5}	5.9×10^{-6}	5.9×10^{-6}

[1] The same PRA model was used for both units.
[2] CDF truncation of 1×10^{-12}/yr. LERF truncation of 1×10^{-13}/yr.
[3] CDF truncation of 1×10^{-11}/yr. LERF truncation of 1×10^{-12}/yr.

PRA = Probabilistic Risk Assessment
CDF = core damage frequency
LERF = large early release frequency
IPE = Individual plant examination
R0 = Revision 0; R1 = Revision 1; R2 = Revision 2; R3 = Revision 3; R4 = Revision 4

The NRC staff considered the peer reviews and other assessments performed for the SQN PRA, and the potential impact of the review findings on the SAMA evaluation. The most relevant of these is the peer review of the Draft SQN CAFTA model. The Level 1 and LERF models in this draft were assessed against the ASME/ANS PRA Standard (ASME/ANS RA–Sa–2009) (ASME 2009) and Regulatory Guide (RG) 1.200 Revision 2 (NRC 2009a). In the ER TVA quoted the overall conclusions of the peer review as follows:

> The review of the SQN PRA was completed with the attached documentation. The outstanding issues primarily pertain to quantification results and documentation issues. The overall conclusions of the peer review team regarding the SQN PRA are as follows:
>
> - The overall model structure is robust and well-developed, but needs refinement,
> - Documentation is thorough, detailed, and well organized such that comparison with the standard is facilitated,
> - The processes and tools utilized for the SQN PRA are at the state of the technology and generally consistent with Capability Category II, and
> - The PRA maintenance and update program includes all necessary processes and does a very good job of tracking pending changes.

> The SQN PRA does meet the ASME/ANS PRA Standard. The SQN PRA has issues which have been documented in Appendix C and should be addressed to improve the quality of the PRA model.

TVA stated that the findings from the peer review have been addressed, incorporated in the model, and are considered resolved. Changes required as a result of resolving findings were incorporated into the CAFTA Revision 0 model which was approved on June 3, 2011. In the ER, TVA provided summaries of the 32 findings and their resolution.

The NRC staff reviewed the description and resolution of each of the peer review findings and asked TVA to respond to several RAIs where the stated resolution was not considered adequate or needed clarification. Based on the licensee's RAI responses, the staff is satisfied that the concerns raised in the RAIs have been resolved. The RAIs and the licensee responses are summarized as follows:

- With regard to Finding 1-10, the resolution indicates that the Level 2 PRA model assumes that feedwater (FW) will always be supplied to a ruptured steam generator if FW is available. In response to an NRC staff RAI to assess the significance of this assumption, TVA indicated that this assumption has no impact on the SAMA analysis since no credit is taken for radionuclide scrubbing for releases from the ruptured steam generator (TVA 2013c).
- With regard to Finding 1-14, concerning the inclusion of post-maintenance test starts in the SQN data set, the resolution is not clear as to whether these test starts were eliminated from the data used in SAMA PRA or not. In response to an RAI, TVA confirmed that they had been removed from the success data used in the SQN data analysis (TVA 2013c).
- With regard to Finding 1-15, concerning certain deficiencies in the general transient event tree including: (1) not considering the impact of specific initiating events like loss of offsite power (LOOP) and loss of DC that may prevent power-operated relief valve (PORV) operation and challenge the pressurizer safety valves and (2) the lack of a separate tree for SBO events results in not addressing the operation of systems such as charging and auxiliary feedwater (AFW) following power recovery, the resolution addresses the modeling of PORV and pressurizer safeties but not the latter issue. In response to an RAI to discuss the impact of not addressing the operation of systems such as charging and AFW following power recovery, TVA estimated that this resulted in a CDF underestimate of approximately 2.5×10^{-8} per year or 0.08 percent and concluded this impact is negligible with respect to the CDF and SAMA analysis. This estimate was obtained from the product of the total frequency of SBO events with successful offsite power recovery and the conditional core damage probability (CCDP) given an RCP seal LOCA (TVA 2013c).
- With regard to Finding 4-3, concerning the inclusion of non-water internal flooding sources, the resolution indicated that the glycol system was the only non-water system that could be of concern for internal flooding. In response to an RAI, TVA indicated that the glycol system was included in the PRA model but subsequently screened out because of the impacted flood areas having a CDF below the 1×10^{-9} per year screening criteria (TVA 2013c).

The SQN SAMA model reflects SQN design, component failure, and unavailability data as of November 30, 2009. In response to an NRC staff RAI, TVA indicated that there were a total of

17 design changes resulting from TVA's review of fire-induced multiple circuit faults for compliance with RG 1.189, Revision 2 (NRC 2009b). Three of these design changes were determined to affect the SQN internal events PRA model. A sensitivity study indicated that the impact on the CAFTA Rev. 0 model result was negligible (approximately 3×10^{-9} per year for CDF and 1×10^{-10} per year for LERF (TVA 2013c)). In addition, TVA is installing new Unit Station Service Transformers (USSTs) for each SQN unit and has replaced Unit 2 steam generators. TVA indicated that these changes would have minimal impact on the results of the SAMA analysis. The impact of the USST change was determined to be 1×10^{-9} per year for CDF and 1×10^{-10} per year for LERF (TVA 2013c). While the replacement Unit 2 steam generators have improved heat transfer characteristics, no change in safety analysis is needed and thus the change would not be expected to impact the SAMA analysis (TVA 2013c).

In response to an NRC staff RAI to identify the systems shared between the two units and to describe how these systems are modeled and how shared system unavailability is accounted for, TVA indicated that the emergency raw cooling water (ERCW), B train of the CCW, plant control air, auxiliary control air, electric power offsite supply and the raw cooling water systems are shared between units. The SQN PRA is a dual-unit model. For the shared systems, the models include components of both units, and the system models are combined and incorporated in the PRA model as appropriate for each unit. The only shared system whose availability is impacted by a unit outage is the CCS, which was accounted for by flag events. TVA indicated that all shared systems are modeled with the most restrictive success criteria based on a dual unit initiating event (TVA 2013c). Based on its review of the LRA and the RAI response, the staff believes that the unavailability of shared components to be modeled adequately for SAMA purposes.

In response to an NRC staff RAI on the consideration of influences in the PRA for one plant from internal flooding occurrences at the other plant, TVA indicated that such effects were incorporated in the PRA model by using input from an internal flooding database that identifies all the plant areas impacted by each flood source. In addition, for internal flooding situations where tripping of the second unit is not required unless there is a subsequent failure to isolate, it was conservatively assumed that both units were tripped at the start of the event (TVA 2013c).

The NRC staff noted in an RAI that, as can be seen from Table F–1, the CDF values for the two units are in some cases significantly different. In response, TVA described the more significant reasons for the differences as being:

- for internal flooding, the difference is caused by the asymmetries in pipe routing, leading to floods having a greater impact on one unit versus the other unit, and
- for the loss of all CCS, the difference is caused by the differing number of valves that could plug/fail close in the CCS for the two units.

The NRC staff also noted in an RAI that the LOOP initiator contributes only 1 to 2 percent to the CDF while SBO contributes 10 to 13 percent and that the Level 1 importance analysis does not include any events for failure of the emergency diesel generators (EDGs) and asked TVA to explain the reasons for this unusual result. In response TVA indicated that most of the SBO CDF contribution results from internal flooding events that result in loss of both 6.9-kV shutdown boards and thus an SBO, and that LOOP contributes only about 15 percent of the total SBO CDF frequency. The EDGs at SQN are of relatively low importance because of the ERCW success criteria, which for a LOOP requires failure of all ERCW pumps to lead to failure of the EDGs, leading to an SBO. In addition, SQN has a utility bus that allows, under certain circumstances, one unit to receive emergency power from the other unit's EDG (TVA 2013c).

In response to an NRC staff RAI to discuss the modeling of a LOOP, TVA stated that the SQN PRA did not model a consequential LOOP. TVA provided the results of a study, which indicated that the risk would increase by 0.3 percent if the consequential LOOP were included (TVA 2013c). The NRC staff concludes that this would have no impact on the selection of cost-beneficial SAMAs.

As stated above, TVA indicated in the ER that ATWS events make up 12 and 14 percent of the CDF for the two SQN units. In response to an NRC staff RAI to explain this unusually high contribution, TVA identified several areas where ATWS modeling in the SAMA PRA resulted in an overestimation of the ATWS contribution to CDF. In reviewing the ATWS modeling, TVA concluded that the unfavorable exposure time, the fraction of the operating cycle in which the amount of pressure relief available is not sufficient to prevent exceeding the design pressure for the primary system, was erroneously included twice and resulted in the overestimation of this contribution to CDF. Further, TVA found that a majority of the cutsets involving failure of the pressure relief valves were caused by battery depletion. Because these are not applicable to an ATWS, the resulting CDF is overestimated. Also, certain features of the power dependency of the reactor protection system were found to be in error particularly for internal flooding sequences. TVA indicated that correcting the modeling in these areas resulted in an ATWS contribution to CDF of 2 percent for Unit 1 and 2.3 percent for Unit 2 (TVA 2013c). The staff is satisfied with TVA's RAI response because TVA's results are conservative and offset other non-conservatisms, as discussed below.

In the ER, TVA briefly described the process and procedures for assuring that the PRA models adequately reflect the as-built and as-operated plant configurations. The PRA Program procedure delineates the responsibilities of both corporate and site personnel and provides guidelines for the initiation of, and the data collection for, PRA model updates. The PRA Procedure implements the PRA Program requirements by elaborating on responsibilities, establishing the technical qualifications for PRA personnel (analysts), and providing specific guidance for the PRA update. Overall, they define the process for implementing regularly scheduled and interim PRA model updates, for tracking issues identified as potentially affecting the PRA models (e.g., because of changes in the plant, errors or limitations identified in the model, industry operational experience), and for controlling the model and associated computer files. The PRA Procedure includes requirements for a review of PRA model updates. Individual work products (such as a system notebook) are reviewed and checked by a second qualified PRA analyst after preparation, followed by review and approval by the PRA supervisor. After completion of the update, a review is performed by a technically qualified individual that reviews changes to the model to ensure that the intent and execution of the change were both accurate and complete.

Given that the SQN internal events PRA model has been peer-reviewed and the peer review findings were all addressed and that, as discussed above, TVA has satisfactorily addressed NRC staff questions regarding the PRA resolving the concerns raised by the RAIs, the NRC staff concludes that the internal events Level 1 PRA model is of sufficient quality to support the SAMA evaluation.

F.2.2.2 External Events

As indicated above, the SQN PRA does not include external events. The SAMA submittal cites the SQN IPEEE to assess the impact of seismic events, internal fire events, and other external events. The SQN IPEEE was submitted in 1995 (TVA 1995), in response to Supplement 4 of GL 88-20 (NRC 1991a), and a revised fire analysis was submitted in 1999 (TVA 1999). No fundamental weaknesses or vulnerabilities to severe accident risk in regard to the external events were identified in the SQN IPEEE. In a letter dated February 21, 2001 (NRC 2001), the

NRC staff stated that on the basis of the staff reviews of the PRA and IPEEE submittal, the staff concludes that TVA's IPEEE process is capable of identifying the most likely severe accidents and severe accident vulnerabilities and, therefore, the SQN IPEEE has met the intent of Supplement 4 to GL 88-20.

The SQN IPEEE seismic analysis was a Seismic Margin Assessment (SMA) following NRC guidance (NRC 1991a, 1991b). The SMA was performed using a Safe Shutdown Equipment List (SSEL) with plant walkdowns in accordance with the guidelines and procedures documented in Electric Power Research Institute (EPRI) Report NP–6041–SL (EPRI 1991). The components on the SSEL were then evaluated for seismic capacity. This evaluation was based upon a review of the plant's seismic qualification documentation, development of new floor response spectra, conducting detailed plant walkdowns and performing selected high confidence in low probability of failure (HCLPF) calculations. Included in the seismic evaluation was the integrity of containment isolation systems.

The IPEEE submittal (TVA 1995) states:

> In summary, the equipment reviewed for SQN during the systematic evaluation of the seismic event proved to be overall rugged in nature and of a sufficient capacity to provide assurance of continued functionality for the Review Level Earthquake (RLE). Only the RHR heat exchanger anchorage welding was reported to have a HCLPF less than the 0.30g prescribed by the RLE, and this component is presently scheduled to be upgraded as discussed in section 7.1.

The IPEEE submittal did not identify any seismic vulnerability beyond five configuration-related items that had been or were being addressed. Corrective action for four of the five were completed at the time of IPEEE preparation with corrective action for the fifth, the residual heat removal (RHR) heat exchanger anchorage, scheduled for implementation in October 1995. The IPEEE transmittal letter confirmed that the RHR anchorage corrective action had been completed and identified one additional modification that had been completed. The Phase I SAMA candidate list discussed in ER Section E.2.2 indicates that all five original corrective actions have been implemented.

In the ER, TVA stated:

> As originally evaluated, assuming a ground level RLE of 0.3g, the overall plant HCLPF capacity at SQN was determined to be at least 0.27g. In response to an NRC request for additional information (RAI), certain components were reevaluated assuming a RLE defined by a NUREG/CR–0098 spectral shape anchored to 0.30g at rock. The limiting recomputed component HCLPF values range from 0.23g to 0.29g.

The TVA responses (TVA 2012b) to the Fukushima Near-Term Task Force Report Recommendation 2.3: Seismic Response Report states that

> The statuses of all IPEEE outliers which were not corrected through physical modification were resolved through re-calculation of the appropriate HCLPF capacities. The 480V Shutdown Transformers required a minor anchorage modification. All IPEEE outliers are now resolved and have minimum HCLPF Capacities above 0.3g.

The TVA further indicated that the seismic design of SQN will be further evaluated by the ongoing Fukushima project requirements (NRC 2012). Also, the improved external flooding mitigation provided by installing additional equipment to provide secondary FW and reactor coolant system (RCS) makeup to both units, all housed in a hardened bunker building, will provide mitigation capability for a seismic-event risk reduction (TVA 2013c). The improved external flood mitigation being planned is discussed in more detail below.

Given that the SMA approach used for the SQN IPEEE seismic assessment does not produce a CDF, TVA used the results of an August 2010 NRC report, "Generic Issue 199 (GI–199), Implications of Updated Probabilistic Seismic Hazard Estimates in Central and Eastern United States on Existing Plants" (NRC 2010) to estimate a seismic CDF. This assessment determined that the weakest link model seismic risk for SQN Units 1 and 2 is 5.1×10^{-5} per year. This is based on a simplified methodology using an SQN plant HCLPF of 0.3g and the 2008 U.S. Geological Survey (USGS) seismic hazards curve. The NRC staff agrees that the use of this seismic CDF is appropriate for determining the seismic contribution to the external event multiplier.

The SQN IPEEE internal fire assessment utilized the methodology of the fire-induced vulnerability evaluation (FIVE) methodology (EPRI 1992). This methodology utilizes a progressive screening approach consisting of:

- qualitative screening based on lack of safe shutdown components and lack of plant trip initiators,
- initial quantitative screening using area-specific fire frequencies and assuming all fires engulf the entire fire area, and
- detailed quantitative screening considering the zone of influence of fires and, for some areas, fire severity and suppression.

In the last step, the main control room was evaluated using the guidance in the EPRI Fire PRA Implementation Guide (EPRI 1994).

Fires inside containment were screened out on the basis of low-combustible loads and limited safe shutdown equipment and cables in accordance with FIVE guidance. For the quantitative screening steps CCDPs were determined using the Revision 1 IPE internal events PRA with increasing refinements concerning the extent of fire damage and recovery actions and a screening CDF criteria of 1×10^{-6} per year (TVA 1999).

The detailed quantification step initially did not take credit for any equipment not specifically credited in the SQN Fire Protection Report. This revealed that the results for a large number of fire areas were overly conservative as no credit was taken for feed-and-bleed cooling. When credit for feed-and-bleed cooling was taken based on walkdown and cable routing information, a large number of additional areas were screened out. Subsequently, the analysis was further refined considering fire severity and the potential for suppression using an event-tree approach. The fire CDF for each of the fire areas evaluated in the final stage of screening is given in Table F–4. All of these had CDFs less than the 1×10^{-6}-per-year screening criteria. The estimated fire CDF for these areas is 5.8×10^{-6} per reactor-year (TVA 2013d).

The Technical Evaluation Report prepared to support the NRC staff evaluation of the SQN IPEEE (NRC 2001) concludes that there are several weaknesses in the fire analysis that could lead to optimistic results. Also, it was observed that the cable spreading room was screened out because of lack of fire sources, and this resulted in missing important lessons about the effects of a cable spreading room fire. While this observation appears to be not strictly true because a cable spreading room fire was analyzed in the SQN IPEEE, the analysis assumed there was no failure of safe shutdown equipment.

In response to an NRC staff RAI to address these weaknesses and observations, TVA indicated that the first weakness, associated with the application of severity factors that could lead to double counting the impact of fire suppression, had been adequately addressed in the response to IPEEE RAI for both SQN and Watts Bar Unit 1, which used the same fire methodology, with the conclusion that no double counting occurred (TVA 2013c).

For the second weakness, associated with a concern over the potential for incorrectly assuming independence between human actions in the main control room fire, TVA described the control room modeling which incorporated control room evacuation with the potential for later recovery. While involving some human actions, the assessment of these events are CCDPs primarily involving hardware failures. Considering this and that the time differences between initial evacuation at 15 minutes and recovery after 60 minutes, TVA concluded that the modeling was acceptable (TVA 2013c).

With regard to the cable spreading room fire, TVA indicated that in the IPEEE an extensive fire in the cable spreading room is assumed to be not credible because of the lack of fire ignition sources and the presence of fire detection and suppression capability. The IPEEE analysis is considered to be a screening analysis. TVA provided in the RAI response another analysis of the cable spreading room that considered fires of varying severities and credit for the installed detection and suppression systems, as well as fire brigade response that yielded a fire CDF slightly less than that shown in Table F–4 (TVA 2013c).

In response to an NRC staff RAI to assess recent fire research and guidance in NUREG/CR–6850 (NRC 2005), TVA cited a December 2010 industry assessment (Nuclear Energy Institute (NEI) 2010) that concluded, “Based on the results and insights from industry fire PRAs, it has been identified that the methods described in NUREG/CR–6850/EPRI TR–1011989 contain excess conservatisms that bias the results and skew insights. While the prior frequently asked question process made some incremental progress in addressing areas of excessive conservatism, many more remain in need of enhancement.” TVA indicated that, based on this assessment, the results of initial NUREG/CR–6850 analyses should not be used to draw conclusions about the IPEEE fire risk estimates. While the NRC staff does not necessarily agree with the conclusions of the NEI assessment, the staff’s concerns have been resolved as discussed in the following paragraph.

In the RAI response, TVA also points out that the fire CDF makes up only a relatively small portion of the external events multiplier (approximately 10 percent) and thus the multiplier is not sensitive to changes in the fire CDF (TVA 2013c). The external event multiplier is discussed in more detail in the last two paragraphs of this subsection. Considering that (1) the SQN fire model has been reviewed by the NRC staff for the IPEEE, that TVA has satisfactorily addressed NRC staff RAIs regarding the fire analysis resolving the concerns raised by the RAIs, (2) the internal events model excluding internal flooding upon which the IPEEE fire CDF is based has a CDF (3.4×10^{-5} per year) that is about three times the current estimate (1.3×10^{-5} per year), and (3) TVA has made a number of plant modifications to reduce the probability of some fire-induced multiple spurious operations as described above, the NRC staff concludes that the IPEEE fire model provides an acceptable basis for identifying and evaluating the benefits of SAMAs.

Table F–4. Significant Fire Areas at SQN Included in Final Screening Phase and Their Corresponding CDF

Fire Area Description	Compartment CDF (per year)	Percent Contribution[1] to Unscreened Fire CDF
Corridor	9.8×10^{-7}	17
Main Control Room/Control Room	9.3×10^{-7}	16
Corridor	5.5×10^{-7}	9
Unit 2 Auxiliary Instrument Room	3.8×10^{-7}	7
Unit 1 Auxiliary Instrument Room	3.8×10^{-7}	6
Cable Spreading Room (Only or Upper)	3.7×10^{-7}	6
Electrical Equipment Room/Auxiliary Relay Room	3.7×10^{-7}	6
480-V Board Room 1B	3.6×10^{-7}	6
250-V Battery Board Room 1 & 2 and Corridor	2.5×10^{-7}	4
480-V Board Room 2B	2.5×10^{-7}	4
480-V Shutdown Board Room 1B2	1.9×10^{-7}	3
480-V Shutdown Board Room 2A2	1.8×10^{-7}	3
Computer Room	1.6×10^{-7}	3
6.9-kV Shutdown Board Room B	1.5×10^{-7}	3
Mechanical Equipment Room	8.2×10^{-8}	1
Auxiliary Control Room	8.0×10^{-8}	1
250-V Battery Room No. 1	5.7×10^{-8}	1
480-V Shutdown Board Room 1A2	4.5×10^{-8}	1
Personnel and Equipment Access Room	4.4×10^{-8}	1
6.9-kV Shutdown Board Room A	2.0×10^{-8}	<1
480-V Shutdown Board Room 1A1	1.1×10^{-8}	<1
Total	$\mathbf{5.8\times10^{-6}}$	

[1] Percentages were rounded to the nearest whole percent for reporting and may not sum to 100 percent because of roundoff error.

The SQN IPEEE analysis of high winds, floods, and other external events followed the recommendations in GL 88-20, Supplement 4. The methodology employed a screening approach following the criteria of the 1975 Standard Review Plan (SRP). The IPEEE submittal indicated that the IPEEE evaluation revealed that the plant meets the 1975 SRP criteria for High Winds, Floods and Transportation and Nearby Facilities Accidents and no recommendations for plant improvements resulted (TVA 1995). The staff approved this evaluation in the SER on the IPEEE (NRC 2001).

The NRC staff notes that, since 2008 TVA has been updating the flood hazard analyses for a number of its nuclear sites, including SQN (TVA 2013a), and as a result has made and is continuing to make a number of improvements to its plants (TVA 2012a). In addition to analyses and improvements associated with the existing licensing bases, TVA is conducting the comprehensive flood hazard reanalysis required by the NRC in its letter issued March 12, 2012, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50.54(f), to all power reactor licensees and holders of construction permits in active or deferred status (NRC 2012).

In response to an NRC staff RAI to discuss the recent external flooding developments and infrastructure plans, TVA indicated in an April 16, 2013, letter (TVA 2013a) as updated by a July 1, 2013, letter (TVA 2013b) that TVA committed to design and install improved flood mitigation systems at SQN Units 1 and 2. The installed systems will be in addition to the flood mode systems currently described in the Sequoyah Nuclear Plant Updated Final Safety Analysis Report, as supplemented by the improvements described in TVA's letter dated June 13, 2012 (TVA 2012a). The flood mitigation systems will incorporate improvements to flood mitigation at SQN through the installation of new components and may utilize certain elements of the Fukushima Dai-ichi mitigation equipment (FLEX). The systems will provide for the following key safety functions for both units:

- reactor decay heat removal and
- RCS makeup and criticality control.

These systems will be installed in a new hardened structure that will ensure a minimum of 15 ft of margin above the current probable maximum flood levels. The final building design will include consideration of risk improvements for scenarios other than flooding (TVA 2013a, 2013b, 2013c). The NRC staff notes that these new systems will significantly reduce the risk associated with external floods and, as well, be expected to reduce the risk from other external events.

As indicated in the ER, a multiplier of 2.9 for Unit 1 and 2.6 for Unit 2 was used to adjust the internal event risk benefit associated with a SAMA to account for external events. This multiplier was based on a fire CDF equal to the sum of the fire-zone CDF values in the final phase of screening or approximately 5.8×10^{-6} per year, a seismic CDF of 5.1×10^{-5} per year and the assumption that other external events are negligible. This results in a ratio of external to internal event CDFs of 1.9 for Unit 1 and 1.6 for Unit 2 or multipliers of 2.9 and 2.6 for Units 1 and 2, respectively.

Given that the SQN IPEEE external events assessments has been reviewed by the NRC staff, that TVA has satisfactorily addressed NRC staff questions regarding the assessment, and TVA is committed to design and install improved flood mitigation systems at SQN Units 1 and 2, the NRC staff concludes that the external events assessments, combined with the results of the analysis of the impacts of new fire and seismic information, is of sufficient quality to support the SAMA evaluation.

F.2.2.3 Level 2 Fission Product Release Analysis

The NRC staff reviewed the general process used by TVA to translate the results of the Level 1 PRA into containment releases, as well as the results of the Level 2 analysis, as described in the ER and in responses to NRC staff RAI (TVA 2013c). As stated above, the Level 2 SQN PRA model that forms the basis for the SAMA evaluation is essentially a completely new model. TVA indicated that the Level 2 model was developed with a focus on the quantification of LERF but does include the development of other end states (TVA 2013d). The model was based on enhancements to NUREG/CR–6595 (NRC 2004) and included quantification of containment threats resulting from high-pressure failure of the reactor vessel and hydrogen deflagrations/detonations as well as additional detail on the treatment of interfacing-systems loss-of-coolant accident (ISLOCA) and induced steam generator tube rupture.

The PDSs provide the link between the Level 1 and Level 2 CET analyses. In the PDS analyses, Level 1 results are grouped together according to characteristics that influence the accident progression following core damage including: containment bypass or not, RCS pressure and wet or dry steam generator. All Level 1 core damage sequences are directly linked into the Level 2 CETs and the PDS bins were used at the various branch points of the CETs to screen out sequences not applicable to that particular branch (TVA 2013c).

The CETs consisted of 18 questions (or events or nodes), which link each PDS to the appropriate portion of the CET or determine the appropriate containment failure type and end state category. This results in seven end state categories, four of which are large early releases, one each for late releases, small early releases and an intact containment. The CET end states are then binned into 12 release categories, shown in Table F–2, which represent similar containment failure modes and release timing and are used in the Level 3 consequence analysis. The Intact end state is not included as a release category because it is assumed to have an insignificant impact on the consequences of a severe accident. The frequency of each release category was obtained by summing the frequency of the individual Level 2 sequences assigned to each release category.

A Modular Accident Analysis Program (MAAP) 4.0.7 model of accident progression was used to support the Level 2 model development including determining (TVA 2013c):

- calculated time to vessel failure,
- ex-vessel cooling success,
- seal table–molten core interaction,
- uncertainty associated with the availability of the ice condenser,
- modeling of the availability of the containment air recirculation fans,
- core damage stopping prior to vessel failure,
- time to hydrogen detonation,
- hydrogen concentrations,
- direct containment heating,
- timing of early containment vessel failure,
- effectiveness of containment heat removal,
- base mat melt through timing, and
- timing of operator action.

In the ER, TVA indicated that as the Level 2 model for SQN was developed with a focus on the quantification of LERF, the quantification of the non-LERF end states is not as accurate as would be obtained from a more rigorous Level 2 model. Normally, the total of all end state release frequencies would be equal to the total CDF. For the SQN SAMA model the total of all release category frequencies, excluding the intact end state, is almost equal to the total CDF for Unit 1 and about 80 percent of the total CDF for Unit 2 (TVA 2013a). In response to an NRC staff RAI, TVA provided the intact end state frequencies (1.45×10^{-5} per year and 2.38×10^{-5} per year for Units 1 and 2, respectively) and indicated that the total release category frequency is between 43 percent and 46 percent higher than the internal event CDF (TVA 2013c).

In several places in the ER, the accuracy of the Level 2 model is discussed. In ER Section E.1.2.1 it is stated:

> The event tree nodes and split fractions were reviewed to ensure that the consequences, in terms of release frequencies, would be larger than would be expected with a fully developed Level 2 model.

and in ER Section E.1.2.3.2

> Quantification of the SQN SAMA Model results in release frequencies that are over predicted.

In response to an NRC staff RAI to discuss the reasons for the inaccuracies and the over prediction of the release category frequencies, TVA described the steps taken in the SAMA model to improve the accuracy and reduce the over prediction. These included adding sequence success logic to the CET and correcting the containment isolation logic. TVA attributed the remaining over prediction to the treatment of success branches within the event trees and the use of the minimum cutset upper bound approximation in the cutset quantification process. While this quantification provides a close approximation to the top event probability when the individual basic events are small (i.e., the rare event approximation), when they are not small the result is an over prediction of the top event probability (TVA 2013c). The NRC staff has reviewed TVA's responses and concludes that the use of these release categories in the SAMA analyses is acceptable because they are expected to be higher than the true values and will, therefore, result in a conservative assessment.

In response to an NRC staff RAI on the treatment of scrubbed and unscrubbed releases from steam generator tube ruptures (SGTRs) and the absence of SGTR initiators in the Level 2 importance analysis results (TVA 2013d, ER Section E.1.2.1), TVA indicated that the SQN SGTR model was based on a model developed by Westinghouse for such events (WCAP 15955). This model was then modified by crediting additional plant-specific considerations that applied to SQN. The change that resulted in the biggest difference was the crediting of the use of manual handwheels to open the steam generator atmospheric relief valves to depressurize/cooldown the primary side. TVA indicated that the SQN model incorporates four SGTR initiators, one for each loop. While the modeling of four initiators results in the individual events being below the importance analysis cutoffs, the NRC staff notes that, based on the RAI response, the total of all the SGTR initiating events is still below the importance cutoff. The NRC staff notes that all of the SGTR CDF sequences are included in Release Category III along with non-SBO ATWS events. This release category takes no credit for scrubbing of releases. Based on its review of TVA's submissions, the staff concludes that this treatment and the erroneously high ATWS frequency, discussed above in Section F.2.2.1, result in an acceptable inclusion of SGTR events in the SQN SAMA risk and cost-benefit analysis.

In response to the NRC staff RAI to describe the Level 2 modeling of small isolation failures to show that the potential for large early releases is properly considered for small isolation failure sequences, TVA provided the results of a sensitivity analysis in which the Release Category V (small early release) frequency was proportionally redistributed to Release Category I (large early release caused by early containment failure), Release Category III (large early release caused by containment bypass) and Release Category IV (late containment failure) based on their relative magnitudes. This resulted in a Release Category V frequency of zero, no change to Release Category II, and an increase in the frequency of Release Categories I, III, and IV (TVA 2013c). The results of this sensitivity analysis on the cost benefit of the SAMAs are described in Section F.6.2 below. In an RAI, the NRC staff noted that in the ER, Release Category V includes small containment isolation failures and that the frequency of this release category makes up approximately 10 percent of the total frequency of all release categories and is larger than the frequency of Release Category I, which is identified as a large early release (refer to Table F–2 above). It is further noted that, because it is expected that a small isolation failure would not prevent large early containment failure caused by events such as hydrogen detonation or direct containment heating, the LERF and resulting risks may be underestimated.

Source terms for use in the Level 3 consequence analysis are based on the dominant accident sequence that contributes to each release category. The release fractions were determined for each representative sequence using a spreadsheet version of the SEQSOR computer code. SEQSOR was used to calculate the release fractions for the NUREG–1150 analysis of Sequoyah (NRC 1990b). The SEQSOR methodology determines release fractions using a parametric approach with probabilistic data blocks based on supporting first principle analyses as well as expert panel judgments. SEQSOR determines the mean release fractions for each representative sequence that makes up each release category using input release characteristics describing the representative scenario and parametric data included in the code. The same data blocks were used in the SEQSOR emulator, except where processes or equipment that needed to be considered for this analysis were not included in the NUREG/CR–4551 analyses. TVA states that the SEQSOR emulator was independently reviewed prior to its use in the Watts Bar Unit 2 analysis of severe accident mitigating design alternatives (SAMDA) (TVA 2011a, 2011b). The release characteristics used for the SQN SAMA analysis are provided in response to an NRC staff RAI (TVA 2013c).

TVA described the representative sequences for each release category, the basis for their selection, and their use in determining the input parameters for the SEQSOR methodology, in response to an NRC staff RAI. That RAI requested TVA to provide a discussion of the representative accident scenarios used for the determination of the release characteristics for each of the release categories and the steps taken to ensure that the benefit of a SAMA is not underestimated for situations in which a SAMA impacts scenarios that could have a lower (non-dominant) frequency but significantly larger consequence than that for the representative scenario. The TVA states that the representative accident scenarios were selected based on the definitions of the release categories and on their frequency contribution to those release categories. In order to ensure that the effects of SAMAs were not underestimated, the input parameters for SEQSOR were stated to be conservatively selected for each release category. The other release characteristics (e.g., time of release, warning time, and release energy) that were input to WinMACCS were also stated to be conservatively selected (TVA 2013c). Release timing and duration for each release category were conservatively determined from the results of MAAP 4.0.7 code analysis. The energy of release for each release category was determined from the NUREG/CR–4551 analysis of Sequoyah (NRC 1990a).

The NRC staff review of this information along with the SEQSOR inputs (TVA 2013c) and the resulting release category characteristics (TVA 2013d, Table E.1–15) concluded that the number of release categories, the representative scenarios used and the determination of SEQSOR inputs is adequate for the Level 2 SAMA analysis.

As indicated above, the current SQN Level 2 PRA model is a complete revision of that utilized in the IPE. In response to an NRC staff RAI regarding the steps taken to ensure the technical adequacy of the new Level 2 model, TVA indicated that the changes made to the Level 2 model for the SAMA analysis were documented in a calculation by its contractor (Enercon), and performed in accordance with their procedures. This calculation was subjected to an internal review and a separate peer review by an individual with extensive SAMA and Level 2 experience prior to its submittal to TVA for review. All comments were incorporated prior to the final approval of the calculation. The changes were added to TVA's model change tracking program and subsequently were incorporated into the SQN Level 2 Model of Record in accordance with TVA procedures (TVA 2013c).

From its review of the Level 2 PRA methodology, TVA's responses to NRC staff RAI, and the peer review of the LERF portion of the model, the NRC staff concludes that, with the exception of the treatment of small early releases caused by small isolation failures, the Level 2 PRA as used in the SAMA analysis provides an acceptable basis for evaluating the benefits associated with various SAMAs. The treatment of small early releases because of small isolation failures is the subject of a sensitivity analysis whose impact on the SAMA analysis is discussed in Section F.6.2 below.

F.2.2.4 Level 3 Consequence Analysis

The TVA used the WinMACCS Version 3.6.0 code to determine the offsite consequences from potential releases of radioactive material (TVA 2013d). As described in Section F.2.1, TVA considered differences in generated power and adjusted the core inventory from a plant of similar design, Watts Bar Unit 1, to determine the core inventory for SQN Units 1 and 2.

The NRC staff reviewed the process used by TVA to extend the containment performance (Level 2) portion of the PRA to an assessment of offsite consequences (Level 3 PRA model). In the Level 3 analysis, release fractions and release categories, discussed in Section F.2.2.3, are combined with the calculated core inventory to yield a source term of radionuclide releases from containment to the outside environment. In response to an NRC staff RAI, TVA provided release category frequencies for the Phase II SAMA candidates (TVA 2013c). Checks performed by NRC staff using this information are described in Section F.6.2.

The TVA presented the major input parameter values and assumptions used in the offsite consequence analyses in the ER (TVA 2013d, Attachment E). The TVA considered site-specific meteorological data for the calendar years 2003 through 2005 and selected meteorological data from 2005 for the analysis as input to the WinMACCS code because they resulted in the highest release quantities (TVA 2013d, Attachment E). Meteorological data was acquired from the SQN meteorological monitoring system and the U.S. Environmental Protection Agency. Meteorological data included wind speed, wind direction, atmospheric stability class, precipitation, and atmospheric mixing heights.

In response to an NRC RAI on the source of precipitation data, modeling of precipitation events, and precipitation influence on calculated doses, TVA provided details and illustrated that the 2005 meteorological data resulted in the highest population dose risk, economic risk, and modified maximum averted cost-risk (MMACR) for the calendar years of 2003 through 2005 (TVA 2013c). Consistent with guidance in NRC (1990b), plume washout in the last grid interval was invoked in the calculations performed by TVA. Compared to the average precipitation rates recorded during precipitation events in 2003 through 2005, TVA selected a significantly greater precipitation rate for plume washout (TVA 2013c). Because increased precipitation rates translate into increased population doses and economic costs, NRC staff finds TVA's overestimation in precipitation rate for plume washout to be conservative and acceptable.

The TVA estimated missing meteorological data by data substitution. For 1 hour of missing data, interpolation was performed with valid data immediately before and after the data gap. For data gaps greater than 1 hour, data were replaced with data from days with similar meteorological conditions immediately before and after the data gap. In response to questions on the amount of missing data, TVA indicated that the percentages of missing data were 3.1, 2.6, and 0.8 percent for calendar years 2003 through 2005, respectively. The NRC staff considers these percentages of missing data to be reasonable and the methods used to substitute missing data to be acceptable for use in the SAMA analysis. Additionally, the sources of data and models for atmospheric dispersion used by the applicant are appropriate for calculating consequences from potential airborne releases of radioactive material. The NRC staff notes that results of previous SAMA analyses have shown little sensitivity to year-to-year differences in meteorological data and concludes that the selection of the 2005 meteorological data for use in the SAMA analysis is appropriate.

The TVA projected population distribution and expected growth within a radius of 80 km (50 mi) out to the year 2041 and used the areal weighting from the SECPOP2000 Version 3.13.1 code to populate the spatial elements of the computer model (TVA 2013d, Attachment E). In response to an NRC staff RAI on estimated population distribution, TVA provided the total population distribution for year 2011 (TVA 2013c). The TVA reported a total population of 1,190,197 within a radius of 80 km (50 mi). In the ER, the total estimated population for the year 2041 was 1,537,408, which represents an increase of 29 percent compared to the population in year 2011. The TVA also used data on Tennessee, North Carolina, Alabama, and Georgia state tourism to calculate a transient to permanent population ratio to increase the projected population to account for visitors (TVA 2013d, Attachment E). The NRC staff considers the methods and assumptions for estimating population reasonable and acceptable for purposes of the SAMA evaluation.

For the 16-km (10-mi) emergency planning zone at SQN, TVA considered information from the Tennessee Multi-Jurisdictional Regional Emergency Response Plan in its determination of evacuation delay time and travel speed (TVA 2013d, Attachment E). The response plan indicated that 100 percent of the population would be prepared to evacuate within 105 minutes from a potential release, which includes 75 minutes for notification and 30 minutes for preparation following notification of an evacuation order. For the baseline Level 3 calculation (TVA 2013d, ER Tables E.1–20 and E.1–21), TVA estimated 95 percent of the population within the emergency planning zone would evacuate with an evacuation speed of 2.2 meters per second (TVA 2013d, ER Tables E.1–22 and E.1–23).

In response to an NRC staff RAI on evacuation parameter values, TVA affirmed that the evacuation assessment considered site-specific conditions for SQN (TVA 2013c). Compared to the evacuation speed recommended in the Tennessee Multi-Jurisdictional Regional Emergency Response Plan, TVA reduced the average evacuation speed by a factor of 2 to account for roadway congestion on local roads with low evacuation capacities. The evacuation speed was reduced by another factor of 2 to account for anticipated population increases in the 16-km (10-mi) emergency planning zone during the period of extended operation (TVA 2013c). The TVA performed sensitivity analyses for different evacuation population fractions and evacuation speeds. Consequence deviations were found to be small. Specifically, the calculated dose risk increased by less than 2 percent when the evacuation fraction was reduced from 95 percent to 90 percent (TVA 2013d, ER Table E.1–23), and the dose risk increased by about 6 percent when the evacuation speed was reduced from 2.2 meters per second to 1.6 meters per second (TVA 2013d, ER Table E.1–22). As described by TVA, evacuation applies to the emergency planning zone with a lower population compared to other areas surrounding SQN. The much larger population outside of the emergency planning zone does not evacuate and accounts for a majority of the total population dose (TVA 2013c). For these reasons, the total population dose is not directly proportional to the fraction of individuals in the emergency planning zone who do not evacuate.

In response to an NRC staff RAI on evacuation sensitivity, TVA provided additional information, which showed relatively small contributions to total population doses from the doses received by evacuating members of the public in the 16-km (10-mi) emergency planning zone and substantiated the low sensitivity of the calculated dose risk to the evacuating population fraction (TVA 2013c). Because TVA used site-specific information, applied more pessimistic (lower) fractions for the evacuating population in the emergency planning zone compared to guidance values (NRC 1997b), and considered the effect of population increases on evacuation parameter values, NRC staff concludes that the evacuation assumptions and analysis are reasonable and acceptable for the purposes of the SAMA analysis at SQN.

The TVA calculated land values using an economic multiplier with economic data from 2002. The economic multiplier was based on the slope of the consumer price index between 1970 and 2010. The TVA extrapolated this slope to the year 2041 to obtain an economic multiplier of 2.0329. The TVA compared regional agricultural data from the 2007 U.S. Census of Agriculture with the generic data in SECPOP2000 code. The TVA found that the generic data corresponded to higher crop values and selected them for use in the analysis to add conservatism. The NRC staff accepts the applicant's approach for price adjustments made to older land value data and selection of generic crop data when those data would lead to more conservative results. The NRC staff finds the data sources used by the applicant in the Level 3 analysis to be appropriate for the SAMA analysis.

The TVA estimated present dollar values based on the internal events PRA at SQN. Offsite economic and offsite exposure costs provided the greatest contributions; together, they accounted for about 76 percent and 72 percent of the total dollar value for Units 1 and 2, respectively. For the baseline discount rate of 7 percent, offsite economic costs contributed about 39 percent to the total dollar value for Unit 1 and 37 percent to the total dollar value for Unit 2 (TVA 2013d, ER Table E.1–32). Compared to the total dollar value, offsite population doses contributed about 36 percent for Unit 1 and 35 percent for Unit 2. Onsite exposure, onsite cleanup, and replacement power costs collectively contributed 24 percent for Unit 1 and 28 percent for Unit 2. Section F.6 provides more detailed information on the cost-benefit calculation and its evaluation.

Based on its review of TVA's submissions, the NRC staff concludes that TVA's methodology to estimate offsite consequences for SQN provides an acceptable basis to assess the risk reduction potential for candidate SAMAs. Accordingly, the NRC staff based its assessment of offsite risk on the CDFs, population doses, and offsite economic costs reported by TVA.

F.3 Potential Plant Improvements

The process for identifying potential plant improvements, an evaluation of that process, and the improvements evaluated in detail by TVA are discussed in this section.

F.3.1 Process for Identifying Potential Plant Improvements

The TVA's process for identifying potential plant improvements (SAMAs) consisted of the following elements:

- review of industry documents, including NEI 05-01 (NEI 2005) and 12 other plant SAMA analyses for potential cost-beneficial SAMA candidates,
- review of potential plant improvements identified in the SQN IPE and IPEEE, and
- review of the risk-significant events in the current SQN PRA Levels 1 and 2 models for modifications to include in the comprehensive list of SAMA candidates.

Based on this process, an initial set of 309 candidate SAMAs, referred to as Phase I SAMAs, were identified. In Phase I of the evaluation, TVA performed a qualitative screening of the initial list of SAMAs and eliminated SAMAs from further consideration using the following criteria:

- The SAMA is not applicable to SQN.
- The SAMA has already been implemented at SQN.

- The SAMA is similar in nature and could be combined with another SAMA candidate.
- The SAMA has an estimated implementation cost in excess of the MMACR.
- The SAMA is related to non-risk significant systems.
- A plant improvement that addresses the intent of the SAMA is already in progress.

Based on this screening, a total of 262 SAMAs were eliminated leaving 47 for further evaluation. The remaining SAMAs, referred to as Phase II SAMAs, are listed in Tables E.2–1 and E.2–2 of Attachment E to the ER (TVA 2013d). In Phase II, a detailed evaluation was performed for each of the 47 remaining SAMA candidates, as discussed in Sections F.4 and F.6.

F.3.2 Review of TVA's Process

The TVA's efforts to identify potential SAMAs included explicit consideration of potential SAMAs primarily for internal events because the current SQN PRA does not include external events. Potential SAMAs for external events were included based on the SQN IPEEE probabilistic analysis of internal fires and deterministic analysis of seismic and other external events.

The initial SAMA list was developed primarily from the review of generic industry SAMAs (NEI 2005), as well as SAMAs from 11 previous license renewal applications and the SAMDA analysis for the Watts Bar Nuclear Power Plant (WBN), Unit 2, operating license application and the associated generic environmental impact statements. To this list, a number of SAMAs were added based on improvements identified in the IPE and IPEEE. Finally, SAMAs were added based on the review of the SQN PRA Level 1 and Level 2 LERF results.

The TVA provided a tabular listing of the Level 1 PRA basic event CDF importances down to a risk reduction worth (RRW) of 1.005. The SAMAs impacting these basic events would have the greatest potential for reducing risk. An RRW of 1.005 for an event corresponds to a reduction in CDF of approximately 0.5 percent given 100 percent reliability of a SAMA that eliminates the basic event. Based on the maximum averted cost-risk (MACR) including external events and uncertainty (see Section F.6.1), this corresponds to a potential maximum benefit including uncertainty of $97,000 for SQN Unit 1 and $88,000 for Unit 2. The NRC staff noted in an RAI that this potentially precludes identifying simple procedure changes that according to ER Section E.2.3 might cost $50,000. The TVA responded to the RAI by extending the reviews of the CDF importances down to RRWs corresponding to a benefit of $50,000. No additional SAMA candidates were identified (TVA 2013c).

In response to an NRC staff RAI that noted there were several risk-significant events in the importance listings for which there were no Phase II SAMAs identified, TVA provided further information as follows (TVA 2013c):

- For five events (PTSFD1PMP_0030142, PTSFR1PMP_0030142, TM_1PMP_003001AS, TM_1PMP0030118A, PMAFD1PMP_00300118) representing failures and unavailabilities of the turbine-driven and motor-driven AFW pumps, Phase I SAMA 223 "Improve reliability of AFW pumps and valves" is identified as an applicable SAMA. This SAMA was dispositioned as follows:

  > The SQN AFW systems meet reliability and unavailability goals established in the maintenance rule program. To improve reliability there are initiatives to upgrade the Terry Turbine Governor Controls and Governor Valve stem material; obtain spares for MDAFWP, TDAFWP, MDAFWP motor; replace Bailey 550

transmitters to increase the reliability of holding as found and as left tolerances. Therefore, implementation of this SAMA is an ongoing process at SQN.

In addition, TVA pointed out that the new reactor decay heat removal system that will be installed to address external flooding issues will significantly reduce the importance of the listed AFW events.

- For event AFWOP3, representing the failure of operators to depressurize and cool down the vessel so that low pressure injection can be used following a small or medium loss of coolant accident with failure of high pressure recirculation, three previously implemented Phase I SAMAs to improve the capacity to cool down and depressurization were described. In addition, two Phase II SAMAs: 103 (Institute simulator training for severe accident scenarios) and 283 [Initiate frequent awareness training for plant operators/maintenance/testing staff on important human actions, including dependent (combination) events, for plant risk] that are applicable to this event were identified and discussed.

The staff noted, for basic events %1RTIE and %1TTIE, representing a general reactor trip and a turbine trip, respectively, the ER states that Phase II SAMA 218, to increase the reliability of power supplies, has been evaluated. In response to an NRC staff RAI to discuss the potential for other SAMAs to reduce the general reactor trip and turbine trip frequency, TVA discussed the implementation of a trip reduction program focused on these two initiators. TVA estimated that such a program would result in a decrease in frequency of, at most 20 percent. This translates into a benefit of approximately $65,000 when 95th percentile uncertainty is considered. Based on previous TVA experience with the development and implementation of reliability studies, a trip reduction program is estimated to cost between $550,000 and $1,250,000. Based on the estimated cost to implement a trip reduction program and the minimal benefit gained, this potential SAMA would not be cost beneficial (TVA 2013c).

TVA also provided and reviewed the basic events with LERF RRWs down to 1.005. All basic events in the Level 2 LERF listing were reviewed to identify potential SAMAs and all were addressed by one or more Phase II SAMAs except those that are phenomena-based split fractions for which no SAMA would be appropriate. The staff notes that because LERF makes up only about 40 percent of the total cost risk, LERF basic events with RRW less than about 1.006 would not be expected to be cost beneficial unless they are also important to CDF.

For SQN, SGTRs do not appear in the importance analyses results because they are below the cutoff used to identify risk-significant events to be addressed by SAMAs. The NRC staff notes that a number of SGTR-related SAMAs were considered by TVA from its review of generic SAMAs, as well as cost-beneficial SAMAs from other plants' SAMA analyses. These SAMAs were either screened out as having been implemented at SQN or having excessive cost or were included in the Phase II analysis and found to be cost beneficial. Thus, the NRC staff concludes that, even if the SGTR is more important than shown in the SQN PRA based on the discussion in Section F.2.2.3, this would not change the SQN determination of cost-beneficial SAMAs.

The TVA also considered the potential plant improvements described in the SQN IPE and IPEEE in the identification of plant-specific candidate SAMAs. The SQN IPE identified 11 enhancements (TVA 1992). The NRC staff review of the Phase I SAMA candidate list during the April 2013 audit indicated that nine were screened as already implemented, one was retained for Phase II and one was combined with another SAMA that was retained for Phase II.

The SQN IPEEE identified five seismic-related improvements (plus minor maintenance housekeeping issues) (TVA 1995). The NRC staff review of the Phase I SAMA candidate list during the April 2013 audit indicated that all five improvements were listed as having been implemented.

The ER Section E.1.1.1 and the SQN IPEEE Safety Evaluation Report (SER) (NRC 2001) indicate that the limiting plant component HCLPF is 0.23g. The NRC staff noted that this is less than the RLE of 0.3g. Further, the Technical Evaluation Report supporting the SER indicates there are 12 components with HCLPFs below the RLE. While NRC concluded that the SQN IPEEE meets the intent of GL 88-20, Supplement 4, the result above indicates that there are some components, which should be examined for the identification of potential cost-beneficial SAMAs. In response to an NRC staff RAI to discuss the actions taken on these 12 items, the final HCLPF values, if available, and the potential for cost-beneficial SAMAs for these SQN components, TVA stated that each of the 12 noted components were re-analyzed. Eleven of the components met the 0.3g requirement. One component, the 480-V shutdown transformer, required a minor modification to the anchorage, which is complete. All IPEEE outliers are now resolved and have minimum HCLPF capacities above 0.3g. Also, TVA indicated that the other low-margin outliers were reviewed to determine if other minor modifications are possible. No modifications that might be cost-beneficial were identified (TVA 2013c).

As indicated, the SQN IPEEE utilized an SMA, which provided no quantitative risk information and limited deterministic seismic capacities for SQN systems, structures, or components. It is thus not possible to identify and evaluate SQN-specific SAMAs to mitigate seismic risk. The recent seismic walkdowns and reassessment of seismic capacities provided assurance that all IPEEE outliers are now resolved and have minimum HCLPF capacities above the RLE of 0.3g (TVA 2012b). In addition, the continuing evaluations in response to Recommendation 2.3 of The Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident will provide further opportunities to identify any seismic vulnerabilities at SQN. Given the above and the NRC staff observation that SAMAs to mitigate the impact of seismic events are expected to be relatively costly and therefore are not likely to be cost beneficial, the staff concludes that the exclusion of seismic-specific SAMAs from the License Renewal evaluation is acceptable.

In response to an NRC staff RAI, TVA also considered SAMAs for the 14 largest fire risk contributors based on the IPEEE evaluation, whose results are summarized in Table F–4. SAMA 287 (Protect, re-route, or modify circuits to upgrade core damage mitigation capability for fires that result in main control room evacuation) involved reducing the risk from fires in four of the important fire areas (Unit 1 Auxiliary Instrument Room, Unit 2 Auxiliary Instrument Room, Main Control Room, and Relay Room). For the other important fire areas, TVA provided an assessment that indicated the benefit of a SAMA that would eliminate 30 percent of the risk of the most important fire area would be $26,000. Because this is well below the minimum estimated hardware cost of $100,000, TVA concluded that cost-beneficial SAMAs for the individual fire areas would not be expected (TVA 2013c). The NRC staff notes that while this $26,000 value does not include the impact of uncertainty, raising the maximum benefit of eliminating 30 percent of the risk of the most important fire areas to $65,000 does not change the conclusion.

In response to an NRC staff RAI on the screening criterion for excessive implementation cost indicated in the ER (TVA 2013d, ER Section E.2.2), TVA indicated that the Phase I screening on excessive implementation cost did not specifically include the impact of the uncertainty multiplier. The TVA described an additional review of the Phase I SAMA candidates screened as having excessive implementation cost that was performed to identify any candidates that should be reconsidered with the uncertainty multiplier of 2.5 applied. The Phase I candidates were grouped into categories based on how the potential SAMA would affect the plant. The categories were SGTR, Injection Capabilities, Containment Response/Venting, Reactor Vessel, and alternating current (AC)/SBO. A bounding maximum potential benefit was developed for each of the categories. These potential benefits, including the uncertainty multiplier, were used to perform a review of the SAMA candidates that had previously been screened based on high implementation costs. All those previously screened remained screened considering the conservative maximum benefit that included the uncertainty (TVA 2013c).

At the onsite audit in April 2013, the NRC staff reviewed the Phase I candidate SAMA list. This review included an assessment of the completeness of the list as well as the Phase I screening disposition of each candidate SAMA. All of the NRC staff questions were resolved satisfactorily, and on the basis of this information and the discussions above, the NRC staff concludes that the set of SAMAs evaluated in the ER, together with those identified in response to NRC staff RAI, addresses the major contributors to both internal and external event CDF.

The NRC staff questioned the applicant about additional potentially lower-cost or more-effective alternatives to some of the SAMAs evaluated (NRC 2013). Individual questions and the results of TVA's responses on the potentially cost-beneficial SAMAs are summarized in Section F.6.2.

The NRC staff notes that the set of SAMAs submitted is not all-inclusive, because additional, possibly even less expensive, design alternatives can always be postulated. However, the NRC staff concludes that the benefits of any additional modifications are unlikely to exceed the benefits of the modifications evaluated and that the alternative improvements would not likely cost less than the least expensive alternatives evaluated, when the subsidiary costs associated with maintenance, procedures, and training are considered.

The NRC staff concludes that TVA used a systematic and comprehensive process for identifying potential plant improvements for SQN, and that the set of SAMAs evaluated in the ER, together with those evaluated in response to NRC staff inquiries, is reasonably comprehensive and, therefore, acceptable. The NRC staff evaluation included reviewing insights from the SQN plant-specific risk studies that included internal initiating events as well as fire, seismic and other external initiated events, and reviewing plant improvements considered in previous SAMA analyses.

The NRC staff also notes that the new improved flood mitigation systems to be installed at SQN Units 1 and 2, discussed above, would be expected to reduce the risk from all external events and possibly some internal events. The new systems are, thus, effectively additional SAMAs to which TVA has committed.

F.4 Risk Reduction Potential of Plant Improvements

In the ER, the applicant evaluated the risk-reduction potential of the 47 SAMAs that were not screened out in the Phase I analysis and retained for the Phase II evaluation. The SAMA evaluations were performed using generally conservative assumptions.

Except for one SAMA associated with internal fires, TVA used model requantification to determine the potential benefits for each SAMA. The CDF, population dose, and offsite economic cost reductions were estimated using the SQN SAMA PRA model for the nonfire SAMAs. The changes made to the model to quantify the impact of SAMAs are detailed in Section E.2.3 of Attachment E to the ER (TVA 2013d). Bounding evaluations were performed to address specific SAMA candidates or groups of similar SAMA candidates. For the fire-related SAMA 287, the benefit was determined by assuming that the CCDP and the associated CDF for the four fire compartments involved was reduced by a factor of 10. The evaluation assumed that all release category frequencies were reduced by the same percentage as CDF. The reduced CDF and release category frequencies were then used to determine the reduction in population dose and offsite economic cost in a manner similar to all other SAMAs (TVA 2013c). The NRC staff notes that the above, as applied by TVA, included increasing the benefit by the external event multiplier, which is a significant conservatism because the SAMA would only impact the fire CDF and not the CDF from nonfire internal events or other external events.

Table F–5 includes the assumptions made to estimate the risk reduction for each of the evaluated SAMAs, the estimated risk reduction in terms of percent reduction in CDF, population dose risk and OECR, and the estimated total benefit (present value) of the averted risk. The estimated benefits reported in Table F–5 reflect the combined benefit in both internal and external events. The determination of the benefits for the various SAMAs is further discussed in Section F.6.

The NRC staff noted in an RAI that for some SAMAs the benefit for the two units is considerably different (e.g., SAMAs 32 and 68). In response, TVA attributed the differences as being caused by the differing impacts of internal flooding on the two units (TVA 2013c).

The benefit for SAMA 8 (increase training on response to loss of two 120-V AC busses) was determined by eliminating the inadvertent actuation of safety injection. In response to an NRC staff RAI to identify any other impacts of the loss of the two busses that would benefit from the training, TVA indicated that additional analyses, with various assumptions regarding 120-V AC busses, were performed to assess the benefit of increased training upon loss of two busses. In most analyses, the averted cost risk exceeded $50,000. Therefore, this SAMA candidate will be retained by TVA for consideration as a potentially cost-beneficial SAMA (TVA 2013c).

Also, relative to SAMA 8, the NRC staff noted that the RRW for loss of a single 120-V AC bus is given, but there is no value for the common cause failure of both busses. In response to an RAI to discuss this omission, TVA responded that loss of an electrical bus is considered to be a passive event and it is TVA practice not to model common cause failures of passive events. Further loss of a single 120-V AC bus will cause a reactor trip (TVA 2013c). Given that SAMA has been retained as a potentially cost-beneficial SAMA and that simultaneous loss of both 120-V AC busses is considered unlikely, the NRC staff determined this issue is resolved for the SQN SAMA analysis.

The NRC staff noted in an RAI that the impact of adding the gas turbine in SAMA 14 was found to be only a 0.35-percent and 0.1-percent reduction in CDF for Units 1 and 2, respectively. In response to the RAI to explain why this is so small considering that SBO is about 10 percent of the CDF, TVA responded that the benefit is small because a majority of SBOs are caused by internal flooding and adding a gas turbine would not mitigate these sequences. Also, the availability at SQN of a utility bus that allows, under certain circumstances, one unit to receive emergency power from the other unit's EDG reduces the importance of emergency power supplies (TVA 2013c).

For SAMA 70 (install accumulators for turbine-driven auxiliary feedwater pump (TDAFWP) flow control valves), it was indicated that a bounding analysis was performed by eliminating the failure of the existing flow-control valves. In response to an NRC staff RAI to confirm that this analysis included the failure caused by lack of air, TVA responded that the analysis assumed success of the human action to restore the TDAFWP speed control following the initiator and loss of air. An additional analysis has been performed to completely eliminate all failures of the AFW-level control valves (including air and human actions) that resulted in a small increase in benefit. The ER concluded that this SAMA is cost-beneficial based on the original analysis, hence this increase did not impact the SAMA assessment (TVA 2013c).

Table F–5. SAMAs Cost/Benefit Analysis for Units 1 and 2 of the SQN

Percentage risk reductions are presented for CDF, population dose risk (PDR), and OECR. Potentially cost-beneficial SAMAs are shown in bold.

Individual SAMA and Assumption	Cost Estimate	Unit 1 Percent Risk Reduction			Unit 1 Internal and External Benefit	Unit 2 Percent Risk Reduction			Unit 2 Internal and External Benefit
		CDF	PDR	OECR		CDF	PDR	OECR	
8—Increase training on response to loss of two 120-V AC buses	**$50,000**	<0.1%	0.0%	0.0%	**>$50,000**[‖] $573 ($1,430)[#]	<0.1%	0.0%	0.0%	**>$50,000**[‖] $226 ($566)[#]
Assumption: To assess the benefit of increased training on loss of two 120-V AC buses causing inadvertent actuation signals, the inadvertent actuation of safety injection was removed from the model. In response to an RAI, determined by TVA to be potentially cost beneficial.									
14—Install a gas turbine generator	$3,350,000		2.4%		$125,000 ($313,000)[#]	0.1%	1.1%	0.8%	$49,500 ($124,000)[#]
Assumption: A new event, failure of the gas turbine generator, was added to the diesel generator supply logic so that failure of the diesel generators and failure of the gas turbine generator are required to lose power to the shutdown boards. The failure probability of the gas turbine generator was assumed to be $4.54{\times}10^{-2}$.									
32—Automatically align emergency core cooling system to recirculation[†]	**$2,100,000**	**13.4%**	**4.2%**	**2.9%**	**$458,00 ($1,144,000)**[#]	**31.8%**	**8.9%**	**6.8%**	**$1,026,000 ($2,564,000)**[#]
Assumption: A bounding analysis was performed by eliminating the failure of the manual action required to align high-pressure recirculation (HARR1) by setting the event to false.									
45—Enhance procedural guidance for use of cross-tied component cooling pumps	**$50,000**	**0.8%**	**1.1%**	**1.2%**	**$83,700 ($209,000)**[#]	**0.6%**	**1.1%**	**1.2%**	**$71,500 ($179,000)**[#]
Assumption: The fault trees for the CCW system were modified to reflect that failure of multiple pumps was required to cease flow to the respective heat exchanger train.									
46—Add a service water pump	$1,043,000	0.7%	1.1%	1.1%	$78,700 ($197,000)[#]	0.3%	0.5%	0.4%	$28,700 ($71,800)[#]
Assumption: A new service water pump with failure on demand and fail to run basic events was added to the model under ERCW pump failure gates.									

Table F–5. SAMAs Cost/Benefit Analysis for Units 1 and 2 of the SQN (continued)

Individual SAMA and Assumption	Cost Estimate	Unit 1 Percent Risk Reduction			Unit 1 Internal and External Benefit	Unit 2 Percent Risk Reduction			Unit 2 Internal and External Benefit
		CDF	PDR	OECR		CDF	PDR	OECR	
55—Install an independent RCP seal injection system, with dedicated diesel	$8,233,000	3.0%	4.0%	4.0%	$290,000 ($724,000)[#]	2.4%	2.5%	2.9%	$184,000 ($460,000)[#]
56—Install an independent RCP seal injection system, without dedicated diesel	$8,233,000	3.0%	4.0%	4.0%	$290,000 ($724,000)[#]	2.4%	2.5%	2.9%	$184,000 ($460,000)[#]
Assumption: The analysis was performed by adding a new seal injection system to the fault tree logic such that RCP seal injection failure would require failure of the new system and both centrifugal charging pumps. No power dependencies were included as part of this addition to the model.									
68—Add a motor-driven FW pump	$10,000,000	20.4%	13.1%	11.9%	$1,112,000 ($2,781,000)[#]	33.3%	13.9%	11.6%	$1,303,000 ($3,259,000)[#]
Assumption: A bounding analysis was performed by removing the initiating events for total and partial loss of FW. Additionally, the fault tree was modified to include an additional FW pump. The failure probability of the pump was assumed to be 0.05, and no dependencies on power or other support system was modeled.[¶]									
70—Install accumulators for TDAFWP flow control valves	**$256,000**	**6.1%**	**4.9%**	**3.2%**	**$348,000 ($870,000)**[#]	**5.12%**	**5.01%**	**3.33%**	**$311,000 ($779,000)**[#]
Assumption: A bounding analysis was performed by eliminating the failure of the existing flow control valves.									
71—Install a new condensate storage tank	$1,710,000	1.2%	2.9%	2.5%	$179,000 ($448,000)[#]	<0.1%	0.0%	0.0%	$509 ($1,270)[#]
Assumption: A bounding analysis was performed by assuming that long term makeup to the tank was always available.									
79—Replace existing pilot-operated relief valves with larger ones	$100,000	<0.1%	0.0%	0.0%	$318 ($796)[#]	0.0%	0.0%	0.0%	$0 ($0)[#]
Assumption: The analysis was performed by modifying the fault tree logic such that failure to establish RCS bleed with pilot operated relief valves using safety injection pumps would require the failure of both pilot operated relief valves instead of just one RCS feed and bleed using centrifugal charging pumps currently only requires one pilot operated relief valve to function properly, therefore, no change was made to the fault tree logic for feed and bleed using centrifugal charging pumps.									
83—Add a switchgear room high-temperature alarm	$100,000	<0.1%	0.0%	0.0%	$764 ($1,910)[#]	<0.1%	0.0%	0.1%	$3,990 ($9,970)[#]
Assumption: A bounding analysis was performed by eliminating the failure of the ventilation fans in the 480-V transformer room, thereby maintaining a proper temperature in the room.									

Table F–5. SAMAs Cost/Benefit Analysis for Units 1 and 2 of the SQN (continued)

Individual SAMA and Assumption	Cost Estimate	Unit 1 Percent Risk Reduction CDF	Unit 1 Percent Risk Reduction PDR	Unit 1 Percent Risk Reduction OECR	Unit 1 Internal and External Benefit	Unit 2 Percent Risk Reduction CDF	Unit 2 Percent Risk Reduction PDR	Unit 2 Percent Risk Reduction OECR	Unit 2 Internal and External Benefit
87—Replace service and instrument air compressors with more reliable compressors	**$886,000***	**6.5%**	**4.2%**	**2.8%**	**$326,000 ($815,000)[#]**	**5.6%**	**4.3%**	**2.9%**	**$293,000 ($732,000)[#]**
Assumption: A bounding analysis was performed by eliminating the failure of cooling to the compressors. This includes compressors for the auxiliary compressed air system and the compressed air system. In response to an RAI, determined by TVA to be potentially cost beneficial.									
88—Install nitrogen bottles as backup gas supply for safety relief valves[†]	**$100,000**	**3.5%**	**0.2%**	**0.2%**	**$78,100 ($195,000)[#]**	**3.1%**	**0.5%**	**0.2%**	**$79,000 ($198,000)[#]**
Assumption: A bounding analysis was performed by modifying the atmospheric relief valve fault tree logic for all four valves to remove their dependence on compressed air.									
103—Institute simulator training for severe accident scenarios	$8,000,000	5.3%	4.4%	4.9%	$372,000 ($930,000)[#]	6.6%	5.0%	5.5%	$397,000 ($993,000)[#]
Assumption: A bounding analysis was performed by reducing the failure probability of important human actions as well as the dependency factors for the important human actions..									
105—Delay containment spray actuation after a large LOCA	**$100,000**	**6.8%**	**2.7%**	**1.8%**	**$257,000 ($641,000)[#]**	**16.0%**	**5.0%**	**3.8%**	**$539,000 ($1,348,000)[#]**
106—Install automatic containment spray pump header throttle valves	**$100,000**	**6.8%**	**2.7%**	**1.8%**	**$257,000 ($641,000)[#]**	**16.0%**	**5.0%**	**3.8%**	**$539,000 ($1,348,000)[#]**
249—High-volume makeup to the refueling water storage tank[†]	**$565,000**	**6.8%**	**2.7%**	**1.8%**	**$257,000 ($641,000)[#]**	**16.0%**	**5.0%**	**3.8%**	**$539,000 ($1,348,000)[#]**
Assumption: A bounding analysis was performed by changing the model so that the refueling water storage tank was always available. This included removing refueling water storage tank rupture, as well as failure to deliver flow from the refueling water storage tank to containment spray pumps A and B. In addition, the failure probability of the human action to align high-pressure recirculation (HARR1), was decreased by half to account for the increased time that the operator would have to perform this action.									
109—Install a passive hydrogen control system	$3,736,000	<0.1%	14.4%	16.1%	$893,000 ($2,232,000)[#]	0.0%	15.0%	17.0%	$811,000 ($2,029,000)[#]
Assumption: A bounding analysis was performed by eliminating the failure of the existing hydrogen mitigation system from Level 2 model logic.									
111—Install additional pressure or leak monitoring instruments for detection of ISLOCAs	$190,000	0.1%	0.7%	0.3%	$30,100 ($75,300)[#]	<0.1%	0.7%	0.3%	$26,800 ($66,900)[#]

Table F–5. SAMAs Cost/Benefit Analysis for Units 1 and 2 of the SQN (continued)

Individual SAMA and Assumption	Cost Estimate	Unit 1 Percent Risk Reduction CDF	PDR	OECR	Unit 1 Internal and External Benefit	Unit 2 Percent Risk Reduction CDF	PDR	OECR	Unit 2 Internal and External Benefit
239—Install additional instrumentation for ISLOCA detection	$190,000	0.1%	0.7%	0.3%	$30,100 ($641,000)[#]	<0.1%	0.7%	0.3%	$26,800 ($66,900)[#]
Assumption: A bounding analysis was performed by removing the letdown line, RHR legs, RHR pump seal, RHR supply, refueling water storage tank piping, safety injection legs, and safety injection pump seals ISLOCA initiating events from the model.									
112—Add redundant and diverse limit switches to each containment isolation valve	$692,000	<0.1%	0.0%	0.0%	$255 ($636)[#]	0.0%	0.0%	0.0%	$0 ($0)[#]
Assumption: A bounding analysis was performed by adding a manual action to the fault tree logic at each containment isolation valve with a failure probability of 10^{-2}.									
136—Install motor generator set trip breakers in control room	$100,000	0.2%	0.4%	0.3%	$25,600 ($64,000)[#]	0.2%	0.5%	0.3%	$22,500 ($56,200)[#]
137—Provide capability to remove power from the bus powering the control rods	$100,000	0.2%	0.4%	0.3%	$25,600 ($64,000)[#]	0.2%	0.5%	0.3%	$22,500 ($56,200)[#]
Assumption: A bounding analysis was performed by eliminating the failure of the manual action to trip the reactor using the main control room hand switch (HAEB1). Additionally, the probability of failure to trip the reactor, given sold state protection system (HART1) was reduced by half. This reduced the probability for failure of this manual action to below the original cognitive error probability, and is thus conservative.									
147—Install digital large break loss-of-coolant-accident protection system	$2,700,000	0.1%	0.0%	0.0%	$2,230 ($5,570)[#]	<0.1%	0.0%	0.0%	$1,700 ($4,240)[#]
Assumption: A bounding analysis was performed by removing the initiating events for large break and medium break LOCAs on each cold leg.									
160—Implement procedures for temporary heating, ventilation, and air conditioning (HVAC)[‡]	**$300,000**	**9.1%**	**7.8%**	**9.1%**	**$665,000 ($1,661,000)[#]**	**5.0%**	**2.3%**	**2.5%**	**$220,000 ($550,000)[#]**
Assumption: The analysis was performed by adding a human action to provide temporary cooling (failure frequency of 10^{-1}) for the following areas given cooler/ventilation failure: turbine-driven auxiliary feedwater pump room; RHR pump rooms A and B; safety injection pump rooms A and B, containment spray room; centrifugal charging pump cooler rooms A and B; and space coolers A and B for boric acid transfer pump and AFW pumps.									

Table F–5. SAMAs Cost/Benefit Analysis for Units 1 and 2 of the SQN (continued)

Individual SAMA and Assumption	Cost Estimate	Unit 1 Percent Risk Reduction CDF	Unit 1 Percent Risk Reduction PDR	Unit 1 Percent Risk Reduction OECR	Unit 1 Internal and External Benefit	Unit 2 Percent Risk Reduction CDF	Unit 2 Percent Risk Reduction PDR	Unit 2 Percent Risk Reduction OECR	Unit 2 Internal and External Benefit
161—Provide backup ventilation for the EDG rooms	$1,000,000*	0.5%	1.3%	1.1%	$81,100 ($203,000)#	0.2%	0.7%	0.6%	$38,300 ($95,700)#
Assumption: A bounding analysis was performed by eliminating failure of the dampers and exhaust fans which provide ventilation to the EDGs and electric board room.									
167—Provide an independent power supply for the air return fans	$100,000	<0.1%	0.0%	0.0%	$255 ($636)#	0.0%	0.0%	0.0%	$0 ($0)#
Assumption: The analysis was performed by removing the power dependency of the containment fans on the 480-V boards to simulate an independent power supply.									
188—Implement modifications to the compressed air system to increase the capacity of the system	$2,782,200	11.2%	5.3%	3.5%	$467,000 ($1,167,000)#	9.7%	5.5%	3.8%	$424,000 ($1,060,000)#
Assumption: To assess the benefit of increasing the capacity of the system, the failure probability of the compressors and dryers for the compressed air and auxiliary compressed air systems was set to zero. The probability of the dyers and compressors being in maintenance was also set to zero to represent improved reliability of the system									
215—Provide a means to ensure RCP seal cooling so that RCP seal LOCAs are precluded for SBO events	**$1,500,000**	**47.5%**	**46.2%**	**54.1%**	**$3,832,000 ($9,580,000)#**	**38.5%**	**44.2%**	**53.2%**	**$3,234,000 ($8,085,000)#**
Assumption: This analysis was used to evaluate the change in plant risk from providing a means to ensure RCP seal cooling so that RCP seal LOCAs are precluded for SBO events. The analysis was performed by adding an additional seal cooling system to the logic "anded" with the existing RCP thermal barrier cooling logic. The new seal cooling system with independent power source was given an unavailability of 0.05 which is representative of a single pump train system.									
218—Improve reliability of power supplies to reduce reactor trip frequency	$500,000	2.8%	1.8%	2.2%	$168,000 ($420,000)#	2.2%	1.8%	2.0%	$141,000 ($352,000)#
Assumption: To assess the benefit of replacing or improving power supplies, the failure probabilities of all batteries, battery chargers, buses, circuit breakers, and transformers were decreased by ten percent. Additionally, the frequencies of loss of offsite power events because of switchyard centered and plant centered events were also decreased by 10 percent.									
226—Install a permanent, self-powered pump to backup normal charging pump	$2,700,000	3.0%	4.2%	4.2%	$303,000 ($757,000)#	2.4%	2.7%	3.0%	$193,000 ($483,000)#

Table F–5. SAMAs Cost/Benefit Analysis for Units 1 and 2 of the SQN (continued)

Individual SAMA and Assumption	Cost Estimate	Unit 1 Percent Risk Reduction CDF	Unit 1 Percent Risk Reduction PDR	Unit 1 Percent Risk Reduction OECR	Unit 1 Internal and External Benefit	Unit 2 Percent Risk Reduction CDF	Unit 2 Percent Risk Reduction PDR	Unit 2 Percent Risk Reduction OECR	Unit 2 Internal and External Benefit
240—Install permanent dedicated generator for normal charging pump	$2,000,000	3.0%	4.2%	4.2%	$303,000 ($757,000)[#]	2.4%	2.7%	3.0%	$193,000 ($483,000)[#]
Assumption: A bounding analysis was performed by eliminating the failure of both centrifugal charging pumps.									
254—Install an alternate fuel oil tank with gravity feed capability	$150,000	0.2%	0.4%	0.4%	$29,100 ($72,800)[#]	<0.1%	0.2%	0.2%	$12,900 ($32,400)[#]
Assumption: To assess the potential benefit, diesel generator fail to run events (including common cause failures) were decreased by ten percent.									
268—Perform an evaluation of the CCW system/AFW area cooling requirements	**$313,000**	**29.5%**	**26.9%**	**31.7%**	**$2,269,000 ($5,673,000)[#]**	**21.3%**	**26.0%**	**31.5%**	**$1,881,000 ($4,704,000)[#]**
Assumption: The analysis was performed by eliminating the failure of the CCW system and AFW space coolers.									
275—Install spray protection on MDAFWPs and pump space coolers[†]	**$800,000**	**8.0%**	**6.9%**	**8.0%**	**$587,000 ($1,467,000)[#]**	**17.8%**	**8.4%**	**8.9%**	**$792,000 ($1,979,000)[#]**
Assumption: A bounding analysis was performed by eliminating spray initiators from the MDAFWPs, and space coolers used to cool MDAFWPs.									
276—Replace one or more existing steam generator atmospheric relief valves with a valve of different design or manufacturer	$1,233,000	1.6%	0.4%	0.2%	$49,300 ($123,000)[#]	2.0%	0.5%	0.2%	$56,200 ($140,000)[#]
Assumption: A bounding analysis was performed by eliminating all of the common cause failures of steam generator atmospheric relief valves.									
277—Improve reliability of control rod mechanisms	$1,218,780	1.3%	2.9%	1.7%	$156,000 ($391,000)[#]	1.1%	3.0%	1.7%	$139,000 ($348,000)[#]
Assumption: The analysis was performed by decreasing the probability of control rods failing to insert by an order of magnitude.									
278—Improve the reliability of the RHR pumps and improve maintenance procedures to reduce potential for common cause failure	$345,000	3.3%	0.7%	0.8%	$106,000 ($264,000)[#]	2.9%	1.1%	1.2%	$116,000 ($291,000)[#]
Assumption: The analysis was performed by decreasing by half the probabilities of RHR pumps failure on demand, fail to run, common cause, and unavailability because of maintenance events.									

Table F–5. SAMAs Cost/Benefit Analysis for Units 1 and 2 of the SQN (continued)

Individual SAMA and Assumption	Cost Estimate	Unit 1 Percent Risk Reduction CDF	Unit 1 Percent Risk Reduction PDR	Unit 1 Percent Risk Reduction OECR	Unit 1 Internal and External Benefit	Unit 2 Percent Risk Reduction CDF	Unit 2 Percent Risk Reduction PDR	Unit 2 Percent Risk Reduction OECR	Unit 2 Internal and External Benefit
279—Improve internal flooding response procedures and training to improve the response to internal flooding events	**$400,000**	**5.3%**	**7.3%**	**7.1%**	**$520,000 ($1,301,000)[#]**	**14.9%**	**10.0%**	**9.8%**	**$796,000 ($1,990,000)[#]**
Assumption: The analysis was performed by reducing the overall failure probability of important flooding human actions, with the flood multiplier for important human actions reduced by a factor of two.									
283—Provide frequent awareness training to plant staff on important human actions	**$345,000**	**5.3%**	**4.4%**	**4.9%**	**$372,000 ($930,000)[#]**	**6.6%**	**5.0%**	**5.5%**	**$397,000 ($993,000)[#]**
Assumption: A bounding analysis was performed by reducing the failure probability of important human actions by ten percent. The human error probability (HEP) dependency factors for important human actions were also improved by ten percent.									
284—Reduce the probability that the pressurizer safety relief valves fail to reclose following a water pressure relief event	$1,566,800	2.40%	0.67%	0.82%	$88,900 ($222,000)[#]	1.8%	0.5%	0.5%	$60,900 ($152,000)[#]
Assumption: A bounding analysis was performed by eliminating the failure of the pressurizer safety relief valves to reseat after a water pressure event.									
285—Protect important equipment in the turbine building from internal flooding[†]	**$955,000***	**8.8%**	**5.8%**	**5.0%**	**$478,000 ($1,196,000)[#]**	**7.6%**	**6.2%**	**5.3%**	**$439,000 ($1,099,000)[#]**
Assumption: The analysis was performed by adding a factor to the flooding initiators that resulted in reduced spray damage to the turbine building distribution boards and the raw cooling water pumps to simulate addition of spray shields. The spray shield was given a failure probability of 10^{-3}.									
286—Install flood doors to prevent water propagation in the electric board room[†,§]	**$4,695,000***	**10.8%**	**26.0%**	**22.4%**	**$1,611,000 ($4,028,000)[#]**	**9.1%**	**26.9%**	**23.5%**	**$1,454,000 ($3,634,000)[#]**
Assumption: The analysis was performed by removing the failure of important equipment from certain floods to simulate watertight doors.									
287—Protect, reroute, or modify circuits to upgrade core damage mitigation capability for fires that result in main control room evacuation	$2,000,000	5.2%	5.1%	5.2%	$398,000 ($994,000)[#]	4.4%	4.3%	4.4%	$308,000 ($771,000)[#]
Assumption: This SAMA is evaluated by assuming the CCDP for the four fire zones impacted is reduced by an order of magnitude to 7.4×10^{-3} and the change in risk is proportional to the equivalent change in internal events CDF.									

Table F–5. SAMAs Cost/Benefit Analysis for Units 1 and 2 of the SQN (continued)

Individual SAMA and Assumption	Cost Estimate	Unit 1 Percent Risk Reduction CDF	PDR	OECR	Unit 1 Internal and External Benefit	Unit 2 Percent Risk Reduction CDF	PDR	OECR	Unit 2 Internal and External Benefit
288—Install spray protection on CCW system pumps and CCW system/AFW space coolers[†,§]	**$1,809,000***	**8.9%**	**9.8%**	**11.6%**	**$793,000 ($1,982,000)[#]**	**6.9%**	**9.6%**	**11.4%**	**$669,000 ($1,674,000)[#]**
Assumption: A bounding analysis was performed by eliminating spray initiator events from the CCW system pumps and CCW system/AFW space coolers fault tree logic.									
289—Install backup cooling system for CCW system/AFW space coolers[†]	**$2,219,000***	**21.7%**	**19.1%**	**22.6%**	**$1,629,000 ($4,072,000)[#]**	**13.7%**	**16.0%**	**19.2%**	**$1,164,000 ($2,909,000)[#]**
Assumption: The analysis was performed by adding a backup space cooler to the fault tree logic, such that failure of the existing and backup coolers is required for failure of the CCW system and AFW space coolers.									

[#] Value in parentheses represents the larger benefit calculated in the sensitivity analysis (TVA 2013d, Attachment E, Tables E.2-3 and E.2-4)

* TVA identified that implementation costs could be shared between Units 1 and 2 for this SAMA and considered the combined total averted cost risk from both Units 1 and 2 in the cost-benefit evaluation.

† By assessing the sensitivity analysis and the resulting increases in estimated benefits (shown in parentheses), TVA considered the following additional SAMAs to be potentially cost beneficial for either one or both of the units: SAMA 32 (Unit 2), SAMA 88 (Units 1 and 2), SAMA 160 (Unit 2), SAMA 249 (Units 1 and 2), SAMA 275 (Units 1 and 2), SAMA 285 (Units 1 and 2), SAMA 286 (Units 1 and 2), SAMA 288 (Units 1 and 2), and SAMA 289 (Units 1 and 2).

‡ For the baseline results presented in this table, SAMA 160 was considered potentially cost beneficial for Unit 1 only. However, TVA considered SAMA 160 to be potentially cost beneficial for Unit 2 based on the sensitivity results (shown in parentheses).

§ SAMAs 286 and 288 were considered to be potentially cost beneficial; because implementation costs could be shared between Units 1 and 2 and the sensitivity analysis results for the combined total averted cost risk from both units (shown in parentheses) exceeded the SAMA implementation cost.

‖ Additional analyses performed by TVA for the loss of two busses indicated that averted cost risk could exceed $50,000 (TVA 2013c).

¶ TVA clarified that although the intent of this SAMA was to increase the availability of main FW pumps, the analysis was conservatively performed to increase the availability of both main FW pumps and AFW pumps (TVA 2013c).

For SAMA 83 (add a switchgear room high-temperature alarm), it was stated that a bounding analysis was performed by eliminating the failure of the ventilation fans in the 480-V Transformer Room, thereby maintaining a proper temperature in the room. In response to an NRC staff RAI to confirm that this room is the only one impacted by loss of switchgear heating, ventilation, and air conditioning (HVAC), TVA responded that the 480-V Transformer Room is the only one impacted by the loss of the switchgear HVAC and that other HVAC improvements are addressed by SAMA 160 (Implement Procedures for Temporary HVAC) and SAMA 161 (Provide backup ventilation for the EDG rooms, should their normal HVAC supply fail) (TVA 2013c).

For SAMA 103 (institute simulator training for severe accident scenarios), it was stated that a bounding analysis was performed by reducing the failure probability of important human actions and that the human error probability (HEP) dependency factors for important human actions were also improved. In response to an NRC staff RAI to identify the HEPs reduced and the amount of the reduction, TVA listed the individual human actions and the dependency factors and indicated that they were each reduced by 10 percent.

SAMA 268 (perform an evaluation of the CCS/AFW area cooling requirements) originated from the SQN IPE and is strictly to perform an analysis of the cooling requirements. In response to an NRC staff RAI, TVA indicated that if area cooling is found to be required then SAMA 289 (install backup cooling system for the CCS/AFW Space Coolers) would address this requirement. SAMA 289 was determined to be potentially cost-beneficial in the sensitivity analyses. If the result of the SAMA 268 evaluation is that CCS/AFW cooling is not required then SAMA 289 would no longer need to be considered (TVA 2013c).

The NRC staff has reviewed TVA’s bases for calculating the risk reduction for the various plant improvements and concludes, with the above clarifications, that the rationale and assumptions for estimating risk reduction are reasonable and generally conservative (i.e., the estimated risk reduction is higher than what would actually be realized). Accordingly, the NRC staff based its estimates of averted risk for the various SAMAs on TVA’s risk reduction.

F.5 Cost Impacts of Candidate Plant Improvements

The TVA estimated the costs of implementing the 47 Phase II SAMAs through the use of other licensees’ estimates for similar improvements and the development of site-specific cost estimates where appropriate.

The TVA indicated the following cost ranges were utilized based on the review of previous SAMA applications and an evaluation of expected implementation costs at SQN.

Type of Change	Estimated Cost Range
Procedural only	$50K
Procedural change with engineering or training required	$50K to $200K
Procedural change with engineering and testing or training required	$200K to $300K
Hardware modification	$100K to >$1,000K

TVA stated that the SQN site-specific cost estimates were based on the engineering judgment of project engineers experienced in performing design changes at the facility and were compared, where possible, to estimates developed and used at plants of similar design and vintage.

In response to an NRC staff RAI to provide further information as to what was included in the SQN cost estimates, TVA indicated that the cost estimates were done in 2012 dollars and included contingency costs and capital overhead. Cost estimates from past projects were used when applicable. For cost estimates that were not based directly on past projects, itemized cost estimates were developed, where applicable and appropriate. Specific hardware costs from recent projects such as piping, valves, electrical cable, and switchgear were used when applicable. Engineering estimates were based on typical man-hours costs for design changes. Training costs were developed based on the man-hours needed to prepare operator training materials. Cost input was received from the electrical, mechanical, and civil disciplines as required. The cost estimates were reviewed by the project manager or the discipline engineering managers (or both), when warranted. Replacement power, lifetime maintenance, escalation and inflation were not considered in the estimate (TVA 2013c).

In response to an NRC staff RAI to discuss how sharing the engineering and design costs between the two SQN units would affect the cost-benefit analysis, TVA indicated that, as stated in the ER, for plant modifications that would provide benefit to both units (e.g., SAMA 286: Install Flood Doors to Prevent Water Propagation in the Electric Board Room), the averted cost risk from Units 1 and 2 were combined to provide a total averted cost risk for the plant. Thus, the implementation costs for these SAMAs were assumed to be shared between the two units. In the response, TVA indicated that the other Phase II SAMAs found not to be cost beneficial in the base analysis fall into three categories as follows:

(1) The SAMAs were found to be cost beneficial in the sensitivity analysis and the sharing of costs is not an issue.

(2) The combined internal and external benefit, including uncertainty for the two units, is less than the single unit estimated cost, and therefore, cost sharing is not an issue.

(3) Five Phase II SAMA candidates do not fall into either of the categories above. They are SAMA 109 (install a passive hydrogen control system), SAMA 136 (install motor generator set trip breakers in control room), SAMA 137 (provide capability to remove power from the bus powering the control rods), SAMA 218 (improve reliability of power supplies to reduce reactor trip), and SAMA 278 (improve reliability of the RHR pumps and improve maintenance procedures to reduce potential for common cause failure).

For SAMA 109, the combined 95th percentile benefit only slightly (14 percent) exceeds the single unit estimated cost and TVA judges that cost sharing would not be sufficient to make this SAMA cost beneficial. For SAMAs 136 and 137 the combined 95th percentile benefit only slightly (20 percent) exceeds the single unit estimated cost. For these SAMAs the implementation cost was originally based on the minimum hardware cost of $100,000. Upon further review TVA concluded that the actual cost would be greater than $100,000 and that neither SAMAs 136 nor 137 would be cost beneficial even if the costs were 100-percent shared. For SAMA 218, TVA estimated that approximately 75 percent of the implementation cost involved hardware and unit-specific costs that could not be shared. This resulted in SAMA 218 not being cost beneficial even at the 95th percentile benefit. For SAMA 278, TVA indicated that, while a large portion of the implementation cost could be shared, the likelihood is that some hardware costs would be required. In addition, the benefit calculation conservatively assumed that all the fail-to-run, fail-to-start, common-cause, and unavailability-caused-by-maintenance events for all of the RHR pumps could be reduced by 50 percent. Given this, TVA considered that this SAMA may be potentially cost beneficial if a significant portion of the cost could be shared.

> However, TVA stated that the planned modification to improve external flooding mitigation, which includes an additional train of decay heat removal, will significantly reduce the benefit of this SAMA to the point where it would not be expected to be cost beneficial (TVA 2013c).

Based on the foregoing, the NRC staff concludes that the potential impact of cost sharing between SQN units has been adequately explored and no change in the cost-beneficial status of the Phase II SAMAs would be expected because of potential cost sharing.

The NRC staff reviewed the applicant's cost estimates, presented in Tables E.2-1 and E.2-2 of Attachment E to the ER. For certain improvements, the NRC staff also compared the cost estimates to estimates developed elsewhere for similar improvements, including estimates developed as part of other licensees' analyses of SAMAs for operating reactors.

The staff noted in an RAI that for SAMA 188 (implement modifications to the compressed air system to increase the capacity of the system) the cost estimate is $2,800,000 compared to $900,000 for SAMA 87 (replace the service and instrument air compressors with more reliable compressors). TVA responded that the reason for the higher cost is because of the higher capacity of the SAMA 188 replacement compressors compared to the SAMA 87 replacement compressors, which were taken to be the same size as the originals but with air cooling instead of service water cooling (TVA 2013c).

The NRC staff noted that for two SAMAs (161 and 284), the source of the cost estimates in ER Tables E.2-1 and E.2-2 was stated to be the minimum hardware cost of $100,000. The staff also noted that the actual estimated costs given in those same tables for those SAMAs were $1,000,000 and $1,566,800 (respectively). The staff asked the applicant to explain this discrepancy. The applicant explained that the stated minimum hardware cost was an error; the correct costs were estimated by SQN to be $1,000,000 for SAMA 161 and $1,566,800 for SAMA 284. (TVA 2013c).

With the above clarifications, NRC staff concludes that the cost estimates provided by TVA are sufficient and appropriate for use in the SAMA evaluation.

F.6 Cost-Benefit Comparison

The TVA's cost-benefit analysis and the NRC staff's review are described in the following sections.

F.6.1 TVA's Evaluation

The methodology used by TVA was based primarily on NRC's guidance for performing cost-benefit analysis (i.e., NUREG/BR–0184, Regulatory Analysis Technical Evaluation Handbook (NRC 1997b)). As described in Section E.1.5.4 of the ER (TVA 2013d), the MMACR was determined for each SAMA according to the following formula, which the staff accepts as mathematically equivalent to the formula in the NUREG/BR–0184:

$$MMACR = EEM\ (W_{PHA} + W_{EA} + W_{O} + W_{CD} + W_{RP})$$

where

EEM = external event multiplier (unitless)

W_{PHA} = present value of averted offsite exposure cost ($)

W_{EA} = present value of averted offsite economic cost ($)

W_{O} = present value of averted onsite exposure cost ($)

W_{CD} = present value of averted onsite cleanup cost ($)

W_{RP} = present value of averted replacement power cost ($)

The TVA's derivation of each of the associated costs is presented separately in this section. For each SAMA, the applicant's analysis determined percentage reductions in population dose risk (PDR%), offsite economic cost risk (OECR%), and onsite cost risk (OCR%). The internal and external benefit from the implementation of an individual SAMA is determined from these percentage reductions and their associated present value costs according to the following formula:

$$\text{SAMA Benefit} = \text{EEM} [(\text{PDR}\%W_{PHA} + \text{OECR}\%W_{EA} + \text{OCR}\% (W_O + W_{CD} + W_{RP})]$$

For each SAMA, the estimated benefit is compared to the cost of implementation. If the cost of implementing the SAMA is larger than the benefit associated with the SAMA, the SAMA is not considered to be cost beneficial. If the cost of implementing the SAMA is smaller than the benefit associated with the SAMA, the SAMA is considered to be cost beneficial.

Sensitivity analyses performed by the applicant can lead to increases in the calculated benefits. Two sensitivity cases were developed by TVA: one used a discount rate of 3 percent and another used an alternative value for failure probability to explicitly account for uncertainty and include margin into cost-benefit evaluation. Additional details on the sensitivity analysis are presented in Section F.6.2.

Averted Offsite Exposure Cost (W_{PHA})

TVA defined W_{PHA} cost as the monetary value of accident risk avoided from population doses after discounting (TVA 2013d, Attachment E). The W_{PHA} costs were calculated using the following formula:

W_{PHA} = Averted public dose risk (person-rem per year)

× monetary equivalent of unit dose ($2,000 per person-rem)

× present value conversion given in the equation on p. 5.27 for C when a facility is already operating (NRC, 1997b)

As stated in NUREG/BR–0184 (NRC 1997b), it is important to note that the monetary value of the public health risk after discounting does not represent the expected reduction in public health risk because of a single accident. Rather, it is the present value of a stream of potential losses extending over the remaining lifetime (in this case, the 20-year renewal period) of the facility. Thus, it reflects the expected annual loss caused by a single accident, the possibility that such an accident could occur at any time over the renewal period, and the effect of discounting these potential future losses to present value. For a discount rate of 7 percent and a 20-year license renewal period, TVA calculated W_{PHA} costs of $968,661 for Unit 1 and $944,983 for Unit 2 because of internal events (TVA 2013d, ER Table E.1-32).

Averted Offsite Economic Cost (W_{EA})

TVA defined W_{EA} as the monetary value of risk avoided from offsite property damage after discounting (TVA 2013d, Attachment E). The W_{EA} values were calculated using the following formula:

W_{EA} = Annual offsite property damage risk before discounting in dollars per year × present value conversion given in equation on p. 5.27 for C for an operational facility (NRC, 1997b)

For a discount rate of 7 percent and a 20-year license renewal period, TVA calculated W_{EA} costs of $1,044,001 for Unit 1 and $1,002,026 for Unit 2 because of internal events (TVA 2013d, ER Table E.1-32).

Averted Onsite Exposure Cost (W_O)

TVA defined W_O as the avoided onsite exposure (TVA 2013d, Attachment E). Similar to the W_{PHA} calculations, the applicant calculated costs for immediate onsite exposure. Long-term onsite exposure costs were calculated consistent with guidance in the regulatory analysis handbook (NRC 1997b), which included an additional term for accrual of long-term doses.

TVA derived the values for averted occupational exposure from information provided in Section 5.7.3 of the Regulatory Analysis Handbook (NRC 1997b). Best estimate values provided for immediate occupational dose (3,300 person-rem) and long-term occupational dose (20,000 person-rem over a 10-year cleanup period) were used. The present value of these doses was calculated using the equations provided in the handbook in conjunction with a monetary equivalent of unit dose of $2,000 per person-rem, a real discount rate of 7 percent, and a time period of 20 years to represent the license renewal period. Immediate and long-term onsite exposure costs were summed to determine W_O cost. TVA calculated W_O costs of $11,267 for Unit 1 and $13,357 for Unit 2 because of internal events (TVA 2013d, ER Table E.1-32).

Averted Onsite Cleanup Cost (W_{CD})

TVA defined W_{CD} as the avoided cost for cleanup and decontamination of the site (TVA 2013d, Attachment E). The applicant derived the values for W_{CD} based on information provided in Section 5.7.6 of NUREG/BR–0184, the regulatory analysis handbook (NRC 1997b).

Averted cleanup and decontamination costs were calculated using the following formula:

W_{CD} = Annual CDF × present value of cleanup costs per core damage event × present value conversion factor.

The total cost of cleanup and decontamination subsequent to a severe accident is estimated in the regulatory analysis handbook to be $\$1.5\times10^9$ (undiscounted). This value was converted to present costs over a 10-year cleanup period and integrated over the term of the proposed license extension. TVA calculated W_{CD} costs of $343,669 for Unit 1 and $407,410 for Unit 2 because of internal events (TVA 2013a, ER Table E.1–32).

Averted Replacement Power Cost (W_{RP})

TVA defined W_{RP} as the avoided costs of replacement power (TVA 2013d, Attachment E). Long-term replacement costs were calculated using the following formula:

W_{RP} = Annual CDF × present value of replacement power for a single event
× factor for remaining service years for which replacement power is required
× reactor power scaling factor

TVA based its calculations on the net electric output for each SQN unit, specifically 1,148 megawatt-electric (MWe) for Unit 1 and 1,126 MWe for Unit 2, and scaled up from the 910 MWe reference plant in NUREG/BR–0184 (NRC 1997b). TVA calculated W_{RP} costs of $294,637 for Unit 1 and $342,590 for Unit 2 because of internal events (TVA 2013a, ER Table E.1–32).

<u>Modified Maximum Averted Cost Risk (MMACR)</u>

Using the above equations, TVA estimated the total present dollar value equivalent associated with completely eliminating severe accidents caused by internal events, referred to as the MACR, to be about $2,662,235 for Unit 1 and $2,710,366 for Unit 2 (TVA 2013a, ER Table E.1–32). To account for the risk contributions from external events and yield the internal and external benefit, TVA selected EEM values of 2.9 for Unit 1 and 2.6 for Unit 2 (TVA 2013d, Attachment E) as discussed further in Section F.6.2. By multiplying MACR and EEM, TVA estimated MMACR to be about $7,720,482 for Unit 1 and $7,046,951 for Unit 2 (TVA 2013a, ER Table E.1–32). As described above in the SAMA benefit formula, components of the MMACR calculation factor into the benefit determination for individual SAMAs.

<u>TVA's Results</u>

If the implementation costs for a candidate SAMA exceeded the calculated benefit, the SAMA was determined to be not cost beneficial. If the SAMA benefit exceeded the estimated cost, the SAMA candidate was considered to be cost beneficial. The TVA's baseline cost-benefit analysis identified nine and eight candidate SAMAs as potentially cost-beneficial for Units 1 and 2, respectively. From a sensitivity analysis, TVA identified an additional seven and nine candidate SAMAs as potentially cost beneficial for Units 1 and 2, respectively. Results of the cost-benefit evaluation are presented in Table F–5. Considering the results from the baseline and sensitivity analyses, the full set of potentially cost-beneficial SAMAs for SQN is:

- SAMA 32 (Unit 2 only): Add the ability to automatically align emergency core cooling system to recirculation mode upon refueling water storage tank depletion.
- SAMA 45 (Units 1 and 2): Enhance procedural guidance for use of cross-tied component cooling pumps.
- SAMA 70 (Units 1 and 2): Install accumulators for turbine-driven auxiliary feedwater pump flow control valves.
- SAMA 88 (Units 1 and 2): Install nitrogen bottles as backup gas supply for safety relief valves.
- SAMA 105 (Units 1 and 2): Delay containment spray actuation after a large LOCA.
- SAMA 106 (Units 1 and 2): Install automatic containment spray pump header throttle valves.
- SAMA 160 (Units 1 and 2): Implement procedures for temporary HVAC.
- SAMA 215 (Units 1 and 2): Provide a means to ensure reactor coolant pump (RCP) seal cooling in order that RCP seal LOCAs are precluded for station blackout events.
- SAMA 249 (Units 1 and 2): High-volume makeup to the refueling water storage tank.
- SAMA 268 (Units 1 and 2): Perform an evaluation of the component cooling water system/auxiliary feedwater (CCS/AFW) area cooling requirements.
- SAMA 275 (Units 1 and 2): Install spray protection on motor-driven AFW pumps and space coolers.

- SAMA 279 (Units 1 and 2): Improve internal flooding response procedures and training to improve the response to internal flooding events.
- SAMA 283 (Units 1 and 2): Initiate frequent awareness training for plant operators/maintenance/testing staff on important human actions, including dependent (combination) events, for plant risk.
- SAMA 285 (Units 1 and 2): Protect important equipment in the turbine building from internal flooding.
- SAMA 286 (Units 1 and 2): Install flood doors to prevent water propagation in the electric board room.
- SAMA 288 (Units 1 and 2): Install spray protection on component cooling pumps and space coolers.
- SAMA 289 (Units 1 and 2): Install backup cooling system for CCS and AFW space coolers.

The TVA indicated that these potentially cost-beneficial SAMAs will be considered in the design process. In the list above, the following SAMAs were identified by TVA to be potentially cost beneficial because of the resulting increases in estimated benefits from sensitivity considerations: SAMA 32 (Unit 2), SAMA 88 (Units 1 and 2), SAMA 160 (Unit 2), SAMA 249 (Units 1 and 2), SAMA 275 (Units 1 and 2), SAMA 285 (Units 1 and 2), SAMA 286 (Units 1 and 2), SAMA 288 (Units 1 and 2), and SAMA 289 (Units 1 and 2). Although SAMA 286 (Units 1 and 2) and SAMA 288 (Unit 2) had estimated benefits that did not exceed the individual unit cost for estimated implementation as shown in Table F–5, these SAMAs were identified as potentially cost beneficial as a result of TVA's consideration of shared implementation costs between Units 1 and 2 and use of the combined total averted cost risk from both Units 1 and 2 in the cost-benefit evaluation. Additional SAMA candidates determined by TVA to be potentially cost beneficial in response to NRC staff RAI are highlighted in Section F.7.

F.6.2 Review of TVA's Cost-Benefit Evaluation

During its review of the cost-benefit analysis performed by TVA, NRC staff compared the applicant's approach with guidance in NUREG/BR–0184 (NRC 1997b) and discount rate guidelines in NEI 05-01 (NEI 2005). NEI guidance states that two sets of estimates should be developed for discount rates of 7 percent and 3 percent (NEI 2005). The TVA performed assessments using both discount rates. The TVA provided a base set of results using a discount rate of 7 percent and a 20-year license renewal period. For the other types of potential sensitivity analyses suggested (NEI 2005), NRC staff finds that sensitivity analyses for plant modifications, peer review findings or observations, and evacuation speed have been adequately addressed in the baseline analysis, including the applicant's responses to NRC staff RAI, as discussed in this appendix. As previously indicated, TVA performed the cost-benefit evaluation using an analysis time period of 20 years. Because TVA explicitly accounted for uncertainty in its sensitivity analysis by applying a multiplication factor of 2.5 and the results of the sensitivity analysis were used to identify additional potentially beneficially SAMAs, NRC staff finds that an additional sensitivity analysis for a time frame longer than 20 years is not necessary. Although longer timeframes would increase estimated benefits compared to baseline results, it is unlikely that influences from a longer timeframe would exceed the factor of 2.5 already considered by TVA. Based on its review of the applicant's cost-benefit evaluation, NRC staff determined that the applicant's approach is consistent with the guidance and acceptable.

The applicant considered possible increases in benefits from analysis uncertainties on the results of the SAMA assessment. In the ER (TVA 2013d, Attachment E), TVA indicated that the 95th percentile value of the SQN CDF was greater than the mean CDF by a factor of 2.14 for Unit 1 and by a factor of 2.26 for Unit 2. A multiplication factor of 2.5 was conservatively selected by the applicant to account for uncertainty. This multiplication factor was applied in addition to separate multiplication factors of 2.9 and 2.6 for CDF increases caused by external events at Units 1 and 2, respectively (TVA 2013d, Attachment E). The TVA's assessment accounted for the potential risk-reduction benefits associated with both internal and external events. NRC staff considers the multipliers of 2.5 for uncertainty at both units, 2.14 for external events at Unit 1, and 2.26 for external events at Unit 2 provide adequate margin and are acceptable for the SAMA analysis. Because SQN is a two unit plant, the applicant identified SAMAs for which implementation costs could be shared between Units 1 and 2 and considered the combined total averted cost risk in the cost-benefit evaluation. NRC agrees that consideration of shared costs is appropriate because additional SAMAs can be identified as potentially cost beneficial.

Using TVA information on the release category frequencies (TVA 2013c), NRC staff checked the calculations of percentage reductions in CDF, population dose risk, and OECR, as well as the calculations of internal and external benefit for selected SAMA candidates. By applying the formula for SAMA benefit presented in Section F.6.1 and comparing the results with those presented in the ER (TVA 2013d, Tables E.2-1 and E.2-2), NRC staff found the results to be in agreement and within small roundoff errors.

As discussed above in Section F.2.2.3, TVA's treatment of small early releases involving small isolation failures potentially results in an underestimation of the consequences and the benefit of the SAMAs. A sensitivity analysis was performed by TVA to determine the effect of this potential underestimation on the SAMA assessment. The results of this analysis indicated there is an increase in benefit, but this increase did not identify any additional cost-beneficial SAMAs (TVA 2013c).

The TVA's baseline cost-benefit analysis identified nine and eight candidate SAMAs as potentially cost-beneficial for Units 1 and 2, respectively. From a sensitivity analysis, TVA identified an additional seven and nine candidate SAMAs as potentially cost beneficial for Units 1 and 2, respectively. In response to NRC RAI, TVA identified four additional SAMA candidates as potentially cost beneficial for both units. These additional cost-beneficial SAMAs arose from the NRC evaluation of the baseline analysis for SAMAs 8 and 87 as well as from questioning from NRC staff on potentially lower cost alternatives. Specifically, NRC staff asked the applicant to evaluate potentially lower-cost alternatives to several candidate SAMAs (NRC 2013), as summarized below:

- Automate the tripping of RCPs on loss of CCW for basic event HASE2 (and others) involving RCP seal cooling failures.
- Opening doors and/or stage portable fans for SAMA 289 involving installing backup cooling for the component cooling water system (CCS)/AFW space coolers.
- Installing spray shields for events %690.0-A01-1_067_S and %669.0-A01_067_S representing the initiator for ERCW spray events in room 690.0-A1 and room 669.0-A01 in the auxiliary building.
- Use portable pump to provide water for the AFW system for SAMA 71 (Install a new condensate storage tank).

- Use temporary ventilation, opening doors, etc. for SAMA 161 (Provide backup ventilation for the EDG rooms, should their normal HVAC supply fail).
- Purchase or manufacture a "gagging device" that could be used to close a stuck-open steam generator safety valve for a SGTR event prior to core damage.

In its response to these questions (TVA 2013c), TVA determined (1) automatically tripping the RCP on loss of CCW as well as (2) manufacturing a gagging device for a steam generator safety valve and developing a procedure or work order for closing a stuck-open valve would be considered as potentially cost beneficial SAMAs. The TVA response for the other alternatives included additional discussion on the relationship to other SAMA candidates, future design changes to improve the external flood mitigation, and cost-benefit justifications. From its review of the original SAMA analysis and additional information, the NRC staff agrees with TVA's disposition of the above lower cost alternatives.

F.6 Conclusions

TVA considered 309 candidate SAMAs based on risk-significant contributors at SQN from updated probabilistic safety assessment models, SAMA-related industry documentation, plant-specific enhancements not in published industry documentations, and its review of SAMA candidates from potential improvements at twelve other plants. Phase I screening reduced the list to 47 unique SAMA candidates by eliminating SAMAs that were not applicable to SQN, had already been implemented at SQN, were combined into a more comprehensive or plant-specific SAMA, had excessive implementation cost, had a very low benefit, or related to in-progress implementation of plant improvements that address the intent of the SAMA.

For the remaining SAMA candidates, TVA performed a cost-benefit analysis with results shown in Table F–5. The baseline cost-benefit analysis identified nine and eight candidate SAMAs as potentially cost beneficial for Units 1 and 2, respectively. From a sensitivity analysis, TVA identified an additional seven and nine candidate SAMAs as potentially cost beneficial for Units 1 and 2, respectively. In response to NRC staff RAI, TVA identified four additional SAMA candidates as potentially cost beneficial for both units. These additional cost-beneficial SAMAs arose from the NRC evaluation of the baseline SAMA analysis and questioning on potentially lower-cost alternatives. In response to NRC staff RAI on the SAMA analyses, TVA indicated that SAMA 8 to increase training on response to loss of two 120-V AC busses and SAMA 87 to replace service and instrument air compressors with more reliable compressors will be retained as potentially cost beneficial for both units (TVA 2013c). In its response to questions on potentially lower-cost alternatives, TVA identified two additional SAMA candidates as potentially cost beneficial for (1) human actions to automatically trip the RCP on loss of CCW and (2) manufacturing a gagging device for a steam generator safety valve and developing a procedure or work order for closing a stuck-open valve (TVA 2013c).

As mentioned in Section F.3.2, the new improved flood mitigation systems to be installed at SQN Units 1 and 2 would be expected to reduce the risk from all external events and possibly some internal events. These new systems are additional plant improvements to which TVA has separately committed (TVA 2013a) as part of SQN's current licensing basis.

NRC staff reviewed TVA's SAMA analysis and concludes that, subject to the discussion in this appendix, the methods used and implementation of the methods were sound. On the basis of the applicant's treatment of SAMA benefits and costs, NRC staff finds that the SAMA evaluations performed by TVA are reasonable and sufficient for the license renewal submittal.

The staff concurs with TVA's conclusion that 20 candidate SAMAs are potentially cost beneficial for SQN Unit 1 and 21 candidate SAMAs are potentially cost beneficial for SQN Unit 2, which was based on generally conservative treatment of costs, benefits, and uncertainties. This conclusion of a moderate number of potentially cost-beneficial SAMAs is consistent with a moderately large population within 80 km (50 mi) of SQN and moderate level of residual risk indicated in the SQN PRA. Because the potentially cost-beneficial SAMAs do not relate to aging management during the period of extended operation, they do not need to be implemented as part of license renewal pursuant to 10 CFR Part 54.

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11. ABSTRACT (200 words or less)
This supplemental environmental impact statement has been prepared in response to an application by Tennessee Valley Authority (TVA) to renew the operating licenses for Sequoyah Nuclear Plant, Units 1 and 2 (SQN), for an additional 20 years. This supplemental environmental impact statement (SEIS) includes the preliminary analysis that evaluates the environmental impacts of the proposed action and alternatives to the proposed action. Alternatives considered include: natural gas combined-cycle generation, supercritical pulverized coal generation, new nuclear generation, combination (wind and solar) alternative, and not renewing the license (the no action alternative). The U.S. Nuclear Regulatory Commission's (NRC's) preliminary recommendation is that the adverse environmental impacts of license renewal for SQN are not great enough to deny the option of license renewal for energy planning decisionmakers. This recommendation is based on the following:
-the analysis and findings in NUREG-1437, "Generic Environmental Impact Statement for License Renewal of Nuclear Plants;"
-the environmental report submitted by SQN;
-consultation with Federal, State, local, and Tribal government agencies;
-the NRC staff's environmental review; and
-consideration of public comments received during the scoping process.

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