United States Nuclear Regulatory Commission

Protecting People and the Environment

NUREG-1437
Supplement 7
Second Renewal

Generic Environmental Impact Statement for License Renewal of Nuclear Plants

Supplement 7, Second Renewal

Regarding Subsequent License Renewal for North Anna Power Station Units 1 and 2

Draft Report for Comment

Office of Nuclear Material Safety and Safeguards

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Draft Report for Comment

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Office of Nuclear Material Safety and Safeguards

Proposed Action	Issuance of subsequent renewed facility operating licenses NPF-4 and NPF-7 for North Anna Power Station, Units 1 and 2, in Louisa County, VA
Type of Statement	Draft Supplemental Environmental Impact Statement
Agency Contact	Tam Tran U.S. Nuclear Regulatory Commission (NRC) Office of Nuclear Reactor Regulation Mail Stop T-4B72 Washington, DC 20555-0001 Email: tam.tran@nrc.gov

Comments:

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COVER SHEET

Responsible Agency: U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation.

Title: Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 7, Second Renewal, Regarding Subsequent License Renewal for North Anna Power Station, Units 1 and 2, Draft Report for Comment (NUREG-1437).

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ABSTRACT

The U.S. Nuclear Regulatory Commission staff prepared this supplemental environmental impact statement (SEIS) as part of its environmental review of Dominion Energy Virginia's application to renew the operating licenses for North Anna Power Station, Units 1 and 2 (North Anna) for an additional 20 years. This SEIS includes the NRC staff's evaluation of the environmental impacts of the license renewal and alternatives to license renewal. Alternatives considered include: (1) new nuclear (small modular reactor or SMR) generation and (2) a combination of solar photovoltaic, offshore wind, new nuclear (SMR), and demand-side management. The NRC staff's preliminary recommendation is that the adverse environmental impacts of license renewal for North Anna are not so great that preserving the option of license renewal for energy-planning decisionmakers would be unreasonable. The NRC staff based its recommendation 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 Dominion Energy Virginia
- the NRC staff's consultation with Federal, State, Tribal, and local agencies
- the NRC staff's independent environmental review
- the NRC staff's consideration of public comments

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

Background

By letter dated August 24, 2020, Dominion Energy Virginia (Dominion) submitted to the U. S. Nuclear Regulatory Commission (NRC) an application requesting subsequent license renewal for the North Anna Power Station, Units 1 and 2 (North Anna), operating licenses (Agencywide Documents Access and Management System (ADAMS) No. ML20246G703, is available electronically from the NRC's Public Electronic Reading Room at: <http://www.nrc.gov/reading-rm.html>. From this site, the public can gain access to ADAMS, which provides the NRC's public documents, by using the ADAMS accession number). The North Anna Unit 1 current operating license (NPF-4) expires at midnight on April 1, 2038; the North Anna Unit 2 current operating license (NPF-7) expires at midnight on August 21, 2040. In its application, Dominion requested license renewal for a period of 20 years beyond the dates when the current operating licenses expire, to 2058 for North Anna Unit 1, and to 2060 for North Anna Unit 2.

Pursuant to Title 10 of the *Code of Federal Regulations* (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), "Operating License Renewal Stage," states that, in connection with the renewal of an operating license, the NRC staff shall prepare an EIS, which is a supplement to the Commission's NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*.

Once the NRC officially accepted Dominion's application, the NRC staff began the environmental review process as described in 10 CFR Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions." The environmental review begins by the NRC publishing in the *Federal Register* a notice of intent to prepare a supplemental environmental impact statement (SEIS) and to conduct scoping for the nuclear power plant. To prepare the North Anna draft SEIS, the NRC staff performed the following actions:

- conducted a public scoping meeting on November 4, 2020 (webinar)
- conducted a remote environmental site audit during the week of December 1, 2020, and a severe accident mitigation alternatives in-office audit on December 9, 2020
- reviewed Dominion's environmental report (ER) and compared it to NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (the GEIS)
- consulted with Federal, State, Tribal, and local agencies
- conducted a review of the issues following the guidance set forth in NUREG-1555, Supplement 1, Revision 1, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants: Supplement 1: Operating License Renewal, Final Report*
- considered public comments received during the scoping comment period

Proposed Action

Dominion initiated the proposed Federal action (issuance of subsequent renewed power reactor operating licenses for North Anna) by submitting an application. The existing North Anna operating licenses were previously renewed for a period of 20 years, and expire at midnight on April 1, 2038, for Unit 1 (NPF-4) and August 21, 2040, for Unit 2 (NPF-7). The NRC's Federal action is to decide whether to issue subsequent renewed licenses authorizing an additional 20 years of operation. If the NRC issues the subsequent renewed licenses, North Anna Units 1 and 2 would be authorized to operate until 2058 and 2060, respectively.

Purpose and Need for Actions

The purpose and need for the proposed action (i.e., issuance of subsequent renewed licenses) is to provide an option that allows for power generation capability beyond the term of the current nuclear power plant operating licenses to meet future system generating needs. Energy-planning decisionmakers such as States, utility operators, and, where authorized, Federal agencies (other than the NRC) may determine these future system generating needs. The Atomic Energy Act of 1954, as amended, and the National Environmental Policy Act of 1969, as amended, require the NRC to perform a safety review and an environmental review of the proposed action. The above definition of purpose and need reflects the NRC's recognition that, unless there are findings in the staff review 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

This SEIS evaluates the potential environmental impacts of the proposed action and reasonable alternatives to that action. The NRC designates the environmental impacts from the proposed action and reasonable alternatives as SMALL, MODERATE, or LARGE.

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.

NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (the GEIS), evaluates 78 environmental issues related to plant operation and classifies each issue as either a Category 1 issue (generic to all or a distinct subset of nuclear power plants as described below) or a Category 2 issue (specific to individual power plants). Category 1 issues are those that meet all the following criteria:

- The environmental impacts associated with the issue 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.

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.

Category 2 issues are site-specific issues that do not meet one or more of the criteria for Category 1 issues; therefore, an SEIS must include additional site-specific review for these non-generic issues.

Table 3-1 in Chapter 3 lists the Category 1 issues that are applicable to North Anna, and the significance levels of their impacts. Dominion and the NRC staff have identified no information that is both new and significant related to Category 1 issues that has the potential to affect the conclusions in the GEIS. This conclusion is supported by the NRC staff's review of Dominion's environmental report and other documentation relevant to the applicant's activities, the public scoping process, and the findings from the NRC staff's site audits. Therefore, the NRC staff relied upon the conclusions of the GEIS for all Category 1 issues applicable to North Anna.

In this SEIS, the NRC staff evaluated Category 2 issues applicable to North Anna, as well as cumulative impacts, and considered new information regarding severe accident mitigation alternatives (SAMAs). Table ES-1 summarizes the Category 2 issues relevant to North Anna and 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, then the findings of the GEIS, as documented in Appendix B to Subpart A, "Environmental Effect of Renewing the Operating License of a Nuclear Power Plant," 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 at North Anna

Resource Area	Relevant Category 2 Issues	Impacts
Groundwater Resources	Radionuclides released to groundwater	SMALL
Terrestrial Resources	Effects on terrestrial resources (noncooling system impacts)	SMALL
Aquatic Resources	Impingement and entrainment of aquatic organisms (plants with once-through cooling systems or cooling ponds)	SMALL
	Thermal impacts on aquatic organisms (plants with once-through cooling systems or cooling ponds)	SMALL
Special Status Species and Habitats	Threatened, endangered, and protected species and essential fish habitat	May affect, but is not likely to adversely affect, the northern long-eared bat. Unlikely to result in effects on the northern long-eared bat habitat.
Historic and Cultural Resources	Historic and cultural resources	Would not adversely affect known historic properties

Resource Area	Relevant Category 2 Issues	Impacts
Human Health	Microbiological hazards to the public (plants with cooling ponds or canals or cooling towers that discharge to a river) Electric shock hazards Chronic effects of electromagnetic fields	SMALL SMALL Uncertain impact
Environmental Justice	Minority and low-income populations	No disproportionately high and adverse human health and environmental effects on minority and low-income populations
Cumulative Impacts	Cumulative impacts	See SEIS Section 3.16
Postulated Accidents	Severe accidents (SAMAs)	See SEIS Appendix F

Alternatives

As part of its environmental review, the NRC is required to consider alternatives to license renewal and evaluate the environmental impacts associated with each alternative. These alternatives can include other methods of power generation (replacement power alternatives), as well as simply not renewing the North Anna operating licenses (the no-action alternative).

In total, the NRC staff initially considered 16 alternatives but later dismissed 14 of these because of technical, resource availability, or commercial limitations that currently exist and that the NRC staff believes are likely to still exist when the current North Anna licenses expire. This left two feasible and commercially viable replacement power alternatives which, in addition to the no-action alternative, the staff evaluates in depth in this report:

- new nuclear (small modular reactor or SMR) alternative
- combination alternative of solar photovoltaic, offshore wind, new nuclear (SMR), and demand-side management

These are the 14 additional alternatives that the NRC staff considered but ultimately dismissed:

- natural gas combined-cycle
- solar power
- wind power
- biomass
- demand-side management
- hydroelectric power
- geothermal power
- wave and ocean energy
- municipal solid waste power
- petroleum-fired power
- coal-fired power
- fuel cells
- purchased power

- delayed retirement of other power generating facilities

The NRC staff evaluated each of the remaining alternatives that was considered to be reasonable, using the same resource areas that it used in evaluating impacts from license renewal. The NRC staff also evaluated any new and significant information that could alter the conclusions of the SAMA analysis that was performed previously in connection with the initial license renewal of North Anna in 2003, which authorized North Anna to be operated for a period of 20 years beyond the original 40-year operating license period.

Recommendation

The NRC staff's preliminary recommendation is that the adverse environmental impacts of subsequent license renewal for North Anna are not so great that preserving the option of subsequent license renewal for energy-planning decisionmakers would be unreasonable. The NRC staff based its recommendation 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 Dominion
- the NRC staff's consultation with Federal, State, Tribal, and local agencies
- the NRC staff's independent environmental review
- the NRC staff's consideration of public comments received during the scoping comment period

ABBREVIATIONS AND ACRONYMS

$	$ dollar(s) (U.S.)
§	Section
°C	degrees Celsius
°F	degrees Fahrenheit
μm	micrometer
AADT	average annual daily traffic
ac	acre(s)
ACHP	Advisory Council on Historic Preservation
ADAMS	Agencywide Documents Access and Management System
AEA	Atomic Energy Act of 1954 (as amended)
ALARA	as low as reasonably achievable
AOI	area of influence
APE	area of potential effect
AWEA	American Wind Energy Association
BEIR	Biologic Effects of Ionizing Radiation
BLM	Bureau of Land Management
BMP	best management practice(s)
BOEM	Bureau of Ocean Energy Management
BTA	best technology available
Btu	British thermal unit
BTU/ft^3	British thermal unit(s) per cubic foot
BWR	boiling-water reactor
CAA	Clean Air Act, as amended through 1990
CCB	Center for Conservation Biology
CCRM	Center for Coastal Resources Management
CDF	core damage frequency
CEQ	Council on Environmental Quality
CFR	*Code of Federal Regulations*
CLB	current licensing basis/bases
cm	centimeter(s)
CO	carbon monoxide
CO2	carbon dioxide
CO2e	carbon dioxide equivalent

COL	combined license
CPUE	catch per unit effort
CSP	concentrating solar power
CVSZ	central Virginia seismic zone
CWA	Clean Water Act (Federal Water Pollution Control Act)
CZMA	Coastal Zone Management Act
dB	decibel(s)
dBA	A-weighted decibels
DHR	Department of Historic Resources (Virginia)
DOE	U.S. Department of Energy
Dominion	Virginia Electric and Power Company or Dominion Energy Virginia
DOT	U.S. Department of Transportation
DSM	demand-side management
EO	Executive Order
EDG	emergency diesel generator
EFH	essential fish habitat
EIA	Energy Information Administration
EIS	environmental impact statement
EMF	electromagnetic field
EPA	U.S. Environmental Protection Agency
EPRI	Electric Power Research Institute
ER	environmental report
ESA	Endangered Species Act
ESP	early site permit
FEIS	final environmental impact statement
FEMA	Federal Emergency Management Agency
fps	feet per second
FR	*Federal Register*
FRN	*Federal Register* notice
FSEIS	final supplemental environmental impact statement
ft	feet
ft3	cubic feet
ft2	feet squared
fps	feet per second

ft/min	feet per minute
FWS	U.S. Fish and Wildlife Service
FWIS	Fish and Wildlife Information Service (Virginia)
g	gram(s)
gal	gallons
GEIS	NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*
GHG	greenhouse gas
GMRS	ground motion response spectrum
gpd	gallons per day
gpm	gallons per minute
gpy	gallons per year
GWd/MTU	gigawatt days per metric ton
GWh	gigawatt hour(s)
GWP	global warming potential
ha	hectare(s)
HDR	HDR Engineering, Inc.
I-64	Interstate 64
I-95	Interstate 95
IEA	International Energy Agency
IEFS	Ion exchange filter system
in.	inch(es)
IPE	individual plant examination
IPEEE	individual plant examination of external events
ISFSI	independent spent fuel storage installation
Juv	juvenile
km	kilometer(s)
kV	kilovolt
kW	kilowatt(s)
kWh/m^2/day	kilowatt hour per square meter per day
L	Liter(s)
lb	pound(s)
LERF	large early release frequency
LLRW	low-level radioactive waste
Lpd	liters per day

LR	license renewal
LRA	license renewal application
m	meters
m/s	meter(s) per second
m^3	cubic meter(s)
m^3/min	cubic meters per minute
MACCS2	MELCOR Accident Consequences Code System
MATS	Mercury and Air Toxics Standards
MB	maximum benefit
MELCOR	Computer code providing practical analytical tool for evaluating severe accident behavior
mgd	million gallons per day
mgy	million gallons of water per year
mi	mile(s)
mL	milliliter(s)
mLd	million liters per day
mm	millimeters
MMBtu	million British thermal units
MMPA	Marine Mammal Protection Act
mph	miles per hour
mrad	milliradiation absorbed dose
mrem	millirem
MSA	Magnuson–Stevens Fishery Conservation and Management Act
msl	mean sea level
mSv	millisievert
MUR	measurement uncertainty recapture
Mw	moment magnitude
MW	megawatt(s)
MWe	megawatt(s) electric
MWd/MTU	megawatt days per metric ton uranium
MWe	megawatts electric
MWt	megawatts thermal
NAAQS	National Ambient Air Quality Standards
NAPS	North Anna Power Station, Units 1 and 2
NCDC	National Climatic Data Center

NCEI	National Centers for Environmental Information
NCES	National Center for Education Statistics
NEI	Nuclear Energy Institute
NEPA	National Environmental Policy Act
NESC	National Electrical Safety Code
NHPA	National Historic Preservation Act
NIEHS	National Institute of Environmental Health Sciences
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
North Anna	North Anna Power Station, Units 1 and 2
NOx	nitrogen oxide
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRC	U.S. Nuclear Regulatory Commission
NRCS	National Resources Conservation Service
NREL	National Renewable Energy Laboratory
NRHP	National Register of Historic Places
NRR	Nuclear Reactor Regulation, Office of (NRC)
O3	ozone
ODCM	offsite dose calculation manual
ORNL	Oak Ridge National Laboratory
OSHA	Occupational Safety and Health Administration
oz	ounce
Pb	lead
PCB	polychlorinated biphenyl
pCi/l	picoCuries per liter
PDA	personnel documentation area
PL	Public Law
PM	particulate matter
PNNL	Pacific Northwest National Laboratory
POWER 2020	Power 2020 conference
PRA	probabilistic risk assessment
PV	photovoltaic
PWR	pressurized water reactor

PYSL	post-yolk-sac-larvae
RCRA	Resource Conservation and Recovery Act of 1976, as amended
rem	roentgen equivalent(s) man
REMP	radiological environmental monitoring program
RG	Regulatory Guide
ROI	region(s) of influence
ROW(s)	right-of-way(s)
RWST	recovery water storage tank
SAMA	severe accident mitigation alternative
sec	second
SEIS	supplemental environmental impact statement
SER	safety evaluation report
SHPO	State Historic Preservation Officer
SIP	State Implementation Plan
SLR	subsequent license renewal
SMR	small modular reactor
SO_2	sulfur dioxide
SOARCA	State-of-the-Art Reactor Consequences
SPDES	state pollution discharge elimination system
SSC	structure, system, and component
Sv	sievert(s)
SWPP	Stormwater Pollution Prevention Plan
UIDL	unidentified life stage
U.S.	United States
U.S.C.	*United States Code*
USCB	U.S. Census Bureau
USGCRP	U.S. Global Change Research Program
USACE	United States Army Corps of Engineers
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
VCEA	Virginia Clean Economy Act of 2020
VDEQ	Virginia Department of Environmental Quality
VDGIF	Virginia Department of Game and Inland Fisheries
VDH	Virginia Department of Health

VDWR	VA Department of Wildlife Resources
VEPCO	Virginia Electric Power Company
VOC	volatile organic compound
VPDES	Virginia Pollutant Discharge Elimination System
VSR	Virginia State Route
WHTF	waste heat treatment facility
WTG	wind turbine generator
YOY	young of year
yr	year
YSL	yolk sac larvae

1.0 INTRODUCTION AND GENERAL DISCUSSION

The U.S. Nuclear Regulatory Commission's (NRC's) environmental protection regulations in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions," implement the National Environmental Policy Act of 1969, as amended (42 U.S.C. 4321 et seq.). This Act is commonly referred to as NEPA. The regulations at 10 CFR Part 51 require the NRC to prepare an environmental impact statement (EIS) before deciding whether to issue an operating license or a renewed operating license for a nuclear power plant.

The Atomic Energy Act of 1954, as amended (42 U.S.C. 2011 et seq.) (AEA), 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. NRC regulations permit these licenses to be renewed beyond the initial 40-year term for an additional period of time, limited to 20-year increments per renewal. The renewed license issuance is based on the results of (a) this environmental review and (b) the NRC staff's aging management review to assure that the facility can continue to operate safely during the proposed period of extended operation (10 CFR 54.29, "Standards for Issuance of a Renewed License"). There are no limitations in the AEA or NRC regulations restricting the number of times a license may be renewed. The decision to seek a renewed license 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 all safety and environmental requirements.

1.1 Proposed Federal Action

Virginia Electric & Power Company, doing business as Dominion Energy Virginia (Dominion) initiated the proposed Federal action by submitting an application for subsequent license renewal for North Anna Power Station, Units 1 and 2 (North Anna or NAPS). The current renewed licenses expire at midnight on April 1, 2038, for Unit 1 (NPF-4), and at midnight on August 21, 2040, for Unit 2 (NPF-7). The NRC's Federal action is to decide 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 Federal action (issuance of subsequent renewed licenses for North Anna) is to provide an option that allows for power generation capability beyond the term of the current renewed nuclear power plant operating licenses to meet future system generating needs. Such needs may be determined by energy-planning decisionmakers such as State regulators, utility owners, and Federal agencies other than the NRC. This definition of purpose and need reflects the NRC's recognition that, unless there are findings in the NRC's safety review (required by the AEA) or findings in the NRC's environmental analysis (required by NEPA) that would lead the NRC to reject a subsequent license renewal application (SLRA), the NRC does not have a role in energy-planning decisions as to whether a particular nuclear power plant should continue to operate.

1.3 Major Environmental Review Milestones

Dominion submitted an environmental report (ER) as an appendix to its SLRA on August 24, 2020 (Agencywide Documents Access and Management System (ADAMS)

Accession No. ML20246G698). Notice of the receipt of the SLRA was published in the *Federal Register* (FR) on September 21, 2020 (Volume 85 of the FR, p. 59334 (85 FR 59334). After reviewing the SLRA and ER, as supplemented, the NRC staff accepted the application for a detailed technical review on October 9, 2020 and published a *Federal Register* notice of acceptability for docketing and opportunity for hearing (October 15, 2020, 85 FR 65438). On October 23, 2020, the NRC published a notice in the *Federal Register* (85 FR 67572) informing the public of the staff's intent to conduct an environmental scoping process, thereby beginning a 30-day scoping comment period. The NRC staff held a public scoping meeting on November 4, 2020, in the form of a webinar. In June 2021, the NRC issued its Environmental Impact Statement Scoping Process Summary Report, North Anna Power Station, Units 1 & 2, Louisa County, VA, (ADAMS Accession No. ML21181A127), which includes the comments received during the scoping process and the NRC staff's responses to those comments (Appendix A.1 of this SEIS).

The NRC staff conducted a remote environmental audit of North Anna during the week of December 1, 2020, and a severe accident mitigation alternatives (SAMAs) teleconference audit at NRC headquarters on December 9, 2020, to independently verify information in Dominion's environmental report. In letters dated December 17, 2020, and January 22, 2021, the staff summarized the SAMA audit and the environmental audit, respectively, and listed the attendees (ADAMS Accession Nos. ML20351A388 and ML21025A340). During these audits, the NRC staff held meetings with plant personnel and reviewed site-specific documentation and photos.

Upon completion of the scoping period, site audits, and review of Dominion's environmental report and related documents, the NRC staff compiled its findings into this draft supplemental environmental impact statement (SEIS). The NRC staff will make this draft SEIS available for a public comment period of 45 days. Based on the information gathered and received during the public comment period, the NRC staff will revise the draft SEIS and will then publish the final SEIS. Figure 1-1 shows the major milestones of the environmental review portion of the NRC's license renewal application review process. The draft SEIS public comment process provides an opportunity for the incorporation of public comments and updating.

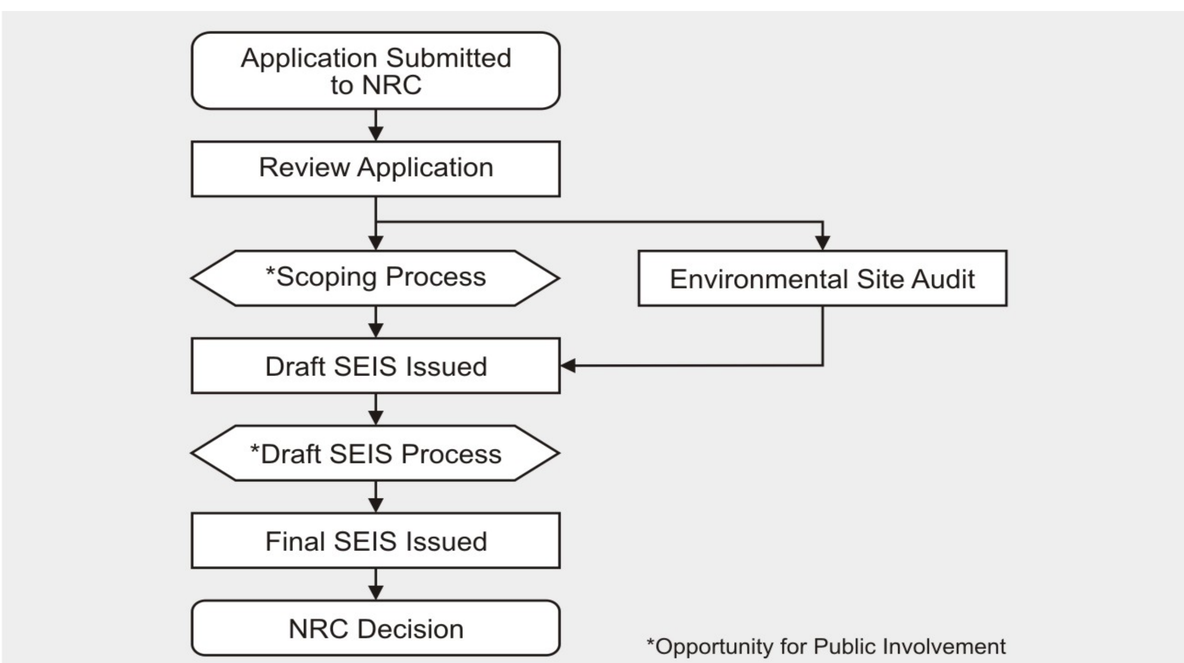


Figure 1-1. Environmental Review Process

The NRC has established a license renewal process that NRC staff and license renewal applicants can complete in a reasonable period of time and that includes clear requirements to assure safe plant operation for up to an additional 20 years of plant life, pursuant to 10 CFR Part 54, “Requirements for Renewal of Operating Licenses for Nuclear Power Plants.” This process consists of separate safety and environmental reviews, which the NRC staff conducts simultaneously and documents in two reports: (1) the safety evaluation report (SER) documents the safety review, and (2) the SEIS documents the environmental review (Figure 1-1). Both reports factor into the NRC’s decision to issue or deny a renewed license.

1.4 Generic Environmental Impact Statement

To improve the efficiency of its license renewal review process, the NRC staff performed a generic assessment of the environmental impacts associated with license renewal. NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Power Plants* (GEIS) (NRC 1996, 1999, 2013a), documents the results of the NRC’s systematic approach to evaluating the environmental consequences of renewing the licenses of individual nuclear power plants and operating them for an additional 20 years. In the GEIS, the staff analyzed in detail and resolved those environmental issues that could be resolved generically. The NRC issued the GEIS in 1996 (NRC 1996), Addendum 1 to the GEIS in 1999 (NRC 1999), and Revision 1 to the GEIS in 2013 (NRC 2013a). Unless otherwise noted, all references to the GEIS include the original 1996 GEIS, Addendum 1, and the 2013 revision (NRC 2013a). The conclusions in the GEIS are codified in Appendix B to Subpart A of 10 CFR Part 51, “Environmental Effect of Renewing the Operating License of a Nuclear Power Plant.”

The GEIS establishes separate environmental impact issues for the NRC staff to independently evaluate. Appendix B to Subpart A of 10 CFR Part 51, “Environmental Effect of Renewing the Operating License of a Nuclear Power Plant,” provides a summary of the staff’s findings in the GEIS. For each environmental issue addressed in the GEIS, the NRC staff does 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 both beneficial and adverse effects
- determines whether the results of the analysis apply to all plants
- considers whether additional mitigation measures would be warranted for impacts that would have the same significance level for all plants

The NRC established its standard of significance for impacts using the Council on Environmental Quality terminology for “significant.”

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.

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.

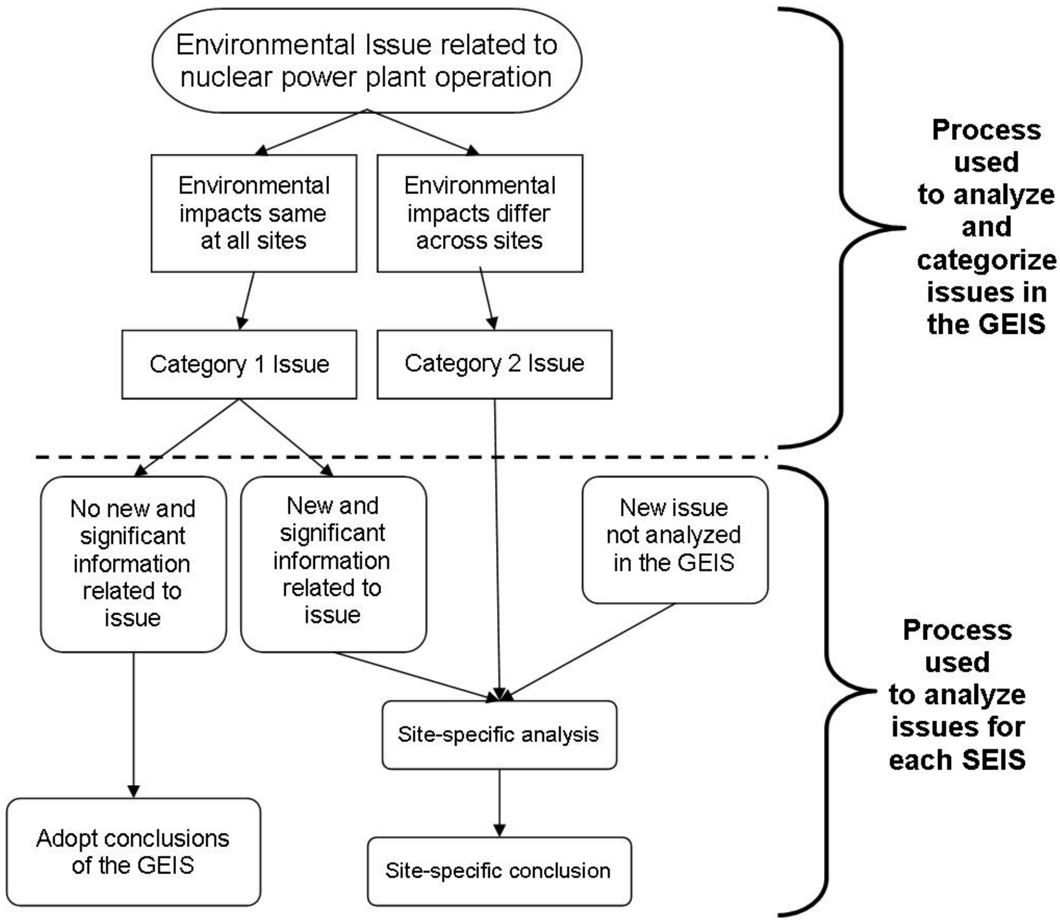
LARGE: Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

The GEIS determines 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 (generic to all or a distinct subset of plants) or Category 2 (site-specific to certain plants only) designation. As established in the GEIS, Category 1 issues are those that meet the following three criteria:

- The environmental impacts associated with the issue have been determined to apply either to all plants or, for some issues, to plants that have 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 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.

For generic issues (Category 1), the SEIS requires no additional site-specific evaluation unless new and significant information has been identified. Chapter 3 describes the process for identifying new and significant information for site-specific analysis. Site-specific issues (Category 2) are those that do not meet one or more of the three criteria of Category 1 issues; therefore, the SEIS requires additional site-specific review for these issues.

The GEIS, Revision 1, evaluates 78 environmental issues, provides generically applicable findings for numerous issues (subject to the consideration of any new and significant information on a site-specific basis), and concludes that a site-specific analysis is required for 17 of the 78 issues. Figure 1-2 illustrates the license renewal environmental review process. The results of that site-specific review are documented in the SEIS.



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

Figure 1-2. Environmental Issues Evaluated for License Renewal

1.5 Supplemental Environmental Impact Statement

This draft SEIS presents the NRC staff's analysis of the environmental effects of the continued operation of North Anna through the subsequent license renewal period, alternatives to subsequent license renewal, and mitigation measures for minimizing adverse environmental impacts. Chapter 3, "Affected Environment, Environmental Consequences, and Mitigating Actions," contains an analysis and comparison of the potential environmental impacts from subsequent license renewal and alternatives to subsequent license renewal. Chapter 4, "Conclusion," presents the NRC's preliminary recommendation on whether the environmental impacts of subsequent license renewal are so great that preserving the option of subsequent license renewal would be unreasonable. The NRC staff will make its recommendation to the Commission regarding the environmental impacts of North Anna subsequent license renewal in the final SEIS, after considering comments received on the draft SEIS during the public comment period.

In preparing the North Anna draft SEIS, the NRC staff carried out the following activities:

- reviewed the information provided in Dominion's ER
- consulted with Federal agencies, State and local agencies, and Tribal Nations
- conducted an independent review of the issues, including the environmental and severe accident mitigation analysis site audits
- considered public comments received during the environmental scoping process

New information can come from many sources, including the applicant, the NRC, other agencies, or public comments. If new information reveals a new issue, the staff will first analyze the issue to determine whether it is within the scope of the license renewal environmental evaluation. If the staff determines that the new issue bears on the proposed action, the staff will then determine the significance of the issue for the plant and analyze the issue in the SEIS.

New and significant information. To merit additional review, information must be both new and significant, and it must bear on the proposed action or its impacts.

1.6 Decisions To Be Supported by the SEIS

This SEIS supports the NRC's decision on whether to renew the operating licenses for North Anna for an additional 20 years. The regulation at 10 CFR 51.103(a)(5) specifies the NRC's decision standard as follows:

> In making a final decision on a license renewal action pursuant to [10 CFR] 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 analysis of environmental impacts in this SEIS will provide the NRC's decisionmakers (the Commission) with important environmental information for consideration in deciding whether to issue renewed licenses for North Anna Units 1 and 2.

1.7 Cooperating Agencies

During the scoping process, the NRC staff did not identify any Federal, State, or local agencies as cooperating agencies for this SEIS.

1.8 Consultations

The Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 et seq.); the Magnuson–Stevens Fisheries Conservation and Management Act (MSA) of 1996, as amended (16 U.S.C. 1801 et seq.); and the National Historic Preservation Act (NHPA) of 1966, as amended (54 U.S.C. 300101 et seq.), require Federal agencies to consult with applicable State and Federal agencies and organizations before taking an action that may affect endangered species, fisheries, or historic and archaeological resources, respectively. See Appendix C for a list of the agencies and groups with which the NRC staff consulted.

1.9 Correspondence

During the review, the NRC staff contacted Federal, State, regional, local, and Tribal agencies listed in Appendix C. Appendix C chronologically lists all correspondence the NRC staff sent and received associated with the Endangered Species Act, the Magnuson–Stevens Fisheries Conservation and Management Act, and the National Historic Preservation Act. Appendix D chronologically lists all other correspondence.

1.10 Status of Compliance

Dominion is responsible for complying with all NRC regulations and other applicable Federal, State, and local requirements. Appendix F, "Laws, Regulations, and Other Requirements," of the GEIS, Revision 1, describes some of the major applicable Federal statutes. Numerous permits and licenses are issued by Federal, State, and local authorities for activities at North Anna. Appendix B of this SEIS contains further information from the North Anna application about Dominion's status of compliance.

1.11 Related State and Federal Activities

The staff reviewed the possibility that activities (projects) of other Federal agencies might impact the renewal of the operating licenses for North Anna. Any such activities could result in cumulative environmental impacts and the possible need for the Federal agency to become a cooperating agency for preparing this SEIS. The NRC staff has determined that there are no Federal projects that would make it necessary for another Federal agency to become a cooperating agency in the preparation of this SEIS (10 CFR 51.10(b)(2)). Table E-1 in Appendix E includes the Federal facilities in the vicinity of North Anna. In addition, Table E-1 identifies the activities (projects) including State activities that were considered during the NRC staff's cumulative environmental impacts review.

Section 102(2)(C) of NEPA requires the NRC to consult with and obtain comments from any Federal agency or designated authority that has jurisdiction by law or special expertise with respect to any environmental impact involved in the subject matter of the SEIS. For example, during the preparation of the SEIS, the NRC consulted with the Commonwealth of Virginia's State Historic Preservation Officer, among others. Appendix C provides a complete list of consultation correspondence.

The NRC staff reviewed the North Anna status of compliance in Chapter 3 and Appendix B. The NRC staff notes that some State or Federal permitting and certification activities could affect NRC license renewal. For example, a Clean Water Act (CWA) Section 401 consistency certification and a Coastal Zone Management Act (CZMA) consistency determination will be needed for North Anna to operate during the SLR period of extended operation, as discussed in Sections 3.2.1 and 3.5.1of this SEIS. In appropriate circumstances (not present here), construction of water intake structures, access roads, or rail spurs may be required for the NRC license renewal action to be implemented. In such instances, some plant construction activities may require a license amendment and an environmental review by the NRC. However, no such activities have been identified for North Anna subsequent license renewal.

2.0 ALTERNATIVES INCLUDING THE PROPOSED ACTION

The NRC's implementation of the National Environmental Policy Act of 1969, as amended (NEPA) (42 U.S.C. 4321 et seq.), requires the NRC to consider potential alternatives to issuing a renewed operating license as well as the environmental impacts of these alternatives. Comparing the environmental impacts of license renewal to those of the alternatives allows the NRC to determine whether the environmental impacts of license renewal are so great that it would be unreasonable for the agency to preserve the option of license renewal for energy-planning decisionmakers (Title 10 of the *Code of Federal Regulations* (10 CFR) 51.95(c)(4)). Ultimately, decisionmakers such as the plant operator, State, or non-NRC Federal officials will decide whether to operate the plant for an additional 20 years (if the NRC renews the license) or shut down the plant and choose an alternative power generation source. Economic and environmental considerations play important roles in the decisions of these non-NRC, energy-planning decisionmakers.

In general, the NRC's responsibility is to ensure the safe operation of nuclear power facilities, not to formulate energy policy, promote nuclear power, or encourage or discourage the development of alternative power generation sources. The NRC does not engage in energy-planning decisions, and it makes no judgment as to which energy alternatives evaluated in the supplemental environmental impact statement (SEIS) would be the best or most-likely alternative to be selected in any given case.

This chapter provides (1) a description of the North Anna Power Station, Units 1 and 2 (North Anna) plant and its operation, (2) a description of the proposed action (NRC renewal of the operating license for North Anna), (3) an indepth evaluation of reasonable alternatives to the proposed action (including the no-action alternative), and (4) a brief description of the alternatives to the proposed action that the NRC staff considered but ultimately eliminated from indepth evaluation.

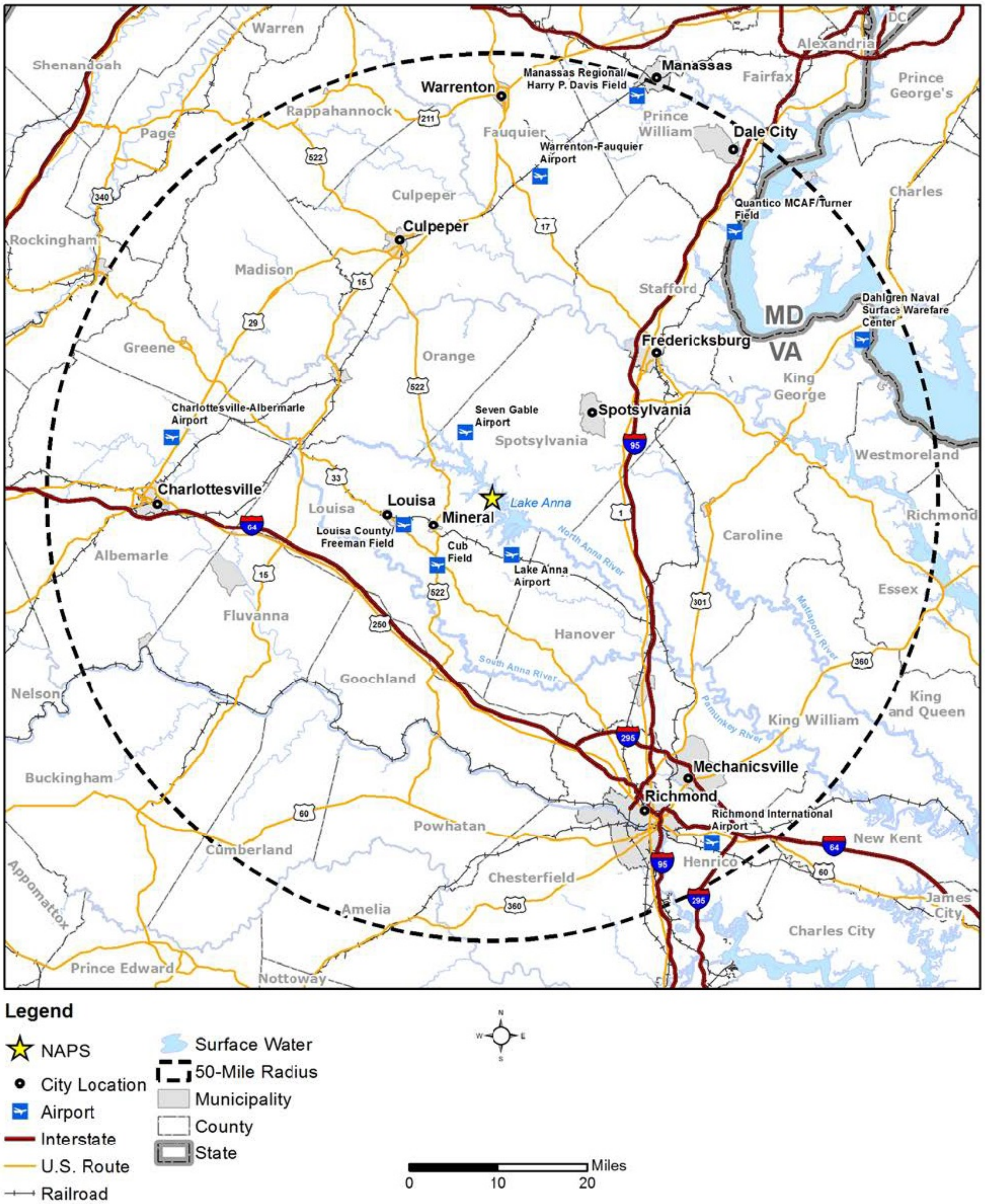
2.1 Description of Nuclear Power Plant Facility and Operation

The physical presence of North Anna buildings and facilities, as well as the plant's operations, are integral to creating the environment that currently exists at and around the site. This section describes certain nuclear power plant operating systems and certain plant infrastructure, operations, and maintenance.

2.1.1 External Appearance and Setting

North Anna is located on the border of Louisa and Spotsylvania counties in northeastern Virginia, on a peninsula along the southern shore of Lake Anna Reservoir. The town of Mineral is located about 7 miles (mi) (11 kilometers (km)) west–southwest, and the town of Louisa (Louisa County seat) is located about 12 mi (19 km) west of the North Anna site. The city of Richmond (the State capital) is the largest population center in the region and is about 40 mi (64 km) southeast of the site (Figure 2-1).

The principal North Anna plant structures are the reactor containments for Units 1 and 2, the auxiliary building, the fuel building, the turbine building, and the main 500 kilovolt switchyard. The physical setting is predominantly rural and rural residential, characterized by farmland and wooded tracts, as well as by the open water of Lake Anna (Dominion 2020b).



Source: Modified from Dominion 2020b

Figure 2-1. North Anna Power Station 50-mi (80-km) Radius Map

2.1.2 Nuclear Reactor Systems

North Anna Units 1 and 2 are Westinghouse pressurized-water reactors (PWRs) with dry containments (steel lined and reinforced concrete). The NRC issued the original North Anna Units 1 and 2 operating licenses on April 1, 1978, and August 21, 1980, respectively, and the first renewed licenses on March 20, 2003 (NRC 2020d). The nuclear reactors produce a nominal core power rating of 2,775 megawatts thermal (MWt) (Dominion 2020b).

North Anna fuel is low enriched uranium dioxide (limited to 5 percent by weight uranium-235) ceramic pellets. The pellets are sealed in tubes made of ZIRLO or optimized ZIRLO. North Anna refueling occurs about every 18 months (Dominion 2020b).

2.1.3 Cooling and Auxiliary Water Systems

Section 2.1.3 of NUREG-1437, Supplement 7, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants: Regarding North Anna Power Station, Units 1 and 2*, describes the operation of the plant's cooling and auxiliary water systems including the withdrawal of water from North Anna Reservoir and the return flow of heated water to the reservoir (NRC 2002b: Section 2.1.3, p. 2-7). Section E2.2.3 of Dominion Energy Virginia's (Dominion's) environmental report (ER), submitted as part of its subsequent license renewal application, provides an expanded description of North Anna's cooling and auxiliary water systems, including the circulating water system, service water system, ultimate heat sink, component cooling water system, fire protection and domestic water supply systems, discharge canal, and waste heat treatment facility (WHTF) (Dominion 2020b: E2.2.3, p. E-2-4 to E-2-11). The NRC staff incorporates this information here by reference and summarizes key information in the following subsections.

Pressurized-water reactors, such as North Anna, heat water to a high temperature under pressure inside the reactor. This type of steam and power conversion system uses three heat transfer (exchange) loops. Section 3.1.2 of NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Power Plants* (known as the GEIS) describes this process (NRC 2013a). North Anna uses a once-through cooling loop (circulating water system) to dissipate heat from the turbine condensers. Figure 2-2 provides a basic schematic diagram of this system.

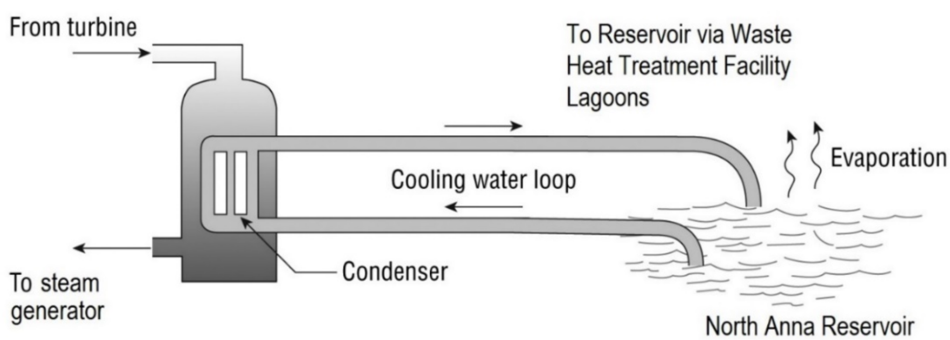


Figure 2-2. Once-Through Cooling Water System with Reservoir Water Source

2.1.3.1 Cooling Water Intake and Discharge

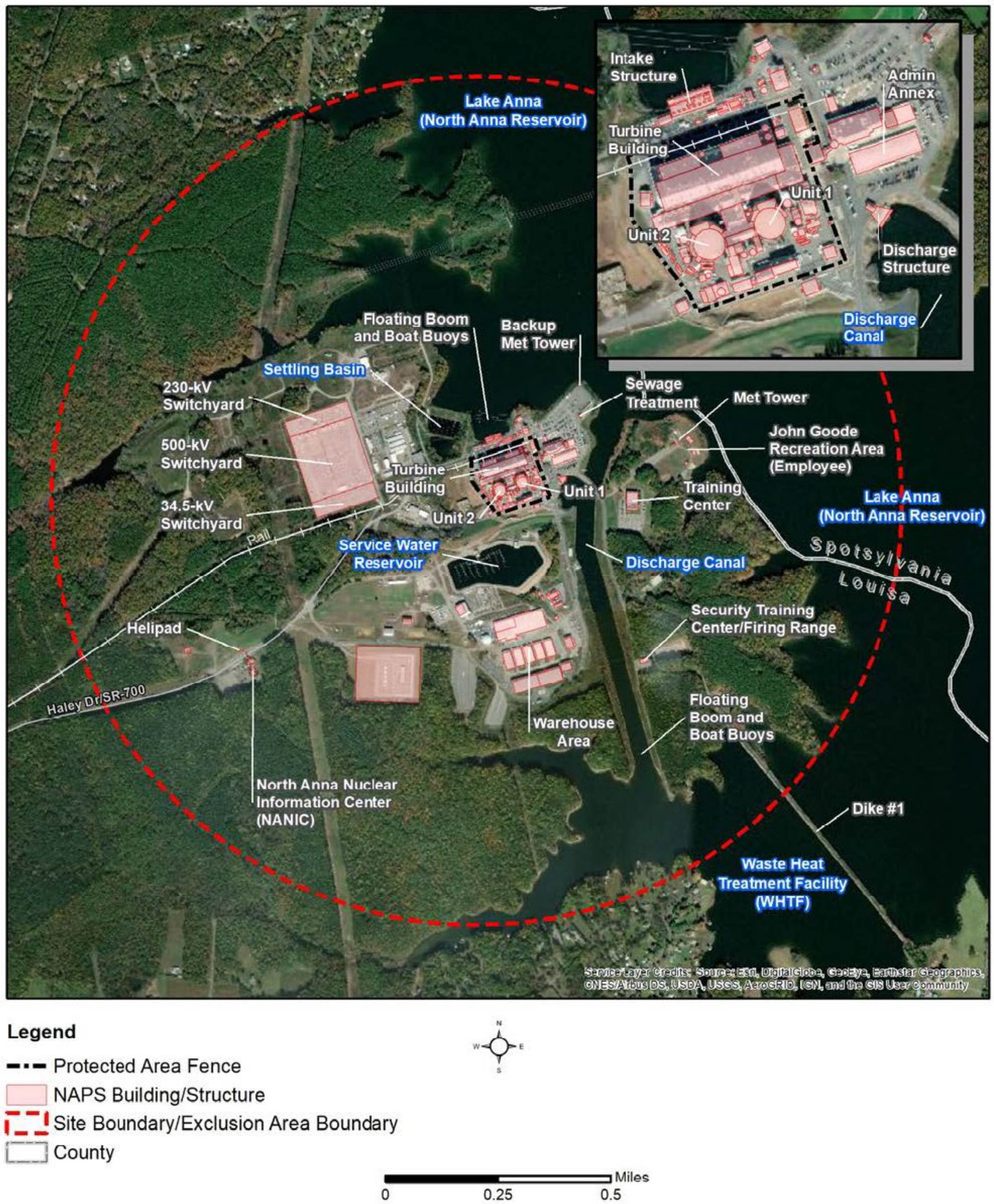
The plant's circulating water system is the principal interface with the hydrologic environment. North Anna withdraws water from North Anna Reservoir through two screen-wells (one for each nuclear unit) housed in the intake structure. Each screen-well contains four intake bays, each of which is equipped with a trash rack and movable rake, a traveling screen, and a circulating water pump. Large debris in the intake water collects on the trash racks, where the rake removes the debris and discharges it into a collection basket. The traveling screens remove smaller debris prior to entering the pumps. The screens have 1/8-in. (0.32 cm) by 1/2-in. (1.27 cm) mesh openings and operate based on a differential pressure trigger. Debris and fish collected from the traveling screens wash into wire baskets for disposal as solid waste.

Each of North Anna's eight circulating water pumps are rated at 238,200 gallons per minute (gpm) (901.6 cubic meters per minute (m^3/min)). The North Anna Reservoir is also a source of makeup water to the service water system. This system supports the component cooling system and dissipates heat using a spray array in the service water reservoir. The service water reservoir and the North Anna Reservoir comprise the plant's ultimate heat sink. Two service water pumps also are located in the intake structure. Each pump is contained in its own screen-well, which is equipped with a trash rack and traveling screen. Each service water pump is rated at 11,500 gpm (43.5 m^3/min). In total, North Anna's maximum surface water withdrawal rate is 1,928,600 gpm (7,290 m^3/min). This rate is equivalent to approximately 2,777 million gallons per day (mgd) (10,512 million liters per day (mLd)). Section 3.5.1.2 of this SEIS summarizes North Anna's surface water withdrawals.

Reservoir water entering the circulating water intake structure bays is pumped through the condensers. The heated circulating water, along with comingled effluents, exits the discharge structure at the top (north end) of the discharge canal (Figure 2-3). The nominal (design) temperature rise in the circulating water passing through the condenser is 14.5 ºF (8.1 ºC). From the discharge canal, the combined effluent enters the first of three, interconnected cooling lagoons that constitute the WHTF. The residence time of the cooling water effluent in the WHTF is about 14 days, which allows for substantial heat loss. The effluent mixes with the ambient water as it travels through each of the three lagoons before exiting the WHTF and entering the North Anna Reservoir at the skimmer wall structure outlet. The structure discharges the effluent as a submerged jet into the reservoir and promotes thorough mixing with the reservoir water. This point is also designated as Outfall 001 under Dominion's Virginia Pollutant Discharge Elimination System (VPDES) permit (see Figure 3-4).

2.1.3.2 Well Water Supply System

Seven groundwater wells supply North Anna's domestic and miscellaneous water needs across the plant site. Four wells (wells 6, 7, 8, and the North Anna Nuclear Information Center well) comprise the plant's domestic supply system, with wells 6, 7, and 8 comprising a single system. The well system supplies water for all domestic applications in the plant, from sanitation to drinking fountains and eyewash stations. The well water system is not interconnected to any other plant process water system, and all four wells are permitted by the Virginia Department of Health. In addition, three other wells (the metrology well, security training building well, and SS-1) provide small volumes of water to support uses at more remote plant site locations. These three wells do not require permits. Table E3.6-3 of Dominion's ER provides construction details for all seven wells (Dominion 2020b). Section 3.5.1.2 of this SEIS discusses North Anna's groundwater withdrawals.



Source: Dominion 2020b

Figure 2-3. North Anna Water Intake and Discharge Locations and Hydrologic Features

2.1.4 Radioactive Waste Management Systems

Section 2.1.4 of NUREG-1437, Supplement 7 describes North Anna's radioactive waste treatment systems (NRC 2002b: Section 2.1.4, p. 2-8–2-12). Section E2.2.6 of Dominion's ER provides an expanded description of North Anna's radioactive waste treatment systems

(Dominion 2020b: Section E2.2.6, p. E-2-16 to E-2-26). This information is incorporated here by reference with key information summarized below and in the following subsections.

The NRC licenses all nuclear plants with the expectation that they will release radioactive material to both the air and water during normal operations. However, NRC regulations require that gaseous and liquid radioactive releases from nuclear power plants meet radiation dose-based limits specified in 10 CFR Part 20, “Standards for Protection Against Radiation,” and the as-low-as-reasonably-achievable (ALARA) criteria in 10 CFR Part 50, Appendix I, “Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion ‘As Low as is Reasonably Achievable’ for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents.” In other words, the NRC places regulatory limits on the radiation dose that members of the public can receive from radioactive effluents of a nuclear power plant. For this reason, all nuclear power plants use radioactive waste management systems to control and monitor radioactive wastes.

North Anna uses the liquid, gaseous, and solid waste management systems to collect and process radioactive materials and waste produced as a byproduct of plant operations. The waste disposal systems can handle the waste produced by simultaneous operation of the two nuclear units. These waste management systems assure that the dose to members of the public from radioactive effluents is reduced to ALARA levels in accordance with NRC regulations.

Dominion maintains a radiological environmental monitoring program (REMP) to assess the radiological impact, if any, to the public and the environment from radioactive effluents released during operations at North Anna. The REMP is discussed in Section 2.1.4.5.

Dominion has an Offsite Dose Calculation Manual (ODCM) that contains the methods and parameters for calculating offsite doses resulting from liquid and gaseous radioactive effluents. These methods ensure that radioactive material discharges from North Anna meet NRC and U.S. Environmental Protection Agency (EPA) regulatory dose standards. The ODCM also contains the requirements for the REMP.

2.1.4.1 Radioactive Liquid Waste Management

Dominion uses waste management systems to collect, analyze, and process radioactive liquids produced at North Anna. These systems reduce radioactive liquids before they are released to the environment. The North Anna liquid waste disposal system meets the design objectives of 10 CFR Part 50, Appendix I, and controls the processing, disposal, and release of radioactive liquid wastes.

The liquid waste disposal system is common to both reactors and accommodates radioactive waste produced during simultaneous operation. The system was designed to receive, process, and discharge potentially radioactive liquid waste. In summary, potentially radioactive liquid wastes originate from the chemical and volume control system, the boron recovery system, the steam generator blowdown system, the vent and drain system sumps, laboratory drains, personnel decontamination area drains, the decontamination system, the sampling system, laundry drains, and spent resin flush water. The system design considers potential personnel exposure and ensures that radioactive releases to the environment are as low as reasonably achievable. During normal plant operation, the total activity from radionuclides leaving the discharge canal does not exceed the limits of applicable regulations. The sources of radioactivity are from the core, fuel rod gap, coolant, and volume control tank for a core with 15 x 15 fuel assemblies.

Various building sump effluents from the vent and drain system are directed by valve lineups to either the high-level or low-level waste drain tanks, depending on the influent activity level. The contaminated drain tanks receive laundry waste and cold laboratory drainage, personnel decontamination area (PDA) shower drainage, and PDA sink drainage. The high-level waste drain tanks receive discharges directly from the hot laboratory drainage and spent resin flush water. They also receive high-level liquid waste from the vent and drain, liquid waste disposal, chemical and volume control, and boron recovery systems. The contents of the high-level waste drain tanks are processed by the ion exchanger filtration system and may be transferred to the low-level waste drain tanks via administrative controls if further treatment is not required. The decontamination system fluid waste treating tank in the decontamination building can be used for additional storage of high-level wastes if necessary. If the activity level of liquids in the low-level drain tanks and the contaminated drain tanks are such that the liquids require further processing, these liquids may also be included in the high-level waste drain tanks. There is a holdup period in the high-level drain tanks for sampling the liquid before it is processed.

The low-level waste drain tanks accumulate waste from the ion exchange filter system (IEFS), vent and drain, boron recovery systems, the fluid waste treating tank, and boron recovery test tanks. The liquids in the low-level waste drain tanks are pumped to the waste header, through the clarifier and are then discharged to the circulating water system or are processed through the liquid waste demineralizer, if needed, prior to discharge. Liquids from the contaminated drain tank, the steam generator blowdown tank, and blowdown from the service water reservoir also could go to the demineralizers in the waste disposal building. North Anna monitors these liquids prior to release to ensure that they will not exceed the limits of 10 CFR Part 20. North Anna performs offsite dose calculations based on effluent samples obtained at this release point to ensure the limits of 10 CFR Part 50, Appendix I are not exceeded. All liquid waste is discharged to the circulating water system and is monitored to ensure radiological control.

North Anna performs periodic sampling of the liquid waste effluent. Prior to discharge, automatic isolation of liquid wastes occurs downstream of the clarifier demineralizer filter when a signal is received from the radiation monitor. The isolation valve can also be operated remotely from the main control room or automatically by a signal from the clarifier surge tank level switches. High activity detected by the radiation monitor overrides the valve control and stops all discharge flow. The discharge flow from the liquid waste disposal system is combined and mixed with the water in the circulating-water discharge tunnel so that the concentration of activity of the combined effluent is maintained ALARA and within NRC limits.

The ODCM prescribes the alarm/trip setpoints for the liquid effluent radiation monitors. Dominion's use of these radiological waste systems and the procedural requirements in the ODCM assures the agency that the dose from radiological liquid effluents at North Anna complies with NRC and EPA regulatory dose standards. Dominion calculates dose estimates for members of the public using radiological liquid effluent release data.

Dominion's annual radioactive effluent release reports contain a detailed presentation of liquid effluents released from North Anna and the resultant calculated doses (NRC 2021). These reports are publicly available on the NRC's Web page.

The NRC staff reviewed 5 years of radioactive effluent release data from 2015 through 2019 (Virginia Electric and Power Company (VEPCO) 2016, 2017, 2018, 2019, 2020). A 5-year period provides a dataset that covers a broad range of activities that occur at a nuclear power plant—such as refueling outages, routine operation, and maintenance—that can affect the generation of radioactive effluents into the environment. The NRC staff compared the data against NRC dose limits and looked for indications of adverse trends (i.e., increasing dose levels or increasing radioactivity levels).

The following summarizes the calculated doses from radioactive liquid effluents released from North Anna during 2019 (VEPCO 2020):

North Anna Unit 1 in 2019

- The total-body dose to an offsite member of the public from North Anna Unit 1 radioactive effluents was 3.51×10^{-1} millirem (mrem) (3.51×10^{-3} millisievert (mSv)), which is well below the 3 mrem (0.03 mSv) dose criterion in Appendix I to 10 CFR Part 50.
- The maximum organ dose (gastrointestinal tract) to an offsite member of the public from North Anna Unit 1 radioactive effluents was 3.65×10^{-1} mrem (3.65×10^{-3} millisievert (mSv)), which is well below the 10 mrem (0.1 mSv) dose criterion in Appendix I to 10 CFR Part 50.

North Anna Unit 2 in 2019

- The total-body dose to an offsite member of the public from North Anna Unit 2 radioactive effluents was 3.51×10^{-1} millirem (mrem) (3.51×10^{-3} millisievert (mSv)), which is well below the 3 mrem (0.03 mSv) dose criterion in Appendix I to 10 CFR Part 50.
- The maximum organ dose (gastrointestinal tract) to an offsite member of the public from North Anna Unit 2 radioactive effluents was 3.65×10^{-1} mrem (3.65×10^{-3} millisievert (mSv)), well below the 10 mrem (0.1 mSv) dose criterion in Appendix I to 10 CFR Part 50.

In the values cited above, the NRC staff divided Dominion's reported total-body and maximum organ liquid effluent doses for the entire facility evenly between Units 1 and 2. This was done to attribute the approximate dose contribution to each of the licensed nuclear units. The NRC staff's review of Dominion's radioactive liquid effluent control program shows that the applicant maintained radiation doses to members of the public that were within NRC and EPA radiation protection standards as contained in Appendix I to 10 CFR Part 50, 10 CFR Part 20, and Title 40, "Protection of Environment," of the *Code of Federal Regulations* (40 CFR) Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations." The NRC staff observed no adverse trends in the dose levels.

During the subsequent license renewal term, Dominion will continue to perform routine plant refueling and maintenance activities. Based on Dominion's past performance in operating a radioactive waste system at North Anna that maintains ALARA doses from radioactive liquid effluents, the NRC staff expects Dominion will maintain similar performance during the subsequent license renewal term.

2.1.4.2 Radioactive Gaseous Waste Management

Dominion calculates dose estimates for members of the public based on radioactive gaseous effluent release data and atmospheric transport models. Dominion's annual radioactive effluent release reports present in detail the radiological gaseous effluents released from North Anna and the resultant calculated doses. As described above in Section 2.1.4.1, the NRC staff reviewed 5 years of radioactive effluent release data from the 2015 through 2019 reports (VEPCO 2016, 2017, 2018, 2019, 2020). The NRC staff compared the data against NRC dose limits and looked for indications of adverse trends (i.e., increasing dose levels) over the period.

The following summarizes the calculated doses from radioactive gaseous effluents released from North Anna during 2019 (VEPCO 2020):

North Anna Unit 1 in 2019

- The air dose due to noble gases with resulting gamma radiation in gaseous effluents was 1.49×10^{-5} millirad (mrad) (1.49×10^{-7} milligray), which is well below the 10 mrad (0.1 milligray) dose criterion in Appendix I to 10 CFR Part 50.
- The air dose from beta radiation in gaseous effluents from North Anna Unit 1 was 1.41×10^{-4} millirad (mrad) (1.41×10^{-6} milligray) dose, which is well below the 20 mrad (0.2 milligray) dose criterion in Appendix I to 10 CFR Part 50.
- The critical organ dose to an offsite member of the public from radiation in gaseous effluents as a result of iodine-131, iodine-133, hydrogen-3, and particulates with greater than 8-day half-lives was 1.62 mrem (1.62×10^{-2} mSv), which is below the 15 mrem (0.15 mSv) dose criterion in Appendix I to 10 CFR Part 50.

North Anna Unit 2 in 2019

- The air dose due to noble gases with resulting gamma radiation in gaseous effluents was 1.49×10^{-5} millirad (mrad) (1.49×10^{-7} milligray), which is well below the 10 mrad (0.1 milligray) dose criterion in Appendix I to 10 CFR Part 50.
- The air dose from beta radiation in gaseous effluents from North Anna Unit 2 was 1.41×10^{-4} millirad (mrad) (1.41×10^{-6} milligray) dose, which is well below the 20 mrad (0.2 milligray) dose criterion in Appendix I to 10 CFR Part 50.
- The critical organ dose to an offsite member of the public from radiation in gaseous effluents as a result of iodine-131, iodine-133, hydrogen-3, and particulates with greater than 8-day half-lives was 1.62 mrem (1.62×10^{-2} mSv), which is below the 15 mrem (0.15 mSv) dose criterion in Appendix I to 10 CFR Part 50.

The NRC staff's review of North Anna's radioactive gaseous effluent control program showed radiation doses to members of the public that were well below NRC and EPA radiation protection standards contained in Appendix I to 10 CFR Part 50, 10 CFR Part 20, and 40 CFR Part 190. The NRC staff observed no adverse trends in the dose levels over the 5 years reviewed.

During the subsequent license renewal term, Dominion will continue to perform routine plant refueling and maintenance activities. Based on Dominion's past performance operating the radioactive waste system to maintain ALARA doses from radioactive gaseous effluents, the NRC staff expects similar performance during the license renewal term.

2.1.4.3 Radioactive Solid Waste Management

North Anna's solid waste disposal system provides for hold-up, packaging, and storage of radioactive waste that will subsequently be shipped offsite to radwaste processors. These activities reduce the amount of waste shipped for offsite disposal. Solid radioactive wastes are logged, processed, packaged, and stored for subsequent shipment and offsite burial by the solid radioactive waste management system. Solid radioactive wastes and potentially radioactive wastes include sludges, spent resin, spent filter cartridges, and miscellaneous solid materials resulting from station operation and maintenance, such as contaminated rags, paper, and equipment parts.

Spent resin material is transferred as slurry for dewatering and shipment in high-integrity containers, which are placed in shielded shipping casks. Within the spent resin facilities, located in the decontamination building, spent resin from the plant's ion exchangers is collected in shielded resin hold-up tanks where the transfer system flushes the resin from the hold-up tank. The resin is then dewatered and transferred to a high integrity container for shipment to a burial site. Spent filter cartridges are placed in prefabricated metal containers and placed in an appropriately shielded location prior to shipment. Solid non-compactible and compactible trash is placed in appropriate containers and shipped to an offsite facility for compacting. A storage area in the waste storage facility serves as a staging area for waste ready for shipment to offsite radwaste processing and disposal facilities.

2.1.4.4 Radioactive Waste Storage

At North Anna, low-level radioactive waste (LLRW) is stored temporarily onsite at a low-level waste storage facility before being shipped offsite for processing or disposal at licensed LLRW treatment and disposal facilities. As indicated in Dominion's ER and discussed with the NRC staff at the virtual audit, North Anna has sufficient existing capability to store all generated LLRW onsite. No additional construction of onsite storage facilities is necessary for LLRW storage during the period of extended operation.

North Anna Units 1 and 2 each store spent fuel in a spent fuel pool and in an onsite independent spent fuel storage installation (ISFSI). The ISFSI safely stores spent fuel onsite in licensed and approved dry cask storage containers. The North Anna ISFSI is licensed under 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 ISFSI license was renewed by the NRC in February 2018 (83 FR 6242); the ISFSI license renewal included a site-specific environmental assessment and finding of no significant impact, in that renewal of the ISFSI license will not significantly affect the quality of the human environment (83 FR 4932).

The North Anna ISFSI currently has three spent fuel storage pads, each of which can accommodate 28 concrete-and-steel storage casks, for a total of 84 casks. Dominion stated in the ER that it has no current plans to add additional storage pads (Dominion 2020b). Therefore, the staff does not consider an expansion of the ISFSI in this SEIS. The NRC staff notes, however, that the impacts of onsite storage of spent nuclear fuel during the period of extended operation have been determined to be SMALL, as stated in 10 CFR Part 51, Appendix B, Table B-1; see also, NUREG-2157, *Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel* (NRC 2014a).

2.1.4.5 Radiological Environmental Monitoring Program

Dominion maintains a radiological environmental monitoring program (REMP) to assess the radiological impact, if any, to the public and the environment from North Anna operations. The REMP measures the aquatic, terrestrial, and atmospheric environment for ambient radiation and radioactivity. Monitoring is conducted for the following: direct radiation, air, precipitation, well water, river water, surface water, milk, food products and vegetation (such as edible broad leaf vegetation), fish, silt, and shoreline sediment. The REMP also measures background radiation (i.e., cosmic sources, global fallout, and naturally occurring radioactive material, including radon).

In addition to the REMP, Dominion established a North Anna onsite groundwater protection initiative program in accordance with NEI 07–07, "Industry Ground Water Protection Initiative"

(NEI 2007). This program monitors the onsite plant environment to detect leaks from plant systems and pipes containing radioactive liquid. Section 3.5.2.3, “Groundwater Quality,” of this SEIS contains information on North Anna’s groundwater protection initiative program.

As described above in Section 2.1.4.1, the NRC staff reviewed 5 years of radioactive effluent release data from 2015 through 2019 (VEPCO 2016, 2017, 2018, 2019, 2020). The NRC staff looked for indications of adverse trends (e.g., increasing radioactivity levels) over the most recently available sampling periods (2015–2019). For this 5-year period, no gamma-emitting isotope detections were reported; however, tritium in excess of the Dominion-established threshold (5,000 pCi/L) has been detected in the groundwater in the reactor containment area (Section 3.5.2.3). Based on monitoring and groundwater flow directions, tritium in groundwater has not migrated beyond the reactor containment areas. Section 3.5.2.3 also contains a historical description of tritium concentrations in groundwater and known spills of water containing tritium (see “Radiological Spills” and “Tritium in Groundwater”).

There is no evidence of tritium in groundwater migrating offsite towards Lake Anna or the surrounding aquifers. The stratigraphy, hydrogeologic characteristics and groundwater flow gradients will likely prevent tritium from reaching Lake Anna and any surrounding aquifers. While tritium concentrations in groundwater sampled at some monitoring wells are above background or threshold concentrations, all samples remain below the EPA-established drinking water maximum contaminant level of 20,000 picocuries per liter (pCi/L).

Based on its review of this information as described in Section 3.5.2.3 of this SEIS, the staff found no apparent increasing trend in concentration or pattern indicating either a new inadvertent release or persistently high tritium concentrations that might indicate an ongoing inadvertent release from North Anna. With the North Anna groundwater monitoring program in place, Dominion should readily detect any future leaks. Monitoring for spills assures that any spill is identified, closely scrutinized, characterized, and remediated. The monitoring data show that there were no significant radiological impacts to the environment from North Anna operations.

2.1.5 Nonradioactive Waste Management Systems

Section 2.1.5 of NUREG-1437, Supplement 7 describes North Anna’s nonradioactive waste systems (NRC 2002b: Section 2.1.5, p. 2-12 to2-13). Section E2.2.7 of Dominion’s ER provides an expanded description of North Anna’s nonradioactive waste system (Dominion 2020b, Section E2.2.7: p. E-2-26 to E-2-46). This information is incorporated here by reference, with key information summarized below and in the following subsections.

Like any other industrial facility, nuclear power plants generate wastes that are not contaminated with either radionuclides or hazardous chemicals. North Anna generates nonradioactive waste as a result of plant maintenance, cleaning, and operational processes. Dominion manages wastes in accordance with applicable Federal and State regulations as implemented through its corporate procedures. North Anna generates and manages the following types of nonradioactive waste:

- <u>Hazardous Wastes</u>: North Anna is classified as a small-quantity hazardous waste generator. The amounts of hazardous wastes generated are only a small percentage of the total wastes generated. These generally consist of paint wastes, spent and off-specification (e.g., shelf-life expired) chemicals, gun cleaning rags with lead residue, and occasional project-specific wastes. Table E2.2-2 in the ER provides a list and the amounts of hazardous waste (Dominion 2020b).

- Nonhazardous Wastes: These generally include glycol and antifreeze (state specific), used polishing resin, nonhazardous paint, coatings, sealants, lubricants, grease, two-part epoxies, and fire barrier foam. Recycled waste typically consists of scrap metal, batteries, and used oil. Municipal waste is disposed of at the local permitted solid waste management facility. Table E2.2-2 in the ER provides a list and the amounts of nonhazardous waste (Dominion 2020b).
- Universal Wastes: These typically consist of used oil, fluorescent lamps, batteries, mercury devices, and electronics (state specific) (Dominion 2020b).

Dominion maintains a list of waste vendors that it has approved for use across the entire company to remove and dispose of the identified wastes offsite (Dominion 2020b).

2.1.6 Utility and Transportation Infrastructure

The utility and transportation infrastructure at nuclear power plants typically interfaces with public infrastructure systems available in the region. Such infrastructure includes utilities, such as suppliers of electricity, fuel, and water; as well as roads and railroads that provide access to the site. The following sections briefly describe the existing utility and transportation infrastructure at North Anna. Site-specific information in this section is derived from Dominion's ER unless otherwise cited.

2.1.6.1 Electricity

Nuclear power plants generate electricity for other users; however, they also use electricity to operate. Offsite power sources provide power to engineered safety features and emergency equipment in the event of a malfunction or interruption of power generation at the plant. Planned independent backup power sources provide power in the event that power is interrupted from both the plant itself and offsite power sources.

2.1.6.2 Fuel

North Anna operates with low-enriched uranium dioxide fuel. With the NRC approval of optimized ZIRLO cladding fuel usage, Dominion operates the reactor cores at up to a maximum fuel discharge burnup rate of 60,000 megawatt-days per metric ton uranium (MWd/MTU) (i.e., the lead rod average burnup limit is 60,000 MWd/MTU). Refueling occurs approximately every 18 months. Dominion stores spent fuel in the spent fuel pool in the fuel handling building or in the ISFSI. As noted above, currently, the North Anna ISFSI includes three spent fuel storage pads, that can accommodate a total of 84 concrete-and-steel storage casks (Dominion 2020b).

2.1.6.3 Water

In addition to cooling and auxiliary water, North Anna uses potable water for plant personnel sanitary and everyday activities (e.g., drinking, showering, cleaning, doing laundry, operating toilets, and operating eye washes). In this SEIS, Section 2.1.3, "Cooling and Auxiliary Water Systems," describes the North Anna industrial water systems.

2.1.6.4 Transportation Systems

Nuclear power plants are served by controlled access roads that are connected to U.S. highways and Interstate highways. In addition to roads, many plants also have railroad connections for moving heavy equipment and other materials. Plants located on navigable waters may have facilities to receive and ship loads on barges. In the next chapter, Section 3.10.6, "Local Transportation," describes the North Anna transportation systems.

2.1.6.5 Power Transmission Systems

For license renewal and subsequent license renewal, the NRC (NRC 2013a) evaluates, as part of the proposed action, the continued operation of those North Anna power transmission lines that connect to the substation where it feeds electricity into the regional power distribution system. The transmission lines that are in scope for the North Anna subsequent license renewal environmental review are onsite and are not accessible to the general public. The NRC also considers the continued operation of the transmission lines that supply outside power to the nuclear plant from the grid. Section 3.11.4, "Electromagnetic Fields," in the next chapter, describes these transmission lines.

2.1.7 Nuclear Power Plant Operations and Maintenance

Maintenance activities conducted at North Anna include inspection, testing, and surveillance to maintain the current licensing basis of the facility and to ensure compliance with environmental and safety requirements. These activities include in-service inspections of safety-related structures, systems, and components; quality assurance and fire protection programs; and radioactive and nonradioactive water chemistry monitoring.

Additional programs include those implemented to meet technical specification surveillance requirements and those implemented in response to NRC generic communications. Such additional programs include various periodic maintenance, testing, and inspection procedures necessary to manage the effects of aging on structures and components. Certain program activities are performed during the operation of the units, whereas others are performed during 18-month scheduled refueling outages (Dominion 2020b).

2.2 Proposed Action

As stated in Section 1.1 of this SEIS, the NRC's proposed Federal action is to decide whether to issue subsequent renewed North Anna operating licenses for an additional 20 years. Section 2.2.1 below provides a description of normal power plant operations during the subsequent license renewal term.

2.2.1 Plant Operations during the Subsequent License Renewal Term

Most plant operation activities during the subsequent license renewal term would be the same as, or similar to, those occurring during the current license term. NUREG-1437, Volume 1, Revision 1, *Generic Environmental Impact Statement for License Renewal of Nuclear Power Plants* (the GEIS) (NRC 2013a), describes the issues that would have the same impact at all nuclear power plants, or a distinct subset of plants (generic issues), as well as those issues that would have different impact levels at different nuclear power plants (site-specific issues). The impacts of generic issues are described in NUREG-1437 as Category 1 issues; those impacts are set out in NUREG-1437 and Table B-1 of 10 CFR Part 51, Appendix B, and those determinations apply to each license renewal application (applicable to plants and sites within the designated generic classification), subject to the consideration of any new and significant information on a plant-specific basis. A second group of issues (Category 2) was identified in NUREG-1437 as having potentially different impacts at each plant, on a site-specific basis; those issues with plant-specific impact levels need to be discussed in a plant-specific SEIS such as this one.

Section 2.1.1 of the GEIS, “Plant Operations during the License Renewal Term,” describes the general types of activities that are carried out during the operation of all nuclear power plants:

- reactor operation
- waste management
- security
- office and clerical work; possible laboratory analysis
- surveillance, monitoring, and maintenance
- refueling and other outages

As part of its subsequent license renewal application, Dominion Energy Virginia (Dominion) submitted an environmental report. Dominion’s environmental report (ER) states that North Anna will continue to operate during the license renewal term in the same manner as it would during the current license term except for additional aging management programs, as necessary. Such programs would address structure and component aging in accordance with 10 CFR Part 54, “Requirements for Renewal of Operating Licenses for Nuclear Power Plants.”

2.2.2 Refurbishment and Other Activities Associated with License Renewal

Refurbishment activities include replacement and repair of major structures, systems, and components. As described in the GEIS, most major refurbishment activities are actions that would typically take place only once in the life of a nuclear plant, if at all (NRC 2013a). For example, replacement of pressurized-water reactor steam generator systems is a refurbishment activity. Refurbishment activities may have an impact on the environment beyond those that occur during normal operations and may require evaluation, depending on the type of action and the plant-specific design.

In preparation for its license renewal application, Dominion evaluated major structures, systems, and components in accordance with 10 CFR 54.21, “Contents of Application—Technical Information,” to identify major refurbishment activities necessary for the continued operation of North Anna during the proposed 20-year period of extended operation (Dominion 2020b).

Dominion did not identify any major refurbishment activities necessary for the continued operation of North Anna beyond the end of the existing operating licenses (Dominion 2020b).

2.2.3 Termination of Nuclear Power Plant Operations and Decommissioning after the License Renewal Term

NUREG-0586, Supplement 1, Volumes 1 and 2, *Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities: Regarding the Decommissioning of Nuclear Power Reactors* (the decommissioning GEIS) (NRC 2002a), describes the environmental impacts of decommissioning. The majority of plant operations activities would cease with reactor shutdown. Some activities (e.g., security and oversight of spent nuclear fuel) would remain unchanged, whereas others (e.g., waste management, administrative work, laboratory analysis, surveillance, monitoring, and maintenance) would continue at reduced or altered levels. Systems dedicated to reactor operations would cease operations. However, if these systems are not removed from the site after reactor shutdown, their physical presence may continue to impact the environment. Impacts associated with dedicated systems that remain in place, or with shared systems that continue to operate at normal capacities, could remain unchanged.

Decommissioning will occur whether North Anna is shut down at the end of its current operating license or at the end of the subsequent period of extended operation 20 years later. There is no site-specific issue related to decommissioning. The license renewal GEIS concludes that license renewal would have a negligible (SMALL) effect on the impacts of terminating operations and decommissioning on all resources (NRC 2013a).

2.3 Alternatives

As stated above, the National Environmental Policy Act of 1969, as amended (NEPA), requires the NRC to consider reasonable alternatives to the proposed action of issuing subsequent renewed operating licenses for North Anna. For a replacement power alternative to be reasonable, it must be either (1) commercially viable on a utility scale and operational before the reactor's operating license expires or (2) expected to become commercially viable on a utility scale and operational before the reactor's operating license expires (NRC 2013a). The NRC published the most recent GEIS revision in 2013, and it incorporated the latest information on replacement power alternatives available at that time; however, rapidly evolving technologies are likely to outpace the information in the GEIS. Thus, for each supplement to the GEIS, the NRC staff must perform a site-specific analysis of replacement power alternatives that accounts for changes in technology and science since the most recent GEIS revision.

The first alternative to the proposed action of the NRC issuing subsequent renewed operating licenses for North Anna is for the NRC to not issue the licenses. This is called the no-action alternative and is described below in Section 2.3.1. In addition to the no-action alternative, this section discusses two reasonable replacement power alternatives. As described in Section 2.3.2 below, these alternatives seek to replace North Anna's generating capacity by meeting the region's energy needs through other means or sources.

2.3.1 No-Action Alternative

At some point, all operating nuclear power plants will permanently cease operations and undergo decommissioning. Under the no-action alternative, the NRC does not issue the subsequent renewed operating licenses for North Anna and the units would shut down at or before the expiration of the current licenses on April 1, 2038 (Unit 1), and August 21, 2040 (Unit 2). The license renewal GEIS describes the environmental impacts that arise directly from permanent plant shutdown. The NRC expects shutdown impacts to be relatively similar, whether they occur at the end of the current license term (i.e., after 60 years of operation) or at the end of a subsequent renewed license term (e.g., after 80 years of operation).

After permanent shutdown, plant operators will initiate decommissioning in accordance with 10 CFR 50.82, "Termination of License." The decommissioning GEIS (NUREG-0586) (NRC 2002a) describes the environmental impacts from decommissioning a nuclear power plant and related activities. The analysis in the decommissioning GEIS bounds the environmental impacts of decommissioning when Dominion terminates reactor operations at North Anna. A licensee in decommissioning must assess in its post-shutdown decommissioning activities report submitted to the NRC whether there are planned decommissioning activities with reasonably foreseeable environmental impacts that are not bounded in previous EISs. Chapter 4 of the license renewal GEIS (NUREG-1437) (NRC 2013a) and Section 3.15.2, "Terminating Plant Operations and Decommissioning," of this SEIS describe the incremental environmental impacts of subsequent license renewal on decommissioning activities.

Termination of operations at North Anna would result in the total cessation of electrical power production by North Anna Units 1 and 2. Unlike the replacement power alternatives described below in Section 2.3.2, the no-action alternative does not expressly meet the purpose and need of the proposed action, as described in Section 1.2, because the no-action alternative 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 North Anna, the no-action alternative would likely create a need for a replacement power alternative. The following section describes a wide range of replacement power alternatives, and Chapter 3 of this SEIS assesses their potential environmental impacts. Although the NRC's authority only extends to deciding whether to issue renewed North Anna Units 1 and 2 operating licenses, the replacement power alternatives described in the following sections represent possible options for energy-planning decisionmakers if the NRC decides not to issue subsequent renewed operating licenses for these units.

2.3.2 Replacement Power Alternatives

In evaluating alternatives to subsequent license renewal, the NRC considered energy technologies or options currently in commercial operation, as well as technologies likely to be commercially available by the time the current North Anna renewed operating licenses expire.

The license renewal GEIS presents an overview of some alternative energy technologies but does not conclude which alternatives are most appropriate. Because alternative energy technologies continually evolve in capability and cost, and because regulatory structures change to either promote or impede the development of particular technologies, the analyses in this chapter rely on a variety of sources of information to determine which alternatives would be available and commercially viable when the current licenses expire. Dominion's ER provides a discussion of replacement power alternatives. In addition, the NRC staff's analyses also consider updated information from the following sources:

- U.S. Department of Energy's (DOE), U.S. Energy Information Administration (EIA)
- other offices within the DOE
- U.S. Environmental Protection Agency
- industry sources and publications

In total, the NRC staff considered 16 replacement power alternatives to the proposed action and eliminated 14, leaving 2 reasonable replacement power alternatives for indepth evaluation. Sections 2.3.2.1 and 2.3.2.2 contain the NRC staff's description of these alternatives. The NRC staff eliminated from in-depth evaluation those alternatives that could not provide the equivalent of North Anna's current generating capacity, as those alternatives would not be able to satisfy the objective of replacing North Anna's power generation. Also, in some cases, the NRC staff eliminated those alternatives whose costs or benefits could not justify inclusion in the range of reasonable alternatives. Further, the NRC staff eliminated as unfeasible those alternatives not likely to be constructed and operational by the time the North Anna licenses expire in 2038 (Unit 1) and 2040 (Unit 2).

The alternatives the NRC staff evaluated in depth include:

- new nuclear (small modular reactors)
- combination alternative (solar, offshore wind, small modular reactors, and demand-side management)

The alternatives the NRC staff considered but eliminated include:

- solar power
- wind power
- biomass power
- demand-side management
- hydroelectric power
- geothermal power
- wave and ocean energy
- municipal solid waste-fired power
- natural gas-fired power
- petroleum-fired power
- coal-fired power
- fuel cells
- purchased power
- delayed retirement of other generating facilities

Section 2.4 of this report contains a brief discussion of each of the 14 eliminated alternatives and provides the basis for each elimination. To ensure that the alternatives considered in the SEIS are consistent with State or regional energy policies, the NRC staff reviewed energy-related statutes, regulations, and policies within the North Anna region. Accordingly, the NRC staff also eliminated from further consideration any alternative that would conflict with these requirements. The evaluation of each alternative considers the environmental impacts across the following 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.

The GEIS assigns most site-specific issues (called Category 2 issues) a significance level of SMALL, MODERATE, or LARGE. For ecological resources subject to the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.) (ESA) and the Magnuson–Stevens Fishery Conservation and Management Act of 1996, as amended (16 U.S.C. 1801 et seq.); and historic and cultural resources subject to the National Historic Preservation Act of 1966, as amended (54 U.S.C. 300101 et seq.) (NHPA), the impact significance determination language is specific to the authorizing legislation. The order in which this SEIS presents the different alternatives does not imply increasing or decreasing level of impact; nor does the order imply that an energy-planning decisionmaker would be more (or less) likely to select any given alternative.

Region of Influence

Dominion's service territory within Virginia contains the company's largest proportion of generation facilities and constitutes the region of influence (ROI) for the NRC staff's analysis of North Anna replacement power alternatives. If the NRC does not issue subsequent renewed licenses, procurement of replacement power for North Anna may be necessary. The power station is located on Lake Anna in Louisa County, VA, with a portion of the site extending into neighboring Spotsylvania County, VA. North Anna is predominately owned and operated by Dominion Energy, Inc. (Dominion). The Old Dominion Electric Cooperative also has a partial (approximately 12 percent) ownership in the plant (Dominion 2020b, 2021a). Dominion provides electricity to customers in Virginia and northeastern North Carolina, and is also a member of PJM Interconnection, the operator of the wholesale electric grid in the Mid-Atlantic region of the United States.

In 2019, electric generators in Virginia had a net summer generating capacity of approximately 28,000 megawatts (MW). This capacity included units fueled by natural gas (49 percent), hydroelectric and pumped storage (15 percent), nuclear power (13 percent), coal (10 percent), and petroleum (8 percent). Biomass and solar sources comprised the balance of generating capacity in the State (EIA 2021b).

The electric industry in Virginia generated approximately 97,000 gigawatt hours (GWh) of electricity in 2019. This electrical production was dominated by natural gas (60 percent), and nuclear power (31 percent). Biomass, coal, hydroelectric, petroleum, and solar energy sources collectively fueled the remaining 9 percent of this electricity (EIA 2021c).

In the United States, natural gas-fired generation rose from 16 percent of the total electricity generated in 2000 to 37 percent in 2019 (EIA 2013, 2020a). Given known technological and demographic trends, the EIA predicts that natural gas-fired generation in the United States will remain relatively constant through 2050, whereas electricity generated from renewable energy is expected to double from 21 percent of total generation to 42 percent over that period (EIA 2021a). However, fossil fuel and renewable energy levels within the North Anna region of influence may not follow nationwide forecasts, and uncertainties in U.S. energy policies and the energy market could affect forecasts. In particular, the implementation of policies aimed at reducing greenhouse gas emissions could have a direct effect on fossil fuel-based generation technologies (Power 2018; EIA 2020b). For example, the Commonwealth of Virginia recently passed the Virginia Clean Economy Act (VCEA). The legislation, which became effective in July 2020, mandates that Dominion Energy's electric generation be 100 percent carbon free by 2045; this would require the closure of all carbon-emitting plants that generate electricity, including plants that generate electricity using natural gas, unless a waiver has been sought by the utility and granted by the State, to allow the continued operation of such plants. It further requires that several coal-fired and oil-fired plants within the State retire by the end of 2024, followed by the retirement of several biomass plants by 2028 (VCEA 2020). Also in 2020, Dominion announced a significant expansion of its greenhouse gas emissions reduction goals, establishing a new companywide commitment to achieve net zero carbon dioxide and methane emissions by 2050 (Dominion 2020b).

The remainder of this section describes in depth the following two reasonable replacement power alternatives to North Anna license renewal:

- a new nuclear (small modular reactor) alternative (Section 2.3.2.1)
- a combination alternative of solar power, offshore wind power, new nuclear (small modular reactor (SMR)) power, and demand-side management (Section 2.3.2.2)

Table 2-1 summarizes key characteristics of the alternative replacement power technologies.

Table 2-1. Overview of Replacement Power Alternatives Considered in Depth

Alternative	New Nuclear (Small Modular Reactor)	Combination (Solar, Off-shore Wind, Small Modular Reactor, and Demand-Side Management)
Summary	Five small modular reactor units for a total of approximately 1,900 MWe	800 MWe from solar, 500 MWe from offshore wind, 400 MWe from small modular reactor generation, and 200 MWe from demand-side management
Location	Within the North Anna site on developed and undeveloped land. Would use North Anna's existing transmission lines and some existing infrastructure (Dominion 2020b)	The solar component would be located at multiple sites distributed across the region of influence (ROI), offsite of the North Anna site. The wind component would be located off the Virginia coast in Federal waters designated for offshore wind development. The small modular reactor component would be located within the North Anna site on developed and undeveloped land (Dominion 2020b). Assumes demand-side management energy savings from within Dominion's service territory.
Cooling System	Closed cycle with mechanical draft cooling towers Cooling water withdrawal—63 mgd Consumptive water use—44 mgd (NRC 2018a)	The small modular reactor unit would use closed-cycle cooling systems with mechanical draft cooling towers. Cooling water withdrawal—13 mgd Consumptive water use—9.2 mgd (NRC 2018a). No cooling system would be required for solar and wind facilities, or demand-side management.
Land Required	Approximately 170 ac (69 ha) for plant facilities (NuScale 2021a)	Solar facilities would collectively require approximately 20,000 ac (8,000 ha) (NRC 2013a). Offshore wind facilities would be sited within an approximately 72 square-nautical mile (62,000 ac) grid (BOEM 2020). Small modular reactor facilities would require approximately 36 ac (14 ha) (NuScale 2021a). Demand-side management requires no land.
Work Force	Peak construction—2,600 workers Operations—1,200 workers (NRC 2018a)	The solar, offshore wind, and small modular reactor units would collectively require approximately 3,100 workers during peak construction and 490 workers during operations. (AWEA 2020; BLM 2019; NRC 2018a; DOE 2011b)

Key: ac = acres, DSM = demand-side management, ha = hectares, mgd = million gallons per day, MWe = megawatts electric, ROI=region of influence

2.3.2.1 New Nuclear Alternative (Small Modular Reactor)

The NRC staff considers the construction of a new nuclear plant to be a reasonable alternative to North Anna's subsequent license renewal. Nuclear generation currently accounts for approximately 34 percent of the electricity produced in Virginia (EIA 2021c). In addition to North Anna, one other nuclear power plant operates within the region of influence: Surry Power Station, Units 1 and 2, is located approximately 86 miles (138 km) to the southeast.

For the new nuclear alternative, the NRC staff considered the installation of multiple small modular reactors (SMRs). Small modular reactors, in general, are light-water reactors that use water for cooling and enriched uranium for fuel in the same manner as conventional, large light-water reactors currently operating in the United States. SMR modules typically generate 300 megawatts electric (MWe) or less, compared to today's larger nuclear reactor designs, that can generate 1,000 MWe or more per reactor. However, their smaller size means that several SMRs can be bundled together in a single containment. Smaller size also means greater siting flexibility, because they can fit in locations not large enough to accommodate a conventional nuclear reactor (NRC 2020d; DOE 2020). SMR design features can include below grade containment and inherent safe shutdown features, longer station blackout coping time without external intervention, and core and spent fuel pool cooling without the need for active heat removal.

SMR power generating facilities are also designed to be deployed in an incremental fashion to meet the power generation needs of a service area, in which generating capacity can be added in increments to match load growth projections (NRC 2018a).

The NRC received the first design certification application for an SMR in December 2016 (NRC 2020e). Following NRC certification, this design could potentially achieve operation on a commercial scale by 2027 (NuScale 2021b). Therefore, SMRs could be constructed and operational by the time the North Anna licenses expire in 2038 and 2040, respectively.

For this subsequent license renewal analysis, the NRC staff assumed an SMR facility would replace North Anna. Although SMR modules typically generate 300 MWe or less, for this analysis the NRC staff assumed the use of a slightly larger (400 MWe) module based upon an established generic SMR plant design and representative construction and operating parameters derived from several commercial designs (NRC 2018a). In its ER, Dominion analyzed replacing 1,672 MWe of North Anna's electrical generation. This value reflects Dominion Energy's ownership portion of the plant's total licensed capacity of approximately 1,892 MWe, but not the approximately 11.6 percent portion under ownership of the Old Dominion Electric Cooperative (Dominion 2020b, 2021a). However, to account for replacing the full amount of North Anna's generating capacity that would be subject to license renewal, the NRC staff assumed that the SMR facility would be comprised of five reactor modules (four 400-MWe modules and one 300-MWe module) with a total net generating capacity of approximately 1,900 MWe.

As indicated in Dominion's ER, the SMR facility footprint would be located within an approximately 200-acre (81-ha) area west of and adjacent to the existing North Anna Units 1 and 2 facilities (Dominion 2020b). This area was previously evaluated in the EIS for the early site permit for North Anna Units 3 and 4 (NRC 2006), and the EIS for combined license for North Anna Unit 3 (NRC 2010). It is comprised of approximately 120 ac (49 ha) of developed land and 80 ac (32 ha) of forested land (Dominion 2020b). The SMR facilities are estimated to require approximately 170 ac (69 ha) of land (NuScale 2021a some of which would have to be cleared to support this alternative. The SMR facilities would use a closed-cycle cooling system with mechanical draft cooling towers. To support the plant's cooling needs, this cooling system would withdraw approximately 63 million gallons per day (mgd) (240,000 cubic meters per day (m^3/d)) of water and consume 44 mgd (170,000 m^3/d) of water. Onsite visible structures could include cooling towers and buildings within the power block (NRC 2018a). Although some infrastructure upgrades may be required, it is assumed that the existing transmission line infrastructure would be sufficient to support the SMR alternative (Dominion 2020b).

2.3.2.2 Combination Alternative (Solar, Offshore Wind, Small Modular Reactor, and Demand-Side Management)

This alternative considers a combination of carbon-free replacement power generation technologies with demand-side management to be a reasonable alternative to North Anna subsequent license renewal. The actual amount of energy to be derived from each type of power in this combination could vary in an almost infinite manner. For this evaluation, the NRC staff assumes that (1) solar photovoltaic power plants would supply 800 MWe, (2) offshore wind facilities would supply 500 MWe, (3) small modular reactors would supply 400 MWe, and (4) energy efficiency initiatives (i.e., demand-side management) would provide 200 MWe of energy savings.

Solar Portion of Combination Alternative

Solar photovoltaic power generation uses solar panels to convert solar radiation into usable electricity. Solar cells are formed into solar panels that can then be linked into photovoltaic arrays to generate electricity. The electricity generated can be stored, used directly, fed into a large electricity grid, or combined with other electricity generators as a hybrid plant. Solar photovoltaic cells can generate electricity whenever there is sunlight, regardless of whether the sun is directly or indirectly shining on the solar panels. Therefore, solar photovoltaic technologies do not need to directly face and track the sun. This capability has allowed solar photovoltaic systems to have broader geographical use than concentrating solar power (which relies on direct sun) (DOE 2011a).

The feasibility of solar energy resources serving as alternative baseload power depends on the location, value, accessibility, and constancy of solar radiation. Solar photovoltaic resources across Virginia are average and range from 4.5 to 5.0 kilowatt hours per square meter per day ($kWh/m^2/day$) (NREL 2018). Nationwide, growth in utility-scale solar photovoltaic facilities (greater than 1 MW) has resulted in an increase from 145 MW in 2009 to over 35,000 MW of installed capacity in 2019 (EIA 2021e).

Solar photovoltaic energy facilities located in the region of influence would generate the solar portion of the combination alternative. For this analysis, the NRC staff assumes that eight approximately 400 MWe standalone, utility-scale solar facilities would be constructed and operated to provide a gross generating capacity of 3,200 MWe. These facilities would be located at offsite locations within the region of influence. Assuming a 25 percent capacity factor (EIA 2021d), the solar units collectively would have an approximate net generating capacity of 800 MWe.

Utility-scale solar facilities require large areas of land to be cleared for the solar panels. For standalone sites, solar photovoltaic facilities may require approximately 6.2 ac (2.5 ha) per megawatt (NRC 2013a). Therefore, a total of approximately 20,000 ac (8,000 ha) would be required to construct and operate the eight proposed solar power installations needed under this alternative. Although not all this land would be cleared of vegetation and permanently impacted, it represents the land enclosed in the total site boundary of the solar facility (NREL 2013). Solar photovoltaic systems do not require water for cooling purposes, but they do require a small amount of water to clean the panels and potable water for the workforce.

In its 2020 Integrated Resource Plan, Dominion identified its plans to substantially increase solar power capacity and generation over the next 15 years (Dominion 2020d). Because the region of influence contains average solar photovoltaic resources and because solar photovoltaic technology is a commercially available option for providing electrical generating capacity, the NRC staff considers the construction and operation of solar photovoltaic facilities to be reasonable when combined with other generation sources.

Offshore Wind Portion of Combination Alternative

The NRC staff assumes that the 500 MWe of wind-generated replacement power under this combination alternative would come from offshore wind farms located along Virginia's Atlantic coast. The offshore wind portion, operating at an expected capacity factor of 50 percent (NREL 2020), would require an installed capacity of 1,000 MWe.

Virginia has large areas with wind energy potential off its Atlantic coast and in the Chesapeake Bay, but onshore resources are limited and there is no utility-scale wind electricity generation in the State (EIA 2020b). However, based on recent developments and planned expansion of offshore wind capabilities, the NRC staff assumes that an additional installed capacity of 1,000 MWe can be reasonably attained by the time the North Anna licenses expire in 2038 and 2040.

In December 2020, Dominion filed a construction and operations plan with the U.S. Bureau of Ocean Energy Management (BOEM) to build the 2,640-MW Coastal Virginia Offshore Wind commercial project, the largest planned offshore wind farm in the United States. This followed Dominion's completed construction of a two-turbine, 12-MW pilot portion of the project earlier that year. Dominion expects to begin construction of the commercial portion of the project in 2024 and operations in 2026. The NRC staff assumes the offshore wind portion of the combination alternative would be in or near the Coastal Virginia Offshore Wind project area, which is located in Federal waters approximately 30 miles (48 km) offshore of Virginia Beach, VA where Dominion has leased approximately 113,000 ac (46,000 ha) for offshore wind development (BOEM 2021; Dominion 2020e).

Modern offshore wind turbine generators (turbines) are substantially larger than those operated on land. From 2000 to 2020, offshore wind turbine sizes have grown from an installed average of 2 MW per turbine to recent designs capable of generating 14 MW per turbine (BOEM 2020). In 2020, Dominion indicated that it had conditionally selected a 14-MW turbine model for developing its commercial offshore wind project (POWER 2020a). For this analysis, the NRC staff assumed that the offshore wind portion of this combination alternative would also use this or a similar-sized turbine, which has a rotor diameter of 722 feet (222 meters) and a total height of approximately 800 ft (245 meters) (Virginia Business 2020; Siemens Gamesa Undated). Accordingly, to attain an installed capacity of 1,000 MW would require the installation of 72 turbines.

Although offshore wind turbines can either be affixed to the seabed or free-floating, water depths associated with the Virginia's offshore wind energy areas are more suitable to fixed models, of which there are various foundation designs. The NRC staff assumes that the 72 turbines supporting the offshore wind component would be constructed in a grid pattern approximately 1 nautical mile (1.9 km) apart using an affixed monopile design driven into the seafloor to depths of approximately 260 ft (80 m) (BOEM 2020), and that each turbine would be located in the center of each square nautical mile (SNM) block, to better isolate each turbine from passing vessels and accidental impacts. Offshore construction impacts are projected to occur within a 95-ac (38.5-ha) temporary work area proximate to each turbine location (BOEM 2015; Dominion 2015). The seabed surrounding each turbine foundation would be protected from ocean current erosion by placement of a permanent 3–6 ft (1–1.5 m) scour-protection rock bed covering approximately 1 ac (0.4 ha) (BOEM 2018). Accordingly, the construction of the turbines supporting the offshore wind component would result in approximately 6,800 ac (2,800 ha) of temporary disturbance and 72 ac (29 ha) of permanent disturbance.

Additional disturbance would result from trenching activities associated with interconnecting the wind turbine generators and exporting the power to onshore facilities. The NRC staff assumes that this alternative would use, to the extent practicable, any available offshore and onshore infrastructure (e.g., offshore electrical service platforms and cable trenches extending to onshore interfaces) associated with Dominion's current and planned development of the Coastal Virginia Offshore Wind project.

Because offshore wind turbines require ample spacing between one another to avoid inter-turbine air turbulence and allow for navigation by ocean vessels, the total area requirement of utility-scale wind farms is significantly larger than the amount of marine environment that would be directly disturbed. Under this alternative, approximately 72 square nautical miles would be required for an installed capacity of 1,000 MWe (BOEM 2020).

In its 2020 Integrated Resource Plan, Dominion indicated that offshore wind generation is a major component of its strategy to meet standards mandated in the Virginia Clean Economy Act, and that it plans to increase total offshore wind generation to more than 5,000 MW over the next 15 years (Dominion 2020d, 2020e). As discussed in Section 2.4.2, although it is unlikely that offshore wind power could fully replace North Anna's generation capacity, Virginia's offshore environment does offer considerable wind power resources, and offshore wind technologies are poised to become a commercially available option for providing electrical generating capacity in the region of interest by the time the current North Anna licenses expire. Accordingly, the NRC staff considers the construction and operation of offshore wind facilities to be a reasonable alternative to subsequent license renewal for North Anna when combined with other generation sources.

<u>Small Modular Reactor Portion of Combination Alternative</u>

The SMR portion of the combination alternative would entail construction and operation of a single-unit, 400-MWe plant located at North Anna. The plant would be similar in function and appearance to the larger SMR plant described in Section 2.3.2.1 for the new nuclear-only alternative. Although some infrastructure upgrades may be required at North Anna in association with the SMR portion of the combination alternative, the NRC staff assumes that the existing transmission line infrastructure would be adequate to support this alternative. Like the new nuclear plant described in Section 2.3.2.1, the SMR portion of the combination alternative would be located within an approximately 200-acre (81-ha) area west of and adjacent to the existing North Anna Units 1 and 2 facilities (Dominion 2020b). However, the single-unit SMR plant would require less land, only about 36 ac (14 ha) (NuScale 2021a).

The SMR plant would use a closed-cycle cooling system with mechanical draft cooling towers. To support the plant's cooling needs, this system would withdraw approximately 13 mgd (50,000 m^3/d) of water and consume 9.2 mgd (35,000 m^3/d) of water (NRC 2018a). Similar to the SMR-only alternative discussed in Section 2.3.2.1, onsite visible structures could include cooling towers and buildings within the power block (NRC 2018a).

<u>Demand-Side Management Portion of Combination Alternative</u>

Energy conservation and efficiency programs are more broadly referred to as demand-side management. Demand-side management programs can include reducing energy demand through consumer behavioral changes or through altering the electricity load so as to not require the addition of new generating capacity. These programs can be initiated by utilities, transmission operators, States, or other load-serving entities.

Although Virginia does not have a mandatory energy efficiency resource standard, demand-side management programs represent a fundamental component of Dominion's 2020 Integrated Resource Plan (Dominion 2020d). Therefore, for this analysis, the NRC staff assumed that Dominion would implement these programs.

Under the combination alternative, demand-side management would be used to replace approximately 200 MW of the electrical generating capacity that North Anna currently provides. Dominion projects that by 2035, its demand-side management programs could potentially reduce electrical demand across Dominion Energy's service area by 383 MWe (Dominion 2020d). Because estimates of reduced electrical demand involve considerable uncertainty, the NRC staff conservatively determined the replacement of 200 MWe of North Anna output through demand-side management programs to be a reasonable assumption supporting the combination alternative.

2.4 Alternatives Considered but Eliminated

The NRC staff originally considered 16 replacement power alternatives to North Anna's subsequent license renewal but ultimately eliminated 14 of these from detailed study. The NRC staff eliminated these 14 alternatives because of technical reasons, resource availability limitations, or commercial or regulatory limitations. Because many of these limitations will likely still exist when the current North Anna licenses expire in 2038 (Unit 1) and 2040 (Unit 2), the NRC staff does not expect that these 14 alternatives will be reasonably available when needed to replace North Anna's generating capacity. This section describes the 14 eliminated alternatives as well as the reasons why the NRC staff eliminated each alternative.

2.4.1 Solar Power

Solar power, including solar photovoltaic and concentrating solar power technologies, generates power from sunlight. Solar photovoltaic components convert sunlight directly into electricity using solar cells made from silicon or cadmium telluride. Concentrating solar power uses heat from the sun to boil water and produce steam. The steam then drives a turbine connected to a generator to ultimately produce electricity (NREL undated).

Solar generators are considered an intermittent resource because their availability depends on ambient exposure to the sun, also known as solar insolation. Insolation rates of solar photovoltaic resources in Virginia are average and range from 4.5 to 5.0 $kWh/m^2/day$ (NREL 2018). With only 611 MWe of utility-scale capacity installed across Virginia as of 2020, solar photovoltaic power represents a small but increasing contribution to the State's electrical power generation (EIA 2020b).

To be considered a viable alternative, a solar alternative must replace the amount of electricity that North Anna currently provides. Assuming a capacity factor of 25 percent (EIA 2021d), approximately 7,600 MWe of additional solar energy capacity would need to be installed in the region of influence to replace the electricity that North Anna provides.

Accordingly, key design characteristics associated with the solar portion of the combination alternative presented in Table 2-1 and Section 2.3.2.2 could be scaled to suggest the relative impacts of using solar as a standalone technology to replace the generating capacity of North Anna. Utility-scale solar facilities require large areas of land to be cleared for the solar panels. Inasmuch as a solar facility may require approximately 6.2 ac (2.5 ha) per megawatt (NRC 2013a), a solar-only alternative that generates 7,600 MWe of solar energy is likely to require more than 47,000 ac (19,000 ha) of land within Dominion's service territory. Because Dominion is already pursuing an aggressive solar strategy to offset current and forecasted fossil capacity reductions, it is expected that acquiring this amount of land could prove to be increasingly difficult as solar development across Virginia continues. In addition, recent difficulties in acquiring land and permitting new solar projects could be worsened if localities and members of the public continue to raise objections to siting solar facilities in their communities (Dominion 2020d).

Considering the above factors, the NRC staff concludes that solar power energy facilities alone do not provide a reasonable alternative to North Anna's subsequent license renewal. However, the NRC staff does consider as reasonable an alternative using solar power in combination with other power technologies, as described in Section 2.3.2.2.

2.4.2 Wind Power

As is the case with other renewable energy sources, the feasibility of wind power serving as an alternative baseload power depends on the location (relative to expected electricity users), value, accessibility, and constancy of the resource. Wind energy must be converted to electricity at or near the point where it is extracted, and currently there are limited energy storage opportunities available to overcome the intermittency and variability of wind resources.

As of December 31, 2019, the United States had more than 105,000 MW of installed wind energy capacity. Texas led all other States in installed land-based wind energy capacity with over 33,000 MW (DOE 2019). To be considered a reasonable replacement power alternative to North Anna's subsequent license renewal, the wind power alternative must replace the amount of electricity that North Anna provides. Assuming a capacity factor of 40 percent for onshore facilities (NREL 2020), land-based wind energy facilities in the region of influence would need to generate approximately 4,750 MW of electricity to replace North Anna's generating capacity of 1,900 MWe. However, Virginia currently has no installed utility-scale wind energy capacity and only limited onshore wind potential available to support the development of future of land-based wind energy systems (EIA 2020b).

Increasing attention has recently been focused on developing offshore wind resources along the Atlantic coast. In 2016, a 30 MW project off the coast of Rhode Island become the first operating offshore wind farm in the United States (Energy Daily 2016). No utility-scale offshore wind farms are currently in operation off the coast of Virginia (EIA 2020b). However, in 2020, Dominion completed construction of the Mid-Atlantic's first offshore wind demonstration project in Federal waters (BOEM 2021; Dominion 2020e). This two-turbine 12-MW demonstration project will help inform the planned 2,600 MW utility-scale development of the adjacent 113,000 ac (46,000 ha) wind energy area leased to Dominion for the CVOW commercial project, which is expected to commence operation in 2026 (BOEM 2021; Dominion 2020e).

Assuming a capacity factor of 50 percent for offshore wind facilities (NREL 2020), these types of facilities in the region of influence would need to generate 3,800 MW of electricity to fully replace North Anna's generating capacity of 1,900 MWe. Accordingly, key design characteristics associated with the offshore wind solar portion of the combination alternative presented in Table 21 and Section 2.3.2.2 could be scaled to suggest the relative impacts of using offshore wind as a standalone technology to replace the generating capacity of North Anna Units 1 and 2. Specifically, an offshore wind-only alternative would likely require 272 wind turbines, thus requiring a total of more than 270 square nautical miles (230,000 ac) (93,000 ha) of suitable marine environment, which would exceed the amount of Federal waters off coastal Virginia that are designated for wind energy leasing. Further, because Dominion is already pursuing an aggressive offshore wind strategy to offset current and forecasted fossil capacity reductions, it is expected that acquiring additional leases to support this level of offshore wind development could prove to be increasingly difficult.

In sum, given the amount of wind capacity necessary to replace North Anna, the intermittency of the resource, the limited amount of offshore Federal waters designated for wind energy leasing, and the status of wind development in the region of influence, the NRC staff finds a wind-only alternative—either land based, offshore, or some combination of the two—to be an unreasonable alternative to North Anna's subsequent license renewal. However, the NRC staff does consider a more limited amount of offshore wind power generation, in combination with other power technologies, to be a reasonable alternative to subsequent license renewal for North Anna, as described in Section 2.3.2.2 of this draft SEIS.

2.4.3 Biomass Power

Biomass resources used for biomass-fired power generation include agricultural residues, animal manure, wood wastes from forestry and industry, residues from food and paper industries, municipal green wastes, dedicated energy crops, and methane from landfills (IEA 2007). Using biomass-fired generation for baseload power depends on the geographic distribution, available quantities, constancy of supply, and energy content of biomass resources. For this analysis, the NRC staff assumes that biomass would be combusted for power generation in the electricity sector.

In 2019, biomass facilities in the region of influence had a total installed capacity of approximately 805 MW, and approximately 3 percent of the total power in the region of influence was generated from biomass sources (EIA 2021b, 2021c). Dominion currently generates 51 MW of electricity from biomass sources, the majority of that coming from wood waste (Dominion 2020b).

For utility-scale biomass electricity generation, the NRC staff assumes that the technologies used for biomass conversion would be similar to the technology used in other fossil fuel plants, including the direct combustion of biomass in a boiler to produce steam (NRC 2013a). Accordingly, biomass generation is considered a carbon-emitting technology and would be subject to the mandates of the Virginia Clean Economy Act. Biomass generation is generally more cost effective when co-fired with coal plants (IEA 2007). However, most biomass-fired generation plants generally only reach capacities of 50 MW, which means replacing the approximately 1,900 MWe generating capacity of North Anna using only biomass would require the construction of approximately 38 new, average-sized biomass facilities. Sufficiently increasing biomass-fired generation capacity by expanding existing biomass units or constructing new biomass units by the time North Anna’s licenses expire in 2038 and 2040, respectively, is unlikely. For these reasons, the NRC staff does not consider biomass-fired generation to be a reasonable alternative to North Anna subsequent license renewal.

2.4.4 Demand-Side Management

As discussed earlier in Section 2.3.2.2, demand-side management refers to energy conservation and efficiency programs that do not require the addition of new generating capacity. In general, residential electricity consumers have been responsible for the majority of peak load reductions, and participation in most demand-side management programs is voluntary (NRC 2013a).

Therefore, the mere existence of a demand-side management program does not guarantee that reductions in electricity demand will occur. The GEIS concludes that, although the energy conservation or energy efficiency potential in the United States is substantial, the NRC is aware of no cases in which an energy efficiency or conservation program alone has been implemented expressly to replace or offset a large baseload generation station (NRC 2013a).

Although Dominion has considered demand-side management measures as part of its resource planning efforts, it is unlikely that additional demand-side management measures alone would be sufficient to offset the energy supply that would be lost by the shutdown of North Anna (Dominion 2020b, 2020d). Therefore, the NRC staff does not consider demand-side management programs alone to be a reasonable alternative to North Anna subsequent license renewal. However, the NRC staff does consider as reasonable an alternative using demand-side management in combination with other power technologies, as described in Section 2.3.2.2.

2.4.5 Hydroelectric Power

Currently, approximately 2,000 hydroelectric facilities operate in the United States. Hydroelectric technology captures flowing water and directs it to a turbine and generator to produce electricity (NRC 2013a). There are three variants of hydroelectric power: (1) run-of-the-river (diversion) facilities that redirect the natural flow of a river, stream, or canal through a hydroelectric facility, (2) store-and-release facilities that block the flow of the river by using dams that cause water to accumulate in an upstream reservoir, and (3) pumped-storage facilities that 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. Although Virginia is home to the largest hydroelectric storage facility in the Nation—the 3,000-MW Bath County Pumped Storage Station—hydroelectric power accounts for less than 2 percent of Virginia's electric power production (EIA 2020b, 2021c).

A 1997 comprehensive survey of hydropower resources identified Virginia as having 617 MW of potential new hydroelectric capacity when adjusted for environmental, legal, and institutional constraints (Conner et al. 1998). These constraints could include (1) scenic, cultural, historical, and geological values; (2) Federal and State land use; and (3) legal protection issues, such as wild and scenic rivers legislation and threatened or endangered fish and wildlife legislative protection. In a separate assessment of nonpowered dams (dams that do not produce electricity), the DOE concluded that hydropower resources in the region of influence could potentially generate 50 MW of electricity (ORNL 2012). These nonpowered dams serve various purposes, such as providing water supply to inland navigation. Although the EIA projects that hydropower will remain a leading source of renewable power generation in the United States through 2040, there is little expected growth in large-scale hydropower capacity in the region of influence (Dominion 2020b; EIA 2013). The potential for future construction of large hydropower facilities has diminished because of increased public concerns over flooding, habitat alteration and loss, and destruction of natural river courses (NRC 2013a).

Given the projected lack of growth in hydroelectric power production, the competing demands for water resources, and the expected public opposition to the environmental impacts that would result from the construction of large hydroelectric facilities, the NRC staff concludes that the expansion of hydroelectric power is not a reasonable alternative to North Anna subsequent license renewal.

2.4.6 Geothermal Power

Geothermal technologies extract the heat contained in geologic formations to produce steam to drive a conventional steam turbine generator. Facilities producing electricity from geothermal energy have demonstrated capacity factors of 95 percent or greater, making geothermal energy a potential source of baseload electric power. However, the feasibility of geothermal power generation to provide baseload power depends on the regional quality and accessibility of geothermal resources. Utility-scale geothermal energy generation requires geothermal reservoirs with a temperature above 200 °F (93 °C). Known utility-scale geothermal resources are concentrated in the Western United States, specifically Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming. In general, most assessments of geothermal resources have been concentrated on these Western States (DOE 2013b; USGS 2008). No utility-scale development of geothermal resources occur within the region of influence (NREL 2016). Given the low resource potential in the region of influence, the NRC staff does not consider geothermal power to be a reasonable alternative to North Anna subsequent license renewal.

2.4.7 Wave and Ocean Energy

Waves, currents, and tides are often predictable and reliable, making them attractive candidates for potential renewable energy generation. Four major technologies may be suitable to harness wave energy: (1) terminator devices that range from 500 kilowatts to 2 MW, (2) attenuators, (3) point absorbers, and (4) overtopping devices (BOEM undated). Point absorbers and attenuators use floating buoys to convert wave motion into mechanical energy, driving a generator to produce electricity. Overtopping devices trap a portion of a wave at a higher elevation than the sea surface; waves then enter a tube and compress air that is used to drive a generator that produces electricity (NRC 2013a). Some of these technologies are undergoing demonstration testing at commercial scales, but none are currently used to provide baseload power (BOEM undated).

The United States' Mid-Atlantic coast is characterized by substantial amounts of wave energy arriving from the north. However, the potential for ocean energy along the continental shelf off Virginia's coast is marginal, and wave and ocean energy generation technologies are still in their infancy and currently lack commercial application (Dominion 2020b; EPRI 2011). For these reasons, the NRC staff does not consider wave and ocean energy to be a reasonable alternative to North Anna subsequent license renewal.

2.4.8 Municipal Solid Waste-Fired Power

Energy recovery from municipal solid waste converts nonrecyclable waste materials into usable heat, electricity, or fuel through combustion. The three types of combustion technologies include mass burning, modular systems, and refuse-derived fuel systems. Mass burning is the method used most frequently in the United States. The heat released from combustion is used to convert water to steam, which is used to drive a turbine generator to produce electricity. Ash is collected and taken to a landfill, and particulates are captured through a filtering system (EPA 2020d).

Currently, 75 waste-to-energy plants are in operation in 21 States, processing approximately 29 million tons of waste per year. These waste-to-energy plants have an aggregate capacity of 2,725 MWe (Michaels and Krishnan 2019). Although some plants have expanded to handle additional waste and to produce more energy, only one new plant has been built in the United States since 1995 (Power 2019). Because the average waste-to-energy plant produces about 50 MWe, approximately 38 average-sized waste-to-energy plants would be necessary to provide the same level of output as North Anna.

The decision to burn municipal waste to generate energy is usually driven by the need for an alternative to landfills rather than a need for energy, and additional stable supplies of municipal solid waste would be needed to support 38 new facilities in the region of influence. In addition, combustion of municipal solid waste is considered a carbon-emitting technology and would be subject to the mandates of the Virginia Clean Economy Act (VCEA). Based on these considerations, the NRC staff does not consider municipal solid waste combustion to be a reasonable alternative to North Anna subsequent license renewal.

2.4.9 Natural Gas-Fired Power

Historically, fossil fuel sources have accounted for the majority of electrical power generation in Virginia. In 2012, natural gas-fueled generation in the Commonwealth exceeded that of coal for the first time. By 2015, natural gas-fired generation in Virginia surpassed nuclear power generation (EIA 2020b). In 2019, natural gas represented approximately 49 percent of the installed generation capacity and 60 percent of the electrical power generated in Virginia (EIA 2021b, 2021c).

Baseload natural gas combined-cycle power plants have proven reliability and can have capacity factors as high as 87 percent (EIA 2015b). A natural gas combined-cycle system generates electricity using a gas turbine that burns natural gas. A steam turbine uses the heat from gas turbine exhaust through a heat recovery steam generator to produce additional electricity. This two-cycle process has a high rate of efficiency because the natural gas combined-cycle system captures the exhaust heat that otherwise would be lost and reuses it. Like other fossil fuel-burning plants, natural gas power plants are a source of greenhouse gases, including carbon dioxide (CO_2) (NRC 2013a).

In its 2020 Integrated Resource Plan, Dominion indicated that up to 970 MW of new gas-fired generation could be necessary over the next 15 to 25 years to address potential system reliability issues resulting from the addition of significant renewable energy resources and the retirement of coal-fired facilities within its service territory (Dominion 2020d). However, because the Virginia Clean Economy Act (VCEA) mandates that future power generation be carbon free by 2045, gas-fired generation would not likely be available as a replacement power alternative during most of the proposed North Anna subsequent license renewal period (i.e., through 2058 and 2060 for Units 1 and 2, respectively). While the VCEA allows utilities to seek a waiver of this prohibition, to address grid reliability or security issues, the NRC staff is presently unable to predict whether Dominion would seek such a waiver in order to continue to operate a natural gas-fueled plant, whether it could successfully demonstrate that a waiver is warranted, or whether Virginia authorities would grant such a waiver request. Accordingly, at this time, the NRC staff concludes that natural gas-fired technologies would not be a reasonable alternative to North Anna subsequent license renewal.

2.4.10 Petroleum-Fired Power

Petroleum-fired electricity generation accounted for less than 1 percent of Virginia's total electricity generation in 2019 (EIA 2021c). The variable costs and environmental impacts of petroleum-fired generation tend to be greater than those of natural gas-fired generation. The historically higher cost of oil has also resulted in a steady decline in its use for electricity generation, and the EIA forecasts no growth in capacity using petroleum-fired power plants through 2040 (EIA 2013, 2015a). The Virginia Clean Economy Act also mandates the retirement of all generation units that emit carbon dioxide as a byproduct of combustion by 2045, and Dominion's Integrated Resource Plan similarly anticipates no increase in the use of petroleum-fired power (Dominion 2020d). Therefore, the NRC staff does not consider petroleum-fired generation to be a reasonable alternative to North Anna subsequent license renewal.

2.4.11 Coal-Fired Power

Although coal has historically been the largest source of electricity in the United States, both natural gas generation and nuclear energy generation surpassed coal generation at the national level in 2020. Coal-fired electricity generation in the United States has continued to decrease as coal-fired generating units have been retired or converted to use other fuels and as the remaining coal-fired generating units have been used less often (EIA 2021g). Virginia exemplifies this trend, with coal historically fueling the largest share of electricity generated in the Commonwealth until 2009, when coal's contribution fell below that of nuclear power (EIA 2020b). In 2019, coal-fired generation accounted for approximately 3.5 percent of all electricity generated in Virginia, a 48 percent decrease from 2000 levels (EIA 2021c).

Baseload coal units have proven their reliability and can routinely sustain capacity factors as high as 85 percent. Among the technologies available, pulverized coal boilers producing supercritical steam (supercritical pulverized coal boilers) have become increasingly common at newer coal-fired plants given their generally high thermal efficiencies and overall reliability.

Supercritical pulverized coal facilities are more expensive than subcritical coal-fired plants to construct, but they consume less fuel per unit output, reducing environmental impacts. Integrated gasification combined cycle is another technology that generates electricity from coal. It combines modern coal gasification technology with both gas turbine and steam turbine power generation. The technology is cleaner than conventional pulverized coal plants because some of the major pollutants are removed from the gas stream before combustion. Although several smaller, integrated gasification combined-cycle power plants have been in operation since the mid-1990s, more recent large-scale projects using this technology have experienced setbacks and opposition that have hindered the technology from being fully integrated into the energy market.

As discussed earlier, the Virginia Clean Economy Act mandates that future power generation be carbon free by 2045 and requires that several coal-fired plants within the Commonwealth retire by the end of 2024. In its Integrated Resource Plan, Dominion proposes to continue steadily reducing the coal-powered portion of its fleet and identifies no plans to add new coal-fired generation to its energy production portfolio (Dominion 2020d). Based on these considerations, the NRC staff concludes that coal-fired technologies would not be a reasonable alternative to North Anna subsequent license renewal.

2.4.12 Fuel Cells

Fuel cells oxidize fuels without combustion and, therefore, without the environmental side effects of combustion. Fuel cells use a fuel (e.g., hydrogen) and oxygen to create electricity through an electrochemical process. The only byproducts are heat, water, and carbon dioxide (depending on the hydrogen fuel type) (DOE 2013a). Hydrogen fuel can come from a variety of hydrocarbon resources. Natural gas is a typical hydrogen source. As of October 2020, the United States had only 250 MW of fuel cell generation capacity (EIA 2021h).

Currently, fuel cells are not economically or technologically competitive with other alternatives for electricity generation. The EIA estimates that fuel cells may cost $6,866 per installed kilowatt (total overnight capital costs in 2020 dollars), which is high compared to other alternative technologies analyzed in this section (EIA 2021f). In June 2021, DOE launched an initiative to reduce the cost of hydrogen production to spur fuel cell and energy storage development over the next decade (DOE 2021). However, it is unclear whether and to what degree this initiative will lead to increased development and deployment of fuel cell technologies in the future.

More importantly, fuel cell units used for power production are likely to be small (approximately 10 MW). The world's largest industrial hydrogen fuel cell power plant is a 50 MWe plant that came online in South Korea in 2020 (Power 2020b). Using fuel cells to replace the power that North Anna provides would require the construction of approximately 190 average-sized units and modifications to the existing transmission system. Given the relatively immature status, limited deployment, and high cost of fuel cell technology, the NRC staff does not consider fuel cells to be a reasonable alternative to North Anna subsequent license renewal.

2.4.13 Purchased Power

It is possible that replacement power may be purchased and imported from outside the North Anna region of influence. Although purchased power would likely have little or no measurable environmental impact in the immediate vicinity of North Anna, 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 2013a). As discussed in its ER, Dominion's purchased power initiatives are focused on acquisition of renewable sources, primarily in the form of solar non-utility generation. Reliance on solar non-utility generators to meet Dominion generation requirements if the North Anna licenses are not renewed, combined with the general transition to renewable sources mandated by the Virginia Clean Economy Act, would likely increase the demand and competition for purchased power contracts (Dominion 2020b).

Purchased power is generally economically adverse because, historically, the cost of generating power has been less than the cost of purchasing the same amount of power from a third-party supplier (NRC 2013a). Power purchase agreements also carry the inherent risk that the supplying plant will not deliver the contracted power.

Based on these considerations, the NRC staff concludes that purchased power does not provide a reasonable alternative to North Anna's subsequent license renewal.

2.4.14 Delayed Retirement of Other Generating Facilities

Retiring a power plant ends its ability to supply electricity. Delaying the retirement of a power plant enables it to continue supplying electricity. A delayed retirement alternative would delay the retirement of generating facilities (other than North Anna) within or near the region of influence.

Power plants retire for several reasons. Because generators are required to adhere to additional regulations that will require significant reductions in plant emissions, some power plant owners may opt for early retirement of older units (which often generate more pollutants and are less efficient) rather than incur the cost for compliance. Additional retirements may be driven by low competing commodity prices (such as low natural gas prices), slow growth in electricity demand, and the requirements of the EPA's Mercury and Air Toxics Standards (EIA 2015a; EPA 2020e).

In 2019, Dominion identified 4,570 MW of fossil fuel- or biomass-fired generation that had or could be retired between 2019 and 2025 (Dominion 2020b). Dominion does not consider the reactivation or continued operation of these carbon emitting plants to be viable alternatives for providing replacement power because it would not support the mandates of the Virginia Clean Economy Act or Dominion's goals for lowering air emissions across its energy generation portfolio (Dominion 2020b). Because of these considerations, the NRC staff concludes that delayed retirement does not provide a reasonable alternative to North Anna's subsequent license renewal.

2.5 Comparison of Alternatives

In this chapter, the NRC staff described one alternative to North Anna license renewal that does not replace the plant's energy generation (the no-action alternative) and two alternatives to license renewal that may reasonably replace North Anna's energy generation. These replacement power alternatives are (1) new nuclear generation (small modular reactor), and (2) a combination of solar generation, offshore wind generation, small modular reactor generation, and demand-side management. Chapter 3 in this SEIS describes and assesses the environmental impacts of the proposed action and the alternatives. Table 2-2 below summarizes the environmental impacts of North Anna's subsequent license renewal, the no-action alternative, and the two reasonable replacement power alternatives to North Anna's subsequent license renewal (Dominion 2020a).

The environmental impacts of the proposed action (issuing subsequent renewed North Anna operating licenses) would be SMALL for all impact categories. In comparison, each of the two reasonable replacement power alternatives has environmental impacts in at least four resource areas that are greater than the environmental impacts of the proposed action of license renewal. In addition, the replacement power alternatives also would bring the environmental impacts inherent in new construction projects. If the NRC takes the no-action alternative and does not issue renewed licenses for North Anna, energy-planning decisionmakers would likely implement one of the two replacement power alternatives discussed in depth in this chapter, or a comparable alternative capable of replacing the power generated by North Anna Units 1 and 2. Based on the NRC staff's review of these two reasonable replacement power alternatives, the no-action alternative, and the proposed action, the NRC staff concludes that the environmentally preferred alternative is the proposed action of subsequent license renewal. Therefore, the NRC staff's preliminary recommendation is that the NRC issue the subsequent renewed North Anna operating licenses.

Table 2-2. Summary of Environmental Impacts of the Proposed Action and Alternatives

Impact Area (Resource)	North Anna License Renewal (Proposed Action)	No-Action Alternative	New Nuclear Alternative (Small Modular Reactor)	Combination Alternative (Solar, Offshore Wind, Small Modular Reactor, and Demand-Side Management)
Land Use	SMALL	SMALL	SMALL to MODERATE	SMALL to LARGE
Visual Resources	SMALL	SMALL	SMALL to MODERATE	SMALL to LARGE
Air Quality	SMALL	SMALL	SMALL	SMALL
Noise	SMALL	SMALL	SMALL	SMALL to MODERATE
Geologic Environment	SMALL	SMALL	SMALL	SMALL to MODERATE
Surface Water Resources	SMALL	SMALL	SMALL	SMALL to MODERATE
Groundwater Resources	SMALL	SMALL	SMALL	SMALL
Terrestrial Resources	SMALL	SMALL	SMALL	SMALL to LARGE
Aquatic Resources	SMALL	SMALL	SMALL	SMALL to LARGE
Special Status Species & Habitats	SEE NOTE[(a)]	SEE NOTE[(b)]	SEE NOTE[(c)]	SEE NOTE[(c)]
Historic and Cultural Resources	SEE NOTE[(d)]	SEE NOTE[(e)]	SEE NOTE[(f)]	SEE NOTE[(f)]

Impact Area (Resource)	North Anna License Renewal (Proposed Action)	No-Action Alternative	New Nuclear Alternative (Small Modular Reactor)	Combination Alternative (Solar, Offshore Wind, Small Modular Reactor, and Demand-Side Management)
Socioeconomics	SMALL	SMALL to MODERATE	MODERATE to LARGE	MODERATE to LARGE
Transportation	SMALL	SMALL	MODERATE to LARGE	MODERATE to LARGE
Human Health	SMALL[g]	SMALL[g]	SMALL[g]	SMALL[g]
Environmental Justice	SEE NOTE[h]	SEE NOTE[h]	SEE NOTE[h]	SEE NOTE[h]
Waste Management and Pollution Prevention	SMALL[i]	SMALL[i]	SMALL	SMALL

[a] May affect, but is not likely to adversely affect, northern long-eared bat. Unlikely to result in effects on the northern long-eared bat habitat. No adverse effects on essential fish habitat.

[b] Overall, the effects on federally listed species, critical habitats, and EFH would likely be smaller under the no-action alternative than the effects under continued operation but would depend on the specific shutdown activities as well as the listed species, critical habitats, and designated EFH present when the no-action alternative is implemented.

[c] The types and magnitudes of adverse impacts to species listed in the Endangered Species Act of 1973, as amended (16 U.S.C 1531 et seq.), designated critical habitat, and EFH would depend on the proposed alternative site, plant design and operation, as well as listed species and habitats present when the alternative is implemented. Therefore, the NRC staff cannot forecast a level of impact for this alternative.

[d] Based on the location of historic properties within and near the area of potential effect, Tribal input, Dominion's administrative procedures, a site-specific cultural resource management plan, and no planned physical changes or ground-disturbing activities, the proposed action (subsequent license renewal) would not adversely affect historic properties.

[e] Until the post-shutdown decommissioning activities report is submitted, the NRC cannot determine whether historic properties would be affected outside the existing industrial site boundary after the nuclear plant is shut down.

[f] The impact determination of this alternative would depend on the specific location of the new facility. The Virginia Department of Historic Resources would need to be consulted prior to any ground-disturbing activities in undisturbed land areas at North Anna.

[g] The chronic effects of electromagnetic fields on human health associated with operating nuclear power and other electricity generating plants are uncertain.

[h] With the exception of the no-action alternative, there would be no disproportionately high and adverse impacts to minority and low-income populations. For the no-action alternative, the loss of jobs and income could have an immediate socioeconomic impact. This could disproportionately affect minority and low-income populations that may have become dependent on these services.

[i] NUREG-2157, *Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel* (NRC 2014b), discusses the environmental impacts of spent fuel storage for the time frame beyond the licensed life for reactor operations.

3.0 AFFECTED ENVIRONMENT, ENVIRONMENTAL CONSEQUENCES, AND MITIGATING ACTIONS

3.1 Introduction

In conducting its environmental review of the North Anna Power Station, Units 1 and 2 (North Anna), subsequent license renewal (SLR) application by Dominion Energy Virginia (Dominion), the staff of the U.S. Nuclear Regulatory Commission (NRC) defines and describes the environment that could be affected by the proposed action (issuing subsequent renewed licenses authorizing an additional 20 years of operation). The staff then evaluates the environmental consequences of the proposed action as well as reasonable alternatives to the proposed action.

Chapter 2 of this supplemental environmental impact statement (SEIS) describes the North Anna facility and its operations, as well as the scope of the agency's proposed action and the no-action alternative. Chapter 2, Section 2.3, further describes the NRC staff's consideration of a range of reasonable alternatives to the proposed action, including the replacement power alternatives that the staff selected for detailed analysis and the supporting assumptions and data relied upon. As noted in Chapter 2, Table 2-1, the site location for the replacement power alternatives would be within the North Anna site or within Dominion's service area. Chapter 2, Table 2-2, summarizes the environmental impacts of the proposed action and alternatives to the proposed action.

In this chapter, the NRC staff first defines the affected environment as the environment that currently exists at and around the North Anna site. Because existing conditions are at least partially the result of past construction and nuclear power plant operations, this chapter considers the nature and impacts of past and ongoing actions and evaluates how, together, these actions have shaped the current environment. This chapter also describes reasonably foreseeable environmental trends. The effects of ongoing reactor operations at the site have become well established as environmental conditions have adjusted to the presence of the facility.[1] Sections 3.2 through 3.13 describe the affected environment for each resource area, followed by the staff's evaluation of the environmental consequences of the proposed action and alternatives to the proposed action. The NRC staff compares the environmental impacts of license renewal with those of the no-action alternative and replacement power alternatives to determine whether the adverse environmental impacts of subsequent license renewal (SLR) are so great that it would be unreasonable to preserve the option of subsequent license renewal for energy-planning decision-makers.

The NRC staff's evaluation of environmental consequences includes the following:

- impacts associated with continued operations similar to those that have occurred during the current license term
- impacts of various alternatives to the proposed action, including a no-action alternative (not issuing the renewed license) and replacement power alternatives (new nuclear (small modular reactor (SMR)) and a combination alternative (new nuclear, solar photovoltaic (PV), offshore wind, and demand-side management)

[1] Where appropriate, the NRC staff has summarized referenced information or incorporated information by reference into this SEIS. This allows the staff to focus on new and potentially significant information identified since initial license renewal of North Anna, Units 1 and 2, in 2003.

- impacts from the termination of nuclear power plant operations and decommissioning after the license renewal term
- impacts of the uranium fuel cycle
- impacts of postulated accidents (design-basis accidents and severe accidents)
- cumulative impacts of the proposed action
- 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
- new and potentially significant information on environmental issues related to the impacts of operation during the renewal term

As stated in Sections 1.4 and 1.5, this SEIS documents the NRC staff's environmental review of the North Anna subsequent license renewal application and supplements the information provided in NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS) (NRC 2013a). The GEIS identifies 78 issues (divided into Category 1 and Category 2 issues) to be evaluated for the proposed action in the subsequent license renewal environmental review process. Section 1.4 of this SEIS explains the criteria for Category 1 issues (generic to all or a distinct subset of nuclear power plants) and Category 2 issues (specific to individual nuclear power plants), as well as the definitions of SMALL, MODERATE, and LARGE impact significance.

For Category 1 issues, the NRC staff relies on the analysis in the GEIS unless otherwise noted. Table 3-1 lists the Category 1 (generic) issues that apply to North Anna during the proposed subsequent license renewal period. To identify any new and significant information, the staff reviewed the applicant's environmental report (ER) (Dominion 2020b), conducted a public environmental scoping process, conducted environmental site audits, and reviewed the sources referenced in this SEIS. For these Category 1 (generic) issues, the NRC staff did not identify any new and significant information that would change the conclusions of the GEIS. Therefore, there are no impacts related to the issues beyond those discussed in the GEIS (Table 3-1 and 3-2 below), as cited in Sections 3.2 to 3.13 below. Section 3.14 describes the staff's process for evaluating new and significant information.

Table 3-1. Applicable Category 1 (Generic) Issues for North Anna

ISSUE	GEIS SECTION	IMPACT
Land Use		
Onsite land use	4.2.1.1	SMALL
Offsite land use	4.2.1.1	SMALL
Visual Resources		
Aesthetic impacts	4.2.1.2	SMALL
Air Quality		
Air quality impacts (all plants)	4.3.1.1	SMALL
Air quality effects of transmission lines	4.3.1.1	SMALL
Noise		

ISSUE	GEIS SECTION	IMPACT
Noise impacts	4.3.1.2	SMALL
Geologic Environment		
Geology and soils	4.4.1	SMALL
Surface Water Resources		
Surface water use and quality (noncooling system impacts)	4.5.1.1	SMALL
Altered current patterns at intake and discharge structures	4.5.1.1	SMALL
Scouring caused by discharged cooling water	4.5.1.1	SMALL
Discharge of metals in cooling system effluent	4.5.1.1	SMALL
Discharge of biocides, sanitary wastes, and minor chemical spills	4.5.1.1	SMALL
Surface water use conflicts (plants with once-through cooling systems)	4.5.1.1	SMALL
Effects of dredging on surface water quality	4.5.1.1	SMALL
Temperature effects on sediment transport capacity	4.5.1.1	SMALL
Groundwater Resources		
Groundwater contamination and use (noncooling system impacts)	4.5.1.2	SMALL
Groundwater quality degradation resulting from water withdrawals	4.5.1.2	SMALL
Terrestrial Resources		
Exposure of terrestrial organisms to radionuclides	4.6.1.1	SMALL
Cooling system impacts on terrestrial resources (plants with once-through cooling systems or cooling ponds)	4.6.1.1	SMALL
Bird collisions with plant structures and transmission lines	4.6.1.1	SMALL
Transmission line right-of-way (ROW) management impacts on terrestrial resources	4.6.1.1	SMALL
Electromagnetic fields on flora and fauna (plants, agricultural crops, honeybees, wildlife, livestock)	4.6.1.1	SMALL
Aquatic Resources		
Entrainment of phytoplankton and zooplankton (all plants)	4.6.1.2	SMALL
Infrequently reported thermal impacts (all plants)	4.6.1.2	SMALL
Effects of cooling water discharge on dissolved oxygen, gas supersaturation, and eutrophication	4.6.1.2	SMALL
Effects of nonradiological contaminants on aquatic organisms	4.6.1.2	SMALL
Exposure of aquatic organisms to radionuclides	4.6.1.2	SMALL
Effects of dredging on aquatic resources	4.6.1.2	SMALL
Effects on aquatic resources (noncooling system impacts)	4.6.1.2	SMALL
Impacts of transmission line ROW management on aquatic resources	4.6.1.2	SMALL
Losses from predation, parasitism, and disease among organisms exposed to sublethal stresses	4.6.1.2	SMALL
Socioeconomics		
Employment and income, recreation, and tourism	4.8.1.1	SMALL

ISSUE	GEIS SECTION	IMPACT
Tax revenues	4.8.1.2	SMALL
Community services and education	4.8.1.3	SMALL
Population and housing	4.8.1.4	SMALL
Transportation	4.8.1.5	SMALL
Human Health		
Radiation exposures to the public	4.9.1.1.1	SMALL
Radiation exposures to plant workers	4.9.1.1.1	SMALL
Human health impact from chemicals	4.9.1.1.2	SMALL
Microbiological hazards to plant workers	4.9.1.1.3	SMALL
Physical occupational hazards	4.9.4.1.5	SMALL
Postulated Accidents		
Design-basis accidents	4.9.1.2	SMALL
Waste Management		
Low-level waste storage and disposal	4.11.1.1	SMALL
Onsite storage of spent nuclear fuel	4.11.1.2	SMALL
Offsite radiological impacts of spent nuclear fuel and high-level waste disposal	4.11.1.3	[a]
Mixed waste storage and disposal	4.11.1.4	SMALL
Nonradioactive waste storage and disposal	4.11.1.4	SMALL
Uranium Fuel Cycle		
Offsite radiological impacts—individual impacts from other than the disposal of spent fuel and high-level waste	4.12.1.1	SMALL
Offsite radiological impacts—collective impacts from other than the disposal of spent fuel and high-level waste	4.12.1.1	[b]
Nonradiological impacts of the uranium fuel cycle	4.12.1.1	SMALL
Transportation	4.12.1.1	SMALL
Termination of Nuclear Power Plant Operations and Decommissioning		
Termination of plant operations and decommissioning	4.12.2.1	SMALL

[a] The environmental impact of this issue for the time frame beyond the licensed life for reactor operations is contained in NUREG-2157 (NRC 2014a).

[b] There are no regulatory limits applicable to collective doses to the general public from fuel cycle facilities. The practice of estimating health effects on the basis of collective doses may not be meaningful. All fuel cycle facilities are designed and operated to meet the applicable regulatory limits and standards. The Commission concludes that the collective impacts are acceptable.

The Commission concludes that the impacts would not be sufficiently large to require the National Environmental Policy Act of 1969 (NEPA) conclusion, for any plant, that the option of extended operation under 10 CFR Part 54 should be eliminated. Accordingly, while the Commission has not assigned a single level of significance for the collective impacts of the uranium fuel cycle, this issue is considered Category 1.

Source: Table B-1 in Appendix B, Subpart A, to 10 CFR Part 51; NRC 2013a

The NRC staff analyzed the Category 2 (site-specific) issues applicable to North Anna during the proposed license renewal period and assigned impacts to these issues as shown in Table 3-2.

Table 3-2. Applicable Category 2 (Site-Specific) Issues for North Anna

ISSUE	GEIS SECTION	IMPACT[a]
Groundwater Resources		
Radionuclides released to groundwater	4.5.1.2	SMALL
Terrestrial Resources		
Effects on terrestrial resources (noncooling system impacts)	4.6.1.1	SMALL
Aquatic Resources		
Impingement and entrainment of aquatic organisms (plants with once-through cooling systems or cooling ponds)	4.6.1.2	SMALL
Thermal impacts on aquatic resources (plants with once-through cooling systems or cooling ponds)	4.6.1.2	SMALL
Special Status Species and Habitats		
Threatened, endangered, and protected species and essential fish habitat	4.6.1.3	May affect, but is not likely to adversely affect northern long-eared bat
Historic and Cultural Resources		
Historic and cultural resources	4.7.1	Would not adversely affect historic properties
Human Health		
Microbiological hazards to the public (plants with cooling ponds or canals or cooling towers that discharge to a river)	4.9.1.1.1	SMALL
Chronic effects of electromagnetic fields[b]	4.9.1.1.1	Uncertain impact
Electric shock hazards	4.9.1.1.1	SMALL
Postulated Accidents		
Severe accidents	4.9.1.2	See Appendix F of this SEIS
Environmental Justice		
Minority and low-income populations	4.10.1	No disproportionately high and adverse human health and environmental effects on minority and low-income populations
		No disproportionately high and adverse human health impacts would be expected in special pathway receptor populations in the region because of subsistence consumption of water, local food, fish, and wildlife
Cumulative Impacts		
Cumulative impacts	4.13	Not applicable

ISSUE	GEIS SECTION	IMPACT[(a)]

[(a)] Impact determinations for Category 2 issues are based on findings described in Sections 3.2 through 3.13 below, as applicable, for the proposed action.

[(b)] This issue was not designated as Category 1 or Category 2 and is discussed in Section 3.11.6.2 below.

Source: Table B-1 in Appendix B, Subpart A, to 10 CFR Part 51; NRC 2013a

3.2 Land Use and Visual Resources

This section describes the land uses and visual resources in the vicinity of the North Anna site. Following this description, the staff analyzes the potential impacts on land use and visual resources from the proposed action (SLR) and alternatives to the proposed action. Section E3.2 of Dominion's ER (Dominion 2020b) describes North Anna's current onsite and offsite land use conditions as well as visual resources.

3.2.1 Land Use

As described in Section 2.1.1 of this SEIS, the North Anna site lies on the borders of Louisa and Spotsylvania counties in northeastern Virginia. The site is located within a triangle formed by the cities of Richmond, Charlottesville, and Fredericksburg, VA (see Figure 2-1). The sections below describe onsite and offsite (within a 6-mile (mi) (10-kilometer (km)) radius) land uses in the affected area. This section also describes the Virginia coastal zone, with an emphasis on the statutory and regulatory provisions that govern its use.

3.2.1.1 Onsite Land Use

According to Dominion (2020b), North Anna Units 1 and 2 are located on a peninsula on the southern shore of Lake Anna, an inland freshwater reservoir created to provide cooling water for the nuclear reactors. Most of the site sits in rural Louisa County, VA, with a portion extending into neighboring Spotsylvania County, VA. See Figure 3.2-1 in Dominion's ER (Dominion 2020b: p. E-3-20), which is incorporated here by reference.

The North Anna site consists of 1,803 acres (ac) (730 hectares (ha)) of which 760 ac (307 ha) are covered by water. Louisa County has zoned the site as I–2, "industrial general zoning district," which allows for utility service. As illustrated in Figure 3.2-1 in Dominion's ER (2020b: p. E-3-20), deciduous, evergreen, and mixed forest types together comprise about 37 percent of the land use cover on the North Anna site. The next largest land use category is open water at 34 percent. The third largest land use category is developed land (to support power plant operations), which totals 16 percent of the site. The remaining 13 percent of the site consists of barren land, shrub/scrub, grassland/herbaceous, pasture/hay, cultivated crops, and wetlands (Dominion 2020b).

The Virginia Electric and Power Company (VEPCO) (now Dominion) created Lake Anna in 1972 by damming the North Anna River (Dominion 2020c). Outside the North Anna site boundary, the shores of the lake are dotted with homes and communities as the land adjacent to the lake has become increasingly residential. Dominion has granted revocable permits to private landowners to erect docks on the Lake Anna shoreline within North Anna site boundaries. A portion of the waste heat treatment facility (WHTF) also lies within the North Anna site. Property owners and their guests, although not the general public, have access to lands above the fluctuating water level of the waste heat treatment cooling lagoons. Boaters on the North Anna Reservoir have access to some waters within North Anna site boundaries. Dominion has placed floating buoys supporting "No Trespassing" signs on North Anna's Lake Anna security buoy barriers (Dominion 2020b). Boaters in the North Anna Reservoir cannot access the waters of the waste heat treatment lagoons, as the two areas are divided by dikes.

In 2003, Dominion submitted an application for an early site permit (ESP) in for construction and operation of one or more new nuclear generating units. The NRC issued a final EIS in support of its review of the ESP in 2006 (NUREG-1811 (NRC 2006)). The NRC then issued the requested ESP in 2007 (NRC 2007). Also in 2007, Dominion submitted a combined license (COL) application for North Anna Unit 3, a new light-water reactor that Dominion proposed building on the North Anna site west of and adjacent to Units 1 and 2.

North Anna Unit 3 would have a footprint of 120 ac (49 ha) and would also use a 96 ac (38.8 ha) tract of land northwest of and contiguous with the North Anna site for construction-related activities. The NRC issued a final SEIS for the North Anna Unit 3 COL in 2010 (NUREG-1917 (NRC 2010)) and issued the COL to Dominion in 2017 (NRC 2017b). In its ER for subsequent license renewal, Dominion stated that it is not pursuing development of and has made no decision to proceed with construction with North Anna Unit 3 (Dominion 2020b).

3.2.1.2 Coastal Zone

Section 307(c)(3)(A) of the Coastal Zone Management Act (CZMA) (16 U.S.C. 1456(c)(3)(A)) requires that applicants for Federal licenses who conduct activities in a coastal zone provide a certification to the licensing agency (here, the NRC) that the proposed activity complies with the enforceable policies of the State's coastal zone program. The Federal regulations that implement the CZMA indicate that this requirement is applicable to renewal of Federal licenses for actions not previously reviewed by the State (15 CFR 930.51(b)(1)). North Anna, located in Louisa County, VA, does not lie within the Virginia coastal zone designated as Tidewater Virginia (VDEQ 2020a: Chapter 7.6). However, neighboring Spotsylvania County (and sections of Lake Anna that lie within it), do lie within the Virginia coastal zone. As a result of this proximity, Dominion is required to provide CZMA certification for the proposed action. The Virginia Department of Environmental Quality (VDEQ) is the lead agency for the Virginia Coastal Zone Management Program and is responsible for coordinating the Commonwealth of Virginia's review of Federal consistency determinations and certifications with cooperating agencies and for responding to the appropriate Federal agency or applicant (VDEQ 2021).

In a letter dated October 1, 2019, Dominion submitted a CZMA consistency certification package to VDEQ in support of the subsequent renewal of the North Anna operating licenses. On December 23, 2019, VDEQ submitted its completed review and analysis of Dominion's Federal consistency certification package. VDEQ concurred that Dominion's proposal is consistent with the enforceable policies of Virginia's Coastal Zone Management Program, provided all applicable permits and approvals are obtained (Dominion 2020b: Attachment E).

3.2.1.3 Offsite Land Use

This section describes offsite land use within a 6-mi (10-km) radius of the North Anna site boundary. This radius includes portions of Louisa and Spotsylvania counties. Lake Anna is the predominant natural feature. According to Dominion (2020b), the largest land use and land cover categories in the 6-mi (10-km) radius are forest (48 percent), open water (14 percent), and developed land (7.6 percent).

Louisa County is primarily rural agricultural, with agriculture and forestry as its dominant land uses. The county maintains a rural character by promoting small towns, historical towns, villages, and open spaces (Louisa County 2019). In contrast, neighboring Spotsylvania County is one of Virginia's fastest growing counties because of its military bases and proximity to Washington, DC, and Richmond, VA. The highest population densities occur along the Interstate-95 corridor and near Fredericksburg, VA (approximately 25 mi (40 km) from the site).

The primary land use in Spotsylvania County is rural residential (Dominion 2020b). Section 15.2-223 of the Code of Virginia requires each county in Virginia to have a comprehensive plan for its physical development. In 2019, Louisa County issued its County of Louisa Comprehensive Plan 2040 (Louisa County 2019); Spotsylvania County issued its comprehensive plan in 2013 with updates in 2016 and 2018 (Spotsylvania County 2018). In addition, the Lake Anna Special Area Plan issued in 2000 seeks to improve the quality of water in the lake and its tributaries with a coordinated watershed program, maintain the rural character of the lake area by concentrating public service activities and commercial development in village centers, and upgrade transportation around the lake to support the growing population and provide safe evacuation routes (Lake Anna 2000).

According to the County of Louisa Comprehensive Plan 2040, "Gold mining took place in Louisa County until the end of the nineteenth century…Other minerals found in the County include silver, copper, lead, mica, sandstone, iron ore, zinc, granite, vermiculite, and quartz. Due to the variety of bedrock types within Louisa County, a host of economic rock and mineral resources are available within the County and continue to be part of the local economy" (Louisa County 2019). However, there are currently no mining activities within 10 mi (16 km) of the plant (Dominion 2020b). The NRC staff is not aware of any plans to mine or explore for subsurface minerals within 10 mi (16 km) of the North Anna site. Dominion states that there no anticipated plans to explore for subsurface minerals within the plant site boundary (Dominion 2020b).

Lake Anna is approximately 17-mi (27-km) long and is divided into two major portions: the North Anna Reservoir and the waste heat treatment facility (WHTF). The closest publicly accessible property to the North Anna site is Lake Anna State Park, about 5 mi (8 km) northwest of the site. The park is 3,127 ac (1,265 ha) and includes 10 mi (16 km) of shoreline. Park amenities include overnight cabins and camping, a swimming beach, a fishing pond, fishing and boating access, and hiking trails (VDCR 2021). Over 400,000 people visited Lake Anna State Park in 2016 (VDCR 2017a).

3.2.2 Visual Resources

The North Anna site is located at the northern boundary of Louisa County, VA, on the south side of Lake Anna. Developed areas of the North Anna site are not generally visible from public roads in Louisa County. According to Dominion (2020b), plant buildings are set back from public roads and hidden from view by heavy forest cover. North Anna buildings are visible when viewed from the north or northeast direction; for example, by boaters on Lake Anna. However, the buildings are set back from the edge of the lake. The tallest structures are the reactor containment buildings, at approximately 191 feet (ft) (58 meters (m)). Other prominent structures include the turbine buildings and the transmission lines (Dominion 2020b).

3.2.3 Proposed Action

As identified in Table 3-1, the impacts of all generic land use or visual resource issues for the proposed action of licensing North Anna for an additional 20 years of operation would be SMALL. The NRC staff did not identify any applicable site-specific (Category 2) land use or visual resource issues, as shown in Table 3-2.

3.2.4 No-Action Alternative

3.2.4.1 Land Use

Under the no-action alternative, the NRC would not issue subsequent renewed licenses, and North Anna would shut down on or before the expiration of the current renewed operating licenses in 2038 and 2040. Onsite land would remain occupied by existing plant facilities until the licensee completes decommissioning. According to Dominion (2020b), decommissioning could take up to 60 years after the permanent shutdown of North Anna. Most transmission lines would remain in service after the plant stops operating. Maintenance of most existing infrastructure would continue. The NRC staff concludes that the land use impacts from the termination of North Anna Units 1 and 2 operations would be SMALL.

3.2.4.2 Visual Resources

Shutdown of North Anna Units 1 and 2 would not significantly change the visual appearance of the site. The most visible structures at the site are the containment buildings, and they would likely remain in place for some time during decommissioning until they are eventually dismantled. Overall, the NRC staff concludes that the impacts of the no-action alternative on visual resources would be SMALL.

3.2.5 Replacement Power Alternatives: Common Impacts

3.2.5.1 Land Use

The NRC staff's analysis of common land use impacts focuses on the amount of land area that would be affected by the construction and operation of a replacement power plant on the North Anna site.

<u>Construction</u>

Construction of a replacement power facility on the North Anna site would likely require the dedication of all land areas on the site. Existing North Anna transmission lines and infrastructure (e.g., roads, fences, water and sewage lines), with any necessary refurbishment, would adequately support each of the onsite replacement power alternatives, thus reducing the need for additional land commitments. Dominion could also use the 96 ac (38.8 ha) of largely cleared land adjacent to the North Anna site that it purchased to support construction of proposed North Anna Unit 3 (NRC 2010).

<u>Operations</u>

Operation of new power plants on the North Anna site would have no land use impacts beyond land committed for the permanent use of the replacement power plant. Additional land may be required to support power plant operations, including land for mining, extraction, and waste disposal activities associated with each alternative.

3.2.5.2 Visual Resources

The NRC staff's visual impact analysis focuses on the degree of contrast between the replacement power plant and the surrounding landscape and the visibility of the new power plant.

<u>Construction</u>

Land for any replacement power plant would require clearing, excavation, and the use of construction equipment. Temporary visual impacts may occur during construction from cranes and other construction equipment. If Dominion uses the additional 96 ac (39 ha) tract of land originally purchased to support construction of proposed Unit 3, that would also affect visual impacts. The tract contains a mixture of deciduous and pine forests and meadows that would be cleared for the construction of Unit 3 or other replacement power plant.

Operations

Visual impacts during plant operations of any of the onsite replacement power alternatives would be similar in type and magnitude. For the new nuclear facility components, new mechanical cooling towers and their associated vapor plumes would be the most obvious visual impact and would likely be visible farther from the site than other buildings and infrastructure. New plant stacks or towers may require aircraft warning lights, which would be visible at night.

3.2.6 New Nuclear (Small Modular Reactor) Alternative

3.2.6.1 Land Use

Construction

Approximately 200 ac (81 ha) of previously developed and undeveloped land on the North Anna site west of and adjacent to Units 1 and 2 would be needed to construct a cluster of five small modular reactors (SMRs) for a new nuclear replacement alternative. The NRC previously licensed this land for the construction of proposed North Anna Unit 3 (which remains unbuilt) in an early site permit (ESP) (NRC 2006). Of these 200 ac (81 ha), 120 ac (49 ha) are developed land and 80 ac (32 ha) are forested (NRC 2010). The NRC staff assumes a similar area would be temporarily disturbed for the construction of the five SMRs. A few small wetland areas and two intermittent streams exist on the Unit 3 ESP site, and Dominion represents that any work with the potential to impact a wetland would be performed in accordance with regulatory requirements. The new cluster of five SMRs would use existing North Anna infrastructure and transmission lines. Considering the information above, including the NRC's earlier analysis of land use impacts for Unit 3 (which were determined to be SMALL (NRC 2010)), the NRC staff concludes that land use impacts from the construction of a new nuclear alternative of five SMRs would be SMALL at the North Anna site because the land is already zoned for industrial use and the site has been used for many years by Units 1 and 2 to generate electricity.

Operations

For the onsite land use impacts of the operation of five new SMRs, proposed Unit 3 offers a relevant comparison for discussion. The environmental impact statement (EIS) for Unit 3 indicates that a 120-ac (49-ha) operations footprint onsite would be permanently disturbed (NRC 2010). The NRC staff estimates the operations footprint for the cluster of five SMRs would be approximately 42-percent larger at 170 ac (69 ha) (see Table 2-1). However, this larger operations area would still fall within North Anna site boundaries. Offsite land use impacts associated with uranium mining and fuel fabrication needed to support nuclear power plant operations would generally be similar to the amount of land needed to support North Anna Units 1 and 2 continued operations, although more land would be required for mining additional uranium for up to 40 years of operation. Based on this information, the NRC staff concludes that the onsite and offsite land use impacts from operating a new nuclear power plant of five SMRs could range from SMALL to MODERATE, depending on how much additional land may be needed for uranium mining and fuel fabrication.

3.2.6.2 Visual Resources

Construction and Operations

Visual impacts from a new nuclear alternative would be similar to the common impacts of all replacement power alternatives described in Section 3.2.5.2, "Visual Resources." Construction activities and equipment such as cranes could be visible from Lake Anna, but these would be temporary and in character for an industrial site (Dominion 2020b). During operations, the visual appearance of the power block for the new five SMRs would differ from that of the existing North Anna Unit 1 and 2 power blocks. First, there would be a 30-ft (9-m) height reduction in the new five SMR plant profile. Currently, the tallest structures for Units 1 and 2 are the reactor containment buildings at 191 ft (58 m) in height. At the new five small modular reactor plant, the tallest structures would be the power blocks at 160 ft (50 m), resulting in a smaller visual impact. However, the new five SMR plants would require construction of 65-ft (20m)-tall mechanical draft cooling towers, which would increase the visual impact in two ways: by adding new tall structures to the site and by producing water vapor plumes that could be visible from great distances. In total, the NRC staff concludes that visual impacts during the construction and operation of a new nuclear power plant at the North Anna site, including cooling tower plumes that could be visible from great distances, depending on seasonal weather conditions, could range from SMALL to MODERATE.

3.2.7 Combination Alternative (Solar, Offshore Wind, Small Modular Reactor, and Demand-Side Management)

3.2.7.1 Land Use

Construction and Operation

The solar portion of the combination alternative would require eight utility-scale solar plants with a total area of 20,000 ac (8,000 ha) of land, with additional land required for construction staging and laydown. Each unit would be off site, but in the North Anna region of influence and with access to Dominion transmission systems. Impacts on land use would depend largely on the land chosen for the solar installations. For example, if the land were previously cleared and used for industrial activity, the impacts on land use would be less significant than if the land were undisturbed forest containing important habitats or near residential or recreational areas. Adding to the land use impact is the fact that standalone solar photovoltaic facilities cannot be co-located with other land uses (e.g., grazing and crop-producing agriculture). The NRC staff concludes that land use impacts from the solar portion of the combination alternative could range from MODERATE to LARGE, depending on the type of land and the location of the land chosen for the construction and operation of the eight solar installations.

Although almost all construction and operation activities for the offshore wind portion of the combination alternative would occur offshore, some onshore land use resources would still be impacted, mainly during construction. In 2020, Dominion completed the pilot portion of Coastal Virginia Offshore Wind project—two operational 6MW wind turbines, 27 m (43 km) off the coast of Virginia Beach, VA. Dominion plans to follow this with the commercial portion of the project—an 852-megawatt (MW) utility-scale offshore wind facility operating by 2026 with two more 852 MW tranches coming online in 2027 (Dominion 2020b). The Coastal Virginia Offshore Wind project is in an area off the coast of Cape Henry, VA, a cape on the northeast corner of Virginia Beach. Virginia Beach City has 38 mi (61 km) of coastline, six public beaches, several local and State parks, and the Back Bay National Wildlife Refuge. It includes important habitats, such as dunes, tidal marshes, nontidal wetlands, and maritime forests. The area's economy is dependent on tourism and recreation. Construction of offshore wind facilities can disturb beaches, dunes, coastal wetlands, and bays during the installation of onshore components, such as interconnection cables, fiber optic cables, switch cabinets, and interconnection stations. Habitat loss may result directly from excavation or indirectly from pollutants from drilling fluids. Erosion may also occur along the cable route and reestablishment of vegetation cover could be slow and cause losses of dune habitat (BOEM 2015).

However, Virginia Coastal Zone Management Program regulations prohibit onshore facilities near sensitive coastal resources, and this will greatly mitigate impacts on land resources during construction. For the pilot portion of the Coastal Virginia Offshore Wind project, Dominion limited onshore construction activities to disturbed areas such as parking lots, roadways, and ROWs to minimize disruption to sensitive shoreline (BOEM 2015). The NRC expects Dominion will continue to comply with Virginia Coastal Zone Management Program regulations and accordingly limit the onshore construction for the commercial portion of the project to disturbed areas. Dominion has proposed that cables for the commercial portion of an offshore wind facility make landfall at the State Military Reservation in Virginia Beach (Camp Pendleton), thus avoiding impacts on shore areas dependent on tourism (CVOW 2021) or shore areas that are relatively undisturbed by human activity. During operations, Dominion would need additional land for onshore facilities to support routine maintenance and other activities. However, it would likely locate these facilities at existing waterfront industrial or commercial sites, resulting in minimal land use impacts (BOEM 2015). Because onshore construction will occur on previously disturbed areas and Dominion has proposed landfall and installation of onshore components on the State Military Reservation, the NRC staff concludes that the impacts on land use from the construction and operation of an offshore wind facility would be SMALL to MODERATE.

The land use impacts for the SMR portion of the combination alternative would be similar to but less than the land use impacts described above in Section 3.2.6.1 for the new nuclear alternative. Under the combination alternative, the licensee would construct and operate only one SMR requiring 36 ac (14 ha) of land, as opposed to a cluster of five SMRs requiring 170 ac (69 ha) of land. Onsite land use impacts from construction and operation of one SMR at the North Anna ESP site would be SMALL, as the land is already zoned for industrial use and is close to the existing North Anna plant. Offsite land use impacts associated with uranium mining and fuel fabrication needed to support the one SMR would likely be less than the amount of land needed to support North Anna Units 1 and 2 operations, although more land may be required for mining additional uranium for up to 40 years of operation. Based on this information, the NRC staff concludes that onsite and offsite land use impacts from the construction and operation of one SMR as part of the combination alternative would be SMALL. The NRC staff has not identified any land use impacts associated with demand-side management.

The NRC staff concludes that overall land use impacts of the combination alternative would be SMALL to LARGE, due to the large area of land required for the solar portion of the alternative and depending on the types of land chosen for the solar plant sites.

3.2.7.2 Visual Resources

Construction and Operations

Utility-scale solar photovoltaic facilities require clearing large areas of land, which can significantly affect visual resources. For the solar portion of the combination alternative, the NRC staff estimates approximately 20,000 ac (8,000 ha) of land for eight solar facilities would be required within the North Anna region of influence with access to existing Dominion transmission lines. Based on the topography, size, and location of the land chosen, the NRC staff concludes that the construction and operation of eight solar PV facilities as part of the combination alternative would have a MODERATE to LARGE impact on visual resources.

For offshore wind facilities, the location, size, and number of turbines greatly affect the visual impact. While some visual impacts will occur during construction, these will be temporary and most visual impacts will occur during operations. Depending on viewing conditions, small to moderately sized turbines placed up to 26 mi (42 km) from the coast can be visible from the shore (Sullivan et al. 2013). When visible, offshore wind turbines can negatively affect tourism and property values—important considerations for the tourism-dependent Virginia coast. In

2020, Dominion completed the pilot portion of its Coastal Virginia Offshore Wind project, which consists of two 6MW turbines placed 27 mi from Virginia Beach—too far to be seen from the coast. The commercial portion of the Coastal Virginia Offshore Wind project will have far greater visual impacts. Dominion estimates it will place 188 wind turbines (CVOW 2021) in a 138,788 ac (56,165 ha) leased rectangular area (BOEM 2013 that lies 21–43 mi (34–69 km) east off the coast of Virginia Beach (BOEM 2012003). Dominion states it will place the turbines 27 mi (43 km) from shore (CVOW 2021). However, unless all 188 turbines are lined up in a row, the NRC assumes some turbines will be closer to shore and others farther, anywhere within the 21–43 mi (34–69 km) from the shore that defines the front and back boundaries of the leased area. As stated earlier, a small-to-moderately sized turbine can be visible up to 26 mi (42 km) from the coast (Sullivan et al. 2013). Depending on placement, there is the possibility that some of Dominion's turbines could be visible from the Virginia Beach shore.

The NRC staff estimates that 72 utility-scale wind turbines would be required to generate the offshore wind portion of the combination alternative, and that the turbines would be similar to the commercial turbines Dominion plans to use in the CVOW project. Dominion's commercial turbines are much larger than the pilot project turbines. For its commercial turbines, Dominion has conditionally selected a 14-MW turbine model with a height of 800 ft (245 m) and rotor diameter of 722 ft (222 m) (CVOW 2021). These are approximately 200 ft (61 meters) taller and 236 ft (72 m) wider than the 6 MW pilot project turbines. Because of the much larger size of the utility-scale commercial wind turbines, the number of turbines (72), the variability of distance from the shore of an important coastal area, and the scenic importance of the Virginia Beach coastal area, the NRC staff concludes that the construction and operation of the offshore wind portion of the combination alternative would have a MODERATE impact on visual resources occurring mainly during operation.

Visual impacts from one SMR constructed and operated as part of the combination alternative would be similar to those described in Section 3.2.6.2, "Visual Resources," for the impacts from the new nuclear replacement power alternative of five SMRs. Construction could be visible from Lake Anna (Dominion 2020b). Two new tall structures would be built, but both would be shorter than the Units 1 and 2 reactor containment buildings. During operations, the mechanical draft cooling towers would produce water vapor plumes that could be visible from great distances and add to the visual impact. Therefore, the NRC staff concludes that visual impacts during the construction and operation of one SMR as part of the combination alternative, including vapor plumes that could be visible from great distances, depending on seasonal weather conditions, could range from SMALL to MODERATE.

The NRC staff has not identified any visual impacts associated with demand-side management. The NRC staff concludes that the visual impacts from the construction and operation of the combination alternative could range from SMALL to LARGE, based on the visual impact of the offshore wind and solar components of the alternative.

3.3 Meteorology, Air Quality, and Noise

This section describes the meteorology, air quality, and noise environment in the vicinity of North Anna. The description of the resources is followed by the staff's analysis of the potential air quality and noise impacts from the proposed action (SLR) and alternatives to the proposed action.

3.3.1 Meteorology and Climatology

Virginia has a generally humid climate characterized by very warm summers and moderately cold winters. However, substantial regional variations in temperature and precipitation patterns occur due to the State's diverse geographic features. Specifically, the influence of the Appalachian Mountains and Blue Ridge Mountains result in the western and northern portions of the State being relatively cooler and drier. In east-central Virginia, the mountains act as a barrier to outbreaks of cold, continental air in winter (NCDC 2020). The Chesapeake Bay and Atlantic Ocean contribute to humid summers and mild winters. Precipitation is uniformly distributed throughout the year, but there is variability in total monthly amounts from year to year.

The NRC staff obtained climatological data from the Richmond International Airport weather station (Richmond weather station). This station is approximately 55 mi (88 km) from North Anna, and the NRC staff used this weather station to characterize the region's climate because of its relatively nearby location and long period of record. Dominion also maintains a meteorological monitoring system comprised of a primary and a backup meteorological tower (Dominion 2020b). The primary meteorological tower is located east of Unit 1 and 2 and measures wind speed, wind direction, horizontal wind direction fluctuation, ambient temperature, differential temperature, dew point, and precipitation. The backup tower is located approximately 1,300 ft (396 m) northeast of the Unit 1 reactor and measures wind speed, wind direction, ambient temperature, and horizontal wind direction. In its environmental report, Dominion provided meteorological observations from the North Anna site (Dominion 2020b) for the 1988–2017 period. The staff evaluated these data in context with the climatological record from the Richmond International Airport weather station.

The mean annual temperature for the 99-year period of record (1920–2019) at the Richmond weather station is 58.4 degrees (°) Fahrenheit (F) (12.7 °Celsius (C)), with the mean monthly temperature ranging from a low of 37.9 °F (3.2 °C) in January and a high of 78.5 °F (25.8 °C) in July (NCDC 2020). The mean annual temperature from the North Anna onsite meteorological tower is 51.7 °F (10.9 °C), with a mean monthly temperature ranging from a low of 36.2 °F (2.3 °C) in January to a high of 77.1 °F (25.1 °C) in July (Dominion 2020b).

The average annual total precipitation for the 99-year period of record (1920–2019) at the Richmond weather station is 43.5 in. (110.5 cm), with mean monthly precipitation ranging from a low of 2.87 in. (7.3 cm) in February, to a high of 4.98 inches (in.) (12.6 centimeters (cm)) in July (NCDC 2020). The mean total annual precipitation from the North Anna onsite meteorological tower is 31 in. (78.7 cm), with a mean monthly precipitation ranging from a low of 1.79 in. (4.5 cm) in February, to a high of 3.55 in. (9.0 cm) in August (Dominion 2020b).

The mean annual wind speed during a 36-year period of record at the Richmond weather station is 7.7 miles per hour (mph) (3.4 m/second (m/s)), with prevailing winds being from the south-southwest (NCDC 2020). The mean annual wind speed from the North Anna onsite meteorological tower is 5.4 mph (2.4 m/s), with prevailing wind direction from the south-southwest (Dominion 2020b).

Virginia is subject to occasional extreme weather events, including severe thunderstorms, tornadoes, winter storms, tropical storms, hurricanes, droughts, and heat waves (Runkle et al. 2017; NOAA 2013a). The following severe weather events have been reported in Louisa County from January 1950 to September 2020 (NCEI 2020):

- Tornado: 11 events
- Flood: 7 events

- Heavy rain: 56 events
- Thunderstorm: 169 events

3.3.2 Air Quality

Under the Clean Air Act (CAA) of 1963, as amended, 42 U.S.C 7401, et seq., the U.S. Environmental Protection Agency (EPA) has set primary and secondary National Ambient Air Quality Standards (NAAQS), 40 CFR Part 50, “National Primary and Secondary Ambient Air Quality Standards”) 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 non-attainment with respect to meeting NAAQS. Areas for which there are insufficient data to determine attainment or non-attainment are designated as unclassifiable. Areas that were once in non-attainment, but are now in attainment, are called maintenance areas; these areas are under a 10-year monitoring plan to maintain the attainment designation status. States have primary responsibility for ensuring attainment and maintenance of the NAAQS. Under Section 110 of the Clean Air Act (42 U.S.C. 7410) and related provisions, States are to submit, for EPA approval, State implementation plans that provide for the timely attainment and maintenance of the NAAQS.

In Virginia, air quality designations are made at the county level. For the purpose of planning and maintaining ambient air quality with respect to the NAAQS, EPA has developed air quality control regions. Air quality control regions are intrastate or interstate areas that share a common airshed. North Anna is located primarily in Louisa County, VA, with a portion of the site extending into neighboring Spotsylvania County, VA. Louisa County and Spotsylvania County are within the Northeastern Virginia Intrastate Air Quality Control Region (40 CFR 81.144). With regards to NAAQS, EPA designates Louisa County and Spotsylvania County in attainment for all criteria pollutants (40 CFR 81.347).

The Virginia Department of Environmental Quality regulates air emissions at North Anna under a State Operating Permit (Air Permit No. 40726). Table 3-3 lists permitted air pollutant emission sources and air permit-specific conditions. In 2019, the North Anna State Operating Permit was amended to remove two auxiliary boilers, and therefore cease operations of these two boilers (VDEQ 2019a). Dominion submits annual emission reports to VDEQ in accordance with the State Operating Permit. Dominion reports that is has not received any notices of violation between 2013 and 2019 (Dominion 2020b). The NRC staff’s review of EPA’s Enforcement and Compliance History Online system 3-year compliance history (April 2018 through December 2020), revealed no notices of violation and no permit exceedances (EPA 2021).

Table 3-3. Permitted Air Emissions Sources at North Anna Power Station, Units 1 and 2

Equipment	Air Permit Condition
One (1) blackout diesel generator	PM_{10}: 1.8 pounds (lbs)/hour, 1.0 tons/year SO_2: 18.5 lbs/hour, 4.6 tons/year NO_2: 157.2 lbs/hour, 39.3 tons/year CO: 29.9 lbs/hour, 10.4 tons/year VOC 6.7 lbs/hour, 1.7 tons/year Opacity: <20% except for one 6-minute period of not more than 30% opacity

Equipment	Air Permit Condition
Four (4) Emergency Diesel Generators	NO_2: 112.4 lbs/hour/engine, 3.2 lbs/MMBtu/engine, 56.2 tons/year

Key: CO= carbon monoxide, NO_x= nitrogen oxide, PM= particulate matter, PM_{10}= particulate matter less than 10 microns, $PM_{2.5}$= particulate matter less than 2.5 microns, SO_2= sulfur dioxide, VOC= volatile organic compounds lbs/MMBtu= pounds per million British thermal unit

Source: VDEQ 2002, VDEQ 2019a

In addition to the air-permitted sources listed in Table 3-3, North Anna has one emergency generator, one diesel generator, and two fire pump diesel generators that are exempt from air-permitting conditions (unpermitted sources). These air emission sources are listed in the State Operating Permit and are considered insignificant equipment emission units of minimal or no air quality concern, in accordance with VAC 5-80-720 (VDEQ 2002, VDEQ 2019a).

Table 3-4 shows annual emissions from the four emergency diesel generators and the blackout diesel generator at North Anna. The contribution of air emissions from sources at North Anna constitutes less than 1 percent of annual emissions from either Louisa County or Spotsylvania County. Section 3.5.13 of this SEIS discusses greenhouse gas (GHG) emissions from North Anna operations.

Table 3-4. Reported Air Pollutant Emissions from North Anna Units 1 and 2

North Anna Emissions (tons/yr)					
Year	**SO_2**	**NO_x**	**CO**	**PM_{10}**	**VOCs**
2014	0.1	9.7	2.4	0.2	0.3
2015	0.05	11.9	3.0	0.2	0.3
2016	0.07	14.2	3.7	0.2	0.4
2017	.04	10.1	2.5	0.2	0.3
Louisa County Emissions (tons/year)					
2017	38	1,301	10,452	1,544	NA
Spotsylvania County Emissions (tons/year)					
2017	53	2,256	18,099	1,238	NA

Key: CO = carbon monoxide, NO_x = nitrogen oxides, SO_2 = sulfur dioxide, PM_{10} = particulate matter less than 10 micrometers, VOC = volatile organic compounds

To convert tons per year to metric tons per year, multiply by 0.90718.

Source for North Anna Air Emissions: Dominion 2020b; Source for Louisa and Spotsylvania County Emissions: EPA 2020a

EPA promulgated the Regional Haze Rule to improve and protect visibility in national parks and wilderness areas from haze, which is caused by numerous, diverse air pollutant sources located across a broad region (40 CFR 51.308–309). Specifically, 40 CFR Part 81, Subpart D, "Identification of Mandatory Class I Federal Areas Where Visibility Is an Important Value," lists mandatory Federal areas where visibility is an important value. The Regional Haze Rule requires States to develop State Implementation Plans to reduce visibility impairment at Class I Federal Areas. There are two Class 1 Federal Areas in Virginia: Shenandoah National Park and James River Face Wilderness, approximately 60 mi (96 km) and 75 mi (121 km), respectively, from North Anna. Federal land management agencies that administer Federal Class I areas consider an air pollutant source that is located greater than 31 mi (50 km) from a Class I area to have negligible impacts with respect to Class I areas if the total SO_2, NO, PM_{10}, and sulfuric acid annual emissions from the source are less than 500 tons per year (70 FR 39104; NRR 2010). Given the distance of North Anna to Class I areas and the air emissions presented in Table 3-4, there is little likelihood that ongoing activities at North Anna adversely affect air quality in any such designated area.

3.3.3 Noise

Noise can be unwanted sound and can be generated by many sources. Sound intensity is measured in logarithmic units called decibels (dB). A dB is the ratio of the measured sound pressure level to a reference level equal to a normal person's threshold of hearing. Most people barely notice a difference of 3 dB or less. Another characteristic of sound is frequency or pitch. Noise may be composed of many frequencies, but the human ear does not hear very low or very high frequencies. To represent noise as closely as possible to the noise levels people experience, sounds are measured using a frequency-weighting scheme known as the A-scale. Sound levels measured on this A-scale are given in units of A-weighted decibels (dBA). Levels can become annoying at 80 dBA and very annoying at 90 dBA. To the human ear, each increase of 10 dBA sounds twice as loud (EPA 1981).

Several different terms are commonly used to describe sounds that vary in intensity over time. The equivalent sound intensity level (Leq) represents the average Leq over a specified interval, often 1 hour. The day-night sound intensity level is a single value calculated from hourly Leq over a 24-hour period, with the addition of 10 dBA to sound levels from 10 p.m. to 7 a.m. This addition accounts for the greater sensitivity of most people to nighttime noise. Statistical sound level (Ln) is the sound level that is exceeded "n" percent of the time during a given period. For example, L90, is the sound level exceeded 90 percent of time and is considered the background level.

As discussed in Section 3.2.1.1, North Anna is designated as an industrial district, and the vicinity of the site is designated as industrial, agricultural, commercial, or residential. Louisa County has a noise ordinance that limits daytime sound levels to 75 dB and nighttime sound levels to 65 dB, measured at the property boundary, for industrial zoning districts. Primary offsite noise sources in the vicinity of North Anna include boats and recreational activities on Lake Anna and vehicular traffic. The nearest resident is located approximately 0.9 mi (1.4 km) north-northeast from North Anna (Dominion 2020b). Primary noise sources at North Anna include turbine generators, transformers, loudspeakers, transmission lines, firing range, emergency diesel generators, and main steam safety valves. Between 2013 and 2020, North Anna received one noise complaint due to a 24-hour emergency diesel generator test run during an outage (Dominion 2020b, Dominion 2021a). If planned potential noise generating activities are scheduled, Dominion may make a public announcement to local media to inform the public of the activity (Dominion 2020b). Dominion does not anticipate refurbishment activities during the proposed subsequent relicensing term. Therefore, the NRC staff expects that noise sources and emissions would remain similar to those currently present at North Anna.

3.3.4 Proposed Action

3.3.4.1 Air Quality

As described in the GEIS (NRC 2013a) and as cited in Table 3-1 for generic issues related to air quality, the impacts of nuclear power plant license renewal and continued operations would be SMALL. The NRC staff's review did not identify any new and significant information that would change the conclusion in the GEIS. Thus, as concluded in the GEIS, for these Category 1 (generic) issues, the impacts of continued operation of North Anna on air quality would be SMALL. There are no site-specific (Category 2) air quality issues applicable to North Anna (Table 3-2).

3.3.4.2 Noise

As described in the GEIS (NRC 2013a) and as cited in Table 3-1 for generic issues related to noise, the impacts of nuclear power plant license renewal and continued operations would be SMALL. The NRC staff's review did not identify any new and significant information that would change the conclusion in the GEIS. Thus, as concluded in the GEIS, for these Category 1 (generic) issues, the impacts of continued operation of North Anna on noise would be SMALL. There are no site-specific (Category 2) air quality issues applicable to North Anna (Table 3-2).

3.3.5 No-Action Alternative

3.3.5.1 Air Quality

Under the no-action alternative, the cessation of North Anna operations would reduce overall air pollutant emissions (e.g., from diesel generators, engines, and vehicular traffic). Therefore, the NRC staff concludes that, if emissions decrease, the impact on air quality from the direct shutdown of North Anna would be SMALL.

3.3.5.2 Noise

The termination of reactor operations would result in a reduction in noise from activities related to plant operation, including noise from the turbine generators, transformers, firing range, main steam safety valves, and vehicular traffic (e.g., workers, deliveries). As site activities are reduced, the NRC staff expects the impact on ambient noise levels to be less than current plant operations; therefore, the NRC staff concludes that impacts on noise levels from the no-action alternative would be SMALL.

3.3.6 Replacement Power Alternatives: Common Impacts

3.3.6.1 Air Quality

<u>Construction</u>

Construction of a power station under a replacement power alternative would result in temporary impacts on local air quality. Air emissions include criteria pollutants (particulate matter, nitrogen oxides, carbon monoxide, and sulfur dioxide), volatile organic compounds, hazardous air pollutants, and GHGs. Air emissions would be intermittent and would vary, based on the level and duration of specific activities throughout the construction phase. During the construction phase, the primary sources of air emissions would consist of engine exhaust and fugitive dust emissions. Engine exhaust emissions would be from heavy construction equipment and commuter, delivery, and support vehicular traffic traveling to and from the facility as well as within the site. Fugitive dust emissions would be from soil disturbances by heavy construction equipment (e.g., earthmoving, excavating, and bulldozing), vehicular traffic on unpaved surfaces, concrete batch plant operations, and wind erosion to a lesser extent.

Various mitigation techniques and best management practices (BMPs) (e.g., watering disturbed areas, reducing equipment idle times, and using ultralow sulfur diesel fuel) could be used to minimize air emissions and to reduce fugitive dust.

Operations

The impacts on air quality as a result of operation of a power station for a replacement power alternative would depend on the energy technology (e.g., nuclear or renewable). Worker vehicles, auxiliary power equipment, and mechanical draft cooling tower operation will also result in additional air emissions.

3.3.6.2 Noise

Construction

Construction of a replacement power facility would be similar to the construction of any industrial facility, in that all involve many noise-generating activities. In general, noise emissions would vary during each phase of construction, depending on the level of human activity, types of equipment and machinery used, and site-specific conditions. Typical construction equipment, such as dump trucks, loaders, bulldozers, graders, scrapers, air compressors, generators, and mobile cranes, would be used, and pile-driving and blasting activities could take place. Other noise sources include construction worker vehicular and truck delivery traffic. However, noise from vehicular traffic would be intermittent.

Operations

Noise generated during operations could come from mechanical draft cooling towers, transformers, turbines, machinery, equipment, and communication announcements and sirens, as well as offsite sources, such as employee and delivery vehicular traffic. Noise from vehicles would be intermittent and at levels similar to noise levels currently generated at North Anna.

Similarly, with the exception of the additional noise from mechanical draft cooling towers, operational noise levels at a replacement power plant, excluding solar PV and offshore wind facilities, would likely be similar to existing noise levels at North Anna.

3.3.7 New Nuclear (Small Modular Reactor) Alternative

3.3.7.1 Air Quality

Construction

Air emissions and sources associated with construction of the new nuclear alternative would include those identified as common to all replacement power alternatives in Section 3.3.6.1. Because air emissions from construction activities would be limited, local, and temporary, the NRC staff concludes that the associated air quality impacts from construction of a new nuclear alternative would be SMALL.

Operations

Operation of the new nuclear alternative would result in air emissions similar in magnitude to air emissions from the operation of North Anna. Sources of air emissions would include stationary combustion sources (e.g., diesel generators, auxiliary boilers, and gas turbines) and mobile sources (e.g., worker vehicles, onsite heavy equipment, and support vehicles). Additional air emissions would result from the new nuclear plant's use of mechanical draft cooling towers (rather than the once-through cooling system currently used by North Anna) and could contribute to impacts associated with the formation of visible plumes, fogging, and subsequent icing downwind of the towers.

In general, most stationary combustion sources at a nuclear power plant would operate only for limited periods, often during periodic maintenance testing. A new nuclear power plant would need to secure a permit from VDEQ for air pollutants associated with its operations (e.g., criteria pollutants, volatile organic compounds, hazardous air pollutants, and GHGs). The NRC staff expects the air emissions for combustion sources from a new nuclear plant to be similar to those currently being emitted from North Anna (see Section 3.3.6.1). Therefore, the NRC staff expects that the combined air quality impact of emissions from onsite sources would be minor.

Additional air emissions would result from the approximately 1,200 employees commuting to and from the new nuclear facility. Given that the NRC estimates that air emissions would be minor and given the attainment status of Louisa County and Spotsylvania County, the NRC staff does not expect air emissions from operation of a new nuclear alternative to contribute to NAAQS violations. The NRC staff concludes that the impacts of operation of a new nuclear alternative on air quality would be SMALL.

3.3.7.2 Noise

Construction

Noise generated during the construction and operation of a new nuclear power plant would be similar to noise for all replacement power alternatives, as discussed in Section 3.3.6.2. Noise impacts during construction would be limited to the immediate vicinity of the North Anna site. Based on the temporary nature of construction activities, the distance of noise-sensitive receptors from the site, consideration of noise attenuation from the construction site, and good noise control practices, the NRC staff concludes that the potential noise impacts of construction activities from a new nuclear alternative would be SMALL.

Operations

Sources of noise during nuclear power plant operations would include industrial equipment, machinery, vehicles, and communications. Noise levels from these sources would be similar to or less than noise levels generated during the operation of North Anna. Mechanical draft cooling towers generate noise during operations. However, given the distance of nearby noise-sensitive receptors from the North Anna site (0.9 mi (1.4 km)), the NRC staff does not expect offsite noise levels from mechanical draft cooling towers to nearby receptors to be greater than current levels. Therefore, noise impacts during SMR operations would be SMALL.

3.3.8 Combination Alternative (Solar, Offshore Wind, Small Modular Reactor, and Demand-Side Management)

3.3.8.1 Air Quality

Construction

Air emissions and sources for construction of the new nuclear and solar portions of this combination alternative would include those identified as common to all replacement power alternatives in Section 3.3.6.1. Air emissions from construction would be localized and intermittent, and well-understood construction BMPs would mitigate air quality impacts. Therefore, the NRC staff concludes that the air quality impacts associated with construction of the new nuclear and solar portions of the combination alternative would be SMALL. No air emissions would result from demand-side management initiatives. Air emissions and sources for construction of the offshore wind component would be as a result of engine exhaust of heavy equipment and vessel traffic associated with installation of the meteorological data collection facilities (meteorological towers or meteorological buoys) and wind turbines. However, given the distance to shore and prevailing westerly winds, the NRC does not anticipate engine exhaust emissions to impact onshore air quality (BOEM 2021). Because vessel traffic traveling to and from offshore sites would be intermittent, and activity onshore would be of short duration, air emissions would be negligible, and the NRC does not anticipate traffic to affect onshore air quality. Therefore, the NRC staff concludes that the air quality impacts associated with construction of the offshore wind component of the combination alternative would be SMALL.

The NRC staff concludes that the overall air quality impacts from construction of the combination alternative would be SMALL.

Operations

Air emissions associated with operation of the new nuclear component would be similar to, but less than, those associated with the new nuclear alternative discussed in Section 3.3.7.1. Air emissions associated with operation of the offshore wind component would be associated with diesel generators supporting meteorological data collection facilities (meteorological towers or meteorological buoys) and engine exhaust of vessel traffic traveling to and from offshore sites for operation and maintenance activities (BOEM 2021). However, given the distance to shore and prevailing westerly winds (BOEM 2021), the use of diesel generators would not impact onshore air quality. Because vessel traffic traveling to and from offshore sites would be intermittent and activity onshore would be of short duration, air emissions would be negligible, and the NRC does not anticipate traffic to affect onshore air quality. Therefore, the NRC staff concludes that the air quality impacts associated with operation of the offshore wind component of the combination alternative would be SMALL.

Air emissions associated with the operation of the solar portion are negligible because no fossil fuels are burned to generate electricity. Emissions from solar fields would include fugitive dust and engine exhaust emissions from vehicles and heavy equipment associated with site inspections, maintenance activities (panel washing or replacement), and wind erosion from cleared lands and access roads. The types of emission sources and pollutants during operation would be similar to those during construction, but noticeably fewer emissions would be released during operation. Therefore, the NRC staff concludes that the air quality impacts associated with operation of the solar portion of the combination alternative would be SMALL. No air emissions would result from demand-side management initiatives. The NRC staff concludes that the overall air quality impacts from operations of the combination alternative would be SMALL.

3.3.8.2 Noise

Construction

Construction-related noise sources for the new nuclear alternative would be similar to the new nuclear alternative discussed in Section 3.3.7.2 of this SEIS. Therefore, the NRC staff concludes that the noise impacts associated with construction of the new nuclear portion of the combination alternative would be SMALL. Depending on the site locations of the solar portion of the combination and distance of nearby noise-sensitive receptors, construction noise can be noticeable. Therefore, noise impacts associated with construction of the solar portion of the combination alternative would be SMALL to MODERATE. Noise impacts would not result from demand-side management initiatives.

Construction-related noise sources associated with the offshore wind component would include boring, drilling, dredging, pile driving, and heavy equipment and vessel traffic. Given the distance from shore (30 mi (48 km)) where the construction activities would occur, noise generated during these activities would not be audible on shore. Therefore, the NRC staff concludes that noise impacts associated with construction of the offshore wind component portion of the combination alternative would be SMALL. The NRC staff concludes that the overall noise impacts associated with construction of the combination alternative would be SMALL to MODERATE.

Operations

Noise impacts associated with the new nuclear portion of the combination alternative would be similar to those described for the new nuclear alternative in Section 3.3.7. Therefore, the NRC staff concludes that operation-related noise impacts from the new nuclear portion of the combination alternative would be SMALL.

Because the solar PV portion of the combination alternative would have no power block or cooling towers, a minimal number of noise sources, such as transformers and vehicular traffic, would be associated with maintenance and inspection activities. Therefore, the NRC staff concludes that operations-related noise impacts from the solar PV portion of the combination alternative would be SMALL.

Given the distance from shore (30 mi (48 km)), wind turbine noise would not be audible on shore. Vessel-traffic-related noise would be intermittent and decrease as distance increases from shore. Navigation of vessels in the vicinity of the turbines would be short term and intermittent, resulting in minor noise impacts to noise-sensitive receptors. Therefore, the NRC staff concludes that operations-related noise impacts from the offshore wind component portion of the combination alternative would be SMALL. Noise impacts would not result from demand-side management initiatives. The NRC staff concludes that the overall noise impacts associated with operation of the combination alternative would be SMALL.

3.4 Geologic Environment

This section describes the geologic environment of the North Anna site and vicinity, including landforms, geology, soils, and seismic conditions. The description of the resources is followed by the NRC staff's analysis of the potential impacts on geologic and soil resources from the proposed action (SLR) and alternatives to the proposed action.

3.4.1 Physiography and Geology

Section 2.4 of the NRC staff's EIS for an early site permit (ESP) at North Anna (NUREG-1811, *Environmental Impact Statement for and Early Site Permit (ESP) at the North Anna ESP Site*) (NRC 2006) describes the physiographic and geologic environment of the North Anna site and vicinity. Section E3.5 of Dominion's ER (Dominion 2020b) also describes the geologic environment of the site and vicinity and provides a somewhat more detailed summary focusing on the North Anna site. The staff incorporates the information in NUREG-1811, Section 2.4 (NRC 2006: p. 2-18, 2-19), here by reference, with key information summarized as follows.

The North Anna site is located along the shore of Lake Anna within the central Piedmont physiographic province between the Blue Ridge province to the west and the Coastal Plain province to the east. The topography of the Piedmont is characterized by relatively low, rolling hills with elevations ranging up to 1,500 ft (460 m) above mean sea level (MSL). The topography of the North Anna site is characterized as gently undulating, with elevations varying from about 200 ft (60 m) to 500 ft (152 m) above MSL.

Hard, crystalline igneous and metamorphic rock formations dominate the site region, with some areas of sedimentary rocks and saprolite or residuum deposits (deeply weathered rock) overlying the crystalline bedrock. The geologic formations have undergone a complex history of deposition, uplift, deformation, and subsequent erosion. The size and number of fractures and faults in the bedrock decrease with depth as the bedrock becomes less weathered and more structurally competent. In contrast, the crystalline metamorphic rocks nearer to the ground surface have undergone extensive weathering to create a layer of saprolite up to about 100-ft

(30-m) thick beneath the site (NRC 2006). The saprolite is either exposed at the surface or is overlain by soil or fill material (Dominion 2020b).

3.4.2 Geologic Resources

The North Anna region was, historically, a host to mining operations for iron, copper, sulfur, gold, and other ores, as well as quarrying for whetstone (NRC 2006). However, there are currently no mining activities within 10 mi (16 km) of the North Anna plant site (Dominion 2020b). In addition, the saprolitic or residual materials that overlie the bedrock across the site are not suitable for structural backfill (NRC 2006).

3.4.3 Soils

Native soils and underlying saprolitic materials were disturbed during plant construction. Soil unit mapping by the Natural Resources Conservation Service (NRCS) identifies site soils, found in and near the North Anna plant complex and extending north and east to the lake and along the discharge canal, as cut and fill land (Dominion 2020b; USDA 2020). The soils located in relatively undisturbed areas surrounding the plant complex to the west, north, and south predominantly consist of sandy loams derived from bedrock residuum. The majority of these soils on flat uplands are rated as prime farmland or farmland of statewide importance. However, NRCS mapping shows that the majority of these soils are rated as somewhat to very limited for building site development due to such factors as slope, depth to bedrock, depth to saturated zone, soil shrink-swell potential, and other factors. The soils generally have a slight-to-moderate erosion hazard, except in eroded and steeply sloped areas where the hazard is moderate to severe (USDA 2020). Nevertheless, soils and fill materials across developed areas of the site are less prone to erosion due to stabilization measures, and Dominion maintains a Stormwater Pollution Prevention Plan (SWPPP) for the North Anna site that includes soil erosion and sediment control measures to prevent erosion and potential water quality impacts (Dominion 2020b). Section E3.5 of Dominion's ER (Dominion 2020b) provides a more detailed description of soils across the North Anna site.

3.4.4 Seismic Setting

North Anna is located in an area of elevated seismicity known as the Central Virginia Seismic Zone (CVSZ) that experiences persistent seismic (earthquake) activity of generally low magnitude (Dominion 2020b; VDMME 2021a). The CVSZ eastern boundary is roughly elliptical and begins along the fall line near Richmond, VA, extending about 75 mi (120 km) to the west towards the Blue Ridge Mountains and approximately 60 mi (100 km) along a north-south axis (Horton et al. 2015; Tarr and Wheeler 2006). The North Anna site is located near the northern boundary of the CVSZ. The locations of historical earthquake epicenters in this seismic zone show that most seismic activity tends to be roughly aligned in an east-to-west direction along the James River.

Over the last 50 years (since 1970), a total of 39 earthquakes with a magnitude equal to, or greater than, 2.5 have been recorded within a 50-mi (80-km) radius of the North Anna site (USGS 2021a). This list includes the August 23, 2011, Central Virginia (Mineral) earthquake. As is common with strong earthquakes, of the 39 earthquakes since 1970, approximately 20 are aftershocks associated with the 2011 Mineral earthquake.

The Mineral earthquake epicenter was 8.7 mi (14 km) south-southeast of Louisa, VA, and approximately 10 mi (16 km) southwest of the North Anna site with a moment magnitude (Mw) = 5.8 (USGS 2021a, 2021b). This earthquake stands as the largest and most damaging seismic event in the Eastern U.S. since the Charleston, SC, earthquake of 1886 (estimated Mw = 7.0) (Horton et al. 2015).

The Mineral earthquake produced very strong to severe shaking near the epicenter and caused significant damage to many homes and other structures. With decreasing intensity with distance from the epicenter, relatively strong shaking also occurred across the North Anna site (USGS 2021b; VDMME 2021b).

At the time of the 2011 Mineral earthquake, North Anna, Units 1 and 2, were operating at full power. In accordance with designed safety features, the earthquake caused a series of trip signals to both reactors, as well as a loss of offsite power to the plant. Following the earthquake, Dominion ensured a safe shutdown condition and then restored offsite power. NRC regulations required that the plant remain shut down until the licensee could demonstrate to the NRC that no functional damage occurred to those features necessary for continued safe operation (NRC 2011).

During the shutdown period, Dominion personnel performed inspections, testing, and analyses in accordance with applicable guidance to verify that no functional damage occurred as a result of the earthquake and that the plant could operate without undue risk to the health and safety of the public (Dominion 2020b; NRC 2011). NRC inspection teams performed independent technical evaluations and assessed Dominion's readiness for restart. The NRC staff concluded that the licensee performed adequate inspections, walkdowns, and testing to ensure that safety-related structures, systems, and components had not been adversely affected by the earthquake, and that Units 1 and 2 could be operated without undue risk to the health and safety of the public (NRC 2011). Subsequently, on November 11, 2011, the NRC approved the restart of North Anna, Units 1 and 2, with Unit 1 restarting on November 14, 2011, and Unit 2 on November 21, 2011.

Following the restart of North Anna, Units 1 and 2, Dominion implemented a long-term seismic margin management plan to further ensure that the plant can continue to operate safely and without undue risk in the event of another earthquake. This plan requires that the design change process and qualification of new and replacement equipment at North Anna account for the Mineral earthquake (Dominion 2018a, 2020b). Dominion's updated final safety analysis report (Dominion 2018a) further documents the scope of this plan.

The NRC evaluates the potential effects of natural hazards, including seismic events, on nuclear power plants on an ongoing basis, separate from the license renewal process. Before the 2011 Mineral earthquake, the NRC established the Near-Term Task Force following the accident at the Fukushima Dai-ichi nuclear power plant resulting from the March 11, 2011, Great Tohoku Earthquake and subsequent tsunami (NRC 2013a). The Near-Term Task Force assessment resulted in the NRC issuing three orders (EA-12-049, EA-12-050, and EA-12-051) on March 12, 2012 to nuclear power plant licensees to mitigate beyond-design-basis events, and issued 10 CFR 50.54(f) letters directing licensees to conduct seismic and flooding reevaluations (NRC 2012). In response to these NRC actions, Dominion performed a number of followup actions at North Anna, which were subject to NRC oversight. In June 2020, the NRC staff issued its determination that Dominion had implemented NRC-mandated safety enhancements at North Anna in response to the NRC orders and that it had also completed its response to the 10 CFR 50.54(f) letter (NRC 2020a).

In addition, and in consideration of the lessons learned following the Fukushima Dai-ichi accident, the NRC staff developed an enhanced process to ensure the ongoing assessment of information on a range of natural hazards that could potentially pose a threat to nuclear power plants. The framework developed as part of this process provides a graded approach that allows the NRC to proactively, routinely, and systematically seek, evaluate, and respond to new hazard information (NRC 2016a). In 2017, the Commission approved the staff's process enhancements for an ongoing assessment of natural hazard information (NRC 2017).

3.4.5 Proposed Action

As evaluated and described in the GEIS (NRC 2013a) and as cited in Table 3-1, the impacts of nuclear power plant license renewal and continued operations on geology and soils would be SMALL. The NRC staff's review did not identify any new and significant information that would change the conclusion in the GEIS. Thus, as concluded in the GEIS, the staff finds that the impacts of North Anna's continued operation on the geologic environment would be SMALL. There are no site-specific (Category 2) geologic environment issues, as shown in Table 3-2.

3.4.6 No-Action Alternative

Under the no-action alternative, there would be little or no incremental impacts on site geology and soils associated with the shutdown of North Anna. This is because before the beginning of decommissioning activities, little or no new ground disturbance would occur at the plant site as operational activities are reduced and eventually cease. As a result, the NRC staff concludes that the impact of the no-action alternative on geology and soils would be SMALL.

3.4.7 Replacement Power Alternatives: Common Impacts

<u>Construction</u>

During facility construction for both replacement power alternatives and associated components, aggregate material (such as crushed stone, riprap, sand, and gravel) would be required to construct buildings, foundations, roads, parking lots, pad sites, transmission lines, and other supporting infrastructure, as applicable. The NRC staff presumes that these resources would be obtained from commercial suppliers using local or regional sources. Land clearing, grading, and excavation work expose soils to erosion and alter surface drainage. The NRC staff also presumes that best management practices (BMPs) would be implemented in accordance with applicable State and local permitting requirements to reduce soil erosion and associated offsite impacts. These practices would include such measures as 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, where applicable. Standard construction practice dictates that topsoil removed during construction and any suitable excavated materials would be stored on site for redistribution, such as for backfill at the end of construction.

<u>Operations</u>

Replacement power facilities would be built in accordance with applicable State and local building codes and would consider such siting and design factors to mitigate potential impacts from natural phenomena. Once facility construction is completed, areas disturbed during construction, whether on land or offshore, would be within the footprint of the completed facilities, overlain by other impervious surfaces (such as roadways and parking lots), or revegetated or stabilized as appropriate, so there would be no additional land disturbance and no direct operational impacts on geology and soils. Consumption of aggregate materials or topsoil for maintenance purposes during operations would be negligible.

3.4.8 New Nuclear (Small Modular Reactor) Alternative

The impacts on geologic and soil resources from construction and operations associated with the new nuclear alternative would likely be similar to but somewhat greater than those described and assumed as common to all alternatives in Section 3.4.7. Implementation of this alternative would use existing infrastructure at the North Anna site to the maximum extent possible, which would reduce construction impacts and connected impacts on site geology and soils, as well as consumption of geologic resources for new facility construction. However, excavation work for the power block may extend to a depth of about 140 ft (43 m) below grade. Blasting of bedrock would be necessary, and construction of ramps along with bracing would likely be required to access and maintain deep excavations during construction. Site construction work would also require the use and consumption of engineered backfill, which would likely need to be procured from offsite regional sources and transported to the site. Nevertheless, disturbance to geologic strata and soil erosion and loss under this alternative would be localized to the North Anna site, and offsite soil erosion impacts would be mitigated by using BMPs. As a result, the NRC staff concludes that the overall impacts on geology and soil resources from the new nuclear alternative would be SMALL.

3.4.9 Combination Alternative (Solar, Offshore Wind, Small Modular Reactor, and Demand-Side Management)

Under this combination alternative, the impacts on geologic and soil resources would likely be similar to but greater than those described and assumed as common to all alternatives in Section 3.4.7 and greater than those under the new nuclear alternative. This greater potential for impacts is primarily due to the substantial land area, along with additional seafloor areas, that would be disturbed at multiple offsite locations, along with the potential for soil erosion and loss of natural soils and sediments from the conversion of land to industrial uses for the solar photovoltaic and offshore wind component of this alternative. Based on these considerations, the NRC staff concludes that the impacts on geology and soil resources from the combination alternative could range from SMALL to MODERATE.

3.5 <u>Water Resources</u>

This section describes surface water and groundwater resources at and around the North Anna site. The description of the resources is followed by the staff's analysis of the potential impacts on surface water and groundwater resources from the proposed SLR action and alternatives to the proposed action.

3.5.1 Surface Water Resources

Surface water encompasses all water bodies that occur above the ground surface, including rivers, streams, lakes, ponds, and man-made reservoirs or impoundments.

3.5.1.1 Surface Water Hydrology

<u>Local and Regional Hydrology</u>

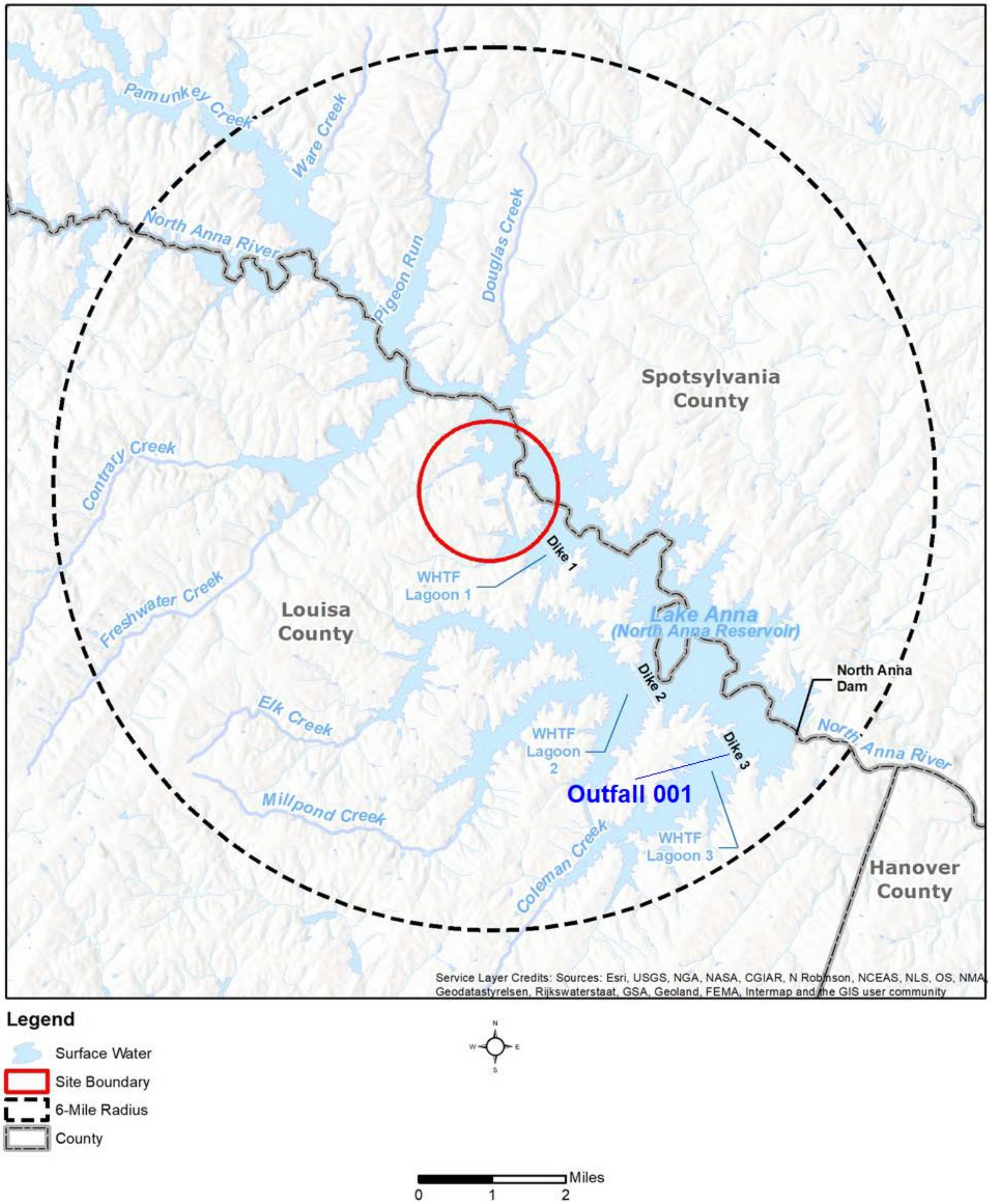
Section 2.6.1.1 of the NRC staff's EIS for an early site permit (ESP) at North Anna (NUREG-1811) (NRC 2006) describes the hydrologic environment of the North Anna site and vicinity. The NRC staff incorporates the information in NUREG-1811, Section 2.6.1.1 (NRC 2006: p. 2-20, 2-21), here by reference.

As discussed in NUREG-1811, the dominant water feature of the site is the Lake Anna Reservoir. The reservoir has a normal operating (full) pool level of 250 ft (76.2 m) MSL. The reservoir was formed by impounding the North Anna River above the North Anna Dam. While Dominion uses the reservoir for nuclear and hydroelectric power generation, operation of the reservoir and the dam provides a flood control function while also ensuring sufficient instream flow in the North Anna River below the dam's spillway. The reservoir is further divided into two distinct bodies of water, Lake Anna and the waste heat treatment facility (WHTF).

Section E3.6.1 of Dominion's ER provides a similar but more detailed description of the hydrologic setting of the Lake Anna Reservoir and WHTF, including the operational characteristics of the reservoir, Lake Anna Dam, and the North Anna Hydro Power Station. This information is incorporated here by reference (Dominion 2020b: E3.6.1, p. E-3-77, E-3-78). In summary, North Anna, Units 1 and 2, uses the WHTF as previously discussed in Section 2.1.3.1 of this SEIS. North Anna withdraws water from the reservoir for use in the circulating and service water systems and discharges the cooling water and comingled effluents back to the WHTF. The return flow then travels through the three, interconnected lagoons of the WHTF and enters the North Anna Reservoir at Dike 3. Figure 3-1 depicts the surface water features of the region in relation to the North Anna Reservoir and North Anna site.

Flooding

The Federal Emergency Management Agency (FEMA) has delineated the flood hazard areas in the vicinity of the North Anna site. FEMA has mapped the majority of the plant site as Zone X, representing areas of minimal flood hazard and lying outside the 0.2 percent annual chance floodplain (100-year flood level). Several small, low areas along the lakeshore and associated with the discharge canal are mapped as Zone AE, reflecting areas within the 100-year flood level with base flood elevations of 254 ft (77.4 m) MSL (Dominion 2020b; FEMA 2020).



Source: Modified from Dominion 2020b

Figure 3-1. Major Surface Water Features Associated with the Lake Anna Watershed

In accordance with the NRC's General Design Criteria (Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities"), plant structures, systems, and components important to safety are designed to withstand the effects of natural phenomena, such as flooding, without loss of capability to perform safety functions. North Anna is designed and located such that the plant site is protected from flooding by Lake Anna and from local intense precipitation and ponding. The plant grade lies above the maximum expected lake surface elevation, including possible wind and wave action. All seismic Category I structures, systems, and components important to safety at North Anna are designed to withstand flooding commensurate with the probable maximum flood (Dominion 2018a, 2020b).

Additionally, the NRC evaluates nuclear power plant operating conditions and physical infrastructure to ensure ongoing safe operations through its Reactor Oversight Process. If new information about changing environmental conditions becomes available, the NRC will evaluate the new information to determine whether any safety-related changes are needed.

3.5.1.2 Surface Water Use

As described in Section 2.1.3.1, North Anna withdraws water from the North Anna Reservoir for use in the circulating water and service water cooling systems. Heated cooling water, along with comingled effluents from auxiliary systems, is returned to the WHTF and flows back to the reservoir through a submerged discharge structure at Dike 3 (see Figure 3-1). This discharge location corresponds to Outfall 001, as designated in North Anna's Virginia Pollutant Discharge Elimination System (VPDES) permit (VDEQ 2014).

North Anna's maximum (hypothetical) surface water withdrawal rate from the reservoir is 1,928,600 gallons per minute (gpm) (7,290 cubic meters per minute (m^3/min)). This rate is equivalent to approximately 2,777 million gallons per day (mgd) (10,512 million liters per day (mLd)). This rate has not changed as previously evaluated by the NRC staff in the SEIS for initial license renewal for North Anna (NRC 2002b). Table 3-5 summarizes North Anna's actual surface water withdrawals from 2015 to 2019.

Actual consumptive water use is not measured at North Anna. However, as evaluated by the NRC staff in Sections 3.5.1.1 and 4.5.1.1 of the GEIS (NRC 2013a), surface water withdrawals by operating nuclear power plants with once-through heat dissipation systems, as with North Anna, have not been found to result in water use conflicts with other users. This is because such systems inherently return all but a very small fraction of the water they withdraw to the water source, as compared to closed-cycle systems (NRC 2013a). The NRC staff estimates North Anna's consumptive water use to be roughly 22 mgd (83 mLd), or approximately 1 percent of the plant's average withdrawal rate over the last 5 years.

Table 3-5. Surface Water Withdrawals, North Anna (2015–2019)

Year	Yearly Withdrawals (mgy)	Daily Withdrawals (mgd)[(a)]
2015	703,030	1,926.1
2016	652,780	1,783.6
2017	706,850	1,936.6
2018	687,360	1,883.2
2019	663,570	1,818.0
Average	**682,718**	**1,870**

[(a)] All reported values are rounded. To convert million gallons per year (MGY) to million cubic meters (m^3) divide by 264.2. To convert million gallons per day (mgd), to million liters per day (mLd), multiply by 3.7854.

Source: Dominion 2020b

Aside from North Anna operations, surface water withdrawals from North Anna Reservoir are primarily non-consumptive in nature and are associated with recreational use. Dominion has not identified any proposed future surface water withdrawals that would affect the watershed of the reservoir (Dominion 2020b). Withdrawals from and impoundments of surface waters within Virginia normally require a water protection permit. No water protection permit is required for any water withdrawal that was in existence on July 1, 1989; however, a permit is required if a new certification under Section 401 of the Clean Water Act of 1972, as amended (CWA), is required to increase a withdrawal (9 VAC 25-210-310); for example, as stated below, North Anna Unit 3 required such a permit. Since North Anna Units 1 and 2 have been in operation since before July 1, 1989, Dominion is exempt from needing a Virginia water protection permit for North Anna Unit 1 and 2 operations (Dominion 2021a). In addition, Dominion does not plan to increase North Anna's surface water withdrawals, and it would not be required to obtain a water protection permit absent an increase in withdrawals.

3.5.1.3 Surface Water Quality and Effluents

Water Quality Assessment and Regulation

In accordance with Section 303(c) of the Federal Water Pollution Control Act (i.e., Clean Water Act of 1972, as amended (CWA) (33 U.S.C. 1251–1387), States have the primary responsibility for establishing, reviewing, and revising water quality standards for the Nation's navigable waters. Such standards include the designated uses of a water body or water body segment, the water quality criteria necessary to protect those designated uses, and an antidegradation policy with respect to ambient water quality. As established under CWA Section 101(a), water quality standards are intended to restore and maintain the chemical, physical, and biological integrity of the Nation's waters and to attain a level of water quality that provides for designated uses. EPA reviews each State's water quality standards to ensure they meet the goals of the CWA and Federal water quality standards regulations (40 CFR Part 131, "Water Quality Standards"). VDEQ issues surface water quality standards in Virginia in accordance with its regulations codified at 9 VAC 25–260.

CWA Section 303(d) requires States to identify all "impaired" waters for which effluent limitations and pollution control activities are not sufficient to attain water quality standards in such waters. Similarly, CWA Section 305(b) requires States to assess and report on the overall quality of waters in their State. States prepare a CWA Section 303(d) list that identifies those water quality limited stream segments that require the development of total maximum daily loads to assure future compliance with water quality standards. The list also identifies the pollutant or stressor causing the impairment and establishes a priority for developing a control plan to address the impairment. The total maximum daily loads specify the maximum amount of a pollutant that a water body can receive and still meet water quality standards. Once established, total maximum daily loads are often implemented through watershed-based programs administered by the State, primarily through permits issued under the National Pollutant Discharge Elimination System (NPDES) permit program, under CWA Section 402, and associated point and nonpoint source water quality improvement plans and associated best management practices (BMPs). States are required to update and resubmit their impaired waters list every 2 years, which ensures that impaired waters continue to be monitored and assessed by the State until applicable water quality standards are met.

VDEQ monitors ambient water quality across Lake Anna (Dominion 2020b). In addition, VDEQ issued its draft integrated CWA Section 303(d)/305(b) report in June 2020 (VDEQ 2020a). Overall, the waters of Lake Anna Reservoir fully support their designated uses for aquatic life, recreation, and wildlife. However, the upper portion of the reservoir near the plant site and south to near Dike 1 (see Figure 3-1) is impaired for fish consumption due to polychlorinated biphenyls (PCBs) in fish tissue. Further, the more southward portion of the reservoir is impaired for fish consumption due to both PCBs and mercury in fish tissue. VDEQ has not determined the sources of these pollutants (VDEQ 2020a, 2020b).

Virginia Pollutant Discharge Eliminating System Permitting Status and Plant Effluents

To operate a nuclear power plant, NRC licensees must comply with the CWA, including associated requirements imposed by EPA or the State, as part of the NPDES permitting system under CWA Section 402. The Federal NPDES permit program addresses water pollution by regulating point sources (i.e., pipes, ditches) that discharge pollutants to waters of the United States. NRC licensees must also meet State water quality certification requirements under CWA Section 401. EPA or the States, not the NRC, sets the limits for effluents and operational parameters in plant-specific NPDES permits. Nuclear power plants require a valid NPDES permit and a current Section 401 Water Quality Certification to operate.

EPA authorized the Commonwealth of Virginia to assume NPDES program responsibility. VDEQ administers the program through its issuance of Virginia Pollutant Discharge Elimination System (VPDES) permits. The Commonwealth's regulations for administering the VPDES program are contained in Virginia Administrative Code 9 VAC 25–31. VDEQ issues VPDES permits on a 5-year cycle.

North Anna is authorized to discharge various wastewater (effluent) streams under VPDES Permit VA0052451. The most recent version of this permit has an effective date of May 8, 2014, and it expired on May 7, 2019 (VDEQ 2014). Dominion submitted a timely and complete VPDES permit renewal application to VDEQ in October 2018 (Dominion 2018b). Therefore, the current 2014 permit remains valid and in force. In March 2019, Dominion submitted supplemental information for its VPDES permit renewal application (Dominion 2019a; Enercon et al. 2019). The NRC staff reviewed Dominion's VPDES renewal application and supplemental materials. The staff found that Dominion has not proposed any substantial changes in North Anna's effluent discharges with consequences for the proposed SLR term.

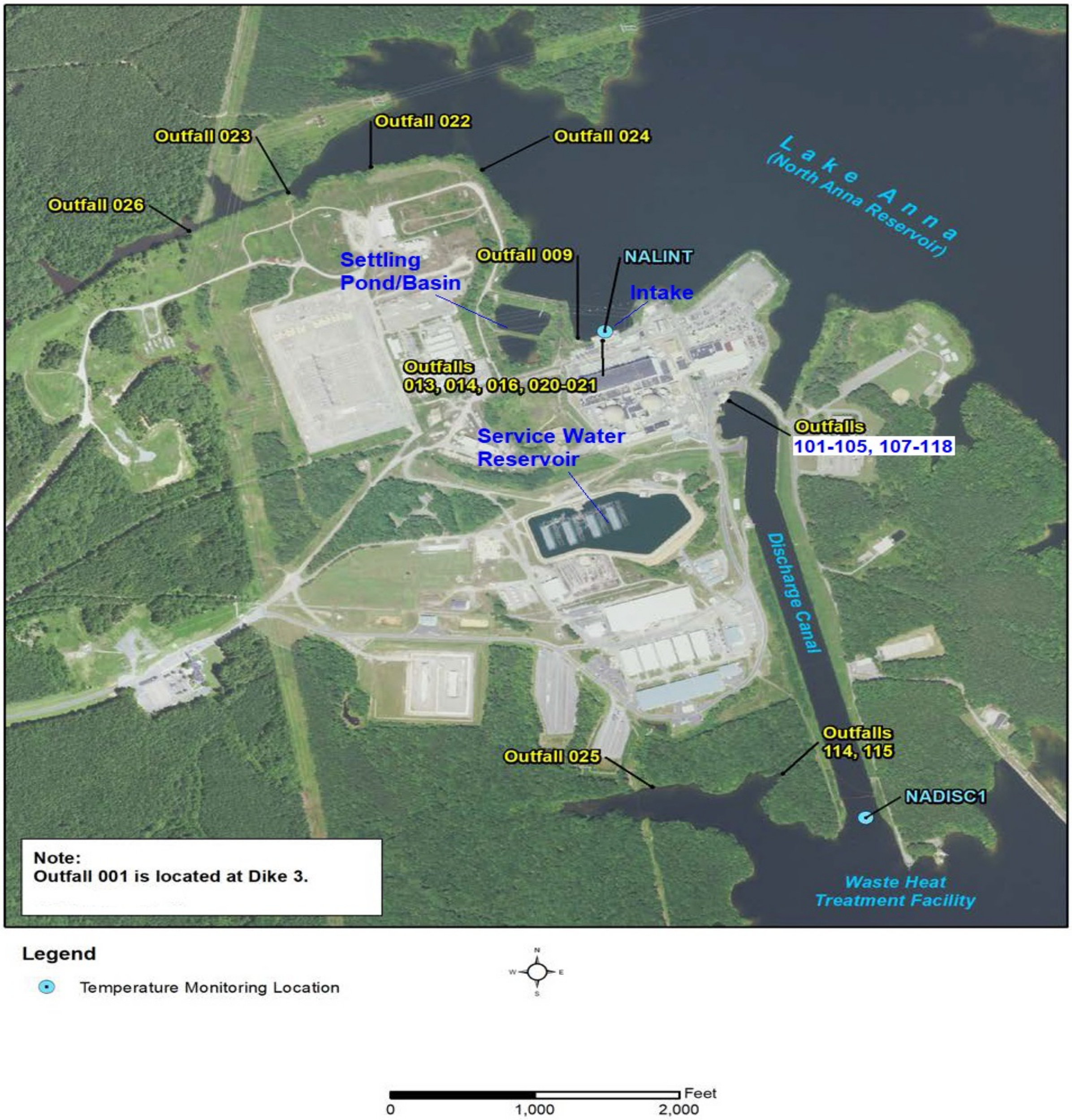
North Anna's current VPDES permit authorizes monitored discharge from 28 outfalls in total, including 10 external outfalls (7 industrial process wastewater and 3 stormwater) and 18 internal outfalls (16 industrial process wastewater and 2 stormwater). External outfalls discharge directly to a surface water body or to a feature that connects directly to a water body, while internal outfalls contribute flow to other waste stream(s) before collectively discharging into an external outfall. Figure 3-2 shows the locations of all major outfalls except for Outfall 001. At North Anna, external Outfall 001 is the combined discharge and monitoring point for all non-contact cooling water return flows and plant effluents that enter the WHTF, as shown in Figure 3-1. Non-contact cooling water discharges are discharges that do not contain or come in contact with raw materials, intermediate products, finished products, or process wastes in a facility (40 CFR 401.11).

North Anna's VPDES permit (VDEQ 2014) specifies the pollutant-specific discharge limitations and monitoring requirements for effluents discharged through each outfall to ensure that North Anna's discharges comply with applicable water quality standards. Depending on the outfall, Dominion is required to monitor flow rate, total suspended solids, pH, heat rejection, temperature, total residual chlorine, oil and grease, biochemical oxygen demand, total suspended solids, metals, nutrients, and other specified parameters. In addition, under its VPDES permit, Dominion must notify and seek approval from VDEQ before using any new biocides or chemical additives that could alter North Anna's effluent quality. Table E3.6-2 in Dominion's ER (Dominion 2020b) summarizes Dominion's effluent (water quality) monitoring requirements under VPDES Permit VA0052451, including a description of the processes that contribute flow to each outfall. The NRC staff incorporates the information in ER Table E3.6-2 (Dominion 2020b: Table E3.6-2, p. E-3-92 through E-3-96) here by reference.

Most notably, North Anna's VDPES permit VA0004090 limits the heat rejected from the plant's condenser cooling water flow to the WHTF to 13.54×10^9 BTU/hour. This calculated value applies at internal Outfall 101. However, the permit imposes no numeric temperature limits on North Anna's cooling water discharges. Dominion maintains a CWA Section 316(a) variance for North Anna's thermal discharges. Under North Anna's VPDES permit, Dominion is required to conduct routine temperature and biological monitoring (fish population surveys) of the North Anna Reservoir, the WHTF, and the North Anna River (Dominion 2020b; VDEQ 2014). Water temperature is monitored at ten stations located in the reservoir and WHTF using continuous recorders. Dominion also monitors cooling water intake and discharge temperatures at two monitoring stations (NALINT and NADISC1, respectively) as shown in Figure 3-2. Dominion does not plan any facility modifications or operational changes for the proposed SLR term that would change North Anna's thermal discharges (Dominion 2020b).

Treated, low-level radioactive liquids are intermittently discharged from the plant's liquid waste disposal system through internal Outfall 101 (VDEQ 2014). The release point is in the circulating discharge tunnel that ultimately leads to the discharge canal and the WHTF. Dominion conducts these releases to ensure that they are as low as reasonably achievable (ALARA) and meet the limits in 10 CFR Part 20, "Standards for Protection Against Radiation," in receiving waters. In addition to periodic sampling of the waste streams, the discharge is continuously monitored, and Dominion can isolate the discharge based on a signal from the radiation monitor (Dominion 2020b).

Five external stormwater outfalls (numbers 014, 022, 024, 025, and 027) receive flow from industrial areas of the plant site. Outfall 009 is the discharge from a large setting pond (basin), depicted in Figure 3-2, that receives both process wastewater and stormwater. Dominion maintains a stormwater pollution prevention plan (SWPPP) that identifies the sources of pollution to comply with the stormwater management conditions of North Anna's VPDES permit. The SWPPP is intended to identify sources of stormwater pollution and document control measures, including BMPs, to eliminate or reduce pollutants in all stormwater discharges from the facility while meeting effluent limitations (Dominion 2020b; VDEQ 2014).



Source: Modified from Dominion 2020b; VDEQ 2014

Figure 3-2. North Anna VPDES Permitted Outfalls and Temperature Monitoring Points

Dominion operates an onsite sewage treatment plant to manage sanitary wastewater from most of the plant site and associated workforce. The plant has a treatment capacity of 30,000 gallons per day (gpd) (114,000 liters per day (Lpd)). Wastewater treatment includes an extended aeration. The plant monitors and discharges treated effluent at internal Outfall 101 in accordance with North Anna's VPDES permit. Sanitary wastewater from the North Anna Nuclear Information Center and security training building is treated and disposed of through septic systems (Dominion 2020b).

For all monitored effluent parameters, Dominion submits discharge monitoring reports to VDEQ in accordance with the reporting schedule specified in North Anna's VPDES permit. Dominion reports that it has not received any notices of violation between 2015 and 2020 and has maintained compliance with North Anna's VPDES permit over this timeframe (Dominion 2020b, 2021a). The NRC staff's review of EPA's Enforcement and Compliance History Online system 3-year compliance history (January 2016 through January 2019) revealed no notices of violation and no permit exceedances during this period (EPA 2020b).

Other Surface Water Resources Permits and Approvals

An applicant (in this case, Dominion) for a Federal license to conduct activities that may cause a discharge of regulated pollutants into navigable waters of the United States is required by CWA Section 401 to provide the licensing agency (in this case, the NRC) with water quality certification from the State (in this case, the Commonwealth of Virginia). This certification denotes that discharges from the project or facility to be licensed will comply with CWA requirements and will not cause or contribute to a violation of State water quality standards. If the applicant has not received a Section 401 certification, the NRC cannot issue a renewed license unless the State has waived the requirement.

The NRC recognizes that some NPDES-delegated States explicitly integrate their CWA Section 401 certification process with NPDES permit issuance. In a letter to Dominion dated September 16, 2020, VDEQ indicated that existing authorizations issued for North Anna facility operations remain valid. Specifically, VDEQ stated, in part, that "[T]he VWP [Virginia Water Protection] permit issued to North Anna Station, VWP permit 10-2001, . . . is the Commonwealth's § 401 Certification for the North Anna Power Station" (VDEQ 2020c). The NRC staff concludes that Dominion has provided the necessary certification under CWA Section 401(a)(1) to support license renewal for North Anna Units 1 and 2.

CWA Section 404 governs the discharge of dredge and fill materials to navigable waters, including wetlands, primarily through the U.S. Army Corps of Engineers (USACE) permits and applicable State-level permitting programs, such as the Virginia Water Protection Compliance Program. However, Dominion does not conduct maintenance dredging in the North Anna plant intake area, discharge canal, WHTF, or the North Anna Reservoir (Dominion 2020b). Therefore, Dominion does not maintain permits applicable to dredge and fill activities.

3.5.2 Groundwater Resources

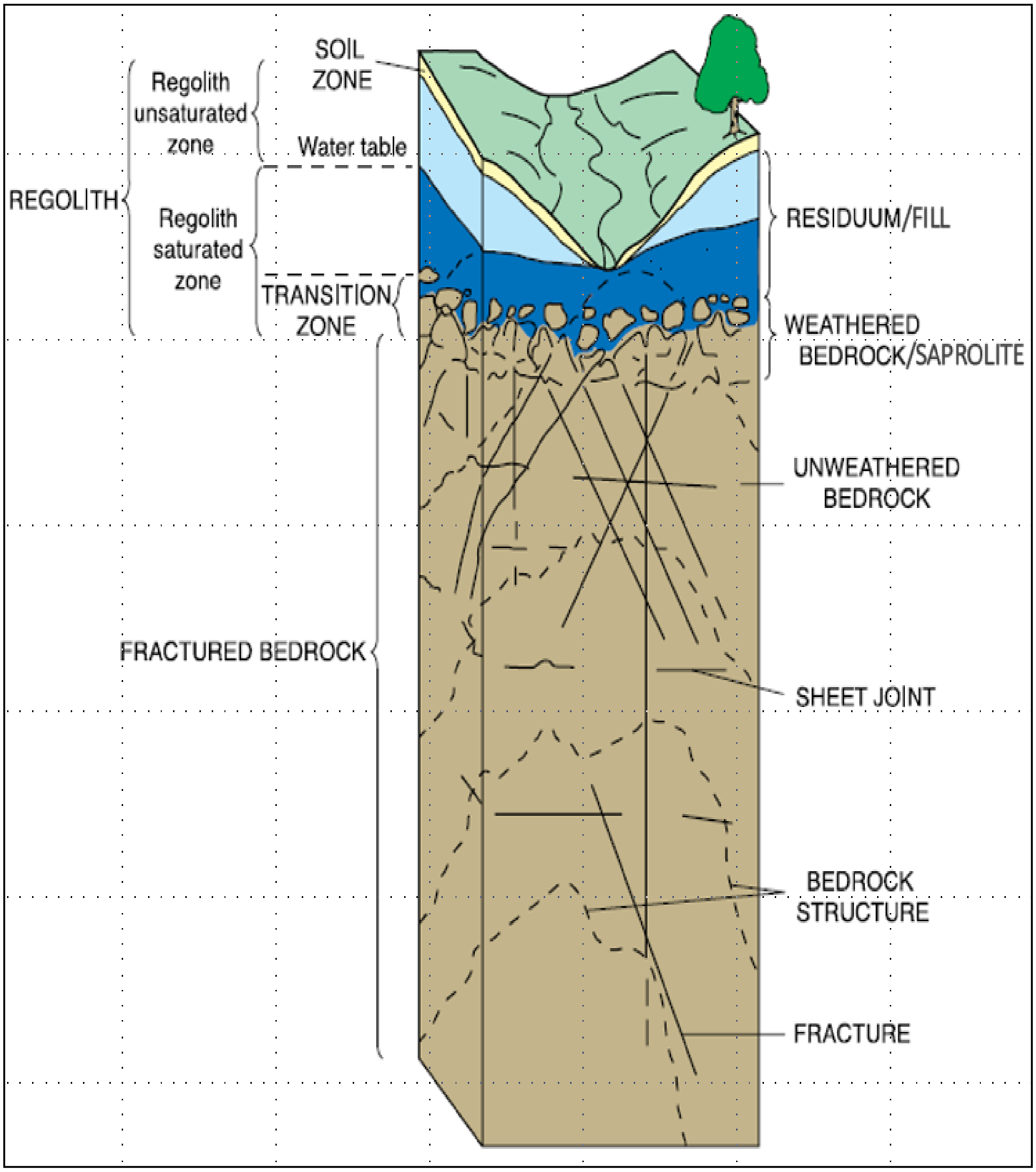
This section describes the groundwater flow systems (aquifers) and water quality in and around the North Anna site. Aquifers are a formation, group of formations, or part of a formation that contain sufficient saturated, permeable material to yield significant quantities of water to wells and springs.

3.5.2.1 Local and Regional Groundwater Resources

Section 2.6.1.2 of the NRC staff's EIS for an early site permit at North Anna (NUREG-1811) (NRC 2006) describes groundwater and the hydrologic environment near the North Anna site. The NRC staff incorporates the information in NUREG-1811, Section 2.6.1.2 (NRC 2006: p. 2-20, 2-21), here by reference.

As discussed in NUREG-1811, the North Anna site lies within the Piedmont province. Within the Piedmont province and the vicinity of the North Anna site, aquifers occur in both the shallow saprolite layer and the deeper fractured crystalline rocks (Figure 3-3). EPA has designated no sole source aquifers in the Piedmont province of Virginia (Dominion 2020b). Aquifer recharge in this region is predominately from local precipitation infiltration. The water table is considered a subdued reflection of the ground surface; therefore, the groundwater generally flows from ridges to valleys or to low-lying areas and surface water bodies such as Lake Anna. The hydraulic connection between Lake Anna and nearby aquifers results in fluctuations of the water table for aquifers in close proximity to the lake; however, given the relatively small fluctuations of the lake water surface elevation, the water table in adjacent aquifers does not change significantly, with a seasonal variation of approximately 2 ft (0.6 m) (Haley & Aldrich 2020). The Lake Anna Special Area Plan indicates that average well yields are higher in areas adjacent to the lake than in other areas of the watershed, concluding that these higher yields are likely due to pumping-induced groundwater recharge from the lake (Lake Anna 2000).

Section 2.6.2.2 of the NRC staff's EIS for an early site permit at North Anna (NUREG-1811) (NRC 2006) describes groundwater resources in the vicinity of the site, with key information summarized as follows. Groundwater in the vicinity of the North Anna site is primarily obtained from springs and wells in either the saprolite or the underlying crystalline bedrock. Most wells completed in the saprolite have been excavated either by hand digging or augering. These shallow wells are susceptible to becoming dry because of seasonal fluctuations in the water table. Drilled wells generally extend deeper through the saprolite into the underlying bedrock. The production of groundwater in the vicinity of the North Anna site is generally insufficient to satisfy large water demands because of the relatively low yield of the aquifers. The majority of groundwater development in the area is for domestic and agricultural use, with some public, light industrial, and commercial use (Dominion 2020b).



From: Swain et al. *2004*

Figure 3-3. Principal Aquifer Components within the Piedmont Province and the North Anna Site

3.5.2.2 Local and Regional Water Consumption

Within the Piedmont Physiographic Province, the groundwater supply in the vicinity of the North Anna site is obtained from wells within the saprolite or the underlying crystalline bedrock. The crystalline metamorphic rocks near the surface have undergone extensive weathering to create a layer of saprolite about 30-m (100-ft) thick beneath the site. The saprolite well yields in the vicinity of the site are typically low, corresponding to the relatively low permeability of the shallow material. Decreasing with depth, fracture networks in the crystalline rock aquifers (Figure 3-4) are one of the most important factors affecting bedrock well yields (Powell and Abe 1985).

The North Anna site is in the Virginia Eastern Groundwater Management Area, which comprises all areas east of Interstate 95 (I-95). In this area, VDEQ requires Groundwater Withdrawal Permits to withdraw more than 300,000 gallons (1.1 million liters (L)) in any month. Permit applications for new groundwater withdrawals or for increases to existing groundwater withdrawals are evaluated for sustainability by considering the combined impacts from all existing lawful withdrawals. Focusing on water quality and supply, the annual State Water Resource Plan (VDEQ 2020d) summarizes water withdrawals and identifies water withdrawal trends Statewide and within the management area.

As described in Section 2.1.3.2, seven onsite wells supply relatively small volumes of water for various uses across the North Anna site. Over the past 7 years, the total groundwater production of these wells has averaged 8,060 gpd (30,500 Lpd). Figure 3-4 shows the locations of these wells. The nearest documented water supply well to the North Anna site is approximately 0.75 mi (1.2 km) northwest of the site boundary across Lake Anna at the Lake Anna Marina (Dominion 2020b: Attachment E).

3.5.2.3 Groundwater Quality

A sole source aquifer is an aquifer that supplies at least 50 percent of the drinking water for an associated service area and no reasonably available alternative drinking water sources exist should the aquifer become contaminated (EPA 2020c). The North Anna site is not located on a sole source aquifer nor do North Anna water supply wells draw from such an aquifer (Dominion 2020b and EPA 2021b).

Section 2.6.3.2 of the NRC staff’s EIS for an early site permit at North Anna (NUREG-1811) (NRC 2006) and Section E3.6.4.2 of the ER (Dominion 2020b) describe groundwater quality in the vicinity of the site. In summary, water quality of the aquifers in the Piedmont physiographic province is generally of good quality; however, as with most crystalline rocks, the mineralogy of the Piedmont bedrock contributes to relatively higher levels of naturally occurring radioactivity in the groundwater with radon activity levels of up to approximately 10,000 pCi/L (USGS 1986). Some coliform contamination has been identified in groundwater near the North Anna site, is likely attributable to private sanitary septic systems in the area (NRC 2006).

Source: Modified from Dominion 2020b

Figure 3-4. Monitoring Wells, Piezometers, and Water Supply Wells at the North Anna Site

<u>Nonradiological Spills</u>

Within the last 5 years, there have been no notices of violation, nonconformance notifications, or related infractions received from regulatory agencies associated with permitted effluent discharges, sanitary sewage systems, or groundwater or soil contamination, nor any involving spills, leaks, and other inadvertent releases (e.g., petroleum products, chemicals, or radionuclides) received (Dominion 2020b, 2021a). A fuel oil leak was noted during 2016 (NRC 2016b) as reported to VDEQ as part of the Underground Storage Tank Program. Dominion remediated the resulting leak, and VDEQ considered the issue closed with no further actions necessary during 2017 (Dominion 2020b).

Radiological Spills

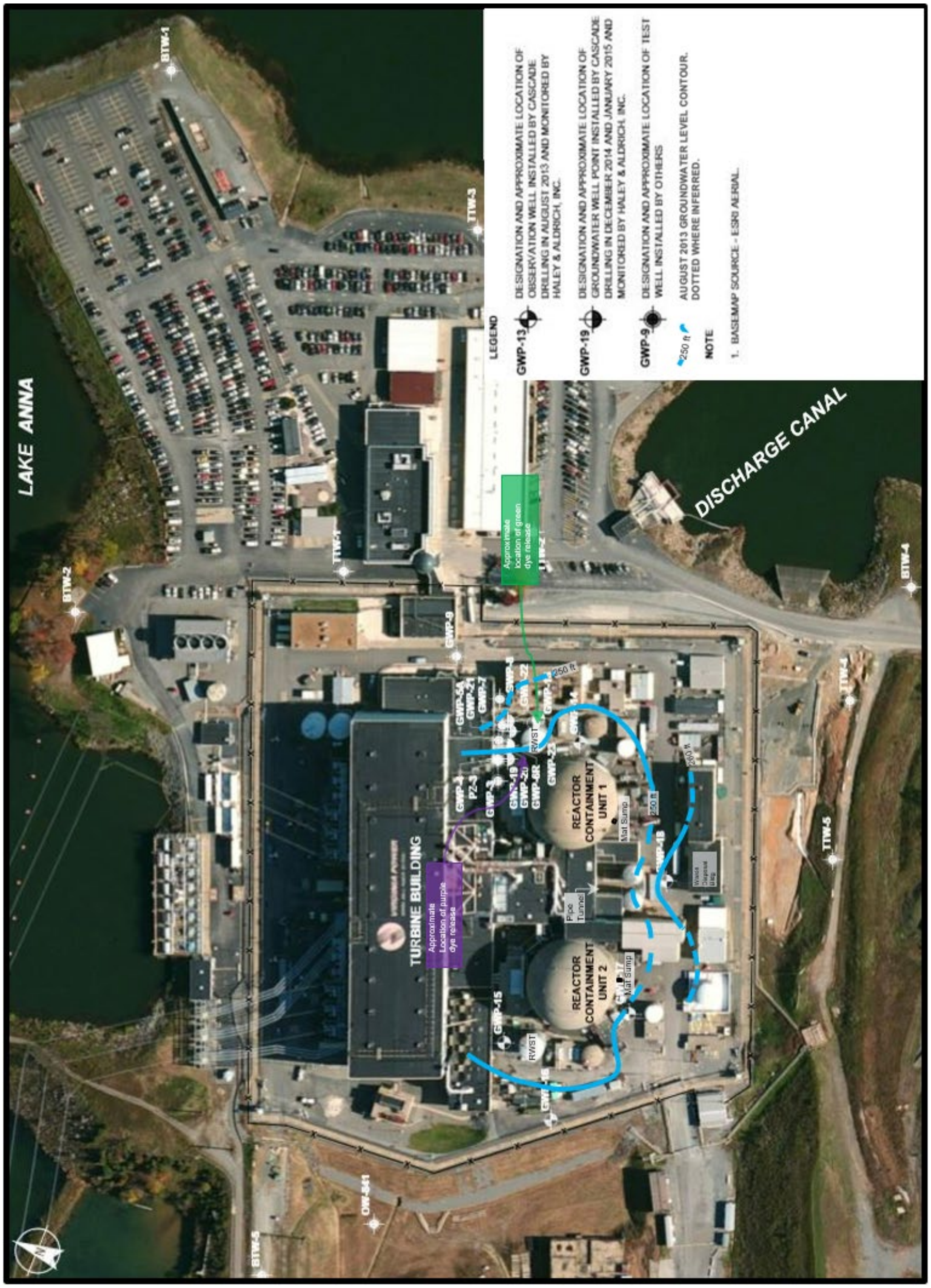
No spills to groundwater have occurred on the North Anna site within the last 5 years, and concentrations have remained below the EPA established maximum contaminant level for drinking water of 20,000 picocuries per liter (pCi/L) (40 CFR 141) (Dominion 2020b). As a byproduct of nuclear reactors, tritium is also produced naturally in the upper atmosphere when cosmic rays strike nitrogen molecules in the air. Tritium is a hydrogen atom that has two neutrons and one proton in the nucleus or an atomic mass of three. As a gas, tritium can react with oxygen to form water and occurs naturally at very low concentrations in groundwater (EPA 2002). Just as nonradiological hydrogen reacts with oxygen to create water, tritium also reacts with oxygen to form “tritiated water” (NRC 2019a). As a liquid, tritium moves easily through the environment in the same way as non-tritiated water.

Tritium emits a weak form of radiation in the form of a low-energy beta particle, which is like an electron. This radiation does not travel very far in air and cannot penetrate human skin. If tritium enters the body, it disperses quickly, being uniformly distributed throughout the soft tissues. Tritium decays into a nonradiological form of helium with a half-life of approximately 12.3 years; after this time, half of the tritium will have decayed to a nonradiological form. If ingested, the human body excretes half of the ingested tritium within approximately 10 days (NRC 2019a).

Tritium in Groundwater

Dye tracer studies, as described in Haley & Aldrich (2020), demonstrated that historical releases of tritium to the ground surface will travel very slowly through the subsurface soils above the water table before reaching monitoring wells. In one instance, (purple) dye released near the ground surface (Figure 3-5) was detected 2 years later at the nearby monitoring well GWP-19 (Haley & Aldrich 2020). Relatively low and persistent tritium concentrations measured in shallow wells (e.g., PZ-3 and GWP-6) are consistent with historical near-surface releases in the area of the Unit 1 recovery water storage tank (RWST). These releases may slowly leach from relatively impermeable subsurface soils due to seasonal variations in the water table elevation that intermittently saturates them, introducing residual tritium. This results in concentration trends that fluctuate around Lake Anna levels of approximately 5,000 pCi/L (Haley & Aldrich 2020). Lake Anna has reached an equilibrium concentration of less than approximately 5,000 pCi/L due to normal operational releases from the plant (NRC 2010b).

As described by Haley & Aldrich (2020), deep (green) dye tracer studies demonstrate that groundwater travels relatively quickly through the deeper permeable zones, reaching the mat sumps within a few days from locations within the protected area (see Figure 3-5). The Unit 1 and Unit 2 mat sumps remove groundwater from around the base of the Unit 1 and Unit 2 basemat foundations and capture the majority of groundwater in the protected area. The captured groundwater is routed to a monitored plant pathway. Constrained by the geology, plant structures, and foundations, groundwater flow paths in the protected area are controlled by mat sump dewatering, as indicated by groundwater-level contours (see Figure 3-5).



Source: Modified from Haley & Aldrich (2020)

Figure 3-5. Site Features and August 2013 Groundwater Contours

To rapidly detect potential spills of radionuclides entering groundwater, monitoring wells have been placed close to, within, and around the reactor containment areas. Table E3.6-3 of the applicant's ER (Dominion 2020b) shows monitoring well construction data. Over the past

15 years, a total of 27 wells or piezometers have been installed and monitored (Haley & Aldrich 2020) as part of the Groundwater Protection Program (GWPP), consistent with the industry's Ground Water Protection Initiative (NEI 2007). The GWPP sampling strategy is designed to collect and analyze samples from locations that are downgradient from systems, tanks, or practices that have the potential to release tritium to groundwater. The monitoring data are reported annually in a series of publicly available annual radioactive effluent release reports (NRC 2021). The subsurface monitoring interval spans the processed fill (extending 10 to 17 ft (3–5 m) below ground surface), the residual soil (below the fill to an approximate depth of 30 to 33 ft (9–10 m) below ground surface), and the competent bedrock (below the residual soil).

Water samples are analyzed for tritium, gamma-emitting particulates, strontium-89/90, transuranics (alpha-emitting radionuclides having an atomic number greater than 92), and plutonium-241. The NRC staff reviewed 5 years of radioactive effluent release data from 2015 through 2019 (VEPCO 2016, 2017, 2018, 2019, 2020). A 5-year dataset is sufficient to encompass a broad range of activities (e.g., refueling outages, routine operation, and maintenance) that may generate radiological effluents and result in corresponding releases to the environment.

Based on a review of the cited Dominion data, the NRC staff confirmed that three wells (PZ-3, GWP-6, and GWP-18) have periodically exceeded a Dominion tritium threshold of 5,000 pCi/L (i.e., one quarter of the EPA drinking water standard). At one other monitoring well (GWP-3), tritium concentrations exceeded 5,000 pCi/L once during July 2018, reaching 6,087 pCi/L. Dominion further investigated tritium concentrations at monitoring wells consistently above the threshold value for potential current and residual sources or release points (Haley & Aldrich 2020). All monitoring wells have maintained tritium concentrations below the EPA drinking water standard (20,000 pCi/L) during the past 5 years.

Relatively low shallow-zone tritium concentrations in the vicinity of PZ-3 are consistent with residual concentrations of the overburden soils, which are a likely result of lingering historical releases from the area of the Unit 1 RWST (Haley & Aldrich 2020). Due to a lack of well installation (construction) records for PZ-3, characterizing associated tritium concentrations at this sampling point as representative of the shallow or deep sampling interval is problematic; however, concentrations in this well may be used to help identify residual tritium distributions defined by targeted intervals of the nearby monitoring wells (e.g., GWP-6). Inclusive of GWP-6, shallow monitoring wells in the vicinity of PZ-3 indicate that relatively higher tritium concentrations may be correlated with higher groundwater elevations, likely due to periodic re-saturation of residual tritium sources, leading to the slow leaching of tritium from low permeability shallow zones (Haley & Aldrich 2020). The slow tritium leaching and limited travel distance from a source is consistent with shallow dye tracer studies (Haley & Aldrich 2020) that demonstrate a relatively long 2-year travel time from the dye release point to GWP-19, a distance of less than approximately 75 ft (23 m) (see Figure 3-5).

Historically, tritium concentrations at GWP-18 have been relatively consistent with Lake Anna concentrations of less than approximately 5,000 pCi/L. During August 2019, tritium concentrations at GWP-18 peaked at 12,930 pCi/L before returning to historical levels during October 2019. Dominion field investigations identified the likely source of the increased tritium concentrations as surface water entering the east-west section of the pipe tunnel (also known as the Boron Recovery Tank Tunnel), running along the north side of the waste disposal building (Figure 3-5), infiltrating through the concrete of the pipe tunnel enclosure, and releasing residual tritium to the ground. The absence of radionuclides other than tritium in the GWP-18 sampling results, combined with the findings of field investigations, supports the conclusion that the elevated tritium concentrations were not caused by pipe leaks within the tunnel.

During 2020, remediation efforts related to GWP-18 tritium concentrations included sealing around external pipe tunnel entry areas to prevent potential surface and rain water runoff ingress (e.g., through personnel access portals, areas of concrete blocks). To date, the sealing of the tunnel has prevented the entry of surface water to maintain dry conditions within the tunnel, preventing any seepage through the tunnel structure to the ground (Haley and Aldrich, 2020). Subsequent to removal of the excess water from the pipe tunnel, concentrations at GWP-18 returned to historical levels that were consistently less than approximately 5,000 pCi/L. The 2020 improvements continue to maintain the pipe tunnel in a dry condition.

Based on flow patterns inferred from groundwater levels (Figure 3-5), tritium releases that may occur in potential source areas (e.g., Unit 1 RWST, pipe tunnel) would be captured in the groundwater extracted by the mat sumps and discharged to a monitored plant pathway. The mat sumps are designed to control water elevations around the Unit 1 and 2 reactor buildings and the auxiliary building while maintaining groundwater elevations of approximately 240 ft MSL. Monitoring well water level observations outside of this area and north of the turbine building indicate that a groundwater flow pathway component towards Lake Anna exists; however, the lack of tritium detection in the monitoring wells within this area indicates that tritium in groundwater does not travel off the North Anna site along this pathway.

<u>Corrective Actions</u>

Dominion has taken the following actions to prevent the release of radionuclides into the groundwater, to further define the extent of contamination, and to reduce tritium concentrations within the groundwater.

- Pipe tunnel sealing prevents surface water from entering the tunnel and leaching through tunnel concrete to the ground.
- After proper abandonment, monitoring well GWP-15 was replaced with GWP-15R due to a nearby piping section replacement to maintain the monitoring well network.
- Monitoring well GWP-6 was replaced with GWP-6R, which was constructed as a 4-in. well to better evaluate well conditions and the surrounding shallow aquifer.
- Near GWP-6R, well GWP-20 was installed and screened within the deeper bedrock/soil interface interval. No tritium was detected in GWP-20, consistent with evidence that a historical shallow source exists in this area releasing low levels of tritium corresponding with seasonal fluctuations of the water table.
- Shallow and deep dye tracer studies confirm the slow movement of groundwater in the shallow zone and the faster movement of groundwater in the more permeable and deeper zone of the bedrock/soil interface.
- Within the area of potential tritium source releases, groundwater captured from basemat dewatering is routed to a monitored plant pathway.
- A monitoring well and environmental sampling network have sufficient temporal sampling intervals and spatial coverage to bound potential source releases and release areas.

3.5.3 Proposed Action

3.5.3.1 Surface Water Resources

As described in the GEIS (NRC 2013a) and as cited in Table 3-1 for generic surface water resources issues, the impacts of nuclear power plant license renewal and continued operations would generally be SMALL. No significant surface water impacts with respect to Category 1 (generic) issues are anticipated during the subsequent license renewal term that would be different from those occurring during the current license term. The NRC staff's review did not identify any new and significant information that would change the conclusion in the GEIS. Thus, as concluded in the GEIS, for these Category 1 (generic) issues, the impacts of continued operation of North Anna on surface water resources would be SMALL. There are no site-specific (Category 2) surface water resources issues applicable to North Anna (Table 3-2).

3.5.3.2 Groundwater Resources

As documented in the GEIS (NRC 2013a) and cited in Table 3-1, groundwater resources would not be significantly affected by continued operations associated with license renewal in most circumstances. As discussed in Section 3.5.2 of this SEIS, the NRC staff identified no new and significant information for applicable Category 1 issues relating to groundwater use and quality. Therefore, as identified in Table 3-1, the impacts for applicable Category 1 groundwater resources issues would be SMALL.

As shown in Table 3-2, the NRC staff identified one site-specific (Category 2) issue related to groundwater resources applicable to North Anna during the license renewal term. This issue is analyzed below.

<u>Radionuclides Released to Groundwater</u>

The staff evaluated the potential contamination of groundwater from the release of radioactive liquids from plant systems into the environment. Section 3.5.2.3 of this SEIS contains a description of North Anna groundwater quality and radionuclides that North Anna has released into groundwater.

As discussed in Section 3.5.2.3, the quality of offsite groundwater aquifers and surface water bodies has not been affected by radiological contamination in the groundwater at North Anna. These water resources should continue to be unaffected over the period of license renewal. Tritium contamination has been detected in the groundwater in a relatively small area within the Unit 1 containment area (see Figure 3-5). Monitoring well sampling results indicate that the tritium contamination is not moving offsite towards Lake Anna. Although tritium groundwater concentrations for some wells (PZ-3, GWP-3, GWP-6 and GWP-18) were above a Dominion threshold level of 5,000 pCi/L within the past 5 years, the most recent monitoring well sampling concentrations have generally remained consistent with Lake Anna levels of less than approximately 5,000 pCi/L. Since 2015, all tritium groundwater concentrations have remained below the EPA-established drinking water maximum contaminant level of 20,000 pCi/L.

The surrounding water resources should continue to remain unaffected during the license renewal period. The NRC staff has concluded that, over the license renewal period, potential groundwater contamination would likely remain on site and no offsite wells should be affected.

The North Anna site has implemented a groundwater corrective action program to identify and stop leaks, and the groundwater gradients due to dewatering of the power block basemat areas further reduce tritium migration. The monitoring well network and the GWPP sampling strategy are robust enough that potential future releases of tritium into the groundwater would likely be readily detected. Therefore, over the period of continued operations, there is little likelihood of significant impacts on the groundwater quality of onsite and offsite aquifers. Present and future operations at North Anna are not expected to impact the quality of groundwater in any aquifers that are current or potential future sources of water for offsite users. Therefore, the NRC staff concludes that the impacts on groundwater use and quality related to radionuclide release from continued operations would be SMALL.

3.5.4 No-Action Alternative

3.5.4.1 Surface Water Resources

Under the no-action alternative, surface water withdrawals would greatly decrease and eventually cease. Stormwater would continue to be discharged from the site, but wastewater discharges would be reduced considerably. As a result, shutdown would reduce the overall impacts on surface water use and quality with the reduction in pollutants discharged and thermal loading to receiving waters, including Lake Anna. Therefore, the impact of the no-action alternative on surface water resources would remain SMALL.

3.5.4.2 Groundwater Resources

With the cessation of operations, there should be a reduction in onsite groundwater consumption and little or no additional impacts on groundwater quality. Therefore, the NRC staff concludes that the impact of the no-action alternative on groundwater resources would be SMALL.

3.5.5 Replacement Power Alternatives: Common Impacts

3.5.5.1 Surface Water Resources

<u>Construction</u>

Construction activities associated with replacement power alternatives may cause temporary impacts on surface water quality by increasing sediment loading to water bodies and waterways. Construction activities may also impact surface water quality through pollutants in stormwater runoff from disturbed areas and excavations, spills and leaks from construction equipment, and from sediment and other pollutants disturbed by associated dredge and fill activities. These pollutants could be detrimental to downstream surface water quality, where applicable, and to ambient water quality in waterways near work sites.

Facility construction activities might alter surface water drainage features within the construction footprints of replacement power facilities, including any wetland areas. Potential hydrologic impacts would vary depending on the nature and acreage of land area disturbed and the intensity of excavation work.

The NRC staff assumes that construction contractors would implement best management practices for soil erosion and sediment control to minimize water quality impacts in accordance with applicable Federal, State, and local permitting requirements. These measures would include spill prevention and response procedures, such as measures to avoid and respond to spills and leaks of fuels and other materials from construction equipment and activities.

For example, land clearing and related site construction activities would need to be conducted under a VDEQ-issued general VPDES permit for discharges from construction activities (VAR10) if more than 1 ac (0.4 ha) of land would be disturbed (9 VAC 25-880). In accordance with the VPDES permit for discharges from construction activities, Dominion and its contractors would need to develop and implement a stormwater pollution prevention plan (SWPPP) that includes erosion and sediment controls, stormwater pollution prevention, and pollution prevention practices to prevent or minimize any surface water quality impacts during construction.

To the maximum extent possible, after any necessary modification, the existing North Anna surface water intake and discharge infrastructure would be used for replacement power components located on the North Anna site. This would reduce potential water quality impacts associated with the construction of new structures at the site.

Construction activities that would be conducted by Dominion and its contractors in and adjacent to waterways, wetlands, nearshore, and offshore areas would be subject to review and approval by applicable Federal and State regulatory agencies. For example, the discharge of dredged or fill material in waterways, at any stream crossings, and placement of structures in navigable waters would be subject to U.S. Army Corp of Engineers permit provisions under CWA Section 404 and Section 10 of the Rivers and Harbors Appropriation Act of 1899, respectively (33 CFR 322 and 323). Additionally, any potential impacts on tidal and nontidal wetlands and adjacent waters, as well as submerged lands, would be subject to regulation by VDEQ and the Virginia Marine Resources Commission (VIMS 2021).

The NRC staff does not expect that any surface water would be diverted or withdrawn to support replacement power facility construction. It is more likely that, where necessary, water would be supplied by a temporary water tap from a municipal source and transported to the point of use or that onsite groundwater could be used (see Section 3.5.5.2, “Construction”). The likely use of ready-mix concrete would also reduce the need for onsite use of nearby water sources to support facility construction. Sanitary water use and wastewater generation would generally be limited to the construction workforce and would likely be accommodated through the use of portable restrooms.

Operation

The NRC staff assumes that thermoelectric power generating components of the replacement power alternatives would use closed-cycle cooling with mechanical draft cooling towers. Makeup water would be obtained from the North Anna Reservoir. Power plants using closed-cycle cooling systems with cooling towers withdraw substantially less water for condenser cooling than a thermoelectric power plant using a once-through system. However, the relative percentage of consumptive water use is greater in closed-cycle plants because of evaporative and drift losses during cooling tower operation (NRC 2013a). Surface water withdrawals would be subject to the Virginia Water Protection Permit Program (9 VAC 25–210).

In addition, closed-cycle cooling systems typically require chemical treatment such as biocide injections to control biofouling (NRC 2013a). Residual concentrations of these chemical additives would be present in the cooling tower blowdown discharged to receiving waters. However, chemical additions would be accounted for in the operation and permitting of liquid effluents. All effluent discharges from the thermoelectric power generation components would be subject to VPDES permit requirements for the discharge of wastewater and industrial stormwater to State waters. VPDES permit conditions require the permit holder to develop and implement a SWPPP and associated BMPs and procedures, which would help reduce surface water quality impacts during facility operation.

3.5.5.2 Groundwater Resources

Construction

Excavation dewatering for foundations and substructures during construction of replacement power generation facilities (e.g., SMR or SMR combined with solar photovoltaic and offshore wind power, including demand-side management, as applicable), may be required to stabilize slopes and permit placement of foundations and substructures below the water table. Groundwater levels in the immediate area surrounding an excavation may be affected, depending on the hydrogeologic conditions of the site, the duration of dewatering, and the methods (e.g., cofferdams, sheet piling, sumps, dewatering wells) used for dewatering. Localized changes could also include altered groundwater flow directions, altered recharge or discharge rates, and groundwater discharge to wetlands. However, the NRC staff expects that any impacts on groundwater flow and quality affected by dewatering would be highly localized, of short duration, with minor effects on other groundwater users. Discharges resulting from dewatering operations would be released in accordance with applicable State and local permits as described above.

Although foundations, substructures, and backfill may alter local groundwater flow patterns, regional trends would remain unaffected. Construction of replacement power generating facilities may contribute to localized changes in groundwater infiltration and quality due to removal of vegetation and construction of buildings, parking lots, and other impervious surfaces. These changes may result in increased runoff and subsurface pollutant infiltration or discharge to nearby water bodies. Application of BMPs and implementation of an SWPPP would prevent or minimize any areawide groundwater quality impacts during construction.

In addition to construction dewatering, onsite groundwater could be used to support construction activities (e.g., dust abatement, soil compaction, water for concrete batch plants). Groundwater withdrawal during construction would have a temporary impact on local water tables or groundwater flow, and these withdrawals and resulting discharges would be subject to applicable permitting requirements.

Operation

Dewatering for building foundations and substructures may be required during the operational life of the replacement power facility. Operational dewatering rates would likely be lower than those rates required for construction and be managed subject to applicable permitting requirements. Dewatering discharges and treatment would be properly managed in accordance with applicable NPDES permitting requirements.

Groundwater may be used during operations for various plant purposes, including general service water, fire protection, demineralized water makeup, and potable and sanitary needs. Water for these and other uses could be obtained from onsite groundwater wells or from a local water supply utility. The operational effects of groundwater use would be similar to those described for construction, with the principal difference being that the duration of pumping for operations would be significantly longer. Any onsite groundwater withdrawals would be subject to applicable State water appropriation and registration requirements.

Effluent discharges (e.g., cooling water, sanitary wastewater, and stormwater) from a facility are subject to applicable Federal, State, and other permits specifying discharge standards and monitoring requirements. Adherence by replacement power facility operators to proper procedures during all material, chemical, and waste handling and conveyance activities would reduce the potential for any releases to the environment, including releases to soil and groundwater.

For replacement power alternatives, the NRC staff assumes that some portion of potable water and water needed for various plant systems would be obtained from onsite groundwater wells during operations. Any groundwater withdrawals would be subject to applicable State water appropriation, permitting, and registration requirements.

In summary, the NRC staff concludes that the common impacts of the replacement power alternatives on groundwater resources would be SMALL.

3.5.6 New Nuclear (Small Modular Reactor) Alternative

3.5.6.1 Surface Water Resources

The hydrologic and water quality assumptions and implications for construction and operations described in Section 3.5.5.1 as common to all replacement power alternatives also apply to this alternative. Additionally, deep excavation work required to construct the nuclear island could require groundwater dewatering (see Section 3.5.5.2). Water pumped from excavations would be managed and discharged in accordance with VPDES requirements. As a result, the staff expects that dewatering would not impact surface water quality.

During operations of the SMR complex, the closed-cycle cooling system would withdraw approximately 63 mgd (238 mLd) of makeup water, with consumptive use of 44 mgd (167 mLd). This withdrawal would be a small fraction of the volume of water that North Anna currently withdraws from the Lake Anna Reservoir. In contrast, the total consumptive use associated with the SMR closed-cycle system would be approximately double that of North Anna's estimated consumptive water use (see Section 3.5.1.2). Nevertheless, this consumptive use would still represent only a small fraction of the reservoir's active and conservation storage volume, consistent with current operations of Units 1 and 2. In addition, the smaller volume of cooling water (primarily cooling tower blowdown) returned to the North Anna WHTF would have a smaller thermal impact on receiving waters than the current once-through cooling system. Based on the above, the NRC staff concludes that the impacts on surface water resources from construction and operations under the new nuclear alternative would be SMALL.

3.5.6.2 Groundwater Resources

The NRC staff did not identify any impacts on groundwater resources for this alternative beyond those discussed above as common to all replacement power alternatives. Therefore, the NRC staff concludes that the impacts on groundwater resources from construction and operation of a new SMR power plant complex would be SMALL.

3.5.7 Combination Alternative (Solar, Offshore Wind, Small Modular Reactor, and Demand-Side Management)

3.5.7.1 Surface Water Resources

The hydrologic and water quality assumptions and implications for construction and operations described in Section 3.5.5.1 as common to all replacement power alternatives also apply to this alternative, except as clarified below.

For the new nuclear component, the operational impacts on surface water resources would be less than those described in Section 3.5.6.1 for the standalone new nuclear alternative. This is because the SMR complex would be smaller with significantly reduced water demands for cooling system makeup and consumptive water use (reduced by about 80 percent). Likewise, the discharge of effluents and cooling tower blowdown would be proportionately reduced.

Installation of utility-scale solar plants would require the construction of pad sites, access roads, and possibly transmission lines or substation improvements (i.e., for sites with no current access to transmission line or sufficient substation infrastructure) with the potential for alteration of surface water drainages at numerous sites across Dominion's service area and totaling 20,000 ac (8,000 ha). As discussed in Section 3.5.5.1, the NRC staff expects that all such construction activities would be conducted in accordance with applicable permits and approvals requiring the implementation of BMPs and procedures to minimize hydrologic and water quality impacts. Completed solar plants would have little to no operational impacts on water resources.

Construction of offshore wind turbine generator (WTG) facilities, including support infrastructure, would disturb and erode marine sediments and temporarily deteriorate water quality in the marine environment over an area of some 6,800 ac (2,800 ha) during pile driving, the laying of cable, and the positioning of construction vessels and vessel anchors. The potential also exists for the discharge of petroleum, oil, and lubricants to marine waters from construction equipment and vessels (BOEM 2015). The NRC staff expects that all marine construction activities would be conducted in accordance with applicable regulations governing erosion control, oil spill prevention and response (i.e., 40 CFR 110 and 112), and marine trash and debris plans and procedures, including U.S. Coast Guard pollution prevention requirements for at-sea discharges (BOEM 2015). Excavation work to emplace submarine cabling to interconnect the WTG installations and to connect the WTGs with onshore electric transmission infrastructure would result in additional land and seafloor disturbance.

Once constructed, the area surrounding each WTG installation would be protected from further erosion, scour, and current action by a pad of rock armor, 3- to 6-ft (1- to 2-m) thick and covering an area of about 1 ac (0.4 ha) around each installation. The WTG facilities would likely result in alteration of water currents, but the changes would be localized. To minimize the potential for operational water quality impacts, the NRC staff presumes that each WTG installation would be designed with built-in spill containment to retain any spills of oil or cooling fluids (BOEM 2015).

During operation and routine maintenance of utility-scale solar plants, relatively small volumes of water would be used to clean solar panels and possibly for operation and maintenance of panel pad sites and access roads.

Operation of WTG installations would be unlikely to have any impacts on marine waters as the turbines are self-contained and do not produce discharges during normal operations (BOEM 2018).

Adherence to appropriate waste management and minimization plans, spill prevention practices, and pollution prevention plans during servicing of solar plant arrays and offshore WTG installations and operation of vehicles connected with site operations would minimize the risks to surface water resources from spills of petroleum, oil, and lubricant products and facility stormwater runoff.

Based on this analysis, the NRC staff concludes the overall impacts on surface water resources from construction and operation under the combination alternative could range from SMALL to MODERATE.

3.5.7.2 Groundwater Resources

The NRC staff did not identify any impacts on groundwater resources for this alternative beyond those discussed above as common to all replacement power alternatives. Therefore, the NRC staff concludes that the impacts on groundwater resources from construction and operation of a combination alternative plant complex would be SMALL.

3.6 Terrestrial Resources

This section describes the terrestrial resources of the North Anna site and the surrounding landscape. Following this description, the staff analyzes potential impacts on terrestrial resources from the proposed action (SLR) and alternatives to the proposed action.

3.6.1 Ecoregion

The North Anna site lies in the Piedmont ecoregion (Dominion 2020b). EPA characterizes this ecoregion (Level III Ecoregion 45) as largely wooded with irregular plains, low rounded hills and ridges, shallow valleys, and scattered monadnocks. The Piedmont is a transitional ecoregion sandwiched between mountainous Appalachian ecoregions to the west and more level coastal ecoregions to the east (EPA 2013). The forest cover was once dominated by Oak-Hickory-Pine forest, but widespread settlement of this portion of northeastern Virginia since the colonial era resulted in forest and soil loss. There are no longer virgin forests, but today, many formerly cultivated lands in the Piedmont ecoregion have reverted to successional pine and hardwood forests (NRC 2006: Section 2.7.1).

The Piedmont ecoregion consists of four subregions, of which two are most relevant to North Anna: (1) the northern inner Piedmont subregion, which contains two arms of Lake Anna and (2) the northern outer Piedmont subregion, which contains the North Anna site. Dominion's description of these two subregions is incorporated here by reference (Dominion 2020b: p. E-3-143 to E-3-144).

Dominion's ER (2020b) includes descriptions of several regional ecosystems in the landscape near the North Anna site, including:

- Piedmont Central Appalachian Mixed Oak/Hardwood Forest Natural Community
- Coastal Plain/Outer Piedmont Acidic Seepage Swamp

The descriptions, presented in Dominion's ER (2020b: p. E-3-150 through E-3-151) characterize the tree canopy, shrub, and herbaceous strata of each plant community relying on information from the Virginia Department of Conservation and Recreation and are incorporated here by reference.

Wetlands are common features in the landscape surrounding the North Anna site. Wetlands are defined by U.S. Army Corp of Engineers as areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas (33 CFR 328.3(c)(4)).

Using the U.S. Fish and Wildlife National Wetlands Inventory, Dominion mapped and estimated there are approximately 19,000 ac (7689 ha) of wetlands within a 6-mi (9.7-km) radius of the North Anna site (Dominion 2020b). These include the following:

- freshwater emergent wetlands—180 ac (73 ha)
- freshwater forested/scrub shrub wetlands—2,500 ac (1,012 ha)
- freshwater pond—200 ac (81 ha)
- lake covering—13,000 ac (5261 ha)
- riverine covering—3,000 ac (1214 ha)

3.6.2 North Anna Site

The North Anna site consists of a peninsula of land jutting into Lake Anna, which partially surrounds the site to the east, north, and southeast. The open water of Lake Anna comprises approximately 34 percent of the site, approximately 37 percent of the site is forest, and approximately 16 percent is developed. The remaining 13 percent of the site consists of barren land, shrub/scrub, grassland/herbaceous, pasture/hay, cultivated crops, and wetlands (Dominion 2020b). Of the terrestrial portion of the site, approximately 30 percent is developed, consisting of power generation and maintenance facilities, administrative buildings, parking lots, roads, mowed grass, and other cleared areas (Dominion 2020b). The remainder of the site lands that have not been cleared and developed mainly consist of hardwood forests and planted pines dominated by a variety of oaks (*Quercus* spp.), yellow poplar (*Liriodendron tulipifera*), sweet gum (*Liquidambar styraciflua)*, and red maple *(Acer rubrum*) trees, as well as scattered pines such as loblolly pines (*Pinus taeda*), Virginia pines (*P. virginiana*), and short-leaf pines (*P. echinata*) (NRC 2006: Section 2.7.1.1). There are also small areas of shrub/scrub, woody wetlands, and grassland/herbaceous land.

North Anna site boundaries include a total of 650 ac (263 ha) of wetland, lake, and riverine waters. Most of the water and wetland acreage is occupied by Lake Anna, with 630 ac (255 ha) inside the North Anna site (Dominion 2020b). Table 3-6 below identifies wetlands and surface water features on the North Anna site.

Table 3-6. Wetlands and Surface Water Features on North Anna Site

Wetland or Water Feature	Area	Percent of Onsite Wetland Habitat
Lake covering	630 ac (255 ha)	97.
Freshwater pond covering	16 ac (6.5 ha)	2.4
Freshwater/forested wetlands	5.6 ac (2.3 ha)	0.9
Riverine covering	1.3 ac (0.5 ha)	0.2

Figure E3.7-2 of the ER (Dominion 2020b: p. E-3-188) shows the location of National Wetland Inventory wetlands on the North Anna site and is incorporated here by reference.

The wildlife species occurring in the forested portions of the North Anna site are typical of the wildlife species found in the upland Piedmont forests of northeastern Virginia. Frequently observed mammals in the upland Piedmont forests include the white-tailed deer (*Odocoileus virginianus*), raccoon (*Procyon lotor*), opossum (*Didelphis virginiana*), gray squirrel (*Sciurus carolinensis*), and gray fox (*Urocyon cinereoagenteus*). These species all also exist on the North Anna site. Smaller mammals such as moles (*Talpidae*), shrews (*Soricidae*), and a variety of mice (*Muridae*) and voles (*Microtus spp.*) are also common on the forested portions of the North Anna site. Groundhogs (*Marmota monax*) live in the grassy areas near forest edges at the site, and beavers (*Castor canadensis*) occur in Lake Anna and its tributaries. Various birds and herpifauna (e.g., snakes, turtles, lizards, and toads) live in the uplands and along the edge of Lake Anna (NRC 2006). In Table E3.73 of its ER, Dominion (2020b: p. E-3-174 through E-3-184) presents a list of terrestrial wildlife species likely to be observed within a 6-mi (10-km) radius of the North Anna site. This list of amphibian, bird, insect, mammal, and reptile species is sourced from the Virginia Department of Game and Inland Fisheries (VDGIF)[2] Fish and Wildlife Information System (FWIS), as accessed in March 2020, and is incorporated here by reference. Dominion does not indicate that any of the species in the table are unusual for the region.

[2] As of July 1, 2020, the VDGIF was renamed and is now known as the Virginia Department of Wildlife Resources (DWR). References to VDGIF in this document include the Virginia DWR.

Several species of residential and migratory wading birds and waterfowl use Lake Anna. Great blue herons (*Ardea herodias*) and belted kingfishers (*Ceryle alcyon*) are present at Lake Anna throughout the year. Mallards (*Anas platyrhynchos*), wood ducks (*Aix sponsa*), and Canada geese (*Branta canadensis*) breed at Lake Anna. Dominion notes that Lake Anna provides important habitat for migratory waterfowl on the Atlantic flyway, a major route for migratory birds during the fall and spring (Dominion 2020b). Especially during very cold winters, elevated water temperature from North Anna station operations helps maintain a large ice-free body of water (NRC 2006: Section 2.7.1.1). Forests, wetlands, and other natural habitats within flyways can help facilitate the seasonal migration of large numbers of birds over long distances separating wintering areas from summer breeding areas.

3.6.3 Important Species and Habitats

3.6.3.1 Federally Listed Species

For a discussion of terrestrial species and habitats that are federally protected under the Endangered Species Act of 1973, as amended, see Section 3.8, "Special Status Species and Habitats," in this report.

3.6.3.2 State-Listed Species

Based on a review of VDGIF and Virginia Natural Heritage Program (VNHP) databases, Dominion identified nine State-listed species known to occur or potentially occur in Louisa or Spotsylvania counties (Dominion 2020b). Of these nine State-listed species, six are terrestrial and three are aquatic. The table of federally and State-listed species provided by Dominion (2020b: p. E-3-186) in Table E3.7-5 of its ER is incorporated here by reference. Four of the State-listed species are also federally listed. As explained above, the NRC staff will address the four State-listed species that are also Federally listed in Section 3.8 of this SEIS. Table 3-7 below shows State-listed species for Louisa and Spotsylvania counties that are not also federally listed. The descriptions of the following State-listed species in Dominion's ER (Dominion 2020b: p. E-3-165 through E-3-167) are incorporated here by reference.

Table 3-7. State-Listed Species for Louisa and Spotsylvania Counties, VA, Potentially Occurring in the North Anna Vicinity (That Are Not Federally Listed)

Common Name	Scientific Name	Class	State Legal Status
Little brown bat	*Myotis lucifugus*	mammal	State Endangered
Rafinesque's eastern big-eared bat	*Corynorhinus rafinesquii macrotis*	mammal	State Endangered
Tricolored bat	*Perimyotis subflavus*	mammal	State Endangered
Loggerhead shrike	*Lanius ludovicianus*	bird	State Threatened
Virginia Piedmont water boatman	*Sigara depressa*	heteropteran (true bugs)	State Endangered

Of the five State-listed species above, three are endangered bats. Two of these bats, the little brown bat and the tricolored bat, were once abundant, but their numbers have declined sharply due to white-nose syndrome (a fungal disease) and possible environmental toxin exposures such as from herbicides and pesticides (Dominion 2020b). The third bat, Rafinesque's big-eared bat, is adapted to temperate arboreal zones of extreme southeast Virginia so is less likely to occur near the North Anna site.

A March 2020 review of the VDGIF FWIS species observation yielded no observation of any of these three State-listed bats within 6 mi (10 km) of North Anna. However, two of the bats—the little brown bat and tricolored bat—were spotted 50 mi (80 km) away from North Anna. In 2016, Dominion contracted a bat survey for the forested portions of the site where proposed North Anna Unit 3 might be located (Dominion 2020b). Contractors used mist net surveys and captured a total of 29 bats in 84 nights. None of the captured bats were federally or State-listed bat species. Although recent surveys have not observed little brown bats and tricolored bats in the North Anna area, it is still possible that they occur there. The little brown bat roosts in both man-made structures and trees, and the tricolored bat may roost in both buildings and trees near water. Such conditions are readily available on the terrestrial portion of the North Anna site (Dominion 2020b). If present at the North Anna site, these bats could forage in the forested areas of oaks, yellow popular, sweet gum, red maple, and occasional loblolly pines and Virginia pines and nest in trees or in man-made structures.

The State-listed threatened bird, the loggerhead shrike, is tolerant of some disturbed habitat but is unlikely to visit developed areas of an active power generation facility. It is also protected under the Migratory Bird Treaty Act (16 U.S.C. 703 et seq.). A March 2020 review of VDGIF FWIS species yielded one possible observation of the loggerhead shrike in Mineral, VA, which at 7 mi (11 km) southwest, is the nearest town to North Anna (Dominion 2020b).

The State-listed endangered insect, the Virginia Piedmont water boatman, is a poorly characterized species. It is also federally identified as a species of concern. This insect is only known to inhabit four sites, all small streams in Virginia's Piedmont province. None of these streams is in Louisa County or Spotsylvania County, the two counties surrounding North Anna, so the Virginia Piedmont water boatman is less likely to be present at or near the North Anna site. As expected, a March 2020 review of VDGIF FWIS species yielded no observation of the Virginia Piedmont water boatman within 6 mi (10 km) of North Anna.

3.6.3.3 Species Protected under the Bald and Golden Eagle Protection Act

The Bald and Golden Eagle Protection Act (16 U.S.C. 668-668c) extends regulatory protections to the bald eagle and golden eagle. The Act prohibits anyone without a permit from the Secretary of the Interior from "taking" bald eagles (or golden eagles), including their parts, nests, or eggs. According to Dominion (2020b), there are four known bald eagle nests adjacent to Lake Anna, and one of these is located on the North Anna site. The Center for Conservation Biology at the College of William and Mary conducts annual surveys for eagle and osprey nests and makes the data publicly available on an online mapping tool. The Center's mapping portal confirms four bald eagle nests adjacent to Lake Anna as of 2018 (CCB 2018). According to Dominion (2020b) all four nests were occupied and produced young in 2019.

3.6.3.4 Species Protected under the Migratory Bird Treaty Act

The Migratory Bird Treaty Act makes it illegal for anyone to take, possess, import, export, transport, sell, purchase, barter, or offer for sale, purchase, or barter, any migratory bird, or the parts, nests, or eggs of such a bird except under the terms of a valid permit issued pursuant to Federal regulations. Dominion has an internal guidance document for compliance with the Migratory Bird Treaty Act. Dominion maintains an annual depredation permit from the U.S. Fish and Wildlife Service (FWS) for Dominion-owned properties in Maryland, Virginia, West Virginia, and North Carolina that authorizes it to take a maximum of 70 black vultures, 20 turkey vultures, 40 Canada geese, and 25 herring gulls. In addition, Dominion's annual depredation permit allows destruction of nests and eggs of 10 herring gull nests and 5 osprey nests (Dominion 2020b).

3.6.3.5 Invasive Species

Invasive species are defined as a non-native organism whose introduction causes or is likely to cause economic or environmental harm, or harm to human, animal, or plant health (EO 13751, Section 2(e)); 81 FR 88609). Executive Order (EO) 13112 (64 FR 6183) directs Federal agencies to not authorize, fund, or carry out actions likely to cause or promote the introduction or spread of invasive species unless they determine that the benefits of the action clearly outweigh the harm from invasive species and that all feasible and prudent measures to minimize risk of harm are taken (EO 13112, Section 2). Dominion maintains guidance documents with policies and procedures for invasive species management at North Anna (Dominion 2020b). Dominion identified the following as important invasive terrestrial plant and animal species:

- Invasive Terrestrial Plant Species: kudzu (*Pueraria montana*), autumn olive (*Elaeagnus umbellate*), and tree-of-heaven (*Ailanthus altissima*)
- Invasive Terrestrial Animal Species: emerald ash borer (*Agrilus planipennis*), rock dove or pigeon (*Columba livia*), and European starling (*Sturnus vulgaris)*

Descriptions of the above-listed invasive species are incorporated here by reference (Dominion 2020b: p. E-3-154 to E-3-156).

3.6.3.6 Important Habitats

Important habitats include any wildlife sanctuaries, refuges, preserves, or habitats identified by State or Federal agencies as unique, rare, or of priority for protection; wetlands and floodplains; and land areas identified as critical habitat for species listed by FWS as threatened or endangered. Important habitats on and around the North Anna site include the wetlands discussed above in Section 3.6.1 and Section 3.6.2. In particular, Lake Anna provides important habitat for migratory waterfowl on the Atlantic Flyway, especially during very cold winters when heat released by station operations maintains an ice-free body of water (NRC 2006).

3.6.4 Proposed Action

As identified in Table 3-1, "Applicable Category 1 (Generic) Issues for North Anna," the impacts of all generic terrestrial resource issues would be SMALL. Table 3-2 identifies only one site-specific (Category 2) issue related to terrestrial resources during the North Anna subsequent license renewal term: Effects on terrestrial resources from noncooling system impacts. This issue is analyzed below. The North Anna site uses a once-through cooling system to remove waste heat from the reactor steam electric system and plant auxiliary (service water) systems and does not use cooling ponds or cooling towers (see Section 2.1.3). Therefore, the Category 2 issue identified in the GEIS related to the effects of water use conflicts with terrestrial resources does not apply.

Category 2 Issue Related to Terrestrial Resources: Effects on Terrestrial Resources (Noncooling System Impacts)

According to the GEIS, noncooling system impacts on terrestrial resources can include those impacts that result from site and landscape maintenance activities, stormwater management, elevated noise levels, and other ongoing operations and maintenance activities that would occur during the license renewal period on and near a plant site. The NRC staff based its analysis in this section on information derived from Dominion's ER (2020b) unless otherwise cited. Dominion has not identified any refurbishment activities during the proposed subsequent relicensing term (Dominion 2020b). No further analysis of potential impacts from refurbishment activities is therefore necessary.

In its ER, Dominion (2020b) states that it will conduct ongoing operational and maintenance activities at the North Anna site throughout the subsequent relicensing term, including landscape maintenance activities, stormwater management, piping installation, and fencing. Dominion states that it would confine these activities to previously disturbed areas. The NRC staff expects that physical disturbance would be limited to paved or disturbed areas or to areas of mowed grass or early successional vegetation and not encroach into wetlands or into the remaining areas of mixed pine-hardwood forest. The NRC staff concurs with Dominion that the anticipated activities would have only minimal effects on terrestrial resources.

Dominion (2020b) states that it has administrative controls in place at the North Anna site to ensure that it reviews operational changes or construction activities and minimizes environmental impacts through BMPs, permit modifications, or new permits, as needed. Dominion further states that regulatory programs for issues like stormwater management, spill prevention, dredging, and herbicides further minimize impacts on terrestrial resources (Dominion 2020b). The NRC staff concurs that continued adherence to environmental management practices and BMPs already established for the North Anna site would continue to protect terrestrial resources during the SLR operational period.

The NRC staff presumes that Dominion will continue to comply with applicable requirements of the Commonwealth of Virginia's regulatory programs. Furthermore, the staff presumes that if appropriate, Dominion will obtain required incidental take permits for impacts on bald eagles.

Operational noise from North Anna facilities extends into the remaining natural areas on the site. However, North Anna has exposed these habitats to similar operational noise levels since it began construction more than 50 years ago. The NRC staff therefore expects that wildlife in the affected habitats have long ago acclimated to the noise and human activity of North Anna operations and adjusted their behavior patterns accordingly. Extending the same level of operational noise levels over the 20-year SLR period is therefore unlikely to noticeably change the patterns of wildlife movement and habitat use.

Based on its independent review, the NRC staff concludes that the landscape maintenance activities, stormwater management, elevated noise levels, and other ongoing operations and maintenance activities that Dominion might undertake during the renewal term would primarily be confined to already disturbed areas of the North Anna site. These activities would neither have noticeable effects on terrestrial resources nor would they destabilize any important attribute of the terrestrial resources on or in the vicinity of the North Anna site. Accordingly, the NRC staff concludes that noncooling system impacts on terrestrial resources from noncooling system activities during the subsequent relicensing term would be SMALL.

3.6.5 No-Action Alternative

Under the no-action alternative, the NRC would not issue a renewed license, and North Anna would shut down on or before the expiration of the current facility operating licenses. Much of the operational noise and human activity at North Anna would cease, reducing disturbance to wildlife in forest cover and other natural vegetation on and near the site. However, some continued maintenance of the North Anna site would still be necessary; thus, at least some human activity, noise, and herbicide application would continue at the site, with possible impacts resembling, but perhaps of a lower magnitude than, those described for the proposed action. Shutdown itself is unlikely to noticeably alter terrestrial resources. Reduced human activity and frequency of operational noise may constitute minor beneficial effects on wildlife inhabiting nearby natural habitats. The NRC staff therefore concludes that the impacts of the no-action alternative on terrestrial resources would be SMALL.

3.6.6 Replacement Power Alternatives: Common Impacts

The NRC staff assumes that each of the replacement power alternatives located on site at North Anna would use the mixed developed and forested land licensed by the NRC early site permit (ESP) for construction of the proposed North Anna Unit 3. Under the ESP for Unit 3, there would be a permanent loss of up to 120 ac (49 ha) of forest, as well as 0.31 ac (0.13 ha) of nontidal wetlands and 752 ft (229 m) of ephemeral streams (Dominion 2020b). An additional maximum of 90 ac (36 ha) would be temporarily disturbed for construction and laydown areas but later revegetated (NRC 2010). Either replacement power alternative would also result in forest and wetland loss. In either case, destruction of the forest cover would reduce the availability of habitat for forest-interior birds and terrestrial plants and animals occurring on the site.

Removing forest cover on the North Anna site would involve the loss of wildlife habitat and reduce the available forest capable of buffering other nearby wildlife habitats from operational noise and human activity. Loss of habitat and increased noise generation during construction and operation of the new facilities could cause terrestrial wildlife to move into other habitats in the surrounding landscape, increasing demands on those habitats and competing with other wildlife. Erosion and sedimentation from clearing, leveling, and excavating land could affect adjacent riparian and wetland habitats, but implementation of appropriate BMPs and revegetation of temporarily disturbed lands would minimize impacts. For any of the replacement power alternatives, the NRC staff also expects that Dominion would obtain any required incidental take permits for impacts on bald eagles.

In the GEIS (NRC 2013a), the NRC staff concluded that terrestrial impacts from operation of nuclear plants would include cooling tower salt drift, noise, bird collisions with plant structures and transmission lines, impacts connected with herbicide application and landscape management, and potential water use conflicts connected with cooling water withdrawals. The applicability of this conclusion is limited, however, because the existing North Anna nuclear facilities use once-through cooling with no cooling towers, whereas new SMRs would instead use mechanical cooling towers.

3.6.7 New Nuclear (Small Modular Reactor) Alternative

In its ER, Dominion (2020b) assumes that the new nuclear alternative consisting of a cluster of SMRs would be built onsite in the area that the NRC previously licensed in an ESP for proposed North Anna Unit 3. This area includes 200 ac (81 ha) of land, of which 120 ac (49 ha) is developed and 80 ac (32 ha) is forested. If the licensee were building Unit 3, the area of land permanently disturbed for construction and operation would be 120 ac (49ha). An additional maximum of 90 ac (36 ha) would be temporarily disturbed for construction and laydown areas but later revegetated (NRC 2010). In comparison with proposed Unit 3, the NRC estimates that the operational footprint area for the new cluster of five SMRs would be larger at 170 ac (69 ha). The five SMRs would use existing North Anna transmission infrastructure and intake and discharge structures. However, the licensee would build new mechanical draft cooling towers for closed-cycle cooling.

The forested portion of the ESP site is relatively recent regrowth vegetated with conifers, hardwoods, shrubs, and herbaceous plants (NRC 2010: Section 4.4.1). Clearing this forested area would displace wildlife to relatively large tracts of adjacent forest to the north, west, and south of the ESP site. Some wildlife mortality would be inevitable, especially among less mobile animals such as toads, lizards, turtles, snakes, moles, voles, and mice (NRC 2006). According to the NRC combined license EIS (NRC 2010), there are no important terrestrial animal species or habitats on the North Anna ESP site. A few small wetland areas (6.7 ac (2.7 ha)) and two intermittent streams exist on the ESP site (NRC 2010). Construction of Unit 3 would permanently disturb approximately 0.31 ac (0.13 ha) of nontidal wetlands and 757 linear ft (231 m) of ephemeral streams (Dominion 2020b p E7-17). Since the proposed SMR cluster would have a larger footprint, the NRC staff assumes it would disturb the same area of wetlands plus additional wetland areas. Dominion would have to perform wetland delineations of affected lands and apply for permits for any wetland fill from USACE and VDEQ. The NRC staff expects that any Federal or State permits authorizing wetland impacts would require mitigation. Wetland losses of this magnitude can typically be mitigated through various forms of compensatory wetland mitigation, such as mitigation banks.

The NRC staff recognizes that the affected land provides habitat for the terrestrial wildlife listed in Section 3.6 of this SEIS and some of the important State-listed or otherwise protected species described in Section 3.6.3. Construction noise could affect wildlife in adjoining forested areas and wetlands. Operational noise from the new cooling towers could also impact wildlife.

Five State-listed species (that are not also federally listed) could possibly occur on or near the ESP site: the loggerhead shrike (*Lanius ludoviciana*), little brown bat (*Myotis lucifugus*), Rafinesque's eastern big-eared bat (*Corynorhinus rafinesquii macrotis*), tricolored bat (*Perimyotis subflavus*), and Virginia Piedmont Water Boatman. As described in Section 3.6.3.2, "State-Listed Species," of this report, recent surveys for these species have not located any individuals within 6 mi (9.7 km) of the North Anna site. The loggerhead shrike was spotted 7 mi (11 km) away in Mineral, VA. Nevertheless, it is possible that State-listed species, especially highly mobile species such as birds and bats, could occur on the site and could lose habitat. Migratory birds will also lose habitat.

To minimize construction-related impacts on wildlife, Dominion represented that it would adhere to State permit conditions that may restrict the timing of certain construction activities to minimize impacts on breeding birds (Dominion 2020b). After completion of the five-SMR cluster, Dominion (2020b) would revegetate the cleared but undeveloped land. Wildlife species able to adapt to human disturbance, such as raccoons (*Procyon lotor*), opossum *(Didelphis virginiana*), mockingbirds (*Mimus polyglottus*), and northern cardinals (*Cardinalis cardinalis*), could then reoccupy the land (NRC 2006).

As the new nuclear SMR facility would use existing North Anna transmission lines, the NRC staff expects no increased potential in wildlife injury from transmission lines. However, the SMR cluster will require adding new, tall structures to the landscape, including mechanical draft cooling towers, 65 ft (20 m) in height, and a power block, 160 ft (50 m) in height. These could result in avian (bird) collisions. In addition, bats, including State-listed bat species noted in Section 3.6.3, could collide with the towers and die. However, the NRC staff expects that bird and bat populations would become accustomed to the presence of the towers and avoid them. Once the SMR cluster is built, operational impacts on terrestrial resources would likely remain as expected for the proposed action. Based on the preceding analysis, the NRC staff concludes that impacts on terrestrial resources from the new nuclear option of five SMRs would be SMALL.

3.6.8 Combination Alternative (Solar, Offshore Wind, Small Modular Reactor, and Demand-Side Management)

Solar Photovoltaic

Impacts on terrestrial habitats and biota from the construction and operation of solar PV plants as part of the combination alternative would depend largely on the amount of land required and the location of the land. The NRC staff estimates that the solar portion of the alternative would require 20,000 ac (8,000 ha) of cleared land for eight solar PV plants in the North Anna region of influence with access to Dominion transmission infrastructure. If the lands chosen for the plants were previously cleared and used for industrial activity, the impacts on terrestrial resources would be less significant than if the lands were virgin forest containing important species and habitats. Once in operation, solar PV plants pose special hazards to birds through collisions with PV equipment and transmission lines, electrocution from substation and distribution lines, and predation when injured after collision (Hathcock 2019). Another less understood cause for bird collisions is known as the lake effect theory. Birds, especially migrating waterfowl and shorebirds, perceive the horizontally polarized light of PV solar panels as bodies of water and are injured or killed when they attempt to land on the panels as if they were water (Horvath et al. 2009). Water-seeking insects can also collide with the panels for the same reasons. In large enough numbers, such insect deaths may affect food webs. The Multiagency Avian-Solar Collaborative Working Group is a collection of Federal and State agencies identifying information needs and best practices for reducing avian impacts from solar energy. Collaboration with government agencies on best practices in the construction and siting of the solar installations can mitigate their impacts on birds. The NRC staff concludes that the impacts on terrestrial resources would be MODERATE to LARGE because the solar plants require large areas of land and clearing the land could result in the significant loss of wildlife, habitats, and vegetation.

Offshore Wind

During construction of an offshore wind facility, terrestrial habitats and biota may be impacted by onshore activities such as installation of interconnection cables, fiber optic cables, and switch cabinets and construction of interconnection stations. Species may experience habitat loss directly from excavation or indirectly from pollutants from drilling fluids. Wildlife could be disturbed by drilling and other operational noise and human activity during the construction period. However, regulations in the Virginia Coastal Zone Management Program prohibit onshore construction near sensitive coastal resources such as wetlands. As with the pilot portion of the project, onshore construction activities for the commercial portion of Dominion's Coastal Virginia Offshore Wind project would likely occur in disturbed areas such as parking lots, roadways, and ROWs, where terrestrial biota are already adapted to human activity (BOEM 2015). In addition, Dominion has proposed that all onshore construction for the commercial portion of the project occur within the boundaries of the State Military Reservation in Virginia Beach, a military site that the National Guard Bureau uses primarily for training the Virginia National Guard and other State National Guard units. The NRC staff presumes that wildlife in the area has long been acclimated to unexpected loud noises, such as from the rifle range, and other human activity involved in military training. The additional noise and human activity from the construction of the onshore components of the offshore wind facility would be temporary and result in minimal permanent loss of habitat.

During operations, offshore wind turbines can impact terrestrial resources largely through the collision of bats and birds with rotating turbine blades. The NRC staff estimates that the combination alternative would require 72 offshore wind turbines to generate the needed replacement power. The current proposal for Dominion's Coastal Virginia Offshore Wind project places the turbines in an offshore leased area 21–43 mi (34–69 km) east of the Virginia Beach shore (BOEM 2012).

Concerning bat collisions, in the mid-Atlantic, bat activity drops off after 12.4 mi (20 km) from shore (Sjollema et al. 2014). It is thus unlikely that nonmigratory cave dwelling bats would be present at turbines approximately 27 mi (43 km) from shore (BOEM 2015). However, it is possible that some migratory tree bats may pass through the turbine sites during migration. The migratory tree bat species that could occur at the turbine sites are the silver-haired bat, eastern red bat, and the hoary bat (Cryan and Brown 2007). The three State-listed bat species for North Anna (the little brown bat, the tricolored bat, and Rafinesque's big-eared bat) would not occur near the turbine sites.

Compared to bats, impacts on birds from the operations of offshore wind turbines are an issue of greater concern. The Coastal Virginia Offshore Wind project will operate in the Atlantic Flyway, a major migratory route for birds that are protected under the Migratory Bird Treaty Act. In addition to direct bird mortality from collision, offshore wind farms in general can disrupt bird flight formations and create barriers between areas that are ecologically linked, such as between roosting sites and feeding sites, breeding sites and wintering sites, and migration route points (Exo et al. 2003). The maintenance and repair of turbines will increase boat activity in the area, which can be very disruptive to some bird species that will change course to avoid boats by as much as several kilometers (Exo et al. 2003).

Impacts on birds from collision with offshore turbines are difficult to accurately quantify because downed individuals will sink or be swept away by the ocean where they cannot be collected and counted. Avian mortality rates at onshore wind turbines have been extensively studied and are estimated as an average of 5.3 birds killed per turbine per year (Loss et al. 2013). However, offshore wind farms tend to use much larger turbines, include larger numbers of turbines, and operate in areas where the background noise from wind and waves hamper bird acoustic perceptions (Exo et al. 2003). These differing conditions make it difficult to use onshore turbine bird mortality rates as the starting point for estimating offshore turbine bird mortality rates (Exo et al. 2003). Nevertheless, in its environmental assessment for the Coastal Virginia Offshore Wind pilot project, the Bureau of Ocean Energy Management estimated that, for an offshore wind turbine located 27 mi (43 km) from the Virginia Beach shore, the yearly bird mortality rate could be much lower than 5.3, as there are fewer birds in the open ocean and many birds avoid turbine sites (BOEM 2015). A total of 13 bird surveys conducted in the Coastal Virginia Offshore Wind project area recorded the presence of 45 bird species.

Of these, a large, long-lived seabird called the northern gannet *(Morus bassanus*) would be the bird species most affected by collision with the turbines. The northern gannet, which is protected under the Migratory Bird Treaty Act (FWS 2020a), represented 81 percent of all bird individuals observed in the area. It was also the bird species most likely to fly at the height of the rotary sweep. The Migratory Bird Treaty Act makes it illegal to take any migratory bird (or parts, nests, or eggs) except under a valid permit issued under Federal regulations, and Dominion would likely need such a permit for a take of northern gannet and other pelagic birds. For its two-turbine Coastal Virginia Offshore Wind pilot project, the estimated take was one northern gannet individual killed per year (BOEM 2015). Stated another way, the estimated take was 0.5 northern gannet individuals per turbine per year. For the 72 turbines required for the combination alternative, the number of northern gannets killed per year would be far greater because there are more turbines spread out over a much larger area. Also, the 14-MW turbines for the commercial project are approximately 33 percent taller in height and 48 percent wider in rotary span than the 6-MW pilot turbines, which could result in a greater potential for bird collision. However, even if the northern gannet take rate increased six-fold from 0.5 individuals per turbine per year to 3 individuals per turbine per year, the estimated loss would be

216 northern gannet individuals per year. This number would not be likely to significantly affect the species. The International Union for the Conservation of Nature (IUCN 2018) lists the northern gannet as a species of least concern because it has a very large range and its population is increasing (Birdlife International 2021), by some estimates as much as 3 percent per year. Birds protected under the Bald and Golden Eagle Protection Act would not occur near the turbines, as golden eagles do not nest in Virginia and typically migrate along the Appalachian mountain ridgelines, and bald eagles do not occur in the open ocean (BOEM 2015).

Based on the above analysis, the impact on terrestrial resources from construction and operation of an offshore wind facility as part of the combination alternative would be MODERATE.

Small Modular Reactor

The terrestrial impacts for the construction and operation of one SMR as part of the combination alternative would be similar to but less than the terrestrial impacts described above (in Section 3.6.7) for the new nuclear alternative. The operation of one SMR would require a much smaller footprint (approximately 21 percent of the footprint size of the five-SMR cluster). A smaller area of forested land and wildlife habitat would be temporarily or permanently disturbed during construction, and there would likely be a shorter period of construction noise and activity to disturb wildlife. Construction of new tall structures at the North Anna site; namely, a new mechanical cooling tower and power block, would result in increased avian and bat collisions. Noise from the operation of the cooling tower could also disturb wildlife. Based on the above information and the conclusion reached in Section 3.6.7 of this SEIS, the NRC staff concludes that terrestrial impacts from construction and operation of one SMR as part of the combination alternative would be SMALL.

Demand-Side Management

The NRC has not identified any impacts on terrestrial resources associated with demand-side management.

Combination Alternative Conclusion

Based on the above discussion of solar, offshore wind, SMR, and demand-side management, the NRC staff concludes that the overall impacts on terrestrial resources from the combination alternative could range from SMALL to LARGE, mainly due to the large area of land and the types of land that could be used for the solar portion and the operational impacts of the offshore wind portion of the alternative.

3.7 Aquatic Resources

This section describes the aquatic resources of the affected environment, including Lake Anna and the North Anna River. The NRC staff has previously characterized these resources in detail in Section 2.2.5 of the FSEIS for initial license renewal (NRC 2002b), Section 2.7.2 of the ESP EIS (NRC 2006), and Section 2.7.2 of the COL EIS (NRC 2010). Section E3.7.1 of Dominion's ER (Dominion 2020b: p. E-3-137 to E-3-142) also describes aquatic resources. This information is incorporated here by reference, with key, new, and updated information summarized below in the following subsections. Following the description of the aquatic environment, the staff analyzes the potential impacts on these resources that would occur as a result of the proposed action (SLR) and alternatives.

3.7.1 Lake Anna

Lake Anna is a 17-mi (27-km)-long man-made impoundment of the North Anna River. Lake Anna remains connected to the river via the North Anna Dam, which includes a spillway and the North Anna Hydro Power Station. The lake is typical of many shallow reservoirs in the southern and mid-Atlantic region. It contains three trophic conditions. The upper portion of the lake is eutrophic, the lower portion is oligotrophic, and the middle is a blend of the two. Following impoundment, high nutrient levels facilitated an initially highly productive biotic community. The aquatic environment exhibited rapid ecological succession during the 1970s. In the 1980s, productivity subsequently decreased, the aquatic community gradually shifted from riverine to lake, and the community ultimately stabilized by the mid-1980s.

Lake Anna can be divided into two distinct sections: the 9,600-ac (3,900-ha) Lake Anna Reservoir and the 3,400-ac (1,400-ha) waste heat treatment facility (WHTF) used for North Anna cooling. During operations, North Anna discharges heated effluent to the WHTF through a single discharge canal located 200 ft (60 m) south of the intake location. Water flows from the discharge canal through a series of three lagoons before reentering the reservoir portion of the lake. The WHTF is separated from the reservoir by a series of dikes. A weir at Dike 3 allows water to flow from the WHTF back into the reservoir. Fish can swim from the reservoir into the WHTF and back. Therefore, the same aquatic community occurs in both regions of the lake.

3.7.1.1 Biological Communities of Lake Anna

The trophic structure of Lake Anna includes primary producers (plankton, macrophytes, and periphyton), primary consumers (zooplankton and benthic macroinvertebrates), and bottom-feeding, planktivorous, and piscivorous fish that serve as secondary and tertiary consumers. Primary producers are organisms that capture solar energy and synthesize organic compounds from inorganic chemicals. They form the trophic structure's foundation by producing the organic nutrients and energy used by consumers. Primary producers in lake systems include phytoplankton, aquatic macrophytes, and periphyton. Of the three, phytoplankton are the major producers in all but very shallow lakes. Figure 3-6 illustrates the trophic structure of Lake Anna.

<u>Plankton</u>

Plankton are small and often microscopic organisms that drift or float in the water column. Phytoplankton are single-celled plant plankton and include diatoms (single-celled yellow algae) and dinoflagellates (a single-celled organism with two flagella). Phytoplankton live suspended in the water column and occur in the limnetic (open water) zone of a lake. Seventy-seven genera of phytoplankton are known to occur in Lake Anna. Diatoms (Bacillariophyta), green algae (Chlorophyta), blue-green algae (Cyanophyta), and dinoflagellates (Pyrrophyta) are the most dominant groups (VEPCO 1986).

Zooplankton are animals that either spend their entire lives as plankton (holoplankton) or exist as plankton for a short time during development (meroplankton). Zooplankton include rotifers, isopods, protozoans, marine gastropods, polychaetes, small crustaceans, and the eggs and larval stages of insects and other aquatic animals. Sixty-six taxa of zooplankton are known to occur in Lake Anna. Polyarthra, Keratella (common rotifers), and Bosmina (a common cladoceran) are most abundant (VEPCO 1986).

<u>Macrophytes and Periphyton</u>

Aquatic macrophytes are large plants, both emergent and submerged, that inhabit shallow water areas. Periphyton consists of single-celled or filamentous species of algae that attach to benthic or macrophytic surfaces. Macrophytes and periphyton occur in the littoral (near-shore and shallow) zone. They tend to be highly productive because they have more access to nutrients through their roots than do phytoplankton. Macrophytes within Lake Anna include cattails and rushes.

Benthic Invertebrates

Benthic invertebrates inhabit the bottom of the water column and its substrates. They include macroinvertebrates (clams, crabs, oysters, and other shellfish) as well as certain zooplankton, such as polychaetes (described previously). Researchers have collected 124 benthic taxa from the Lake Anna region before impoundment. In pre-impoundment collections, the eastern elliptio (*Elliptio complanatus*), Atlantic spike (*E. producta*), and striated fingernail clam (*Sphaerium striatum*) were prevalent in the North Anna River basin. Currently, the introduced Asian clam (*Corbicula* spp.) dominates benthic invertebrate collections from both Lake Anna and the lower North Anna River (Dominion 2020b).

In 2008, Creek Laboratory, LLC conducted a mussel survey in Lake Anna in fulfillment of VPDES permit requirements. Dominion reported the results of this effort in Appendix 1 of its 2008 Lake Anna and lower North Anna River environmental study annual report (Dominion 2009). Researchers collected specimens through shoreline searches, snorkeling, and SCUBA diving at 22 sites throughout Lake Anna on 5 days in the fall of 2008. The three most common species were eastern elliptio, eastern floater (*Pyganodon cataracta*), and pond papershell (*Utterbackia imbecilis*). Eastern floater and pond papershell were found throughout Lake Anna in soft substrate, such as deep silt or detritus. Eastern elliptio were found in the WHTF, mid-lake, and lower lake locations in a variety of substrates but most commonly in mixed sand and gravel. Asian clams were also present throughout the survey area. Mussels were most abundant within the WHTF lagoons, although Creek Laboratory states, in its survey report, that the cause of this is unknown and may be due to temperature regime, relatively constant current, better substrate in the WHTF than in other areas of the lake, or a combination of these factors. Researchers found no federally or State-listed freshwater mussels at any of the survey sites.

Ichthyoplankton

Because Lake Anna is a closed system, ichthyoplankton of all aquatic species that inhabit the lake are present. Ichthyoplankton have been sampled during three periods. From 1978 to 1983, VEPCO performed entrainment sampling at the North Anna intake in connection with a CWA Section 316(b) demonstration (VEPCO 1985). In 1984 and 1985, VEPCO collected ambient ichthyoplankton samples throughout the lake in support of its CWA Section 316(a) demonstration (VEPCO 1986). In 2016 and 2017, HDR Engineering, Inc. (HDR) performed entrainment sampling at the North Anna intake in connection with an updated CWA Section 316(b) demonstration (HDR 2018a). Larvae of black crappie (*Pomoxis nigromaculatus*), white perch (*Morone americana*), yellow perch (*Perca flavescens*), gizzard shad (*Dorsoma cepedianum*), and sunfishes (*Lepomis* spp.) were the most prevalent taxa collected during each of these sampling efforts. Notably, no fish eggs were collected in the 1978–1983 entrainment samples or in the 1984–1985 ambient samples, and only a relatively small number of nonviable eggs were collected in 2016–2017 entrainment samples. This is likely because most species of fish in Lake Anna produce demersal, adhesive eggs that do not occur in the water column where sampling occurred. Table 3-11 lists the ichthyoplankton taxa reported during each of the three studies. Section 3.7.3.1.2 of this SEIS discusses the results of the two entrainment studies in detail.

Juvenile and Adult Fish

Over 40 species of fish representing 16 families have been reported from Lake Anna (NRC 2010). Fish within the lake are a combination of those originating from the North Anna River and local farm ponds during initial impoundment and those introduced by VDGIF, which manages Lake Anna's fish populations. Recreationally important species include largemouth bass (*Micropterus salmoides*), striped bass (*Morone saxatilis*), bluegill (*Lepomis macrochirus*), yellow perch, black crappie, white perch, pumpkinseed (*L. gibbosus*), redear sunfish (*L. microlophus*), redbreast sunfish (*L. auritus*), channel catfish (*Ictalurus punctatus*), and white catfish (*Ameiurus catus*). Primary forage species include threadfin shad (*Dorosoma petenense*), gizzard shad, and blueback herring (*Alosa aestivalis*).

Since its creation, the VDGIF has stocked Lake Anna to support recreational fishing. Initial introductions included largemouth bass, bluegill, redear sunfish, and channel catfish (VDGIF 2020a). Subsequently, the VDGIF stocked channel catfish, largemouth bass (northern and southern strains), redear sunfish, striped bass, and walleye to improve and diversify the fishery. In the 1980s, VDGIF introduced blueback herring and threadfin shad to provide forage for pelagic predators. In 1994, VEPCO, under VDGIF's approval, stocked the WHTF with sterile triploid herbivorous grass carp (*Ctenopharyngodon idella*) to control the growth of the nuisance plant hydrilla (*Hydrilla verticillata*) (NRC 2002b). Today, VDGIF continues to stock striped bass annually. All other species are self-sustaining.

Since 1987, Dominion has conducted quarterly gill net and electrofishing sampling of Lake Anna. Researchers set nets in February, May, August, and November at 15 locations throughout the lake and WHTF (6 gill net stations and 9 electrofishing stations) (see Figures 5 and 8 in Dominion 2020f). All sampling is performed in accordance with Dominion's 2014 study plan (Dominion 2014), which VDEQ and VDGIF have reviewed and approved to ensure that the plan addresses the relevant VPDES permit and Clean Water Act Section 316(a) requirements.

Gizzard shad, channel catfish, white perch, threadfin shad, largemouth bass, and white catfish are typically the numerically dominant species caught in gill net samples. Centrarchids (sunfishes, including largemouth bass) are typically the numerically dominant taxa collected by electrofishing. Since sampling began, gill net catch per unit effort (CPUE) for channel catfish has slowly increased throughout Lake Anna; gill net CPUEs for white perch and white catfish have been consistent; and gill net CPUEs for gizzard shad and threadfin shad have exhibited high annual variability and seem to follow a cyclical pattern. Within the WHTF, gill net CPUEs for channel catfish and gizzard shad have been highly variable over time, while gill net CPUEs for white perch, largemouth bass, and white catfish have been relatively stable. Electrofishing CPUEs of the most numerically dominant species, including bluegill, green sunfish, redbreast sunfish, largemouth bass, and redear sunfish, have exhibited high variation over time but appear to oscillate over distinct averages (Dominion 2020f).

In the past four years of sampling (2015–2019), Dominion's researchers have collected a total of 34 species of fish representing 10 families by gill net and electrofishing combined. Table 3-12 lists each collected taxon by family. Full results of Dominion's Lake Anna fish sampling appear in its annual reports (Dominion 2016a, 2017, 2018c, 2019b, 2020f). Dominion's study plan (Dominion 2014) describes sampling methods and materials in detail.

VDGIF also performs periodic sampling to support its management of the reservoir's fisheries and to inform future stocking. Table 3-12 lists fish taxa collected by VDGIF in Lake Anna over the period 2003–2015, as reported in a 2016 *Lake Anna Fisheries Management Report* (VDGIF 2016). Unlike Dominion, VDGIF does not distinguish between lake and WHTF sampling stations during its sampling; thus, taxa in Table 3-12 are reported for the entirety of Lake Anna.

3.7.1.2 Important Species and Habitats of Lake Anna

This section summarizes important fisheries of Lake Anna as well as State-protected and other special status species. Section 3.8 discusses federally listed species separately; however, none occur in Lake Anna.

Commercially Important Fisheries

Commercial fishing is not permitted on Lake Anna. Thus, there are no commercially important fisheries.

Recreationally Important Fisheries

Lake Anna is a popular angling destination. The lake experiences moderate fishing pressure for its size. Species most sought by anglers, in order of preference, are largemouth bass, striped bass, black crappie, and sunfish. According to VDGIF's most recently available fisheries management report, annual fishing pressure within the lake has varied from between 12.8 and 13.7 hours per acre since 2005 (VDGIF 2016). Table 3-8 lists the mean abundance of recreationally important species for the period 2003–2015.

Table 3-8. Mean Abundance of Recreationally Important Fish in Lake Anna, 2003–2015

Scientific Name	Common Name	Mean Abundance[a]
Morone americana	white perch	12.0
Pomoxis nigromaculatus	black crappie	8.6
Ictalurus punctatus	channel catfish	5.7
Morone saxatilis	striped bass	5.2
Ameiurus catus	white catfish	3.1
Micropterus salmoides	largemouth bass	1.5
Lepomis macrochirus	bluegill	0.5
Lepomis microlophus	redear sunfish	0.4
Ictalurus furcatus	blue catfish	0.1
Lepomis auritus	redbreast sunfish	0.1
Perca flavescens	yellow perch	0.1
Lepomis gibbosus	pumpkinseed	—
Micropterus dolomieu	smallmouth bass	—
Morone chrysops x saxatilis	striped bass hybrid	—
Sander vitreus	walleye	—
Stizostedion vitreum x canadense	saugeye	—

[a] Fish per net, per night; — = not reported.

Source: VDGIF 2016

Although VDGIF has stocked a number of species since the lake's impoundment, in the past 20 years, the agency has only stocked striped bass and walleye hybrids (e.g., saugeye), and currently VDGIF only stocks striped bass (VDGIF 2016). VDGIF has varied its stocking rates and locations in an attempt to determine optimum future stocking rates for Lake Anna.

VDGIF has stocked striped bass and hybrids at an average rate of 18 fish per acre, which is considerably higher than rates for other large southeastern reservoirs. Striped bass in Lake Anna exhibit rapid juvenile growth followed by slow adult growth, which is a typical pattern in southeastern reservoirs containing marginal habitat. Summer temperatures and dissolved oxygen conditions at Lake Anna are typically marginal for adult fish, especially in the lower portion of the reservoir. VDGIF stocked striped bass hybrids in 2014 on a 1-year experimental basis. Hybrids typically perform better within marginal habitat.

VDGIF stocked saugeye (a walleye hybrid) in 2013 at a rate of 10 fish per acre as part of an experiment to determine whether this hybrid would perform better in Lake Anna than walleye. Although this was originally a one-time stocking event, VDGIF is considering periodic future stocking of this species.

<u>State-Protected and Other Special Status Species</u>

The Commonwealth of Virginia enacted the Virginia Endangered Plant and Insect Species Act (Va. Code Section 3.2-1000 et seq.) in 1979 to protect Virginia-endemic species from possible extinction throughout all or a significant part of those species' native ranges. Under the authority of this act, VDGIF lists fish, mollusks, freshwater crustaceans, and marine mammals as State-endangered or threatened. Additionally, under the Virginia Wildlife Action Plan (VDGIF 2015), VDGIF identifies many aquatic species as Species of Greatest Conservation Need. The distribution and abundance of such species are indicative of the greater diversity and health of wildlife within the State.

No State-listed species or Species of Greatest Conservation Need occur in Lake Anna (Dominion 2020b; Roble 2020; VDCR 2020; VDGIF 2020b; VDGIF 2020c).

The American eel (*Anguilla rostrata*) inhabits Lake Anna and is a Tier III species ("High Conservation Need") in the Virginia Wildlife Action Plan (VDGIF 2015). It is an elongated, snakelike fish native to freshwater rivers and streams throughout North and South America. The species is catadromous and spawns in the Sargasso Sea of the Western Atlantic. It spends its adult life in streams with continuous flow or in muddy, silt-bottomed lakes. Adults usually feed at night on worms, small fish, crustaceans, clams, and other mollusks. Dominion researchers collected one individual of this species in the North Anna Reservoir by electrofishing in May 2019 (Dominion 2020f). This species has not otherwise been reported from Lake Anna. American eel were likely introduced into Lake Anna during initial impoundment.

3.7.1.3 Invasive and Nuisance Species of Lake Anna

Nonnative species are those species that are present only because of introduction and that would not naturally occur either currently or historically in an ecosystem. Invasive species are nonnative organisms whose introduction causes or is likely to cause economic or environmental harm or harm to human, animal, or plant health (81 FR 88609). For purposes of this discussion, nuisance species are nonnative species that alter the environment but that do not rise to the level of invasive.

Invasive and nuisance aquatic species in Lake Anna include hydrilla, the northern snakehead (*Channa argus*), and the Asian clam.

Hydrilla is an exotic submerged aquatic plant that occurs in still or slow-moving freshwater and can tolerate a wide range of conditions, which allows it to out-compete native vegetation. It became established in Lake Anna in the 1980s. In 1994, Dominion, in coordination with the

State, released sterile triploid herbivorous grass carp (*Ctenopharyngodon idella*) to control the growth of this nuisance plant (Dominion 2020b). Dominion has also developed a hydrilla management plan in coordination with local stakeholders and agencies. The plan includes a citizen-led monitoring program, grass carp stockings, and herbicide application. Currently, hydrilla in the reservoir and WHTF portions of Lake Anna is minimal. In 2019, the plant's presence did not necessitate any specific management or control.

The northern snakehead is a predatory fish native to parts of Asia and Russia. As an invasive species, it out-competes native top-level predators and can substantially deplete available food resources, including zooplankton, larvae, small fish, and crustaceans. It is also able to survive in low-oxygen waters. Snakeheads were found to be self-sustaining in the York drainage of Lake Anna as of 2017 (VDWR 2020). Dominion researchers also collected one snakehead in the North Anna arm of the lake during 2019 electrofishing surveys. Dominion maintains procedures concerning snakeheads that require personnel to report collection and location of the catch and to kill the individual(s) in accordance with State-level invasive species guidance.

The Asian clam, which is now ubiquitous in many major U.S. freshwater systems, is capable of surviving in relatively cold waters and reproduces rapidly. Once established, Asian clams can alter benthic substrates, out-compete other native benthic invertebrates, and cause the decline or local disappearance of native mussel and clam populations. Asian clams are particularly damaging to intake pipes for power and water facilities when large numbers of the clams, either dead or alive, clog the pipes. Individuals will also biofoul the pipes by attaching themselves to pipe walls where they incrementally obstruct more flow as they grow. Although present in Lake Anna, Asian clams have not yet occurred in concentrations that would necessitate Dominion to take management actions, such as low-level chlorination or biocide application (Dominion 2020b). In 1990, Dominion initiated a semiannual sampling program to monitor the Asian clam population. Sampling indicates that the population is highly variable. In grab sample surveys of two locations in the North Anna Reservoir and two locations in the WHTF over the period 1991–2019, researchers collected from 22 individuals (2019) to 201 individuals (2011). Dominion maintains procedures and protocols to control the proliferation of the Asian clam. These include saving specimens of any mussels or clams found in North Anna water systems for inspection and identification and implementation of boat and trailer disinfection procedures.

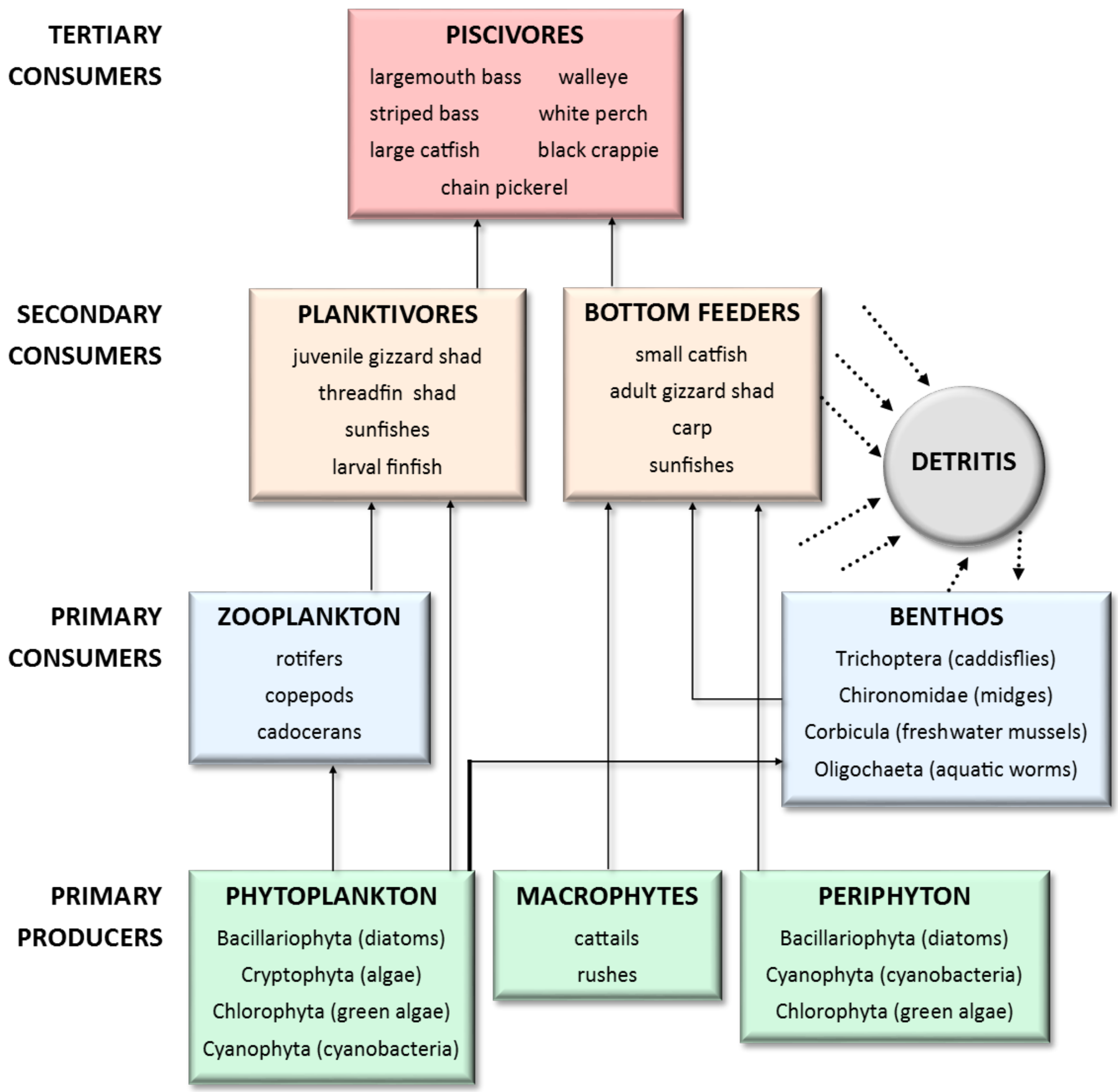


Figure 3-6. Trophic Structure of Lake Anna

3.7.2 North Anna River

The North Anna River downstream of the North Anna Dam is small (ranging from 75–150-ft (23–45-m) wide), but it supports a diverse assemblage of freshwater species. Fish abundance and diversity have steadily increased following Contrary Creek mine site reclamation and restoration, which began soon after impoundment of the River and creation of Lake Anna. The North Anna River joins the South Anna River 23 mi (37 km) downstream from the North Anna Dam to form the Pamunkey River.

3.7.2.1 Biological Communities of the North Anna River

Like many southern streams, the North Anna River periphyton community is dominated by diatoms. Immediately downstream of Lake Anna, caddisflies compose the majority of the benthic macroinvertebrate community. Farther downstream, macroinvertebrate communities show more diversity and are similar to those of the South Anna River (NRC 2002b).

The river's fish community includes a diverse assemblage of stream fishes. Over 35 species of 13 families have been reported from the North Anna River downstream of the dam. Redbreast sunfish are consistently among the most abundant species in the river. Satinfin shiner (*Cyprinella analostana*), American eel, rosyface shiner (*Notropis rubellus*), rosefin shiner (*Lythrurus ardens*), swallowtail shiner (*Notropis procne*), and margined madtom (*Noturus insignis*) are also relatively common. Recreationally important species include smallmouth bass, bluegill, and striped bass. Dominion samples the fish community of the North Anna River below the dam three times each year using electric seine and backpack electrofishing. Researchers collect samples in May, July, and September at four river stations bordering Louisa, Spotsylvania, Hanover, and Caroline counties (see Figure 12 in Dominion 2020f). Researchers perform sampling in accordance with Dominion's study plan (Dominion 2014), and Dominion reports its results to VDEQ and VDGIF annually. Species richness, the number of species present in the North Anna River, has consistently been high during sampling efforts. Over the period 1999–2018, mean species richness was 26. Dominion also calculates diversity and evenness indices. Shannon's diversity index uses species abundance and evenness to calculate richness. If abundance is primarily concentrated in one species, the index will be closer to zero. Diversity in North Anna River samples is fairly consistent year-to-year. This value ranged from 1.96 to 2.5 over the period 1999–2019 with an average score of 2.25. Pielou's evenness index is the count of individuals of each species in an area and ranges from 0 (no evenness) to 1 (complete evenness). Evenness in North Anna River samples is also consistent year-to-year. This value ranged from 0.6 to 0.8 over the period 1999–2019, with an average score of 0.7.

VDGIF also periodically samples the North Anna River to assess the condition of recreational fisheries. Of particular interest in the lower river are largemouth and smallmouth bass because these species are the most sought after by anglers. Since 2006, VDGIF has released no new sampling reports or data on the North Anna River. Summaries of VDGIF's 2006 and other past sampling efforts are reported in Section 2.7.2.3 of the NRC's ESP EIS (NRC 2006) and Section 2.7.1.1 of the COL EIS (NRC 2010).

3.7.2.2 Important Species and Habitats of the North Anna River

This section summarizes important fisheries of the North Anna River as well as State-protected and other special status species. Section 3.8 discusses federally listed species separately.

<u>Commercially Important Fisheries</u>

Commercial fishing is not permitted in the North Anna River (Dominion 2020b; NRC 2010). Thus, there are no commercially important fisheries.

<u>Recreationally Important Fisheries</u>

The most sought-after species in the North Anna River include smallmouth bass, bluegill, and striped bass. VDGIF sampled the North and South Anna Rivers in connection with the proposed North Anna Unit 3 in 2008. Table 3-9 lists the mean sampling abundance of recreationally important species collected during this effort.

Table 3-9. Mean Sampling Abundance of Recreationally Important Fish in the North Anna River, 2006

Scientific Name	Common Name	Sampling Abundance[a]
Lepomis auritus	redbreast sunfish[c]	1107
Micropterus dolomieu	smallmouth bass[c]	85
Micropterus salmoides	largemouth bass[c]	39
Lepomis macrochirus	bluegill[c]	7
Lepomis gibbosus	pumpkinseed[c]	2
Lepomis microlophus	redear sunfish[c]	2

[a] Fish per kilometer collected via electrofishing at three sampling sites.

Source: VDGIF 2008

State-Protected and Other Special Status Species

Four State-protected or Virginia Wildlife Action Plan priority species occur in Louisa and Spotsylvania counties (see Table 3-10). These species are as follows:

- dwarf wedgemussel (*Alasmidonta heterodon*)
- green floater (*Lasmigona subviridis*)
- American eel
- least brook lamprey (*Lampetra aepyptera*)

The dwarf wedgemussel is a small, greenish-brown freshwater bivalve that is endangered within Virginia. It is also federally listed as endangered under the Endangered Species Act. Although the species occurs within Louisa and Spotsylvania Counties, VDGIF reports no occurrences of it within the North Anna River (VDGIF 2020b, 2020c). Section 3.8 of this SEIS describes the dwarf wedgemussel in further detail.

The green floater is a freshwater bivalve that inhabits streams and small rivers. It is threatened within Virginia and is a candidate for Federal listing under the Endangered Species Act. VDGIF reports occurrences of this species within the upper Pamunkey River watershed (VDGIF 2020b, 2020c). Section 3.8 of this SEIS describes the green floater in further detail.

The American eel is a Tier III ("High Conservation Need") species in the Virginia Wildlife Action Plan (VDGIF 2015), but the State has not given it any formal protective status. Section 3.7.1.2 describes it briefly. Within the North Anna River, VDGIF reports occurrences of this species at Hawkins Creek and Long Creek (VDGIF 2020b, 2020c). Dominion researchers have also collected the species during annual river sampling efforts described previously in this SEIS.

The least brook lamprey is a Tier I ("Critical Conservation Need") species in the Virginia Wildlife Action Plan (VDGIF 2015), but the State has not given it any formal protective status. It is a nonparasitic lamprey with a long, eel-shaped body and deeply notched dorsal fin. It prefers clean, clear gravel riffles and runs of creeks and small rivers. It is herbivorous in immature stages and does not feed as an adult. Within the North Anna River, VDGIF reports occurrences of this species at Hawkins Creek and Long Creek (VDGIF 2020b, 2020c). Dominion researchers have also collected the species during annual river sampling efforts described previously in this SEIS. In 2006, VDGIF collected the species at a catch per unit effort (CPUE) of 13 individuals per kilometer over three electrofishing sampling sites (VDGIF 2008).

Table 3-10. State-Protected Aquatic Species in the North Anna River

Scientific Name	Common Name	Protected Status[(a)]	WAP Ranking[(b)]	Conservation Opportunity[(c)]
Alasmidonta heterodon	dwarf wedgemussel	FE, SE	I	a
Lasmigona subviridis	green floater	CL, ST	II	a
Anguilla rostrata	American eel	-	III	a
Lampetra aepyptera	least brook lamprey	-	I	c

(a) Endangered Species Act protection status as follows: FE = federally endangered; FT = federally threatened; PT = proposed to be listed as federally threatened; CL = candidate for federal listing. Commonwealth of Virginia protection status as follows: SE=State endangered; ST=State threatened.

(b) Virginia Wildlife Action Plan (WAP) status (I-IV) as follows: I = Tier I, Critical Conservation Need, II = Tier II, Very High Conservation Need; III = Tier III, High Conservation Need; IV = Tier IV, Moderate Conservation Need.

(c) WAP conservation opportunity rankings (a-c) as follows: a = on the ground management strategies/actions exist and can be feasibly implemented; b = on the ground actions or research needs have been identified but cannot feasibly be implemented at this time; c = no on the ground actions or research needs have been identified or all identified conservation opportunities have been exhausted.

3.7.2.3 Invasive and Nuisance Species of the North Anna River

The Center for Invasive Species and Ecosystem Health identifies over 200 invasive species in Louisa and Spotsylvania counties (CISEH 2020). The Virginia Invasive Species Management Plan (VISAC 2018) names the northern snakehead and zebra mussel (*Dreissena polymorpha*) to be the two aquatic invasive species of particular concern in Virginia's aquatic environments.

As stated in Section 3.7.1.3, "Invasive and Nuisance Species of Lake Anna," the northern snakehead is self-sustaining in Lake Anna. The Virginia Department of Wildlife Resources reports that the species does not occur south of the North Anna Dam (VDWR 2020). The U.S. Geological Survey (USGS) Nonindigenous Aquatic Species Database includes one record of the species in Gold Mine Creek, a tributary stream of Lake Anna (USGS 2020). However, the NRC staff identified no information confirming whether the species occurs in the North Anna River.

The zebra mussel is a freshwater bivalve from Russia that forms dense colonies on any hard surface, living or inanimate. Individuals will attach to boats, pipes, piers, docks, plants, clams, and even other mussels. Zebra mussels can cause significant biofouling of industrial intake pipes at power and water facilities. According to the USGS's Nonindigenous Aquatic Species Database, the zebra mussel has not been reported from the North Anna River (USGS 2020). Dominion has also not reported the species in biological sampling of the river or reservoir (Dominion 2020f).

Table 3-11. Ichthyoplankton Taxa Reported from Lake Anna, 1978–1982, 1984–1985, and 2016–2017

Scientific Name	Family	Common Name[a]	Entrained Ichthyoplankton, 1978–1983[b]	Ambient Ichthyoplankton, 1984–1985[c]	Entrained Ichthyoplankton, 2016–2017[d]
Centrarchidae spp.	Centrarchidae	sunfishes			x
Lepomis spp.	Centrarchidae	sunfish species	x	x	x
Lepomis macrochirus	Centrarchidae	bluegill[c]			x
Micropterus salmoides	Centrarchidae	largemouth bass[c]	x	x	x
Alosa aestivalis	Clupeidae	blueback herring			x
Clupeidae spp.	Clupeidae	herrings and shads			x
Dorsoma spp.	Clupeidae	gizzard or threadfin shad			x
Dorosoma cepedianum	Clupeidae	gizzard shad	x	x	x
Dorosoma petenense	Clupeidae	threadfin shad			x
Cyprinidae spp.	Cyprinidae	minnows			x
Notemigonus crysoleucas	Cyprinidae	golden shiner			x
Notropis hudsonius	Cyprinidae	spottail shiner			x
Ameiurus catus	Ictaluridae	white catfish[c]			x
Ictalurus punctatus	Ictaluridae	channel catfish[c]	x		x
Pomoxis nigromaculatus	Ictaluridae	black crappie[c]	x	x	
Poxomis spp.	Ictaluridae	crappie species			x
Morone americana	Moronidae	white perch[c]	x	x	x
Etheostoma spp.	Percidae	darter species			x
Perca flavescens	Percidae	yellow perch[c]	x	x	x
n/a	n/a	nonviable eggs			x
n/a	n/a	unidentified finfish			x

[a] All taxa reported were larvae. Viable eggs have not been collected in Lake Anna's water column. Nonviable eggs (i.e., unfertilized, dead, or decaying) were collected in 2016 and 2017 but were not identified by taxa.

[b] VEPCO 1986, Table 6.3-2.

[c] VEPCO 1985, Table 6.1.1.

[d] HDR 2018a, Table 4-2.

Table 3-12. Fish Taxa Reported from Lake Anna, 2003–2019

Scientific Name	Family	Common Name	All Stations, 2003–2015[a]	Lake Stations, 2016–2019[b]	WHTF Stations, 2016–2019[c]
Amia calva	Amiidae	bowfin	-	x	x
Anguilla rostrata	Anguillidae	American eel	-	x	-
Carpiodes cyprinus	Catostomidae	quillback	x	x	x
Catostomus commersoni	Catostomidae	white sucker	x	x	-
Erimyzon oblongus creek	Catostomidae	chubsucker	x	-	-
Hypentelium nigricans	Catostomidae	northern hog sucker	x	-	-
Moxostoma macrolepidotum	Catostomidae	shorthead redhorse	x	x	x
Chaenobryttus gulosus	Centrarchidae	warmouth	x	x	x
Lepomis auritus	Centrarchidae	redbreast sunfish[c]	x	x	x
Lepomis cyanellus	Centrarchidae	green sunfish	x	x	x
Lepomis gibbosus	Centrarchidae	pumpkinseed[c]	-	x	x
Lepomis macrochirus	Centrarchidae	bluegill[c]	x	x	x
Lepomis microlophus	Centrarchidae	redear sunfish[c]	x	x	x
Micropterus salmoides	Centrarchidae	largemouth bass[c]	x	x	x
Alosa aestivalis	Clupeidae	blueback herring	x	x	-
Dorosoma cepedianum	Clupeidae	gizzard shad	x	x	x
Dorosoma petenense	Clupeidae	threadfin shad	x	x	x
Campostoma anomalum	Cyprinidae	central stoneroller	-	-	-
Ctenopharyngodon idelle	Cyprinidae	grass carp	x	x	x
Cyprinella analostana	Cyprinidae	satinfin shiner	-	x	-
Cyprinus carpio	Cyprinidae	common carp	x	x	x
Notemigonus crysoleucas	Cyprinidae	golden shiner	x	x	-
Notropis amoenus	Cyprinidae	comely shiner	-	x	-
Notropis hudsonius	Cyprinidae	spottail shiner	x	x	-
Semotilus corporalis	Cyprinidae	fallfish	x	-	-

Scientific Name	Family	Common Name	All Stations, 2003–2015[a]	Lake Stations, 2016–2019[b]	WHTF Stations, 2016–2019[c]
Esox niger	Esocidae	chain pickerel	x	x	-
Ameiurus catus	Ictaluridae	white catfish[c]	x	x	x
Ictalurus furcatus	Ictaluridae	blue catfish[c]	x	x	-
Ictalurus natalis	Ictaluridae	yellow bullhead	x	x	x
Ictalurus nebulosus	Ictaluridae	brown bullhead	x	x	x
Ictalurus punctatus	Ictaluridae	channel catfish[c]	x	x	x
Pomoxis nigromaculatus	Ictaluridae	black crappie[c]	x	x	x
Morone americana	Moronidae	white perch[c]	x	x	x
Morone chrysops x saxatilis	Moronidae	striped bass hybrid[c]	x	x	x
Morone saxatilis	Moronidae	striped bass[c]	x	x	x
Etheostoma olmstedi	Percidae	tessellated darter	-	x	-
Perca flavescens	Percidae	yellow perch[c]	x	x	-
Sander vitreus	Percidae	walleye[c]	x	-	-
Stizostedion vitreum x canadense	Percidae	saugeye[c]	x	x	x
TAXA COUNT			**32**	**34**	**23**

x = collected in survey samples; - = not collected in survey samples.

[a] Taxa collected in Lake Anna gill net samples by VDGIF researchers as reported in Table 4 of VDGIF 2008.

[b] Taxa collected in Lake Anna gill net and electrofishing samples by Dominion researchers as reported in Tables 5 and 10 of Dominion 2016a, Dominion 2017, Dominion 2018c, Dominion 2019b, Dominion 2020f.

[c] Recreationally important species.

Table 3-13. Fish Taxa Reported from the North Anna River, 2015–2019

Scientific Name[a]	Family	Common Name
Trinectes maculatus	Achiridae	hogchoker
Anguilla rostrata	Anguillidae	American eel
Aphredoderus sayanus	Aphredoderidae	pirate perch
Hypentelium nigricans	Catostomidae	northern hog sucker
Chaenobryttus gulosus	Centrarchidae	warmouth
Lepomis auritus	Centrarchidae	redbreast sunfish[b]
Lepomis cyanellus	Centrarchidae	green sunfish
Lepomis macrochirus	Centrarchidae	bluegill[b]
Lepomis microlophus	Centrarchidae	redear sunfish[b]
Micropterus dolomieu	Centrarchidae	smallmouth bass[b]
Micropterus punctulatus	Centrarchidae	spotted bass
Micropterus salmoides	Centrarchidae	largemouth bass[b]
Alosa aestivalis	Clupeidae	blueback herring
Campostoma anomalum	Cyprinidae	central stoneroller
Cyprinella analostana	Cyprinidae	satinfin shiner
Lythrurus ardens	Cyprinidae	rosefin shiner
Nocomis micropogon	Cyprinidae	river chub
Nocomis spp.	Cyprinidae	cyprinid species
Notemigonus crysoleucas	Cyprinidae	golden shiner
Notropis amoenus	Cyprinidae	comely shiner
Notropis hudsonius	Cyprinidae	spottail shiner
Notropis procne	Cyprinidae	swallowtail shiner
Notropis rubellus	Cyprinidae	rosyface shiner
Notropis telescopus	Cyprinidae	telescope shiner
Semotilus corporalis	Cyprinidae	fallfish
Esox niger	Esocidae	chain pickerel
Ameiurus catus	Ictaluridae	white catfish[b]
Ictalurus natalis	Ictaluridae	yellow bullhead
Ictalurus punctatus	Ictaluridae	channel catfish[b]
Noturus gyrinus	Ictaluridae	tadpole madtom
Noturus insignis	Ictaluridae	margined madtom
Etheostoma olmstedi	Percidae	tessellated darter
Etheostoma vitreum	Percidae	glassy darter
Percina notogramma	Percidae	stripeback darter
Percina peltata	Percidae	shield darter
Lethenteron appendix	Petromyzontidae	American brook lamprey
Petromyzon marinus	Petromyzontidae	sea lamprey

[a] Taxa listed in table are those collected in North Anna River electrofishing samples by Dominion researchers as reported in Tables 14 and 15 of Dominion 2016a, 2017, 2018c, 2019b, 2020f, Tables 14 and 15.

[b] Recreationally important species.

3.7.3 Proposed Action

As identified in Table 3-1 of this SEIS, the impacts of all Category 1 (generic) aquatic resource issues would be SMALL. Table 3-2 identifies two Category 2 issues that require site-specific analysis for each proposed license renewal to determine whether impacts would be SMALL, MODERATE, or LARGE. These issues are (1) impingement and entrainment of aquatic organisms and (2) thermal impacts on aquatic organisms. The sections below analyze each of these issues in detail.

3.7.3.1 Impingement and Entrainment of Aquatic Organisms (Plants with Once-Through Cooling Systems or Cooling Ponds)

For plants with once-through cooling systems or cooling ponds such as North Anna, the NRC staff determined in the GEIS that impingement and entrainment of aquatic organisms is a Category 2 issue that requires site-specific evaluation (NRC 2013a). In 2002, the NRC staff evaluated the impacts of the initial North Anna license renewal on aquatic organisms as two issues: “impingement of fish and shellfish” and “entrainment of fish and shellfish in early life stages.” For both issues, the NRC staff determined that the impacts of continued operation of North Anna would be SMALL during the initial license renewal term (i.e., 2018–2038 for Unit 1 and 2020–2040 for Unit 2) (NRC 2002b). In 2013, the NRC staff issued Revision 1 of the GEIS (NRC 2013a). In the revised GEIS, the staff combined the two aquatic issues into a single site-specific issue: “impingement and entrainment of aquatic organisms (plants with once-through cooling systems or cooling ponds).” This section evaluates this consolidated issue as it applies to continued operation of North Anna during the proposed subsequent license renewal term (i.e., 2038–2058 for Unit 1, and 2040–2060 for Unit 2).

Impingement occurs when organisms are trapped against the outer part of an intake structure’s screening device (79 FR 48300). The force of the intake water traps the organisms against the screen, and individuals are unable to escape. Impingement can kill organisms immediately or cause exhaustion, suffocation, injury, and other physical stresses that contribute to later mortality. The potential for injury or death is generally related to the amount of time an organism is impinged, its fragility (susceptibility to injury), and the physical characteristics of the screen wash and fish return systems of the intake structure. EPA has found that impingement mortality is typically less than 100 percent if the cooling water intake system includes fish return or backwash systems (79 FR 48300). Because impingeable organisms are typically fish with fully formed scales and skeletal structures and well-developed survival traits, such as behavioral responses to avoid danger, many impinged organisms can survive under proper conditions (79 FR 48300).

Entrainment occurs when organisms pass through the screening device and travel through the entire cooling system, including the pumps, condenser or heat exchanger tubes, and discharge pipes (79 FR 48300). Organisms susceptible to entrainment are of smaller size, such as ichthyoplankton, larval stages of shellfish and other macroinvertebrates, zooplankton, and phytoplankton. During travel through the cooling system, entrained organisms experience physical trauma and stress, pressure changes, excess heat, and exposure to chemicals (Mayhew et al. 2000). Because entrainable organisms generally consist of fragile life stages (e.g., eggs, which exhibit poor survival after interacting with a cooling water intake structure, and early larvae, which lack a skeletal structure and swimming ability), EPA has concluded that, for purposes of assessing the impacts of a cooling water intake system on the aquatic environment, all entrained organisms die (79 FR 48300).

Entrainment susceptibility is highly dependent upon life history characteristics. For example, broadcast spawners with non-adhesive, free-floating eggs that drift with water current may become entrained in a cooling water intake system. Nest-building species or species with adhesive, demersal eggs are less likely to be entrained in early life stages. Susceptibility of larval life stages to entrainment depends on body morphometrics and swimming ability.

If several life stages of a species occupy the source water, that species can be susceptible to both impingement and entrainment. For instance, adults and juveniles of a given species of fish may be impinged against the intake screens, while larvae and eggs may pass through the screening device and be entrained through the cooling system. The susceptibility to either impingement or entrainment relates to the size of the individual relative to the size of the mesh on the screening device. By definition, EPA considers aquatic organisms that can be collected or retained on a sieve with 0.56-in. (1.4-cm) diagonal openings to be susceptible to impingement (79 FR 48300). This equates to screen device mesh openings of 1/2 in. by 1/4 in. (1.3 cm by 0.635 cm), which is slightly larger than the openings on the typical 3/8-in. square mesh found at many nuclear power plants. Organisms smaller than the 0.56-in. (1.4-cm) mesh are considered susceptible to entrainment.

The magnitude of impact that impingement and entrainment creates on the aquatic environment depends on plant-specific characteristics of the cooling system as well as characteristics of the local aquatic community. Relevant plant characteristics include location of the cooling water intake structure, intake velocities, withdrawal volumes, screening device technologies, and the presence or absence of a fish return system. Relevant characteristics of the aquatic community include species present in the environment, life history characteristics, population abundances and distributions, special species statuses and designations, and regional management objectives.

North Anna Cooling Water Intake System

The North Anna cooling water intake system impinges and entrains aquatic organisms as it withdraws water from Lake Anna. Section 2.1.3 of this SEIS describes the North Anna cooling and auxiliary water systems in detail. Features relevant to the impingement and entrainment analysis are summarized below.

Lake Anna water first interacts with the cooling water intake structure at screenwells housed in the intake structure at the end of a cove just north of North Anna on the southwestern shore of Lake Anna. Water flows through one of two screenwells, followed by one of four intake bays. As North Anna withdraws lake water, fish and other aquatic organisms that cannot swim fast enough to escape the flow of water may be swept into the intake. Intake flow is 0.62 ft per second (fps) (0.19 m/s) as measured at each forebay approximately 16 ft (5 m) out from the trash racks (VEPCO 1986). Thus, organisms within the source water that cannot resist or escape this flow are drawn into the intake structure along with the water.

Once within one of the intake bays, organisms encounter a steel trash rack made of 0.5-in. (3cm)-wide by 3.5-in. (8.9-cm)-thick vertical bars placed at 4-in. (10-cm) intervals (HDR 2018a). The trash racks and associated mechanical rakes remove large debris for disposal. Approximately 16 ft (4.9 m) downstream from each trash rack, organisms encounter Ristroph traveling screens made of 0.125-in. (0.32-cm) by 0.5-in. (1.3-cm) 16-gauge mesh with 0.53-in. (1.34-cm) diagonal openings (HDR 2018a). Organisms that are too large to pass through the traveling screen mesh, such as juvenile and adult fish and shellfish, become impinged on the screens. Through-screen velocity is 2.57 fps (0.78 m/s) based on a wetted screen area of 350 square ft (ft^2) (107 m^2) and at extremely low water level and a percent of wetted screen area that is not wire mesh of 59 percent (Enercon et al. 2019).

Screen wash pumps wash impinged organisms and other debris off the screens and into wire baskets for disposal. The screens are designed to rotate once every 24 hours or whenever a predetermined pressure differential exists across the screens (VEPCO 1985). However, Dominion personnel operate the screens manually on an as-needed basis. North Anna does not have a fish return system, so all impinged organisms are either collected at the trash racks or on the traveling screens and disposed of as solid waste along with other debris.

Organisms small enough to pass through the traveling screen mesh, such as fish eggs, larvae, and other zooplankton, are entrained into the cooling water system. Entrained organisms pass through the entire cooling system and reenter Lake Anna along with heated effluent at the WHTF through a single discharge canal located 200 ft (60 m) south of the intake location. Water flows from the discharge canal through a series of three lagoons before reentering the reservoir portion of the lake. During this process, entrained organisms are subject to mechanical, thermal, and toxic stresses.

Clean Water Act Section 316(b) Requirements for Existing Facilities

CWA Section 316(b) addresses the adverse environmental impacts caused by the intake of cooling water from waters of the United States. This section of the CWA grants EPA the authority to regulate cooling water intake structures to minimize adverse impacts on the aquatic environment. Under CWA Section 316(b), EPA has issued regulations for existing facilities, such as North Anna, at 40 CFR 122 and 40 CFR 125, Subpart J. Existing facilities include power generation and manufacturing facilities that are not new facilities as defined at 40 CFR 125.83 and that withdraw more than 2 mgd of water from waters of the United States and use at least 25 percent of the water they withdraw exclusively for cooling purposes.

Under the CWA Section 316(b) regulations, the location, design, construction, and capacity of cooling water intake structures of regulated facilities must reflect the best technology available (BTA) for minimizing impingement mortality and entrainment. EPA, or authorized States and Tribes, impose BTA requirements through NPDES permitting programs. In Virginia, VDEQ administers the VPDES program and issues VPDES permits to regulated facilities.

With respect to impingement mortality, the BTA standard requires that existing facilities comply with one of the following seven alternatives (40 CFR 125.94(c)):

(1) operate a closed-cycle recirculating system as defined at 40 CFR 125.92 (subsequently referred to in this SEIS as “Compliance Alternative 1”)

(2) operate a cooling water intake structure that has a maximum through-screen design intake velocity of 0.5 fps (0.15 m/s)

(3) operate a cooling water intake structure that has a maximum through-screen intake velocity of 0.5 fps (0.15 m/s)

(4) operate an offshore velocity cap as defined at 40 CFR 125.92 that is installed before October 14, 2014

(5) operate a modified traveling screen that the NPDES Permit Director determines meets the definition at 40 CFR 125.92(s) and that the NPDES Permit Director determines is the BTA for impingement reduction

(6) operate any other combination of technologies, management practices, and operational measures that the NPDES Permit Director determines is the BTA for impingement reduction

(7) achieve the specified impingement mortality performance standard

Options (1), (2), and (4) above are essentially preapproved technologies requiring no demonstration or only a minimal demonstration that the flow reduction and control measures are functioning as EPA envisioned. Options (3), (5), and (6) require that more detailed information be submitted to the permitting authority before the permitting authority may specify it as BTA for a given facility. The permitting authority may also review site-specific data and conclude that a de minimis rate of impingement exists and, therefore, no additional controls are warranted to meet the BTA impingement mortality standard.

With respect to entrainment, the CWA Section 316(b) regulations do not prescribe a single nationally applicable entrainment performance standard because EPA did not identify a technology for reducing entrainment that is effective, widely available, feasible, and does not lead to unacceptable non-water quality impacts (79 FR 48300). Instead, the permitting authority must establish the BTA entrainment requirement for each facility on a site-specific basis. In establishing site-specific requirements, the regulations direct the permitting authority to consider the following factors (40 CFR 125.98(f)(2)):

(i) numbers and types of organisms entrained, including, specifically, the numbers and species (or lowest taxonomic classification possible) of federally listed, threatened and endangered species, and designated critical habitat (e.g., prey base)

(ii) impact of changes in particulate emissions or other pollutants associated with entrainment technologies

(iii) land availability inasmuch as it relates to the feasibility of entrainment technology

(iv) remaining useful plant life

(v) quantified and qualitative social benefits and costs of available entrainment technologies when such information on both benefits and costs is of sufficient rigor to make a decision

In support of entrainment BTA determinations, facilities must conduct site-specific studies and provide data to the permitting authority to aid in its determination of whether site-specific controls would be required to reduce entrainment and which controls, if any, would be necessary.

Analysis Approach

When available, the NRC staff relies on the expertise and authority of the NPDES permitting authority with respect to the impacts of impingement and entrainment. Therefore, if the NPDES permitting authority has made BTA determinations for a facility under CWA Section 316(b) in accordance with the current regulations at 40 CFR 122 and 40 CFR 125, which were issued in 2014 (79 FR 48300), and that facility has implemented any associated requirements, the NRC staff assumes that adverse impacts on the aquatic environment will be minimized. In such cases, the NRC staff concludes that the impacts of either impingement, entrainment, or both would be SMALL for the proposed license renewal term.

In cases where the NPDES permitting authority has not made BTA determinations, the NRC staff analyzes the potential impacts of impingement, entrainment, or both, using a weight of evidence approach. In such an approach, the staff considers multiple lines of evidence to assess the presence or absence of ecological impairment (i.e., noticeable or detectable impact) on the aquatic environment. For instance, as its lines of evidence, the staff might consider the cooling water intake system design, the results of impingement and entrainment studies performed at the facility, and trends in fish and shellfish population abundance indices. The staff then considers these lines of evidence together to predict the level of impact (SMALL, MODERATE, or LARGE) that the aquatic environment is likely to experience over the course of the proposed license renewal term.

Baseline Condition of the Resource

For the purposes of its impingement and entrainment analysis, the NRC staff assumes that the baseline condition of the resource is the Lake Anna aquatic community as it occurs today. The current community is a combination of species that were present during initial impoundment and those that have been stocked for recreational purposes. All fish and benthic invertebrate populations are self-sustaining with the exception of striped bass, which VDGIF continues to stock annually. Recent sampling indicates no major upward or downward trends in juvenile or adult fish populations. While species richness, evenness, and diversity within the community may change or shift between now and when the proposed subsequent license renewal period would begin, the NRC staff finds the aquatic community as it occurs today to be a reasonable surrogate in the absence of fishery and species-specific projections.

3.7.3.1.1 Impingement

Impingement Area of Influence

In connection with Dominion's 40 CFR 122.21(r) submittal to VDEQ, HDR (HDR 2018b) calculated the North Anna impingement area of influence (AOI). The impingement AOI is the area encompassed by the 0.5-fps (0.15-m/s) velocity contour at the cooling water intake system. At this boundary and beyond it, the potential for impingement is approximately zero; within this boundary, the potential increases with increasing proximity to the intake. Organisms within the AOI have a high probability of being impinged, but actual entrainment will be the product of physical and biological factors that vary over space, time, and species. For instance, because juvenile and adult fish have differing swimming abilities and differing preferred habitats, including those that involve natural water velocities above 0.5 fps (0.15 m/s), a particular organism within the 0.5-fps (0.15-m/s) velocity contour will vary in susceptibility to impingement.

HDR (HDR 2018b) calculated the impingement AOI to be represented as a quarter circle area originating at the center of the cooling water intake structure with a radius of 211 ft (64 m), based on the velocity thresholds of 0.5 fps (0.15 m/s). The calculated AOI equates to a surface area of 35,000 ft^2 (0.8 ac; 0.3 ha) over which organisms may be susceptible to impingement. This represents an extremely small portion of Lake Anna (less than 0.001 percent of the lake's total surface area). This AOI would remain the same during the proposed license renewal term. The AOI is considered further below as one component affecting the NRC staff's conclusion on entrainment.

Impingement Mortality BTA

In 2017, VDEQ, in consultation with EPA, agreed with Dominion's determination that North Anna meets the administrative criteria of a closed-cycle recirculating system consistent with the definition in 40 CFR 125.92(c)(2) (Dominion 2020b; VDEQ 2017). Under the regulatory definition, a closed-cycle recirculating system is one that passes cooling water through the condenser and other components of the cooling system and reuses the water for cooling multiple times. Such a system can include impoundments of waters of the United States where the impoundment was constructed before October 1, 2014, and was created for the purpose of serving as part of the cooling water system.

Lake Anna was created by impounding the North Anna River to use as a cooling water source for surface condensers and other heat exchanger equipment at North Anna. Accordingly, North Anna is eligible to meet the impingement mortality reduction standard through Compliance Alternative 1 (40 CFR 125.94(c)(1)) described previously in this section. In Dominion's 2018 VPDES permit renewal application to VDEQ, Dominion confirmed that it has selected this method for North Anna compliance with the impingement mortality BTA standard specified in 40 CFR 122.21(r)(6) (HDR 2018b). VDEQ is currently reviewing Dominion's application. As one component of its review, VDEQ will make a final determination regarding its agreement with Dominion's chosen method.

Impingement Conclusion

Because Compliance Alternative 1 is a preapproved alternative under CWA Section 316(b) regulations, and because EPA and VDEQ have confirmed that North Anna meets the criteria for a closed-cycle recirculating system for purposes of CWA Section 316(b) compliance, the NRC staff finds that the adverse impacts on the aquatic environment associated with impingement are minimized. Further, the impingement AOI is an extremely small percentage of Lake Anna (less than 0.001 percent of the lake's total surface area). Collectively, this information indicates that impingement is unlikely to cause noticeable or detectable impacts on Lake Anna's aquatic populations. Accordingly, the NRC staff finds that the impacts of impingement during the proposed subsequent license renewal term would neither destabilize nor noticeably alter any important attribute of the aquatic environment and would, therefore, result in SMALL impacts on aquatic resources.

3.7.3.1.2 Entrainment

Entrainment BTA

VDEQ has not made an entrainment BTA determination for North Anna. It will make that determination as one component of issuing a renewed VPDES permit following its review of Dominion's 2018 renewal application. When VDEQ makes its BTA determination, it may (or may not) impose additional requirements to reduce or mitigate the effects of entrainment at North Anna. Such requirements would be incorporated as conditions of the renewed VDPES permit, which would be issued and take effect before the renewed operating license period. The NRC staff assumes that any additional requirements that VDEQ may impose would minimize the impacts of entrainment over the course of the proposed license renewal term, in accordance with CWA Section 316(b) requirements.

Because VDEQ's entrainment BTA determination is currently pending, the NRC staff considers other lines of evidence below to evaluate the magnitude of impact that entrainment would likely represent during the proposed SLR period of operation. In its analysis, the NRC staff considers results of entrainment studies, entrainment reduction methods, and entrainment AOI.

Entrainment Studies

Two entrainment studies have been undertaken at North Anna. VEPCO conducted the first study from 1978–1983, and HDR Engineering, Inc. conducted the second study from 2016 to 2017. This section summarizes the results of each study.

Entrainment Sampling, 1978–1983

From 1978 through 1983, VEPCO conducted weekly entrainment sampling at the North Anna cooling water intake from March through July of each year. Researchers gathered ichthyoplankton samples with 505-μm mesh conical plankton nets equipped with flowmeters at near-surface, mid-depth, and near-bottom depths in front of the North Anna intake forebay. Ten-minute tows were gathered four times per sample day. All samples were collected and preserved and then later processed in a laboratory for identification, enumeration, and further analysis. A 1985 CWA Section 316(b) demonstration report (VEPCO 1986) shows the results of this effort. The information in this section is summarized from that report unless otherwise indicated.

VEPCO collected a total of 7,908 organisms of seven distinct taxa in its entrainment samples. All collected ichthyoplankton were larvae; no fish eggs were collected in any samples. VEPCO attributed this to the fact that most species of fish in Lake Anna produce demersal, adhesive eggs that are unlikely to occur in the water column, where they would be susceptible to entrainment. VEPCO also did not collect any early life stages of shellfish in its samples.

Gizzard shad was the most abundantly collected species over all sample years. It accounted for 65.7 percent of collections. White perch (16.7 percent), sunfishes (13.4 percent), yellow perch (4.9 percent), and black crappie (1.0 percent) were the next most abundant taxa. Channel catfish and largemouth bass were each represented by the collection of a single individual. Sunfishes and yellow perch were more prevalent in the first year than in following years, whereas white perch numbers generally increased over the study period.

During the study, yellow perch were typically the first species to appear in each year’s collections. Larvae of this species appeared in late March to early April when water temperatures approached 12 °C (54 °F). White perch appeared in mid-April when water temperatures approached 14 °C (57 °F), and the species peaked in mid-May. Gizzard shad appeared in late April to early May at water temperatures of 14–18 °C (57–64 °F), and the species peaked in early June. Sunfishes appeared last in May to June, when temperatures rose to at least 19 °C (66 °F). Both gizzard shad and sunfishes were collected in low numbers in July.

Larvae were most abundant during midnight collections; 43 percent of larvae were collected during the 2,400-hour sample over all years and sampling events. Gizzard shad and white perch were most common during the midnight collections. Sunfishes were more frequently collected during daylight hours, and yellow perch abundance fluctuated during sample intervals.

In terms of depth, sunfishes, yellow perch, and black crappie were collected primarily at the surface; gizzard shad were collected primarily from middle and bottom depths; white perch were generally evenly distributed among the depths. Over all species and collection years, the percentage of larvae was roughly even among the three collection depths.

VEPCO used the results of entrainment sampling to calculate percent cropping, the reduction in adult recruitment caused by entrainment, for each species, assuming 100 percent mortality of entrained larvae (see Table 3-14). Cropping was below 1 percent for all species. Based on its analysis, VEPCO concluded that the reduction in adult recruitment attributable to entrainment at North Anna is well below values reported in scientific literature to cause significant impact on fishery or individual populations. For instance, numerical losses of 5.48 percent of the standing crop of gizzard shad, 15.3 percent of the standing crop of white and yellow bass (combined), and 0.59 percent of sunfishes on Lake Sangchris in Illinois did not result in observable adverse effects on the sport fishery of that lake (Porak and Tranquilli 1981). VEPCO concluded that the species that experience entrainment have sufficient capacity within their populations to offset the associated losses.

Table 3-14. Mean Entrainment Equivalent Adults by Species, 1978–1983

Species	Mean No. Larvae Entrained (in millions)	Mean No. Equivalent Adults	Mean Total Standing Crop (in millions)	Mean Percent Cropping
black crappie	41.0	63,375	2.3	0.85
white perch	23.0	12,964	1.5	0.66
yellow perch	20.0	6,249	1.7	0.46
gizzard shad	80.0	15,080	7.7	0.23
sunfishes	21.0	11,289	33.0	0.04

Entrainment Sampling, 2016–2017

From April through September 2016 (Year 1) and March through September 2017 (Year 2), HDR conducted bimonthly entrainment sampling at North Anna. Researchers gathered ichthyoplankton samples with 335-μm mesh hoop nets used to filter approximately 330 cubic ft (ft^3) (100 cubic meters (m^3)) of intake water pumped through a 4-in. (10-cm) polyvinyl chloride pipe opening at each of three depths (near-surface, mid-depth, and near-bottom depths) along the front of the Unit 2 bar racks. One-hundred-minute tows were gathered four times per sample day for a total of 288 samples during the study period. All samples were collected and preserved and then later processed in a laboratory for identification, enumeration, and further analysis. Results of this effort are reported in a 2018 entrainment characterization study report (HDR 2018a). The information in this section is summarized from that report unless otherwise indicated.

HDR collected a total of 1,781 organisms of 13 distinct taxa in its entrainment samples. All organisms were finfish. Taxonomic diversity was low (see Table 3-11). The number of distinct taxa ranged from a monthly low of one in September of each year to a high of seven in May 2016. The most taxonomically rich samples were collected in spring: April (five taxa in each year) and May (seven taxa in Year 1 and five taxa in Year 2). Overall, herrings and shad combined (Clupeidae), threadfin/gizzard shad (*Dorsoma* spp.; including the distinct taxa gizzard shad and threadfin shad), and sunfishes (*Lepomis* spp.) dominated collections.

With respect to life stages, post-yolk-sac larvae (PYSL) dominated collections. PYSL accounted for 83 percent of collected organisms in Year 1 samples and 96 percent of collected organisms in Year 2 samples. Yolk sac larvae (YSL) comprised 6 percent of Year 1 collections and 2 percent of Year 2 collections. Very few juveniles or adult fish appeared in samples, and all eggs were nonviable (e.g., unfertilized, dead, or decaying). Collectively, these three life stages accounted for 5 percent or less.

Table 3-15 presents the total number of organisms collected by taxa and life stage for the two years of sampling. During Year 1, PYSL of herrings and shad (37 percent) and sunfishes (33 percent) were the most abundantly collected life stage and taxa. Threadfin/gizzard shad PYSL (3 percent) and herrings and shad YSL (3 percent) were collected in low abundances. The remaining taxa accounted for 2 percent or less of the total collections. In Year 2, PYSL of herrings and shad (68 percent), threadfin/gizzard shad (13 percent), and sunfishes (9 percent) were the most abundant life stage and taxa. PYSL of threadfin/gizzard shad (13 percent) and threadfin shad (2 percent) were collected in relatively higher abundance than the first year. White perch PYSL (2 percent), herrings and shad of unidentified life stage larvae (less than 1 percent), and herrings and shad YSL (less than 1 percent) were collected in relatively low abundance during the second year compared to the first year. The remaining taxa accounted for 1 percent or less of the total collection. No federally or State-protected species were collected in any samples in either year.

HDR evaluated entrainment densities by sample depth strata (i.e., near-surface, mid-depth, and near-bottom). Although collection densities varied by year, taxa, and month, overall, mid-depth and near-bottom samples accounted for the majority of entrained organisms. During both sampling years, slightly more organisms were collected at mid-depth (48 percent in 2016 and 56 percent in 2017) than near-bottom (46 percent in 2016 and 33 percent in 2017). Nearly all taxa and life stages appeared at all three depths with no consistent trends.

With respect to diel variation, entrainment densities were higher at night (2,200 hours) during Year 1 and similarly higher in late afternoon (1,600 hours) and at night (2,200 hours) during Year 2. Diel patterns did not exhibit a clear relationship to depth strata, although HDR postulated that organisms appeared to move from the bottom during nighttime to mid-depth during daylight.

With respect to seasonal variation, samples contained the highest densities of organisms in May, June, and July. These samples consisted primarily of herring and shad PYSL (May to July), sunfishes (June and July and extending into August in Year 1), and threadfin/gizzard shad (May to June in Year 2). March, April, and September samples exhibited the lowest densities.

HDR used sample results and actual intake flows[3] to estimate year-specific total entrainment for each entrained species and life stage. Table 3-16 presents taxon-specific estimated annual entrainment for each sampling year. HDR estimated annual baseline entrainment during Year 1 to be 53,593,333 finfish and 67,924,622 finfish under actual intake flows and design flows, respectively. During Year 2, HDR estimated annual baseline entrainment to be 83,421,119 finfish and 99,782,529 finfish under actual intake flows and design flows, respectively. Because no shellfish were collected during the study, estimated annual shellfish entrainment was zero.

HDR also used the study data to estimate monthly and annual entrainment abundances for a typical season (March through September) (see Table 3-17). Of the projected 68,564,980 entrained fish per season, HDR estimated larvae of threadfin shad (43 percent), gizzard shad (28 percent), and bluegill (20 percent) to be the most abundantly entrained life stage and species (Enercon et al. 2019). Monthly entrainment abundance was highest in July and lowest in September.

Overall, HDR found that the results of its 2016-2017 study compared well with the 1978–1983 entrainment study. In both studies, gizzard shad, white perch, and sunfishes were the dominant taxa. Both studies reported peak herring, shad, and white perch densities in spring months followed by sunfishes in summer months. Blueback herring and threadfin shad were not available for collection in the earlier study because these species were introduced to Lake Anna in the 1980s. The earlier study collected no fish eggs, which it attributed to the dominance of species with demersal, adhesive eggs. This is consistent with the later study. HDR did not draw any overall conclusions with respect to the impacts of entrainment on Lake Anna finfish populations.

Synthesis of Entrainment Study Results

The above-described entrainment studies support several important conclusions about entrainment. First, shellfish do not appear to be susceptible to entrainment at North Anna.

[3] As defined by the 2014 final CWA Section 316(b) rule (79 FR 48300), the actual intake flow is defined as the average volume of water withdrawn by the cooling water intake system over the previous three years (2015–2017).

Neither the 1978–1983 study nor the 2016–2017 study collected early life stages of any shellfish. Second, eggs of finfish do not appear to be susceptible to entrainment at North Anna because the fish that inhabit Lake Anna produce adhesive, demersal eggs that do not occur in the water column where they would be subject to the flow of the North Anna intake.

PYSL of finfish are susceptible to entrainment and accounted for the majority of entrainment study collections over both study periods. Herrings, shads, and sunfishes are the most prevalently entrained species. To a lesser extent, perches are also entrained. Entrainment of all other taxa is minimal.

This line of evidence alone, however, does not provide a complete enough picture for the NRC staff to evaluate whether entrainment is measurably affecting these species' populations. Tables 3-15, 3-16, and 3-17 show year-by-year data and annual and monthly estimates. There are not enough sequential sampling years, however, to reliably ascertain a trend in entrainment impacts on the species' populations. The potential effects of entrainment on these taxa are further evaluated under "Finfish Monitoring Trends" below.

Entrainment Area of Influence

In connection with Dominion's 40 CFR 122.21(r) submittal to VDEQ, HDR (2018b) calculated the North Anna entrainment AOI. The entrainment AOI is the area within which plankton may be drawn into the intake rather than transported away in the ambient flow. For an organism to become entrained, it must enter the entrainment AOI of the cooling water intake system. Organisms within the AOI have a high probability of being withdrawn by the intake, but not all organisms within the AOI will be entrained. Actual entrainment will be the product of physical and biological factors that vary over space, time, and species. Physical and temporal factors that influence the AOI include the following (EPRI 2004):

- speed, direction, and distribution of flow in the waters that surround the cooling water intake structure
- bathymetry of the surrounding waters
- intake flow rate and variability of flow to the intake
- design of the intake

HDR (2018b) calculated the entrainment AOI based on velocity thresholds of 0.3 fps (0.09 m/s) and 0.1 fps (0.03 m/s). These velocities represent the upper and lower intake induced velocities and are consistent with the velocities used in other AOI studies for similar lake environments. HDR found the entrainment AOI to be represented as a quarter circle area originating at the center of the cooling water intake structure with a radius of 351 ft (107 m) to 1,054 ft (321 m), based on the velocity thresholds of 0.3 fps (0.09 m/s) or 0.1 fps (0.03 m/s), respectively. At locations where the intake-induced velocity is lower, the ambient wind-induced currents likely determine the flow patterns and, thus, the movement of nonmotile and limited mobility organisms within the water column.

The calculated AOI equates to a surface area of 872,500 ft^2 (20 ac; 8 ha) over which organisms may experience the draw of the North Anna intake current. This represents an extremely small portion of Lake Anna (less than 0.1 percent of the lake's total surface area). This AOI would remain the same during the proposed license renewal term.

Finfish Monitoring Trends

Dominion and VDGIF perform aquatic sampling to monitor the health of Lake Anna's finfish populations. Dominion has conducted quarterly gill net and electrofishing sampling of Lake Anna since 1987, and VDGIF performs periodic sampling to support management of the reservoir's fisheries and inform future stocking of recreationally important finfish species. Section 3.7.1.1 of this SEIS describes these sampling efforts and associated results.

As established previously in this section under "Entrainment Studies," the taxa and life stages most susceptible to entrainment are PYSL of herrings, shads, and sunfishes, and to a lesser extent, perches. Gillnet CPUEs for shads (gizzard and threadfin) during the Dominion sampling of Lake Anna indicate a cyclical pattern with high annual variability. Electrofishing CPUEs of sunfishes (bluegill, green sunfish, redbreast sunfish, and redear sunfish) have exhibited high variation over time but appear to oscillate over distinct averages. All other taxa have exhibited relatively stable CPUEs in gillnet and electrofishing samples. Those with year-to-year fluctuations have not exhibited any consistent upward or downward trends. Overall, both Dominion and VDGIF sampling results indicate that Lake Anna contains a relatively diverse assemblage of freshwater finfish, including many recreationally important species.

This line of evidence indicates that the level of entrainment of finfish into the North Anna cooling water intake system is not causing noticeable or detectable impacts on Lake Anna's aquatic populations. Because water withdrawals, and the associated risk of entrainment, would remain the same under the proposed action, the NRC staff anticipates similar (i.e., nondetectable) effects during the proposed subsequent license renewal period.

Entrainment Reduction Methods

As explained previously, the CWA Section 316(b) regulations direct the permitting authority to establish BTA entrainment requirements for each facility on a site-specific basis. For North Anna, VDEQ will make that determination as one component of issuing a renewed VPDES permit. As part of its VPDES permit renewal application, Dominion considered two methods to reduce entrainment: seasonal flow reductions and installation of 2-mm fine-mesh screens.

Under the seasonal flow reduction method, Dominion would reduce intake flow by 21.875 percent in May and June of each year. Such an operational change would result in an overall entrainment reduction of 9.9 percent annually for an estimated total entrainment of 61,744,007 finfish per year (Enercon et al. 2019). Under this scenario, entrainment of largemouth bass larvae and young-of-year (YOY) would drop by 22 percent and entrainment of black crappie larvae would drop by 18 percent (see Table 3-20 in Enercon et al. 2019). Both of these species are recreationally important game fish in Lake Anna, and thus, these reductions could be valuable to the recreational fishery.

Under the fine-mesh screen method, Dominion would install and operate 2-mm (0.08-in.) fine-mesh screens, which would replace the current Ristroph traveling screens, which are made of 0.125-in. (0.32-cm) by 0.5-in. (1.3-cm) 16-gauge mesh with 0.53 in. (1.34 cm) diagonal openings. Enercon et al. (2019) estimated that the through-screen velocity for such screens would be 1.44 fps (0.44 m/s) at the design intake flow, assuming the screens are 100 percent clean. This method would reduce entrainment by 8.7 percent to an estimated total entrainment of 62,591,613 finfish each year. Under this scenario, largemouth bass larvae and YOY entrainment would drop by 77 and 82 percent, respectively; channel catfish and white catfish larvae entrainment would drop by 88 percent; bluegill YOY entrainment would drop by 77 percent, and black crappie larvae entrainment would drop by 1.5 percent (see Table 3-30 in

Enercon et al. 2019). All of these species are recreationally important game fish in Lake Anna, and thus, these reductions could be valuable to the recreational fishery.

Dominion has not instituted either of these entrainment reduction methods at North Anna. As indicated previously, VDEQ is currently reviewing Dominion's VDPES permit renewal application. VDEQ could require Dominion to implement these or other methods as BTA for entrainment. However, VDEQ will not make such a determination until it completes its review. Accordingly, the NRC staff is presently unable to predict what VDEQ might require as an outcome of that process.

Entrainment Conclusion

Entrainment studies indicate that finfish eggs and shellfish (all life stages) are not susceptible to entrainment at North Anna. PYSL of herrings, shads, and sunfishes, and to a lesser extent, perches, are the most susceptible life stage and taxa. Finfish monitoring trends indicate no consistent upward or downward trends in these taxa's populations over several decades of monitoring (see Section 3.7.1.2). Further, the entrainment AOI is an extremely small percentage of Lake Anna (less than 0.1 percent of the lake's total surface area). Collectively, this information indicates that entrainment is unlikely to be causing noticeable or detectable impacts on Lake Anna's aquatic populations.

Because water withdrawals, and the associated risk of entrainment, would remain the same under the proposed action, the NRC staff anticipates similar (i.e., non-detectable) effects during the proposed SLR period. Further, VDEQ will make an entrainment BTA determination as part of issuing a renewed VDPES permit, which would be issued and take effect before the renewed operating license period. If VDEQ imposes any additional requirements beyond those contained in the current permit, those requirements would likely further reduce the impacts of entrainment over the course of the proposed SLR term, in accordance with CWA Section 316(b) requirements. For instance, if VDEQ requires Dominion to institute seasonal flow reductions or fine-mesh screens, such as those described under "Entrainment Reduction Methods," the impacts of entrainment would be reduced from current levels. The NRC staff assumes that any additional requirements that VDEQ imposes would further reduce the impacts of entrainment over the course of the proposed SLR term.

For the reasons described above, the NRC staff finds that the impacts of entrainment of aquatic organisms resulting from the proposed subsequent license renewal of North Anna would be SMALL.

3.7.3.1.3 Impingement and Entrainment Conclusion

For the reasons summarized above under "Impingement Conclusion" and "Entrainment Conclusion," the NRC staff concludes that the impacts of impingement and entrainment on aquatic organisms resulting from the proposed subsequent license renewal of North Anna would be SMALL.

Table 3-15. Total Number of Fish Collected in Entrainment Samples by Taxa and Life Stage, 2016–2017

Taxa[(a)]	Life Stage[(b)]	Year 1[(c)] Total Number	Year 1[(c)] Percent	Year 2[(d)] Total Number	Year 2[(d)] Percent
herrings and shad	post-yolk-sac larvae	191	36.6	519	68.3
common sunfishes	post-yolk-sac larvae	172	33.0	65	8.6

Taxa[a]	Life Stage[b]	Year 1[c] Total Number	Year 1[c] Percent	Year 2[d] Total Number	Year 2[d] Percent
white perch	post-yolk-sac larvae	23	4.4	14	1.8
herrings and shad	unidentified	19	3.6	3	0.4
threadfin/gizzard shad	post-yolk-sac larvae	15	2.9	98	12.9
herrings and shad	yolk-sac larvae	14	2.7	1	0.1
largemouth bass	juvenile	11	2.1	3	0.4
unidentified finfish	unidentified	10	1.9	5	0.7
gizzard shad	yolk-sac larvae	9	1.7	1	0.1
gizzard shad	post-yolk-sac larvae	7	1.3	1	0.1
threadfin shad	post-yolk-sac larvae	7	1.3	18	2.4
channel catfish	post-yolk-sac larvae	6	1.1	4	0.5
blueback herring	juvenile	5	1.0	–	–
Bluegill	juvenile	5	1.0	1	0.1
common sunfishes	juvenile	5	1.0	–	–
yellow perch	yolk-sac larvae	5	1.0	4	0.5
Crappie	post-yolk-sac larvae	4	0.8	–	–
Sunfish	post-yolk-sac larvae	4	0.8	–	–
white perch	yolk-sac larvae	3	0.6	4	0.5
Darters	post-yolk-sac larvae	2	0.4	–	–
golden shiner	post-yolk-sac larvae	1	0.2	–	–
herrings and shad	egg	1	0.2	5	0.7
largemouth bass	post-yolk-sac larvae	1	0.2	–	–
Minnow	post-yolk-sac larvae	1	0.2	3	0.4
white catfish	post-yolk-sac larvae	1	0.2	–	–
blueback herring	Adult	–	–	1	0.1
blueback herring	post-yolk-sac larvae	–	–	2	0.3
Darters	yolk-sac larvae	–	–	2	0.3
gizzard shad	juvenile	–	–	1	0.1
spottail shiner	post-yolk-sac larvae	–	–	1	0.1
threadfin shad	juvenile	–	–	1	0.1
yellow perch	post-yolk-sac larvae	–	–	3	0.4
TOTAL		**522**	**100.0**	**760**	**100.0**

[a] Presented in order of abundance in Year 1 collections.
[b] Juv = juvenile; UIDL = unidentified life stage; PYSL = post-yolk-sac larvae; YSL = yolk-sac larvae
[c] April–September 2016.
[d] March–September 2017.

Source: HDR 2018b, Table 9-4

Table 3-16. Estimated Annual Entrainment Based on Year-Specific Densities with Sampling Year-Specific Flows and CWA-Defined Actual Intake Flows, 2016–2017

Taxa[(a)]	Life Stage[(b)]	Year 1[(c)] Year-Specific Flows	Year 1[(c)] CWA-Defined AIF	Year 2[(d)] Year-Specific Flows	Year 2[(d)] CWA-Defined AIF
herrings and shad	PYSL	20,276,410	20,642,505	57,056,877	56,066,514
common sunfishes	PYSL	18,576,046	19,019,503	7,290,097	7,222,922
white perch	PYSL	1,833,833	1,971,714	1,342,639	1,155,013
herrings and shad	UIDL	1,767,519	1,830,032	310,189	296,406
threadfin/gizzard shad	PYSL	1,620,776	1,653,221	11,153,969	11,011,082
herrings and shad	YSL	1,235,293	1,297,914	107,494	107,662
largemouth bass	Juv	1,130,569	1,133,726	322,916	321,280
gizzard shad	YSL	937,037	945,083	107,943	108,112
unidentified finfish	UIDL	922,339	954,354	511,562	479,885
threadfin shad	PYSL	769,285	784,991	2,062,885	2,037,833
gizzard shad	PYSL	750,834	766,959	114,673	113,280
channel catfish	Juv	657,642	673,865	458,461	452,336
common sunfishes	YSL	536,828	550,571	–	–
blueback herring	Juv	529,870	530,284	–	–
sunfish	PYSL	424,748	432,138	–	–
crappie	PYSL	383,429	391,252	–	–
yellow perch	YSL	352,685	389,999	368,159	276,193
white perch	YSL	216,976	239,933	376,372	301,291
darters	PYSL	213,696	213,864	–	–
white catfish	PYSL	111,407	113,644	–	–
herrings and shad	Egg	108,097	108,181	536,756	537,595
largemouth bass	PYSL	100,376	100,454	–	–
minnow	PYSL	71,631	79,210	331,503	325,597
golden shiner	PYSL	66,007	72,991	–	–
blueback herring	PYSL	–	–	188,656	160,408
darters	YSL	–	–	190,379	161,874
gizzard shad	Juv	–	–	114,781	113,387
spottail shiner	PYSL	–	–	89,595	76,180
threadfin shad	Juv	–	–	114,933	113,537

Taxa[a]	Life Stage[b]	Year 1[c] Year-Specific Flows	Year 1[c] CWA-Defined AIF	Year 2[d] Year-Specific Flows	Year 2[d] CWA-Defined AIF
yellow perch	PYSL	–	–	270,280	173,530
TOTAL		**53,593,333**	**54,896,388**	**83,421,119**	**81,611,917**

[a] Presented in order of estimated Year 1 year-specific flow entrainment abundance.
[b] Juv = juvenile; UIDL = unidentified life stage; PYSL = post-yolk-sac larvae; YSL = yolk-sac larvae.
[c] April–September 2016.
[d] March–September 2017.

Source: HDR 2018b, Table 9-7

Table 3-17. Average Monthly and Annual Entrainment Abundance Estimates by Taxa and Life Stage

Species[a]	Life Stage	Estimated No. of Organisms Entrained[b]							Total No.	% of Total
		Mar	Apr	May	Jun	Jul	Aug	Sep		
threadfin shad	larvae	–	–	–	8408464	20598529	277649	–	**29,284,642**	**42.7**
gizzard shad	larvae	–	1224817	12226671	2703674	2606352	113991	–	**18,875,505**	**27.5**
bluegill	larvae	–	–	1147544	4446438	3709910	3906478	251729	**13,462,099**	**19.6**
white perch	larvae	183465	1365580	439906	–	–	–	–	**1,988,951**	**2.9**
blueback herring	larvae	123688	1165299	–	–	–	–	–	**1,288,987**	**1.9**
largemouth bass	YOY	–	–	619908	107596	–	–	–	**727,504**	**1.1**
yellow perch	larvae	316554	286387	–	–	–	–	–	**602,941**	**0.9**
channel catfish	larvae	–	–	–	–	226601	336500	–	**563,101**	**0.8**
gizzard shad	egg	–	–	322888	–	–	–	–	**322,888**	**0.5**
bluegill	YOY	–	–	–	–	–	275286	–	**275,286**	**0.4**
blueback herring	YOY	–	–	265142	–	–	–	–	**265,142**	**0.4**
black crappie	larvae	–	41653	170511	–	–	–	–	**212,164**	**0.3**
spottail shiner	larvae	–	38090	–	162799	–	–	–	**200,889**	**0.3**
tessellated darter	larvae	–	80937	109731	–	–	–	–	**190,668**	**0.3**
golden shiner	larvae	–	80036	–	–	–	–	–	**80,036**	**0.1**
white catfish	larvae	–	–	–	–	56822	–	–	**56,822**	**0.1**
threadfin shad	YOY	–	–	–	–	56769	–	–	**56,769**	**0.1**
gizzard shad	YOY	–	–	–	–	56694	–	–	**56,694**	**0.1**
largemouth bass	larvae	–	–	54892	–	–	–	–	**54,892**	**0.1**
TOTAL		**623,707**	**4,282,799**	**15,357,193**	**15,828,971**	**27,311,677**	**4,909,904**	**251,729**	**68,565,980**	**100.0**

[a] Presented in order of abundance.

[b] Estimates based on 3 years of actual intake flow (2015–2017) and actual mean entrainable ichthyoplankton densities from pump samples collected during April through September 2016.

Source: Enercon et al. 2019, Table 3-18

3.7.3.2 Thermal Impacts on Aquatic Organisms (Plants with Once-Through Cooling Systems or Cooling Ponds)

For plants with once-through cooling systems or cooling ponds such as North Anna, the NRC has determined in the GEIS (NRC 2013a) that thermal impacts on aquatic organisms is a Category 2 issue that requires site-specific evaluation. In 2002, the NRC staff evaluated the thermal impacts of the initial North Anna license renewal on aquatic organisms under the issue "heat shock." The NRC staff determined that the impacts of continued operation of North Anna would be SMALL during the initial LR term (i.e., 2018–2038 for Unit 1 and 2020–2040 for Unit 2) (NRC 2002b). In 2013, the NRC issued Revision 1 of the GEIS (NUREG-1437) (NRC 2013a). In the revised GEIS, the staff renamed the issue of "heat shock" to "thermal impacts on aquatic organisms." The renaming did not affect the scope of the issue for license renewal. This section of the SEIS evaluates thermal impacts as they apply to continued operation of North Anna during the proposed subsequent LR term (i.e., 2038–2058 for Unit 1, and 2040–2060 for Unit 2).

The primary form of thermal impact of concern at North Anna is heat shock. Heat shock occurs when water temperature meets or exceeds the thermal tolerance of a species for some duration of exposure (NRC 2013A). In most situations, fish are capable of moving out of an area that exceeds their thermal tolerance limits, although some aquatic species lack such mobility. Heat shock is typically observable only for fish, particularly those that float when dead. In addition to heat shock, thermal plumes resulting from thermal effluent can create barriers to fish passage, which is of particular concern for migratory species. Thermal plumes can also reduce the available aquatic habitat or alter habitat characteristics in a manner that results in cascading effects on the local aquatic community.

<u>North Anna Effluent Discharge</u>

North Anna discharges heated effluent to the WHTF through a single 27-ft (8-m)-deep, 100-ft (30-m)-wide discharge canal. The canal conveys cooling water flow a distance of about 3,600 ft (1,100 m) to the head of the WHTF at a velocity of 2 fps (0.6 m/s). The North Anna VPDES permit limits waste heat rejected to the WHTF from North Anna to 13.54×10^9 BTU)/hour (VDEQ 2014). Once within the WHTF, water flows through interconnecting canals and a series of three lagoons. Water residence time in the WHTF is approximately 14 days, depending on the condenser flow rate.

The easternmost dike separating the WHTF lagoons contains the circulating water outlet, which is a skimmer wall discharge structure with a submerged jet. Effluent reenters the North Anna Reservoir from this jet, designated as Outfall 001 in the VPDES permit, at about 8 fps (2.4 m/s). Although submerged, the slope of the reservoir bottom immediately adjacent to the skimmer wall structure directs the effluent to the surface. The warmer, less dense heated effluent tends to rise to the surface of the reservoir where the remaining waste heat dissipates into the atmosphere.

Typically, no thermal plume is evident in spring or summer, even during near-maximum operating temperatures (Dominion 2020b; VEPCO 1986). In cooler months, upper lake, mid-lake, and lower lake layers exhibit noticeable temperature differences, but differential cooling and warming of surface waters in the shallow upper lake and the deeper lower lake made it difficult to identify or precisely define a thermal plume (Dominion 2020b). The VPDES permit does not require Dominion to report discharge temperatures from the WHTF to the Lake Anna Reservoir (VDEQ 2014). However, the permit requires Dominion to monitor water temperatures at locations throughout the WHTF and reservoir (Dominion 2020b).

Clean Water Act Section 316(a) Requirements for Point Source Discharges

CWA Section 316(a) addresses the adverse environmental impacts associated with thermal discharges into waters of the United States. This section of the act grants EPA the authority to impose alternative, less-stringent, facility-specific effluent limits (called “variances”) on the thermal component of point source discharges. To be eligible, facilities must demonstrate, to the satisfaction of the NPDES permitting authority, that facility-specific effluent limitations will assure the protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife in and on the receiving body of water. CWA Section 316(a) variances are valid for the term of the NPDES permit (i.e., 5 years). Facilities must reapply for variances with each NPDES permit renewal application. EPA issued regulations under CWA Section 316(a) at 40 CFR 125, Subpart H.

Analysis Approach

When available, the NRC staff relies on the expertise and authority of the NPDES permitting authority with respect to thermal impacts on aquatic organisms. Therefore, if the NPDES permitting authority has made a determination under CWA Section 316(a) that thermal effluent limits are sufficiently stringent to assure the protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife in and on the receiving body of water, and that facility has implemented any associated requirements, then the NRC staff assumes that adverse impacts on the aquatic environment will be minimized. In such cases, the NRC staff concludes that thermal impacts on aquatic organisms would be SMALL for the proposed LR term.

In cases where the NPDES permitting authority has not granted a 316(a) variance, the NRC staff analyzes the potential impacts of thermal discharges using a weight of evidence approach. In this approach, the staff considers multiple lines of evidence to assess the presence or absence of ecological impairment (i.e., noticeable or detectable impact) on the aquatic environment. For instance, as its lines of evidence, the staff might consider characteristics of the cooling water discharge system design, the results of thermal studies performed at the facility, and trends in fish and shellfish population abundance indices. The staff then considers these lines of evidence together to predict the level of impact (SMALL, MODERATE, or LARGE) that the aquatic environment is likely to experience over the course of the proposed LR term.

Baseline Condition of the Resource

For the purposes of its thermal analysis, the NRC staff assumes that the baseline condition of the resource is the Lake Anna aquatic community as it occurs today. The current community is a combination of species that were present during initial impoundment and those that have been stocked for recreational purposes. All fish and benthic invertebrate populations are self-sustaining with the exception of striped bass, which VDGIF continues to stock annually. While species richness, evenness, and diversity within the community may change or shift between now and when the proposed SLR period would begin, the NRC staff finds the aquatic community as it occurs today to be a reasonable surrogate in the absence of fishery- and species-specific projections.

CWA 316(a) Thermal Variance

In April 1983, VEPCO notified the Virginia State Water Control Board that it intended to request alternative effluent limitations under CWA Section 316(a). VEPCO sought the variance because water temperatures in Lake Anna in the vicinity of Outfall 001 and in the shallow reaches near all of its tributaries occasionally exceed the maximum regulatory criteria of 32 °C (89.6 °F), thereby subjecting VEPCO to possible enforcement action under the CWA without an approved CWA Section 316(a) variance. In 1984 and 1985, VEPCO conducted a CWA 316(a) demonstration that concluded that alternative temperature effluent limitations are justifiable based on the following factors (VEPCO 1986):

- A balanced indigenous community has been maintained.
- The community has not sustained prior appreciable harm.
- A shift towards nuisance species in the receiving water has not occurred and is not likely to occur.
- A zone of passage will not be impaired to the extent that it will not provide for normal movement of populations of dominant species of fish, and economically important species of fish, shellfish, and wildlife.
- There will be no adverse impact on threatened or endangered species.
- There will be no destruction of rare or unique habitat.
- The use of biocides, such as chlorine, has not resulted in appreciable harm to the community.

Section 4.1.3 of the NRC's 2002 FSEIS (NRC 2002b) and Section E4.6.2.4 of Dominion's ER (Dominion 2020b) describe this study and its results in detail.

The Virginia State Water Control Board reviewed the demonstration study report and approved the variance in September 1986. As such, the Board found that effluent limitations more stringent than the thermal limitations included in the NPDES permit were not necessary to assure the propagation of a balanced, indigenous population of shellfish, fish, and wildlife in Lake Anna and the North Anna River downstream of the lake (VDEQ 2014b).

Since the original 316(a) demonstration study, Dominion has monitored temperatures using continuous recorders at seven upper lake monitoring stations, three WHTF stations, and one North Anna river station (see Attachment 12 of the VPDES Permit Fact Sheet (VDEQ 2014b) for temperature recorder locations). On the basis of the original study and this continuing monitoring, Dominion has requested, and VDEQ has granted, continuance of the CWA Section 316(a) variance in successive VPDES permits. Most recently, in 2014, VDEQ evaluated temperature data from Dominion's 2008–2011 post-316(a) monitoring annual reports, consulted with VDGIF, and concluded that its best professional judgement is that the CWA Section 316(a) variance continue with the 2014 renewed VPDES permit (VDEQ 2014). VDEQ maintained the post-316(a) demonstration monitoring requirements in the 2014 permit to ensure continued verification of the original CWA Section 316(a) study results and justification for the variance. Section 25 of the VPDES Permit Fact Sheet (VDEQ 2014b) describes the monitoring requirements in detail.

In its 2018 VDPES permit renewal application, Dominion again requested continuance of the CWA Section 316(a) variance on the basis of the following:

- Facility operations have not significantly increased heat input.
- The station's thermal loading to the lake from North Anna is not expected to increase.
- The annual biological reports indicate that Lake Anna and the lower North Anna River continue to support a well-balanced ecological community.

As part of its VPDES permit renewal application review, VDEQ will consider Dominion's request for continuance of the variance. VDEQ may determine that the original CWA Section 316(a) demonstration, paired with Dominion's continued temperature monitoring, is sufficient to assure the protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife in Lake Anna and the North Anna River downstream of the lake. Alternately, VDEQ may require additional mitigation or monitoring in the renewed VPDES permit.

Thermal Impacts Conclusion

Because VDEQ has granted Dominion multiple, sequential variances under CWA Section 316(a), the NRC staff finds that the adverse impacts on the aquatic environment associated thermal effluent are minimized. Because characteristics of the thermal effluent would remain the same under the proposed action, the NRC staff anticipates similar effects during the proposed SLR period. Further, VDEQ will continue to review the CWA Section 316(a) variance with each successive VPDES permit renewal and may require additional mitigation or monitoring in a future renewed VPDES permit if it deems such actions to be appropriate to assure the protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife in Lake Anna and the North Anna River downstream of the lake. The NRC staff assumes that any additional requirements that VDEQ imposes would further reduce the impacts of the North Anna thermal effluent over the course of the proposed SLR term. For these reasons, the NRC staff finds that thermal impacts during the proposed SLR period would neither destabilize nor noticeably alter any important attribute of the aquatic environment and would, therefore, result in SMALL impacts on aquatic organisms.

3.7.4 No-Action Alternative

If North Anna were to cease operating, impacts on the aquatic environment would decrease or stop following reactor shutdown. Some withdrawal of water from Lake Anna would continue during the shutdown period to provide cooling to spent fuel in the spent fuel pool until that fuel could be transferred to dry storage. The amount of water withdrawn for these purposes would be a small fraction of water withdrawals during operations, would decrease over time, and would likely end within the first several years following shutdown. The reduced demand for cooling water would substantially decrease the effects of impingement, entrainment, and thermal effluent on aquatic organisms, and these effects would wholly cease following the transfer of spent fuel to dry storage. Effects from cold shock would be unlikely, given the small area of lake affected by thermal effluent under normal operating conditions, combined with the phased reductions in withdrawal and discharge of lake water that would occur following shutdown.

The NRC staff concludes that the impacts of the no-action alternative on aquatic resources would be SMALL.

3.7.5 Replacement Power Alternatives: Common Impacts

Construction impacts for many components of either replacement power alternative would be qualitatively and quantitatively similar. Construction could result in aquatic habitat loss, alteration, or fragmentation; disturbance and displacement of aquatic organisms; mortality of aquatic organisms; and increase in human access. For instance, construction-related chemical spills, runoff, and soil erosion could degrade water quality in Lake Anna, its tributaries, or the North Anna River by introducing pollutants and increasing sedimentation and turbidity. Dredging and other in-water work could directly remove or alter the aquatic environment and disturb or kill aquatic organisms. Because construction effects would be short term, associated habitat degradation would be relatively localized and temporary. Effects could be minimized by the use of existing infrastructure, such as the North Anna intake and discharge systems, as well as use of existing transmission lines, roads, parking areas, and certain existing buildings and structures on the site. Aquatic habitat alteration and loss could be minimized by siting components of the alternatives farther from waterbodies and away from drainages and other aquatic features.

Water quality permits required through Federal and State regulations would control, reduce, or mitigate potential effects on the aquatic environment. Through such permits, the permitting agencies could include conditions requiring Dominion to follow BMPs or to take certain mitigation measures if adverse impacts are anticipated. For instance, USACE oversees Section 404 permitting for dredge and fill activities, and VDEQ oversees VPDES permitting and general stormwater permitting. Dominion would likely be required to obtain each of these permits to construct a new replacement power alternative on the North Anna site. Notably, the EPA final rule under Phase I of the CWA Section 316(b) regulations applies to new facilities and sets standards to limit intake capacity and velocity to minimize impacts on fish and other aquatic organisms in the source water (40 CFR 125.84). Any new replacement power alternative subject to this rule would be required to comply with the associated technology standards.

With respect to operation of a new replacement power alternative, operational impacts for either alternative would be qualitatively similar but would vary in intensity, based on each alternative's water use and consumption. Both alternatives would involve new nuclear power generation, in the form of SMRs. The new reactors would use mechanical draft cooling towers to dissipate waste heat. The NRC staff analyzed the impacts of operating cooling tower plants on the aquatic environment in the GEIS (NRC 2013a) and determined that operation of nuclear facilities with cooling towers would result in SMALL impacts on the aquatic environment, including those impacts resulting from impingement, entrainment, and thermal effluents. This is due to the relatively low volume of makeup water withdrawal for plants with a cooling tower system and the minimal heated effluent that would be discharged. Water use conflicts would be unlikely, given that any new power alternative would be sited on the existing North Anna site and would consume a small fraction of the lake's flow past the plant.

3.7.6 New Nuclear (Small Modular Reactor) Alternative

The types of impacts that the aquatic environment would experience from this alternative are characterized in the previous section discussing impacts common to all replacement power alternatives. In that section, construction impacts are sufficiently addressed as they would apply to the new nuclear alternative. Based on that discussion, the NRC staff finds that impacts of construction would be SMALL because construction effects would be of limited duration, the new plant would use some of the existing site infrastructure and buildings, and required Federal and State water quality permits would likely include conditions requiring BMPs and mitigation strategies to minimize environmental effects.

With respect to operation, Federal and State water quality permits would control and mitigate many of the potential effects on the aquatic environment, including water withdrawal and discharge, such that the associated effects would be unlikely to noticeably alter or destabilize any important attribute of the aquatic environment. The NRC staff finds that the impacts of operation of a new nuclear (SMR) alternative would be SMALL.

The NRC staff concludes that the impacts on aquatic resources from construction and operation of a new nuclear (SMR) alternative would be SMALL.

3.7.7 Combination Alternative (Solar, Offshore Wind, Small Modular Reactor, and Demand-Side Management)

The impacts of constructing the offshore wind component of this alternative would include increased turbidity, noise, vibration, and other physical disturbances to the aquatic environment from pile-driving, turbine construction, and submarine power cable installation. Cable installation could disturb large spans of aquatic habitat and would be especially detrimental to nearshore and estuarine habitats used by early life stages of finfish and shellfish. Dredging would likely be necessary in some areas to prepare for cable installation and would result in destruction of the existing benthic habitat and temporary habitat loss until the benthic community could repopulate the area. Increased vessel anchoring during survey activities, construction, installation, and maintenance would increase turbidity and disturb the benthic environment. Accidental releases of contaminants from fuel and chemical spills would also pose a hazard to the aquatic environment and would be especially detrimental to nearshore, estuarine, and unique or sensitive habitats (BOEM 2020). As explained under the discussion of impacts common to all alternatives, water quality permits required through Federal and State regulations would control, reduce, or mitigate potential effects on the aquatic environment. Through such permits, the permitting agencies could include conditions requiring Dominion to follow BMPs or to take certain mitigation measures if adverse impacts are anticipated. The impacts of construction of the offshore wind component of this alternative on aquatic resources would likely be MODERATE to LARGE, depending on the sensitivity and uniqueness of the particular aquatic habitats affected.

During operation of the offshore wind component of this alternative, fuel and chemical spills would remain a potential hazard. The presence of permanent structures could lead to impacts on finfish and aquatic invertebrates through entanglement from gear loss, hydrodynamic disturbance, fish aggregation, habitat conversion, and migration disturbances. These impacts may arise from buoys, met towers, foundations, scour/cable protection, and transmission cable infrastructure. However, structure-oriented or hard-bottom species could benefit from the new structures because they would have new material upon which to anchor themselves and build colonies. (BOEM 2020). The impacts of operation of this component of the alternative on aquatic resources would be SMALL to MODERATE, depending on the effectiveness of the measures implemented to control accidental releases of contaminants or to clean up such releases if they occur.

The impacts of constructing the solar PV component of this alternative are also addressed in the previous sections discussing impacts common to all alternatives. These effects would be SMALL to MODERATE, depending on the site(s) selected, the aquatic habitats present, and the extent to which construction would degrade, modify, or permanently alter those habitats. Operation of the solar PV component would have no discernable effects on the aquatic environment.

The types of impacts that the aquatic environment would experience from the SMR component of this alternative are characterized in the previous two sections discussing impacts common to all alternatives and impacts of the new nuclear alternative. Construction and operation impacts of this component of the combination alternative would be qualitatively similar. Because the nuclear component of the combination alternative would involve construction and operation of only one SMR, less cooling water would be required, which would result in fewer impacts on the aquatic environment. The impacts of construction and operation of this component of the alternative on aquatic resources would be SMALL.

The demand-side management component would have no discernable effects on the aquatic environment.

The NRC staff concludes that the impacts on aquatic resources from construction and operation of a combination alternative would be MODERATE to LARGE during construction and SMALL to MODERATE during operation. The higher magnitude of potential impacts experienced by the aquatic environment is primarily attributable to the offshore wind component of the alternative.

3.8 Special Status Species and Habitats

This section addresses species and habitats that are federally protected under the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.), and the Magnuson–Stevens Fishery Conservation and Management Reauthorization Act, as amended (16 U.S.C. 1801–1884). Before taking a Federal action, such as the issuance of the proposed subsequent renewed licenses for North Anna, the NRC has direct responsibilities under these statutes. Sections 3.6 and 3.7 of this SEIS address terrestrial and aquatic species and habitats protected by other Federal statutes and the Commonwealth of Virginia under which the NRC does not have such responsibilities.

3.8.1 Endangered Species Act: Federally Listed Species and Critical Habitats

FWS and the National Marine Fisheries Service (NMFS) jointly administer the Endangered Species Act. The FWS manages the protection of, and recovery effort for, listed terrestrial and freshwater species, and the NMFS manages the protection of, and recovery effort for, listed marine and anadromous species. The following sections describe the North Anna action area and the species and habitats that may occur in the action area under the FWS and NMFS jurisdictions.

3.8.1.1 Endangered Species Act: Action Area

The implementing regulations for Section 7(a)(2) of the Endangered Species Act 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 federally listed species and critical habitats because only species and habitats that occur within the action area may be affected by the Federal action.

For the purposes of assessing the potential impacts of North Anna subsequent license renewal on federally listed species, the NRC staff considers the action area to consist of the following.

<u>North Anna Site</u>: The terrestrial region of the action area consists of 1,043 ac (422 ha) within the North Anna site in Louisa County, VA. The site is situated on a peninsula on the southern shore of Lake Anna. It includes developed land to support power plant operations (293 ac (119 ha)), deciduous forest (348 ac (141 ha)), evergreen forest (307 ac (124 ha)), mixed forest (17 ac (7 ha)), shrub/scrub (164 ac (66 ha)), woody wetlands (25 ac (10 ha), and cultivated land (18 ac (7 ha)). Section 3.2 and Section 3.6 of this SEIS describe the developed and natural features of the site and the characteristic vegetation and habitats.

<u>Lake Anna</u>: The aquatic region of the action area encompasses the impingement AOI (described in Section 3.7.3.1.1 of this SEIS), the entrainment AOI (described in Section 3.7.3.1.2 of this SEIS), the WHTF, and the area of the Lake Anna Reservoir that experiences increased temperatures from discharge of heated effluent at Outfall 001 (described in Section 3.7.3.2 of this SEIS).

The NRC staff recognizes that, although the described action area is stationary, federally listed species can move in and out of the action area. For instance, a migratory bird could occur in the action area seasonally as it forages or breeds within the action area. Thus, in its analysis, the NRC staff considers not only those species known to occur directly within the action area but those species that may passively or actively move into the action area. The NRC staff then considers whether the life history and habitat requirements of each species make it likely to occur in the action area where it could be affected by the proposed license renewal. The following sections first discuss listed species and critical habitats under FWS jurisdiction, followed by those under NMFS jurisdiction.

3.8.1.2 Endangered Species Act: Federally Listed Species and Critical Habitats under U.S. Fish and Wildlife Service Jurisdiction

Based on a search of the North Anna action area, two federally listed species under FWS jurisdiction may be present in the North Anna action area: the northern long-eared bat (*Myotis septentrionalis*) and the dwarf wedgemussel (FWS 2021). No candidate species, proposed species, or critical habitats (proposed or designated) occur within the North Anna action area (FWS 2021).

The NRC staff evaluated the effects of North Anna operation on the dwarf wedgemussel in 2002 as part of its environmental review for the initial North Anna LR term (NRC 2002b). The NRC staff found no records indicating the presence of the species in the action area or in Lake Anna, its tributary streams, or the North Anna River near North Anna. Accordingly, the NRC staff concluded that the initial North Anna license renewal would not affect this species. In 2006 and 2010, the NRC addressed the dwarf wedgemussel in its environmental reviews for the North Anna ESP and COL (NRC 2006; NRC 2010). The staff identified no new information indicating occurrences of the species in the vicinity of the North Anna site. During the current subsequent license renewal review, the NRC staff has identified no additional information that would indicate the presence of the dwarf wedgemussel in the North Anna action area. Accordingly, this species is not considered in any further detail in this SEIS.

During the NRC staff's environmental review for the 2003 license renewal, the staff considered potential impacts of continued North Anna operation on two additional freshwater mussels: the Atlantic pigtoe (*Fusconala masoni*) (proposed threatened) and James spinymussel (*Pleurobema collina*) (federally endangered) (NRC 2002b). The staff found that neither species had been observed in Lake Anna, in its tributary streams, or in the North Anna River near North Anna. Accordingly, the NRC staff concluded that the initial North Anna license renewal would not affect these species.

In 2006 and 2010, the NRC staff also addressed the Atlantic pigtoe and James spinymussel, as well as the green floater (federally under review), in its environmental reviews for the North Anna ESP and COL (NRC 2006, 2010). At that time, the NRC staff identified VDGIF records of the green floater occurring in the upper Pamunkey River watershed. However, the NRC staff identified no records of any of the three mussels occurring in the action area. During the current subsequent license renewal review, the NRC staff has identified no additional information that would indicate the presence of these mussels in the North Anna action area. Accordingly, these species are not considered in any further detail in this SEIS.

In its environmental review for the 2003 license renewal, the NRC staff evaluated the bald eagle (*Haliaeetus leucocephalus*) and determined that license renewal would not affect this species. FWS subsequently delisted this species due to the species' recovery. The bald eagle remains federally protected under the Bald and Golden Eagle Protection Act, which is discussed in Section 3.6.4 of this SEIS.

In 2009, 2010, and 2012, the Williamsburg Environmental Group, Inc. conducted botanical surveys on the North Anna site and alternative sites, in connection with Dominion's COL application, to determine the presence of the small whorled pogonia (*Isotria medeoloides*) (federally threatened). The surveys determined that the species was not present, and Dominion communicated its survey results to the appropriate regulatory agencies (Dominion 2016b).

The NRC staff has not evaluated the northern long-eared bat during any previous environmental reviews of North Anna or the North Anna site because FWS did not list the species under the Endangered Species Act until 2015. Accordingly, the NRC staff addresses this species in this SEIS and evaluates the potential effects of subsequent license renewal on this species. The sections below describe the habitat requirements, life history, and regional occurrence of the northern long-eared bat.

Northern Long-eared Bat (*Myotis septentrionalis*)

FWS listed the northern long-eared bat as threatened throughout its range in 2015 (80 FR 17974). In 2016, FWS determined that designating critical habitat for the species was not prudent because such designation would increase threats to the species resulting from vandalism and disturbance and could potentially increase the spread of white-nose syndrome (81 FR 24707). Information in this section is organized according to the description of the species in the FWS *Federal Register* notice associated with the final rule to list the species (80 FR 17974) and draws from this source unless otherwise indicated.

Taxonomy and Species Description

Although there have been few genetic studies on the northern long-eared bat, FWS describes it as a monotypic species (i.e., having no subspecies). This species has been recognized by different common names, including Keen's bat, northern Myotis, and the northern bat.

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. Adults weigh 5 to 8 grams (g) (0.2 to 0.3 ounces (oz)), and females tend to be slightly larger than males. Individuals are medium to dark brown on the back, dark brown on the ears and wing membranes, and tawny to pale brown on the ventral side. Within its range, the northern long-eared bat can be confused with the little brown bat (*Myotis lucifugus*) or the western long-eared myotis (*M. evotis*).

Distribution and Relative Abundance

Species Range. The northern long-eared bat is found across much of the eastern and north-central United States and all Canadian provinces from the Atlantic coast west to the southern Northwest Territories and eastern British Columbia. Its range includes 37 U.S. states. The species is widely distributed within the eastern portion of its range, which includes Delaware, Connecticut, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, Pennsylvania, Vermont, Virginia, West Virginia, New York, Rhode Island, and the District of Columbia. Before documentation of white-nose syndrome, northern long-eared bats were consistently captured during summer mist-net and acoustic surveys within this region. However, as white-nose syndrome has spread, growing gaps exist within the eastern region where bats are no longer being captured or detected. In other areas, occurrences are sparse. Frick et al. (2015) documented the local extinction of northern long-eared bats from 69 percent of 468 sites where white-nose syndrome has been present for at least 4 years in Vermont, New York, Pennsylvania, Maryland, West Virginia, and Virginia, which was by far the highest extinction rate among six species of North American hibernating bats considered during the study.

Status Within Virginia. As of 2016, FWS reports 11 known northern long-eared bat hibernacula and 12 known occupied maternity roost trees in Virginia (FWS 2016). Historically, the species has been captured in both summer and winter surveys within the State. However, since the appearance of white-nose syndrome in Virginia (2008–2009), winter and summer survey captures have sharply declined. In a 2015 environmental assessment associated with the northern long-eared bat final rule under Section 4(d) of the Endangered Species Act Section, FWS made the following estimates of Virginia's northern long-eared bat population (FWS 2015a):

- 277,920 total adults
- 138,960 total pups
- 6,948 maternity colonies of an average size of 20 individuals
- 48.3 percent occupancy of Virginia's available forested habitat
- 7.29 percent use of Virginia's available forested habitat as maternity roost areas

Habitat

Winter Habitat. Northern long-eared bats predominantly overwinter in hibernacula of various sizes that include underground caves and abandoned mines. Preferred hibernacula have relatively constant, cool temperatures with very high humidity and no air currents. Individuals most often roost in small crevices or cracks in cave or mine walls or ceilings but are also infrequently observed hanging in the open. Less commonly, northern long-eared bats overwinter in abandoned railroad tunnels, storm sewers, aqueducts, attics, and other non-cave or mine hibernacula with temperature, humidity, and air flow conditions resembling suitable caves and mines.

Summer Habitat. In summer, northern long-eared bats typically roost individually or in colonies underneath bark or in cavities or crevices of both live trees and snags. Males and nonreproductive females may also roost in cooler locations, including caves and mines. Individuals have also been observed roosting in colonies in buildings, barns, on utility poles, and in other man-made structures. The species has been documented to roost in many species of trees, including black oak (*Quercus velutina*), northern red oak (*Q. rubra*), silver maple (*Acer saccharinum*), black locust (*Robinia pseudoacacia*), American beech (*Fagus grandifolia*), sugar maple (*A. saccharum*), sourwood (*Oxydendrum arboreum*), and shortleaf pine (*Pinus echinata*). Foster and Kurta (1999) found that, rather than being dependent on particular tree species, northern long-eared bats are likely to use a variety of trees as long as they form suitable cavities or retain bark. Owen et al. (2002) found that tree-roosting maternal colonies chose roosting sites in larger trees that were taller than the surrounding stand and in areas with abundant snags. Carter and Feldhamer (2005) indicate that resource availability drives roost tree selection more than the actual tree species. However, several studies have shown that the species more often roosts in shade-tolerant deciduous trees than in conifers. Additionally, FWS concludes in its final listing that the tendency for northern long-eared bats to use healthy live trees for roosting is low.

Northern long-eared bats actively form colonies in the summer, but such colonies are often in flux because members will frequently depart to be solitary or to form smaller groups and later return to the main unit. This behavior is described as "fission-fusion," and it also results in individuals often switching tree roosts (typically every 2 to 3 days). Roost trees are often close to one another within the species' summer range, with various studies documenting distances between roost trees ranging from 20 ft (6.1 m) to 2.4 mi (3.9 km).

Spring Staging. Spring staging is the period between winter hibernation and spring migration to summer habitat when bats begin to gradually emerge from hibernation. Individuals will exit the hibernacula to feed but reenter the same or alternative hibernacula to resume periods of physical inactivity. The spring staging period is believed to be short for the northern long-eared bat and may last from mid-March through early May, with variations in timing and duration based on latitude and weather.

Fall Swarming. Fall swarming is the period between the summer and winter seasons and includes behaviors such as copulation, introduction of juveniles to hibernacula, and stopovers at sites between summer and winter regions. Both males and females are present together at swarming sites, and other bat species are often present as well. For northern long-eared bats, the swarming period may occur between July and early October, depending on latitude within the species' range. Northern long-eared bats may use caves and mines during swarming. Little is known about roost tree selection during this period, but some studies suggest that a wider variation in tree selection may occur during swarming than during the summer.

Roost Trees. Northern long-eared bats roost in cavities, crevices, hollows, or under the bark of live and dead trees and snags of greater than 3 in. (8 cm) diameter at breast height. Isolated trees may be considered suitable habitat when they exhibit these characteristics and are less than 1,000 ft (300 m) from the next nearest suitable roost tree within a wooded area. Northern long-eared bats appear to choose roost trees based on structural suitability rather than exhibiting a preference for specific species of trees.

Biology

Hibernation. Northern long-eared bats hibernate during winter months. Individuals arrive at hibernacula in August or September, enter hibernation in October and November, and emerge from hibernacula in March or April. The species has shown a high degree of repeated hibernaculum use, although individuals may not return to the same hibernacula in successive seasons. Northern long-eared bats often inhabit hibernacula in small numbers with other bat species, including little brown bats, big brown bats (*Eptesicus fuscus*), eastern small-footed bats (*Myotis leibii*), tri-colored bats (*Perimyotis subflavus*), and Indiana bats (*M. sodalis*). Northern long-eared bats have been observed moving among hibernacula during the winter hibernation period, but individuals do not feed during this time, and the function of this behavior is not well understood.

Migration and Homing. Northern long-eared bats migrate relatively short distances (between 56 and 89 km (35 and 55 mi)) from summer roosts and winter hibernacula. The spring migration period typically occurs from mid-March to mid-May, and fall migration typically occurs between mid-August and mid-October.

Reproduction. Northern long-eared bats mate from late July in northern regions to early October in southern regions. Hibernating females store sperm until spring, and ovulation takes place when females emerge from hibernacula. Gestation is estimated to be 60 days, after which time females give birth to a single pup in late May or early June. Females raise their young in maternity colonies, which generally consist of 30 to 60 individuals (females and young). Roost tree selection changes depending on the reproductive stage, with lactating females roosting higher in tall trees with less canopy cover. Young are capable of flight as early as 3 weeks following birth. Maximum lifespan for northern long-eared bats is estimated to be up to 18.5 years, and the highest rate of mortality occurs during the juvenile stage.

Foraging Behavior. Northern long-eared bats are nocturnal foragers that use hawking and gleaning in conjunction with passive acoustic cues to collect prey. The species' diet includes moths, flies, leafhoppers, caddisflies, beetles, and arachnids. Individuals forage 1 to 3 m

(3 to 10 ft) above the ground between the understory and canopy of forested hillsides and ridges, with peak foraging activity occurring within 5 hours after sunset.

Home Range. Northern long-eared bats exhibit site fidelity to their summer home range, during which time individuals roost and forage in forests. Studies indicate a variety of home range sizes—from as little as 8.6 ha (21.3 ac) to as large as 172 ha (425 ac). Some studies indicate differences in ranges between sexes, while others find no significant differences.

Factors Affecting the Species

FWS identifies white-nose syndrome, a disease caused by the fungus *Pseudogymnoascus destructans*, to be the predominant threat to the northern long-eared bat's continued existence. Other factors include human disturbance of hibernacula and loss of summer habitat due to forest conversion and forest management.

Occurrence Within the Action Area

The North Anna action area falls within the general range of the northern long-eared bat. However, no known hibernacula, roost trees, or summer habitat occur within the action area, according to VDGIF records (VDGIF 2021). The closest hibernaculum or summer habitat is approximately 70 mi (112 km) west of the North Anna site in the Shenandoah Mountains (VDGIF 2021).

In 2016, Dominion commissioned GAI Consultants, Inc. (GAI) to conduct mist net surveys of the North Anna site in connection with the North Anna COL application (GAI 2016). Researchers selected and operated nine net sites using three net sets operated between two and five nights each for a total of 84 net nights of effort, in accordance with FWS mist net guidelines for nonlinear projects within the Appalachian Indiana Bat Recovery Unit. All mist net sites were located within or immediately adjacent to the North Anna site. Sites included logging roads, abandoned railroad corridors, a stream, a forest edge, open forest interior, and forested trails. Habitat surrounding these sites was predominantly young and mature mixed forest, and common trees included tulip poplar (*Liriodendron tulipifera*), Virginia pine (*Pinus virginiana*), white oak (*Quercus alba*), red oak, and red maple (*Acer rubrum*).

Researchers set nets between May 16 and May 28, 2016, to correspond to the May 15–August 15 summer habitat survey window prescribed by FWS and VDGIF. A federally and State-permitted biologist identified all collected bats. An FWS-approved surveyor for bats in Virginia was also present throughout the survey. GAI collected a total of 29 bats of two species: 23 eastern red bats (*Lasiurus borealis*) and six silver-haired bats (*Lasionycteris noctivagans*). Due to the time of year that the survey was conducted, all individuals were adults. As a result of the survey, GAI found no evidence that northern long-eared bats use the project area during summer months. GAI concluded that the species is likely absent from the area or, if present, occurs rarely and in extremely small numbers.

Based on the above information, the NRC staff concludes that northern long-eared bats are not present in the action area in winter due to the lack of nearby hibernacula. Northern long-eared bats are also unlikely to occur in the action area in other seasons, based on the 2016 mist nest survey results and lack of VDGIF records. However, the NRC staff conservatively assumes that forests within the action area, which cover 672 ac (272 ha), could support foraging, mating, and sheltering in the spring, summer, and fall. If present during these seasons, individuals would only occur very occasionally and in very low numbers.

Summary of Potential Species Occurrence in the Action Area

Table 3-18 below summarizes the potential for each federally listed species mentioned in this section to occur in the action area

Table 3-18. Occurrences of Federally Listed Species in the Action Area under U.S. Fish and Wildlife Jurisdiction

Species	Type of and Likelihood of Occurrence in Action Area
Atlantic pigtoe	Not present.
dwarf wedgemussel	Not present.
green floater	Not present.
James spinymussel	Not present.
northern long-eared bat	Seasonal presence in spring, summer, and fall possible in very low numbers in action area forests of sufficient size to support foraging, mating, and sheltering.
small whorled pogonia	Not present.

3.8.1.3 Endangered Species Act: Federally Listed Species and Critical Habitats under National Marine Fisheries Service Jurisdiction

No federally listed species or designated critical habitats under NMFS jurisdiction occur in the action area (NMFS 2019). Therefore, this section of the SEIS does not contain a discussion of any such species or habitats.

3.8.1.4 Magnuson–Stevens Act: Essential Fish Habitat

Under the provisions of the Magnuson–Stevens Act, the Fishery Management Councils and NMFS have designated essential fish habitat (EFH) for certain federally managed species. EFH is defined as the waters and substrate necessary for spawning, breeding, feeding, or growth to maturity (16 U.S.C. 1802(10)). For each federally managed species, the Fishery Management Councils and NMFS designate and describe EFH by life stage (i.e., egg, larva, juvenile, adult).

No EFH occurs within Lake Anna. Therefore, this section of the SEIS does not discuss any species or habitats protected under the Act.

3.8.2 Proposed Action

As identified in Table 3-2 of this SEIS, threatened, endangered, and protected species and EFH is a Category 2 issue that requires site-specific analysis for each proposed license renewal to determine whether impacts would be SMALL, MODERATE, or LARGE. This issue is analyzed below.

3.8.2.1 Endangered Species Act: Federally Listed Species and Critical Habitats under U.S. Fish and Wildlife Jurisdiction

In Section 3.8.1.2, the NRC staff determines that one listed species may occur in the action area: the northern long-eared bat. Section 3.8.1.2 includes relevant information on the habitat requirements, life history, and regional occurrence of this species. In the sections below, the NRC staff analyzes the potential impacts of the proposed North Anna subsequent license renewal on this species. Table 3-19 identifies the NRC staff's Endangered Species Act effect determination that resulted from the staff's analysis. In Section 3.8.1.2, the NRC staff also describes several other federally listed species that were addressed in previous NRC environmental reviews of North Anna or the North Anna site. The staff explains that these species do not occur in the action area; therefore, the staff does not address these species any further because subsequent license renewal would have no effect on them.

Table 3-19. Effect Determinations for Federally Listed Species Under U.S. Fish and Wildlife Service Jurisdiction

Species	Federal Status[(a)]	Potentially Present in the Action Area?	Effect Determination[(b)]
Northern long-eared bat	Federally Threatened	Yes	May affect, but is not likely to adversely affect

[(a)] Under the Endangered Species Act, species may be designated as federally endangered (FE) or federally threatened (FT).

[(b)] The NRC staff makes its effect determinations for federally listed species in accordance with the language and definitions specified in the FWS and NMFS Endangered Species Consultation Handbook (FWS and NMFS 1998).

Northern Long-Eared Bat (*Myotis septentrionalis*)

In Section 3.8.1.2 of this SEIS, the NRC staff concludes that northern long-eared bats may occur in the action area's forests in spring, summer, and fall. If present, northern long-eared bats would occur rarely and in low numbers.

The potential stressors that northern long-eared bats could experience from operation of a nuclear plant (generically) are as follows.

- mortality or injury from collisions with plant structures and vehicles
- habitat loss, degradation, disturbance, or fragmentation, and associated effects
- behavioral changes resulting from refurbishment or other site activities

This section addresses each of these stressors below.

Mortality or Injury from Collisions with Plant Structures and Vehicles

Several studies have documented bat mortality or injury resulting from collisions with man-made structures. Saunders (1930) reported that five bats of three species—eastern red bat, hoary bat (*L. cinereus*), and silver-haired bat—were killed when they collided with a lighthouse in Ontario, Canada. In Kansas, Van Gelder (1956) documented five eastern red bats that collided with a television tower. In Florida, Crawford and Baker (1981) collected 54 bats of seven species that collided with a television tower over a 25-year period; Zinn and Baker (1979) reported 12 dead hoary bats at another television tower in the State over an 18-year period; and Taylor and Anderson (1973) reported 1 dead yellow bat (*Lasiurus intermedius*) at a third Florida television tower. Bat collisions with communications towers have been reported in North Dakota, Tennessee, and Saskatchewan, Canada; with convention center windows in Chicago, IL; and with power lines, barbed wire fences, and vehicles in numerous locations (Johnson and Strickland 2003).

More recently, bat collisions with wind turbines have been of concern in North America. Bat fatalities have been documented at most wind facilities throughout the United States and Canada (USGS 2015). For instance, during a 1996–1999 study at the Buffalo Ridge wind power development project in Minnesota, Johnson et al. (2003) reported 183 bat fatalities, most of which were hoary bats and eastern red bats. The USGS Fort Collins Science Center estimates that tens to hundreds of thousands of bats die at wind turbines in North America each year (USGS 2015).

Bat collisions with man-made structures at nuclear power plants are not well documented but are likely rare, based on the available information. In an assessment of the potential effects of operation of the Davis-Besse Nuclear Power Station in Ohio, the NRC staff (NRC 2014b) noted that four dead bats were collected at the plant during bird mortality studies conducted from 1972 through 1979. Two red bats (*Lasiurus borealis*) were collected at the cooling tower, and one big brown bat and one tri-colored bat were collected near other plant structures. The NRC staff (NRC 2014b) found that future collisions of bats would be extremely unlikely and, therefore, discountable, given the small number of bats collected during the study and the marginal suitable habitat that the plant site provides. FWS (2014a) concurred with this determination. In a 2015 assessment associated with Indian Point Nuclear Generating Units 2 and 3, in New York, the NRC staff (NRC 2015) determined that bat collisions were less likely to occur at Indian Point than at Davis-Besse because Indian Point does not have cooling towers or similarly large obstructions. The tallest structures on the Indian Point site are 134-ft (40.8-m)-tall turbine buildings and 250-ft (76.2-m)-tall reactor containment structures. The NRC staff (NRC 2015) concluded that the likelihood of bats colliding with these and other plant structures on the Indian Point site during the LR period was extremely unlikely to occur and, therefore, discountable. FWS concurred with this determination (FWS 2015b). In 2018, the NRC staff (NRC 2018b) determined that the likelihood of bats colliding with site buildings or structures on the Seabrook Station, Unit 1, site in New Hampshire would be extremely unlikely. The tallest structures on that site are a 199-ft (61-m)-tall containment structure and 103-ft (31-m)-tall turbine and heater bay building. FWS (FWS 2018) concurred with the NRC staff's determination. Most recently, the NRC staff (NRC 2020b) determined that the likelihood of bats colliding with site buildings or structures on the Surry Power Station, Units 1 and 2, site in Surry, VA, would be extremely unlikely. FWS (FWS 2019) again concurred with the NRC staff's determination on the premise that activities associated with that license renewal would be consistent with the activities analyzed in the FWS programmatic biological opinion dated January 5, 2016 (FWS 2016).

On the North Anna site, the tallest site structures are the reactor containment buildings, each of which is 191 ft (58 m) high (Dominion 2020b). The turbine buildings and transmission lines are also prominent features on the site. To date, Dominion has reported no incidents of injury or mortality of any species of bat on the North Anna site associated with site buildings or structures. Accordingly, the NRC staff finds the likelihood of future northern long-eared bat collisions with site buildings or structures to be extremely unlikely and, therefore, discountable.

Vehicle collision risk for bats varies depending on factors including time of year, location of roads and travel pathways in relation to roosting and foraging areas, the characteristics of individuals' flight, traffic volume, and whether young bats are dispersing. Although collision has been documented for several species of bats, the Indiana Bat Draft Recovery Plan (FWS 2007) indicates that bat species do not seem to be particularly susceptible to vehicle collisions. However, FWS also finds it difficult to determine whether roads pose a greater risk for bats colliding with vehicles or a greater likelihood of decreasing risk of collision by deterring bat activity (FWS 2016). In most cases, FWS expects that roads of increasing size decrease the likelihood of bats crossing the roads and, therefore, reduce collision risk (FWS 2016).

During the proposed North Anna subsequent LR term, vehicular traffic from truck deliveries, site maintenance activities, and personnel commuting to and from the site would continue throughout the LR period as they have during the current licensing period. Vehicle use would occur primarily in areas that bats would be less likely to frequent, such as along established county and State roads or within industrial-use areas of the North Anna site. Additionally, most vehicle activity would occur during daylight hours when bats are less active. To date, Dominion has reported no incidents of injury or mortality of any species of bat on the North Anna site associated with vehicle collisions. Accordingly, the NRC staff finds the likelihood of future northern long-eared bat collisions with vehicles to be extremely unlikely and, therefore, discountable.

Habitat Loss, Degradation, Disturbance, or Fragmentation, and Associated Effects

As previously discussed in this SEIS, the North Anna action area includes forested habitat that northern long-eared bats may rarely to very occasionally inhabit in spring, summer, and fall. In its final rule listing the northern long-eared bat (80 FR 17974), FWS stated that forest conversion and forest modification from management are two of the most common causes of habitat loss, degradation, disturbance, or fragmentation affecting the species. Forest conversion is the loss of forest to another land use type, such as cropland, residential, or industrial. Forest conversion can affect bats in the following ways (80 FR 17974):

- loss of suitable roosting or foraging habitat
- fragmentation of remaining forest patches, leading to longer flights between suitable roosting and foraging habitat
- removal of travel corridors, which can fragment bat colonies and networks
- direct injury or mortality during active forest clearing and construction

Forest management practices maintain forest habitat at the landscape level, but they involve practices that can have direct and indirect effects on bats. Impacts from forest management are typically temporary in nature and can include positive, neutral, and negative impacts, such as the following (80 FR 17974):

- maintaining or increasing suitable roosting and foraging habitat within the species' home range (positive)
- removing trees or small areas of forest outside of the species' summer home range or away from hibernacula (neutral)
- removing potential roost trees within the species' summer home range (negative)
- performing management activities near hibernacula that could disturb hibernating bats (negative)
- direct injury or mortality during forest clearing (negative)

Concerning forest conversion and its effects, the proposed action would not involve forest conversion or other activities that could result in similar impacts. Accordingly, bats would not experience the effects identified above and associated with forest conversion from the proposed action.

Concerning forest management, the proposed action would not involve forest management specifically. However, Dominion would continue to perform vegetation maintenance on the site over the course of the proposed license renewal term. Most maintenance would be of grassy, mowed areas between buildings and along walkways within the industrial portion of the site or on adjacent hillsides. Dominion would continue to maintain onsite transmission line ROWs in accordance with North American Electric Reliability Corporation standards. Less-developed areas and forested areas would be largely unaffected during the subsequent license renewal term. Dominion does not intend to expand the existing facilities or otherwise perform construction or maintenance activities within these areas (Dominion 2020b). Site personnel may occasionally remove select trees around the margins of existing forested areas if those trees are deemed hazardous to buildings, infrastructure, or other site facilities or to existing overhead clearances (Dominion 2020b). Negative impacts on bats could result if such trees are potential roost trees. Bats could also be directly injured during tree clearing. However, tree removal would be infrequent, and Dominion personnel would follow company guidance (Dominion 2020b), as explained below, to minimize potential impacts on bats.

Dominion requires its personnel and contractors to consider potential impacts on northern long-eared bats before site maintenance activities involving tree clearing. Dominion maintains companywide guidance that specifies how its personnel should proceed, depending on the type of tree clearing or site maintenance being performed. This guidance is summarized below for hazardous tree removal, existing ROW maintenance and expansion, clearing of less than or equal to 10 ac (4 ha) of trees, and clearing of greater than 10 ac (4 ha) of trees that are not in or adjacent to an existing ROW.

<u>Hazardous Tree Removal</u>. The FWS Endangered Species Act 4(d) rule for the northern long-eared bat (81 FR 1900) does not prohibit or restrict hazardous tree removal to protect human life or property. Before undertaking hazardous tree removal, Dominion documents its determination that the action meets the FWS definition of hazardous tree removal. Dominion does not specifically coordinate with FWS for such activities but avoids clearing hazardous trees during the brooding season in June and July.

<u>Existing Right-of-Way Maintenance and Expansion</u>. The FWS northern long-eared bat 4(d) rule does not prohibit routine maintenance and expansion of up to 100 ft (30 m) from either edge of an existing ROW, as long as the project does not occur within 0.25 mi (0.4 km) of a known hibernaculum, does not involve cutting of known maternity roost trees in June or July, and does not involve clear-cutting within 0.25 mi (0.4 km) of known maternity roost trees in June or July. Before undertaking existing ROW maintenance and expansion, Dominion personnel review previously conducted bat surveys in the project area. If there are none, Dominion coordinates with the applicable FWS field office or the State resource agency, as appropriate. If known roost trees or hibernacula occur within 0.25 mi (0.4 m) of the project area, Dominion does not perform clearing in June or July without prior coordination with FWS. If surveys have been conducted and those surveys identify no maternity roost trees, Dominion does not coordinate with FWS before undertaking the activity.

<u>Clearing of Less Than or Equal to 10 Acres of Trees</u>. The FWS Gloucester, VA, field office interprets the northern long-eared bat 4(d) rule to not prohibit projects resulting in less than or equal to 10 ac (4 ha) of tree clearing if those projects are outside of certain location restrictions. For such projects, Dominion follows the process described above for existing ROW maintenance and expansion before undertaking tree clearing.

<u>Clearing of Greater Than 10 Acres of Trees That Are Not in or Adjacent to an Existing Right-of-Way</u>. The FWS Gloucester, VA, field office interprets the northern long-eared bat 4(d) rule to prohibit all projects not occurring in or adjacent to an existing ROW and resulting in greater than 10 ac (4 ha) of tree clearing that may affect the species. For such projects, Dominion requires its personnel to coordinate with FWS before undertaking such a project. The company recognizes that FWS will likely require habitat surveys or acoustic or mist net bat surveys for such projects with clearing planned between April 15 and September 15, if such surveys have not been completed within the past 5 years. If surveys do not identify suitable bat habitat or bats on the project site, and FWS agrees with the survey results, Dominion does not restrict clearing to a particular time of year. If surveys identify bats on the project site, Dominion restricts clearing to between September 16 and April 14. Alternately, Dominion may coordinate with FWS to determine if there are options that would allow clearing in the spring and summer. Dominion recognizes that State resource agencies may have additional requirements related to surveys or development of habitat conservation plans for which coordination may be necessary.

The NRC staff finds that the measures summarized above, in addition to the infrequency with which hazardous trees would likely be removed in forested areas, would not measurably affect any potential spring staging, summer roosting, or fall swarming habitat in the action area. Direct injury or mortality to bats during tree removal is also unlikely because Dominion company guidance would ensure that personnel take the appropriate measures to avoid this potential impact. For instance, Dominion could avoid this impact by removing hazardous trees in the winter when bats are unlikely to be present on the site. Additionally, the continued preservation of the existing forested areas on the site during the subsequent license renewal term would result in positive impacts on northern long-eared bats if they are present within or near the action area.

Behavioral Changes Resulting from Refurbishment or Other Site Activities

Construction or refurbishment and other site activities, including site maintenance and infrastructure repairs, could prompt behavioral changes in bats. Noise and vibration and general human disturbance are stressors that may disrupt normal feeding, sheltering, and breeding activities (FWS 2016). At low noise levels or farther distances, bats initially may be startled but would likely habituate to the low background noise levels. At closer range and louder noise levels, particularly if accompanied by physical vibrations from heavy machinery, many bats would likely be startled to the point of fleeing from their daytime roosts. Fleeing individuals could experience increased susceptibility to predation and would expend increased levels of energy, which could result in decreased reproductive fitness (FWS 2016, Table 4-1). Increased noise may also affect foraging success. Schaub et al. (2008) found that the foraging success of the greater mouse-eared bat (*Myotis myotis*) diminished in areas with noise mimicking the traffic sounds that would be experienced within 15 m (49 ft) of a highway.

Within the North Anna action area, noise, vibration, and other human disturbances could dissuade bats from using the action area's forested habitat during migration, which could also reduce the fitness of migrating bats. However, bats that use the action area have likely become habituated to such disturbance because North Anna has been consistently operating for several decades. According to FWS, bats that are repeatedly exposed to predictable, loud noises may habituate to such stimuli over time (FWS 2010). For instance, Indiana bats have been documented as roosting within approximately 1,000 ft (300 m) of a busy State route adjacent to Fort Drum Military Installation and immediately adjacent to housing areas and construction activities on the installation (U.S. Army 2014). Northern long-eared bats would likely respond similarly.

Continued operation of North Anna during the SLR term would not include major construction or refurbishment and would involve no other maintenance or infrastructure repair activities besides routine activities already performed on the site. Levels and intensity of noise, lighting, and human activity associated with continued day-to-day activities and site maintenance during the subsequent license renewal term would be similar to ongoing conditions since North Anna began operating, and such activity would only occur on the developed, industrial-use portions of the site. While these disturbances could cause behavioral changes in migrating or summer roosting bats, such as the expenditure of additional energy to find alternative suitable roosts, the NRC staff assumes that northern long-eared bats, if present in the action area, have already acclimated to regular site disturbances. Thus, continued disturbances during the SLR term would not cause behavioral changes in bats to a degree that would be able to be meaningfully measured, detected, or evaluated or that would reach the scale where a take might occur.

Summary of Effects

The potential stressors evaluated in this section are unlikely to result in effects on the northern long-eared bat that could be meaningfully measured, detected, or evaluated, and such stressors are otherwise unlikely to occur for the following reasons:

- Bat collisions with nuclear power plant structures in the United States are rare, and none have been reported at North Anna. Vehicle collisions attributable to the proposed action are also unlikely, and none have been reported at North Anna.
- The proposed action would not involve any construction, land clearing, or other ground-disturbing activities.
- Continued preservation of the existing forested areas on the site would result in positive impacts on northern long-eared bats.
- Bats, if present in the action area, have likely already acclimated to the noise, vibration, and general human disturbances associated with site maintenance, infrastructure repairs, and other site activities. During the SLR term, such disturbances and activities would continue at current rates and would be limited to the industrial-use portions of the site.

Conclusion for the Northern Long-eared Bat

All potential effects on the northern long-eared bat resulting from the proposed action would be insignificant or discountable. Therefore, the NRC staff concludes that the proposed action *may affect but is not likely to adversely affect* the northern long-eared bat.

In a letter dated October 26, 2020, FWS concurred with this determination based on the premise that activities associated with the proposed license renewal with the potential to affect the northern long-eared bat are consistent with the activities analyzed in the FWS January 5, 2016, programmatic biological opinion (FWS 2016, FWS 2020b). The FWS's October 26, 2020, letter documents that the NRC staff has fulfilled its ESA Section 7(a)(2) obligations with respect to the proposed North Anna subsequent license renewal. The NRC staff notes that ESA regulations at 50 CFR 402.16 prescribe certain circumstances that require Federal agencies to reinitiate consultation. As of the date of issuance of this draft SEIS, the NRC staff has identified no information that would warrant reinitiation of consultation.

3.8.2.2 Endangered Species Act: Federally Listed Species and Critical Habitats under National Marine Fisheries Service Jurisdiction

No federally listed species or critical habitats under NMFS jurisdiction occur within the action area (see Section 3.8.1.3). Therefore, the NRC staff concludes that the proposed action would have no effect on federally listed species or habitats under this agency's jurisdiction.

3.8.2.3 Endangered Species Act: Cumulative Effects

The Endangered Species Act regulations at 50 CFR 402.12(f)(4) direct Federal agencies to consider cumulative effects as part of the proposed action effects analysis. Under the Endangered Species Act, cumulative effects are 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 402.02). Cumulative effects under the Endangered Species Act do not include past actions or other Federal actions requiring separate Endangered Species Act Section 7 consultation, which differs from the definition of "cumulative impacts" under NEPA.

When formulating biological opinions under formal Endangered Species Act Section 7 consultation, FWS and NMFS (FWS and NMFS 1998) consider cumulative effects when determining the likelihood of jeopardy or adverse modification. Therefore, cumulative effects need only be considered under the Endangered Species Act if listed species will be adversely affected by the proposed action and formal Section 7 consultation is necessary (FWS 2014b). Because the NRC staff concluded earlier in this section that the proposed license renewal is not likely to adversely affect any federally listed species and would not destroy or adversely modify designated critical habitats, the NRC staff did not separately consider cumulative effects for the listed species and designated critical habitats. Further, the NRC staff did not identify any actions within the action area that meet the definition of cumulative effects under the Endangered Species Act.

3.8.2.4 Magnuson–Stevens Act: Essential Fish Habitat

No EFH occurs within the action area (see Section 3.8.1.4). Therefore, the NRC staff concludes that the proposed action would have no effect on EFH.

3.8.3 No-Action Alternative

Under the no-action alternative, the NRC would not issue a renewed license, and North Anna would shut down on or before the expiration of the current renewed facility operating licenses. Upon shutdown, the plant would require substantially less cooling water and would produce little to no discernable thermal effluent. Thus, the potential for impacts on all aquatic species related to cooling system operation would be significantly reduced. The Endangered Species Act action area under the no-action alternative would most likely be the same or similar to the area described in Section 3.8.1.1. No federally listed species or designated critical habitats currently occur in the action area (see Section 3.8.1), nor does any EFH occur in the region (see Section 3.8.2). Thus, shutdown is unlikely to result in impacts on such species and habitats. However, actual impacts would depend on the specific shutdown activities and whether any listed species, critical habitats, or designated EFH are present when the no-action alternative is implemented.

3.8.4 Replacement Power Alternatives: Common Impacts

The Endangered Species Act action area and estuarine waters potentially containing designated EFH for any of the replacement alternatives would depend on factors including site selection, current land uses, planned construction activities, temporary and permanent structure locations and parameters, and the timeline of the alternative. The listed species, critical habitats, and EFH potentially affected by a replacement power alternative would depend on the boundaries of that alternative’s effects and the species and habitats federally protected at the time the alternative is implemented. For instance, if North Anna continues to operate until the end of the current license terms and a replacement power alternative is implemented at that time, FWS and NMFS may have listed new species, delisted currently listed species whose populations have recovered, or revised EFH designations. These listing and designation activities would change the potential for the various alternatives to impact special status species and habitats. Additionally, requirements for consultation under Section 7 of the Endangered Species Act with FWS and NMFS as well as EFH consultation with NMFS would depend on whether Federal permits or authorizations are required to implement each alternative.

Sections 3.6.5 and 3.8.6 describe the types of impacts that terrestrial and aquatic resources would experience under each alternative. Impacts on special status species and habitats would likely be similar in type. However, the magnitude and significance of such impacts could be greater for special status species and habitats because such species and habitats are rare and more sensitive to environmental stressors.

3.8.5 New Nuclear (Small Modular Reactor) Alternative

The impacts of this alternative are largely addressed in the impacts common to all replacement power alternatives described in the previous section. Because the NRC would remain the licensing agency under this alternative, the Endangered Species Act and Magnuson–Stevens Act would require the NRC to consult with FWS and NMFS, as applicable, before issuing a license for construction and operation of the new facility. During these consultations, the agencies would determine whether the new reactors would affect any federally listed species, adversely modify or destroy designated critical habitat, or result in adverse effects on EFH. If the new facility requires a CWA Section 404 permit, USACE may be a cooperating agency for required consultations, or USACE may be required to consult separately. Ultimately, the magnitude and significance of adverse impacts on special status species and habitats would depend on the site location and layout, plant design, plant operations, and the special status species and habitats present in the area when the alternative is implemented.

3.8.6 Combination Alternative (Solar, Offshore Wind, Small Modular Reactor, and Demand-Side Management)

Section 3.8.5 above addresses the impacts of the SMR component of this alternative The NRC does not license solar or wind facilities or play a role in energy-planning decisions; therefore, the NRC would not be responsible for ESA Section 7 or EFH consultation for these components of the alternative. The Federal and private responsibilities for addressing impacts on special status species and habitats under these components of this alternative would be similar to those described in Section 3.8.4. Ultimately, the magnitude and significance of adverse impacts on special status species and habitats resulting from the combination alternative would depend on the site location and layout, plant design, plant operations, and the special status species and habitats present in the area when the alternative is implemented.

3.9 Historic and Cultural Resources

This section describes the cultural background and the historic and cultural resources found at North Anna and in the surrounding area. The description of the resources is followed by the staff's analysis of the potential impacts on historic and cultural resources from the proposed action (SLR) and alternatives to the proposed action.

3.9.1 Cultural Background

Section 2.2.9.1 of NUREG-1437, Supplement 7, and Section 2.9.1 of NUREG-1811, describe the cultural background (history) of the North Anna site and vicinity (NRC 2002b: p. 2-45, 2-46; NRC 2006: p. 2-72, 2-73). A similar description is presented in Section E3.8.2 of Dominion's ER (Dominion 2020b: Section E3.8.2, p. E-3-192 through E-3-194). This information is incorporated here by reference and summarized below. The NRC staff's environmental review identified no other new and significant information during the site audit, the scoping process, or the evaluation of other available information.

The North Anna site and surrounding area exhibit evidence of both prehistoric and historic occupation by Native Americans and Euro-Americans. Archaeological records suggest that this region was potentially occupied by Native American populations during the Paleoindian Period (before 8000 BC), the Archaic Period (about 8000 BC to 1200 BC), and the Woodland Period (about 1200 BC to AD 1600) (Dominion 2020b: Section E3.8.1).

At the time of European contact and subsequent intrusion into the area surrounding North Anna, the lands, including the piedmont and mountains of western Virginia, were occupied by several Siouan-speaking Indian groups. One of the Monacan Indian groups, part of the larger Monacan Confederacy, is commonly associated with the area of present-day Louisa County (NRC 2002b).

European settlement of the area around the North Anna site began shortly after 1700 AD. The earliest nonnative economy of the area was based on growing tobacco in the fertile lands along the North and South Anna River valleys. In the early 1800s, production of tobacco resulted in severe soil exhaustion, and wheat and corn replaced it as staple crops. Although the area remained largely rural and agricultural, mining and quarrying became important to the economy of Louisa County with the discovery of gold in western Spotsylvania County in 1806. Iron, copper, sulfur, gold, and other ores were mined, and whetstone materials were quarried. Although most of the local gold mines closed by 1865 after exhausting the most accessible deposits, the area just upriver from North Anna remained the scene of intensive gold mining from about 1830 to 1900. Agriculture continued to be the main economic focal point through the mid-twentieth century, with timber mills becoming increasingly important (Dominion 2020b: Section E3.8.2; NRC 2002b).

3.9.2 Historic and Cultural Resources at North Anna

Similar to the description of the cultural history, Section 2.2.9.2 of NUREG-1437, Supplement 7, and Section 2.9.1 of NUREG-1811, describe the survey of historic records to identify potential historic and cultural resources that may be present at the North Anna site (NRC 2002b: p. 2-47; NRC 2006: p. 2-74 and 2-75). Dominion's ER presents a similar description (Dominion 2020b: Sections E3.8 through E3.8.5, p. E-189 through E-3-196). This information is incorporated here by reference and summarized below.

No documented cultural resources surveys were conducted of the North Anna site prior to construction of the plant. Reconnaissance-level historic and archaeological investigations completed in 1969 and 1970 for both the North Anna site area and the lakebed area yielded few results. In addition, 33 historic period cemeteries were identified in the area along the river to be inundated. Many of these were avoided by adjusting project boundaries, although some were "removed" prior to inundation (Dominion 2020b; NRC 2006).

Cultural resource surveys of the North Anna property were conducted in 2001 to support initial license renewal, with additional surveys being conducted in 2003, 2006, and 2007. Five cultural resource sites have been recorded within the North Anna site boundaries:

- The Collins Cemetery Site (054-5024) has been recorded in the eastern portion of the North Anna property. The cemetery includes a dry-laid stone wall and nine marked graves associated with the late 19th century Beech Hill home of John Lewis Collins. The National Register of Historic Places (NRHP) status of the site has not been determined.

- A second cemetery (44LS0221) is located in the western portion of the property and includes 12 possible human interments. The NRHP status was classified as potentially eligible by the Virginia State Historic Preservation Officer (SHPO).

- A third cemetery (44LS0227) is also located in the western portion of the property. The cemetery includes 30 possible human interments, enclosed by a tall chain link fence. The NRHP status was classified as not evaluated by the Virginia SHPO.
- A fourth cemetery (44LS0222) is also located in the western portion of the North Anna property. This cemetery includes seven possible interments and is surrounded by a tall chain link fence. The NRHP status was classified as potentially eligible by the Virginia SHPO.
- A single dwelling (44LS0226) is located in the western portion of the North Anna Units 1 and 2 property and includes the remains of several stone walls and a chimney, as well as an artifact scatter. The NRHP status was classified as not evaluated by the Virginia SHPO.

No other archaeological sites have been recorded, but the entire site has not been subjected to archaeological survey. Constructing North Anna Units 1 and 2 likely disturbed any historic and cultural material that may have been located within the power plant footprint. However, much of the surrounding area remains largely undisturbed (Dominion 2020b).

An archaeological sensitivity analysis of Dominion's North Anna property was completed in 2001. Its purpose was to identify portions of the property with the potential to yield archaeological material. The analysis was based on previous archaeological investigations, a review of archival and secondary historical sources, topography, and a walkover of the property. The property was divided into three zones based on the potential for cultural resources and recommendations for ground disturbance within those areas. The three zones are: no potential (disturbed land), low potential (near disturbed locations with greater than 15 percent slope), and moderate-to-high potential (undisturbed and relatively flat land) (Dominion 2020b).

Other historic properties located near North Anna include prehistoric and historic era archaeological sites, historic districts, and buildings, as well as sites, structures, and objects that may be considered eligible for listing in the National Register of Historic Places (NRHP). Historic and cultural resources also include traditional cultural properties that are important to a living community of people for maintaining their culture. "Historic property" is the legal term for a historic or cultural resource that is included in, or eligible for inclusion in, the NRHP. There are three historic properties within a 6-mi (10-km) radius of the North Anna site that are listed in the NRHP: the Jerdone Castle, the Harris-Poindexter House and Store, and Andrews Tavern (Dominion 2020b).

3.9.3 Procedures and Integrated Cultural Resources Management Plan

Cultural resources on the North Anna site are managed and protected by Dominion's historic resources consultation guidance and cultural resources description process, which is specifically applicable to Dominion's North Anna Power Station and Surry Power Station. The guidance document and the cultural resources description process ensure that cultural resources are protected from unauthorized disturbance and removal. The guidance protects both known and undiscovered cultural resources by establishing a step-by-step process for all activities that require a Federal permit, use Federal funding, or have the potential to impact cultural resources (Dominion 2020b).

3.9.4 Proposed Action

Table 3-2 identifies one site-specific (Category 2) issue related to historic and cultural resources applicable to North Anna during the SLR term. This issue is analyzed below.

3.9.4.1 Category 2 Issue Related to Historic and Cultural Resources: Historic and Cultural Resources

The National Historic Preservation Act of 1966, as amended (54 U.S.C. 300101 et seq.) (NHPA), requires Federal agencies to consider the effects of their undertakings on historic properties. Issuing a renewed operating license to a nuclear power plant is an undertaking that could potentially affect historic properties. Historic properties are defined as resources included in, or eligible for inclusion in, the NRHP. The criteria for eligibility are listed in Title 36, "Parks, Forests, and Public Property" (36 CFR), Section 60.4, "Criteria for Evaluation," and include (a) association with significant events in history, (b) association with the lives of persons significant in the past, (c) embodiment of distinctive characteristics of type, period, or construction, and (d) sites or places that have yielded, or are likely to yield, important information.

The historic preservation review process (NHPA Section 106) is outlined in regulations issued by the Advisory Council on Historic Preservation (ACHP) in 36 CFR Part 800, "Protection of Historic Properties." The NRC complies with the obligations required under NHPA Section 106 through its process under NEPA (42 U.S.C. 4321 et seq.) In accordance with NHPA provisions, the NRC is required to make a reasonable effort to identify historic properties included, or eligible for inclusion, in the NRHP in the area of potential effect (APE). The APE for a license renewal action includes the power plant 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 during the license renewal term. Accordingly, the APE for North Anna license renewal includes the 1,800-ac (730-ha) North Anna site that may be affected by maintenance and operations activities associated with continued reactor operations during the SLR term. The APE may also extend beyond North Anna property (i.e., Dominion's property at North Anna) if maintenance and operations activities affect offsite historic properties. This is irrespective of land ownership or control.

If there are no historic properties within the APE or the undertaking (license renewal) would have no effect on historic properties, the NRC provides documentation of this finding to SHPO. In Virginia, the SHPO is within the Virginia Department of Historic Resources (DHR), which is responsible for administering Federal- and State-mandated historic preservation programs to identify, evaluate, register, and protect Virginia's archaeological and historical resources. The NRC also notifies all consulting parties, including Indian Tribes, and makes this finding public (through the NEPA process) before issuing the renewed operating license. Similarly, if historic properties are present and could be affected by the undertaking, the NRC is required to assess and resolve any adverse effects in consultation with the SHPO and any Indian Tribe that attaches religious and cultural significance to identified historic properties.

3.9.4.2 Consultation

In accordance with 36 CFR 800.8(c), "Coordination with the National Environmental Policy Act," on October 30, 2020, the NRC staff initiated written consultations with the ACHP and the Virginia SHPO (see Appendix C.3).

Also, on October 30, 2020, the NRC staff initiated consultation with the following federally recognized Tribes (see Appendix Section C.3, "National Historic Preservation Act Section 106 Consultation"):

- Absentee-Shawnee Tribe
- Catawba Indian Nation
- Cherokee Nation

- Chickahominy Indian Tribe
- Chickahominy Indians—Eastern Division
- Delaware Nation
- Delaware Tribe of Indians
- Eastern Band of Cherokee Indians
- Eastern Shawnee Tribe of Oklahoma
- Monacan Indian Nation
- Nansemond Indian Nation
- Pamunkey Indian Tribe
- Rappahannock Tribe
- Shawnee Tribe
- Tuscarora Nation of New York
- United Keetoowah Band of Cherokee Indians in Oklahoma
- Upper Mattaponi Indian Tribe

In these letters, the NRC staff provided information about the proposed action, defined the APE, and indicated that the NRC would comply with Section 106 of the NHPA through the NEPA process, in accordance with 36 CFR 800.8(c). The NRC staff invited participation in the identification and possible decisions concerning historic properties and invited participation in the scoping process. Separate from these consultations, the NRC staff also sent letters inviting the following State-recognized Tribes to participate in the scoping process: the Cheroenhaka (Nottoway) Tribe, the Mattaponi Tribe, the Meherrin Nation, the Nottoway Tribe, and the Patawomeck Tribe.

The NRC staff received responses from three federally recognized Tribes with which the staff had initiated consultation. The response from the Pamunkey Indian Tribe expressed several concerns, including "potential environmental impacts from the renewal of the operating license"; NRC's "ability to conduct a National Environmental Policy Act (NEPA) review which will address potential cumulative effects"; and the effectiveness of "conducting an environmental review so early in the life cycle of the current license…". Accordingly, they asked to review associated documents and indicated that they "would like to consult further with [NRC] on this matter to address why the license renewal is being reviewed so early." In response, the NRC staff opened a dialogue with the Pamunkey Indian Tribe and invited them to attend the North Anna SLR environmental site audit discussions regarding historic and cultural resources.

Other responses were received from the Delaware Tribe, which indicated that it "has no historic interest in this region of Virginia and therefore has no objection to the project"; and the Cherokee Nation, which stated that North Anna Units 1 and 2 are located "outside the Cherokee Nation's Area of Interest," and that they defer to "federally recognized Tribes that have an interest in this land base at this time."

3.9.4.3 Findings

As described in Section 3.9.2, there are five identified historic resources on the North Anna property. Dominion has administrative procedures and a site-specific cultural resource management plan in place to manage and protect cultural resources at North Anna. There are no planned physical changes or ground-disturbing activities at North Anna to support license renewal (Dominion 2020b). In 2019, the Virginia DHR responded to a notice of Dominion's intention to pursue renewal of North Anna Units 1 and 2 operating licenses, stating they "concur that the continued operation of the facility would not adversely affect historic properties." In that letter, the Virginia DHR also asked that Dominion consult on all projects involving ground-disturbing activities at North Anna in areas not previously disturbed, and ensure that contact information remains valid in any updates to disturbing activities at North Anna in areas not previously disturbed, and ensure that contact information remains valid in any updates to associated planning documents (Dominion 2020b).

In 2020, the Virginia DHR requested that Dominion also complete an architectural survey of the North Anna facility and assess its eligibility for the NRHP (Dominion 2020b). An architectural survey commissioned by Dominion in 2020 recommended that North Anna buildings are not eligible for listing in the National Register of Historic Places. The Virginia DHR concurred with this assessment and determined that no historic properties will be affected by the continued operation of the facility (VDHR 2021).

Based on the location of historic properties within and near the APE, Tribal input, Dominion's administrative procedures and site-specific cultural resource management plan, and the absence of any planned physical changes or ground-disturbing activities, the NRC staff concludes that the proposed action (subsequent license renewal) would not adversely affect historic properties (36 CFR 800.4(d)(1)).

3.9.5 No-Action Alternative

Known historic properties and cultural resources at North Anna would be unaffected if the NRC does not renew the operating license and Dominion terminates reactor operations. As stated in the decommissioning GEIS (NUREG-0586, Supplement 1), the NRC concluded that impacts on cultural resources would be SMALL at nuclear plants where decommissioning activities would only occur within existing industrial site boundaries. Impacts cannot be predicted generically if decommissioning activities would occur outside of the previously disturbed industrial site boundaries, because impacts depend on site-specific conditions. In these instances, impacts could only be determined through site-specific analysis (NRC 2002a).

In addition, 10 CFR 50.82, "Termination of License," requires power reactor licensees to submit a post-shutdown decommissioning activities report to the NRC. The post-shutdown decommissioning activities report describes planned decommissioning activities at the nuclear plant. Until the post-shutdown decommissioning activities report is submitted, the NRC staff cannot determine whether historic properties would be affected outside the existing industrial site boundary after the nuclear plant ceases operations.

3.9.6 Replacement Power Alternatives: Common Impacts

If construction and operation of replacement power alternatives require a Federal license or permit (i.e., Federal undertaking), a Federal agency would need to make a reasonable effort to identify historic properties within the APE. The agency would then need to consider the effects of the undertaking on historic properties in accordance with NHPA Section 106. Identified historic and cultural resources would need to be recorded and evaluated for eligibility for listing in the NRHP. If it is determined that historic properties are present and could be affected by the undertaking, any adverse effects would need to be assessed and mitigated in consultation with the Virginia SHPO and any affected Indian Tribe through the Section 106 process.

Construction

The potential impact on historic properties and other cultural resources during the construction of replacement power facilities would vary depending on the degree of ground disturbance.

Undisturbed land areas would need to be surveyed to identify and record historic and cultural material. Any historic and cultural resources and archaeological sites found during these surveys would need to be evaluated for eligibility for listing in the NRHP. Areas of greatest cultural sensitivity should be avoided while maximizing the use of previously disturbed areas.

Operation

Historic properties and cultural resources could be affected by ground-disturbing maintenance activities when operating the replacement power plant. As in the case of construction (discussed above), undisturbed land areas would need to be surveyed to identify and record historic and cultural material. Any historic and cultural resources and archaeological sites found during these surveys would need to be evaluated for eligibility for listing in the NRHP. Areas of greatest cultural sensitivity should be avoided while maximizing the use of previously disturbed areas.

3.9.7 New Nuclear (Small Modular Reactor) Alternative

Potential impacts on historic properties and other cultural resources during construction and operation of a new SMR unit would include those common to all replacement power alternatives. The extent of potential impacts on historic properties would depend on the degree to which the land chosen for the new nuclear facility has been previously developed or disturbed. Some structures, such as the power block, may be visible offsite. Avoidance of historic and cultural material may not be possible but could be managed. The impact determination of this alternative would depend on the specific location of the new facility. The Virginia DHR would need to be consulted before commencing any ground-disturbing activities in undisturbed land areas at North Anna.

3.9.8 Combination Alternative (Solar, Offshore Wind, Small Modular Reactor, and Demand-Side Management)

Potential impacts on historic properties and other cultural resources during construction and operation of a combination of solar PV, offshore wind, and new nuclear power generating facilities would include those common to all replacement power alternatives. Some infrastructure upgrades could be required. The extent of impact on historic properties would depend on the area chosen for these new facilities. Taller structures such as wind turbines would be visible for extended distances.

Avoidance of historic and cultural material may not be possible but could be managed. Activities associated with demand-side management would not likely have any direct impact on historic properties and other cultural resources. The impact determination of this alternative would depend on the specific location of new facilities. The Virginia DHR would need to be consulted before commencing any ground- or seabed-disturbing activities in undisturbed areas at North Anna and at other onshore and offshore locations within its jurisdiction.

3.10 Socioeconomics

This section describes current socioeconomic factors that have the potential to be affected by changes in power plant operations at North Anna Units 1 and 2. North Anna 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 North Anna power plant operations depends on its ability to respond to changing environmental, social, economic, and demographic conditions.

3.10.1 Power Plant Employment

The socioeconomic region of influence is defined by the areas where North Anna Units 1 and 2 workers and their families reside, spend their income, and use their benefits, thus affecting the economic conditions of the region. Dominion employs a permanent workforce of approximately 900 workers, including approximately 175 supplemental employees (Dominion 2020b). Approximately 80 percent of North Anna Units 1 and 2 workers reside in one independent city and five counties in Virginia (see Table 3-20). The remaining workers are spread among 30 cities and counties in Virginia and other states, with numbers ranging from 1 to 31 workers per city or county. Because most of the North Anna Units 1 and 2 workers are concentrated in Louisa and Orange counties, the greatest socioeconomic effects are likely to be experienced there. The focus of the impact analysis, therefore, is on the socioeconomic impacts of continued North Anna Units 1 and 2 operations on these two counties.

Table 3-20. Residence of Dominion Employee by Virginia County or City

County or City*	Number of Employees	Percentage of Total
Total	903	100.0
Fredericksburg*	65	7.2
Hanover	82	9.1
Henrico	79	8.7
Louisa	325	36.0
Orange	104	11.5
Spotsylvania	69	7.6
Other counties and cities	179	19.8

* Virginia independent cities.

Source: Dominion 2020b

Refueling outages occur on an 18-month staggered cycle for Units 1 and 2 and historically have lasted approximately 32 days per unit. During refueling outages, site employment typically increases by an additional 500 to 1,000 temporary workers (Dominion 2020b). Outage workers come from all regions of the country; however, most are from Virginia.

3.10.2 Regional Economic Characteristics

Goods and services are needed to operate North Anna Units 1 and 2. Although procured from a wider region, some portion of these goods and services are purchased directly from within the socioeconomic region of influence. These transactions sustain existing jobs and maintain income levels in the local economy. This section presents information on employment and income in the North Anna Units 1 and 2 socioeconomic region of influence.

3.10.2.1 Regional Employment and Income

According to the U.S. Census Bureau's (USCB) 2015–2019 American Community Survey 5-Year Estimates, the educational, health, and social services industry represented the largest employment sector in the socioeconomic region of influence, followed by retail (USCB 2021).

Estimated income information for the socioeconomic region of influence (USCB 2015–2019 American Community Survey 5-Year Estimates) is presented in Table 3-21.

Table 3-21. Estimated Income Information for the North Anna Socioeconomic Region of Influence (2015–2019, 5-Year Estimates)

	Louisa County	Orange County	Virginia
Median household income (dollars)[(a)]	60,975	71,548	74,222
Per capita income (dollars)[(a)]	34,041	32,292	39,278
Families living below the poverty level (percent)	7.9	5.1	7.1
People living below the poverty level (percent)	11.8	8.2	10.6

[(a)] In 2019 inflation-adjusted dollars

Source: USCB 2021

3.10.2.2 Unemployment

According to the Census Bureau's 2015–2019 American Community Survey 5-Year Estimates, the unemployment rates in Louisa County and Orange County were 5.4 and 5.7 percent, respectively. Comparatively, the unemployment rate in Virginia during this same time period was 4.6 percent (USCB 2021).

3.10.3 Demographic Characteristics

According to the 2010 Census, an estimated 154,124 people lived within 20 mi (32 km) of North Anna, which equates to a population density of 123 persons per square mile (Dominion 2020b). This translates to a Category 4, "Least sparse" population density using the license renewal GEIS (NRC 1996) measure of sparseness, which is defined as "greater than or equal to 120 persons per square mile within 20 mi [32 km]." An estimated 1,905,160 people live within 50 mi (80 km) of North Anna with a population density of 243 persons per square mile (Dominion 2020b). With one community within a 50-mile radius having a population greater than 100,000 persons, this translates to a Category 4, "Close proximity" population density, using the license renewal GEIS (NRC 1996) measure of proximity (greater than or equal to 190 persons per square mile within 50 mi (80 km)). Therefore, North Anna is in a "high" population area based on the license renewal GEIS sparseness and proximity matrix.

Table 3-22 shows population projections and percent growth from 1980 to 2060 in the two-county North Anna region of influence. Over the last several decades, Louisa and Orange counties have experienced increasing populations. Based on this information, the populations of Louisa County and Orange County are projected to continue to increase at a moderate rate.

Table 3-22. Population and Percent Growth in North Anna Socioeconomic Region of Influence Counties 1980–2010, 2019 (Estimated), and 2020–2060 (Projected)

Year		Louisa County		Orange County	
		Population	Percent Change	Population	Percent Change
Recorded	1980	17,825	–	18,063	–
	1990	20,325	14.0	21,421	18.6
	2000	25,627	26.1	25,881	20.8
	2010	33,153	29.4	33,481	29.4
Estimated	2019	37,591	13.4	37,051	10.7
Projected	2020	36,737	10.8	36,119	7.9
	2030	41,959	14.2	40,969	13.4
	2040	46,534	10.9	45,194	10.3
	2050	51,540	10.8	50,669	21.1
	2060	56,439	9.5	55,519	9.6

Sources: Decennial population data for 1970–2010 and estimated 2019 (USCB 2021); projections for 2020–2040 by University of Virginia, WCCPS (2019); 2050–2060 calculated.

The 2010 Census demographic profile of the two-county region of influence population is presented in Table 3-23. According to the 2010 Census, minorities (race and ethnicity combined) comprised approximately 21 percent of the total two-county population (USCB 2021). The largest minority populations in the region of influence were Black or African American (approximately 16 percent), followed by Hispanic, Latino, or Spanish origin of any race (approximately 3 percent).

Table 3-23. Demographic Profile of the Population in the North Anna Region of Influence in 2010

	Louisa County	Orange County	Region of Influence
Total Population	32,248	32,730	64,978
Race (Percent of Total Population, Not Hispanic or Latino)			
White	77.1	81.4	79.3
Black or African American	18.2	12.7	15.5
American Indian and Alaska Native	0.4	0.0	0.2
Asian	0.6	0.6	0.6
Native Hawaiian and Other Pacific Islander	0.0	0.0	0.0
Some other race	0.1	0.0	0.0
Two or more races	1.3	1.8	1.6
Hispanic, Latino, or Spanish Ethnicity of Any Race			
Hispanic or Latino	716	1,096	1,812
Percent	2.2	3.3	2.8
Total minority	7,381	6,072	13,453
Percent of total population	22.9	18.6	20.7

Source: USCB 2021.

According to the Census Bureau's 2015–2019 American Community Survey 5-Year Estimates (USCB 2021), minority populations in the region of influence increased by nearly 2,400 persons since 2010 and now comprise approximately 22 percent of the population (see Table 3-24). The largest changes occurred in the population of people who identify themselves as being of more than one race, which grew by over 1,200 persons since 2010, an increase of over 100 percent. The next largest change was an increase in the Hispanic, Latino, or Spanish origin of any race population, which grew by more than 1,000 persons, or approximately 42 percent since 2010.

Table 3-24. Demographic Profile of the Population in the North Anna Region of Influence, 2015–2019, 5-Year Estimates

	Louisa County	Orange County	Region of Influence
Total Population	36,040	36,010	72,050
Race (percent of total population, Not Hispanic or Latino)			
White	78.0	78.1	78.1
Black or African American	14.7	12.7	13.7
American Indian and Alaska Native	0.2	0.3	0.3
Asian	0.6	0.9	0.7
Native Hawaiian and Other Pacific Islander	0.0	0.0	0.0
Some other race	0.0	0.3	0.1
Two or more races	3.5	2.8	3.1
Hispanic, Latino, or Spanish Ethnicity of Any Race			
Hispanic or Latino	1,059	1,801	2,860
Percent	2.9	5.0	4.0
Total minority	7,914	7,893	15,807
Percent of total population	22.0	21.9	21.9

Source: USCB 2021.

3.10.3.2 Transient Population

Within 50 mi (80 km) of North Anna, recreational opportunities attract daily and seasonal visitors who create a demand for temporary housing and services. Based on the Census Bureau's 2015–2019 American Community Survey 5-Year Estimates (USCB 2021), approximately 19,000 seasonal housing units are located within 50 mi (80 km) of North Anna. Of those, 2,346 housing units are in the two-county socioeconomic region of influence.

3.10.3.3 Migrant Farm 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 living near North Anna who 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 minority and low-income workers would be underrepresented in the decennial Census population counts.

The U.S. Department of Agriculture's National Agricultural Statistics Survey conducts the Census of Agriculture every 5 years. This results in a comprehensive compilation of agricultural production data for every county in the United States. Beginning with the 2002 Census of Agriculture, farm operators were asked whether they hired migrant workers—defined as a farm worker whose employment required travel—to do work that prevented the workers from returning to their permanent place of residence the same day.

Information about both migrant and temporary farm labor (working less than 150 days) can be found in the 2017 Census of Agriculture. Table 3-25 presents information on migrant and temporary farm labor within 50 mi (80 km) of North Anna.

Table 3-25. Migrant Farm Workers and Temporary Farm Labor in Counties Located Within 50 mi (80 km) of North Anna

County[(a)]	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)]
Total	3,499	2,388	7,464	108
		Maryland		
Charles	67	56	[(c)]	2
		Virginia		
Albemarle	288	157	674	6
Amelia	88	74	185	4
Buckingham	85	62	182	3
Caroline	42	29	130	9
Chesterfield	27	25	111	1
Culpepper	178	134	315	9
Cumberland	51	37	110	1
Essex	29	20	40	-
Fairfax	41	35	426	-
Fauquier	367	252	700	17
Fluvanna	57	54	117	-
Goochland	101	72	147	-
Greene	47	30	60	2
Hanover	161	116	402	5
Henrico	18	13	54	2
King and Queen	35	27	47	-
King George	27	20	63	-
King William	29	16	52	2
Louisa	***102***	***73***	***198***	***6***
Madison	152	99	177	3
New Kent	20	18	40	-

County[a]	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]
Orange	***154***	***98***	***484***	***6***
Page	137	87	211	7
Powhatan	67	54	154	2
Prince William	90	63	175	4
Rappahannock	129	99	242	4
Richmond	31	17	(c)	-
Rockingham	697	421	1,350	8
Spotsylvania	86	69	300	-
Stafford	23	13	26	-
Westmoreland	73	48	292	5

(a) Counties within 50 mi (80 km) of North Anna with at least one block group located within the 50-mi (80-km) radius.

(b) Table 7. Hired Farm Labor—Workers and Payroll: 2017.

(c) Withheld to avoid disclosing data for individual farms.

Note: ROI counties are in bold italics.

Source: 2017 Census of Agriculture—County Data (NASS 2021)

According to the 2017 Census of Agriculture, approximately 7,500 farm workers were hired to work for less than 150 days and were employed on 2,388 farms within 50 mi (80 km) of North Anna. The county with the highest number of temporary farm workers (1,350 workers on 421 farms) was Rockingham County, VA (NASS 2021). Approximately 108 farms, in the 50-mi (80-km) radius of North Anna, reported hiring approximately 740 migrant workers in the 2017 Census of Agriculture. Fauquier County, VA, had the highest number of farms (17) reporting migrant farm labor (NASS 2021).

3.10.4 Housing and Community Services

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

3.10.4.1 Housing

Table 3-26 lists the total number of occupied and vacant housing units, vacancy rates, and median values of housing units in the region of influence. Based on the Census Bureau's 2015–2019 American Community Survey 5-year Estimates (USCB 2021), there were approximately 32,600 housing units in the region of influence, of which over 27,000 were occupied. The median values of owner-occupied housing units in the region of influence range from $233,100 in Louisa County to $244,400 in Orange County. The homeowner vacancy rate also varied slightly between the two counties, from 2 percent in Louisa County to 1.3 percent in Orange County (USCB 2021).

Table 3-26. Housing in the North Anna Region of Influence (2015–2019, 5-Year Estimate)

	Louisa County	Orange County	Region of Influence
Total housing units	**17,438**	**15,142**	**32,580**
Occupied housing units	13,871	13,679	27,550
Total vacant housing units	3,567	1,463	5,030
Percent total vacant	2.0	1.3	15.4
Owner-occupied units	11,103	10,777	21,880
Median value (dollars)	223,100	244,400	233,591
Owner vacancy rate (percent)	2.0	1.3	1.7
Renter-occupied units	2,768	2,902	5,670
Median rent (dollars/month)	937	987	963
Rental vacancy rate (percent)	4.3	1.1	2.7

Source: USCB 2021

3.10.4.2 Education

The Louisa County Public School district comprises six public schools, with a total of 4,900 students in the 2018–2019 school year. These six schools include four elementary schools (grades pre-kindergarten through 5), one middle school (grades 6 through 8), and one high school (grades 9 through 12). The schools are in Mineral and Louisa, VA (NCES 2021).

3.10.4.3 Public Water Supply

Major water sources for Louisa County and the towns of Louisa and Mineral include Lake Anna, groundwater wells, an irrigation lake on Spring Branch, and the Northeast Creek Reservoir. Approximately 25,590 people use private groundwater wells for residential water supply. Overall, Louisa County reported using 28.44 mgd in 2010, with water use demand projected to rise to 45.64 mgd by 2040. Of this total, the community water system used approximately 0.618 mgd, with use projected to rise to 1.918 mgd in 2040. Future water demands in the county may exceed the current supply by the year 2025. Louisa County partnered with Fluvanna County to create the James River Water Authority, which has a Virginia Water Protection Permit for withdrawal from the James River. North Anna is not connected to a municipal system and accesses potable water through a series of groundwater wells (Dominion 2020b).

The Louisa County Water Authority has two public water facilities and two wastewater treatment facilities servicing residents and industry. The county and the town of Louisa share ownership of the regional sewage treatment plant, but each owns and operates its own collection system. The town of Mineral owns and operates its collection system. Additional public sewage treatment facilities in Louisa County include the Zion Crossroads Wastewater Treatment Plant and Laurel Hill Water and Sewer System. Less than 20 percent of the county's present population is serviced by public or private wastewater treatment facilities. Most residents and businesses in Louisa County are served by septic tanks and sanitary drainage fields.

In Orange County (population 33,481 in 2010) and the towns of Gordonsville and Orange, the major water sources include the Rapidan River, purchased water, and groundwater wells. Approximately 17,280 people use private groundwater wells for residential water supply.

Overall, Orange County reported using 1.84 mgd in 2010, with water use demand projected to rise to 4.47 mgd by 2040. Of this total, the community water system used 1.363 mgd in 2010, with use projected to rise to 3.697 mgd in 2040. Possible alternatives to address future water demand, include increasing the existing, permitted surface water withdrawal, developing new raw water storage, and developing new groundwater supplies (Dominion 2020b).

While population and water demand are projected to increase during the subsequent license renewal term, existing water sources are expected to meet the increasing needs of the population. Louisa and Orange counties have enough water service capabilities to meet the needs of the public (Dominion 2020b).

3.10.5 Tax Revenues

Dominion pays annual property taxes to both Louisa County and Spotsylvania County, based on the assessed value of North Anna Units 1 and 2. In 2019, Dominion Virginia, LLC paid approximately $11.5 million in property taxes to Louisa County (Table 3-27). Total property tax revenues for North Anna County were approximately $52.2 million. The assessed valuation of Dominion property in Louisa County was approximately $1.8 billion in 2019. As seen in Table 3-30, in 2019, Dominion's property tax payments to North Anna County represented roughly 19 percent of the county's property tax revenues.

The county's total revenues from the general fund were $92 million for fiscal year 2019. The largest program receiving county funding was education, with 35.1 percent, or $32.2 million, in payments to the school system. This was followed by 15.7 percent, or $14.4 million, for public safety, and 10 percent, or $9.1 million, for health and welfare services. The remainder was expended across a variety of programs, including judicial administration; public works; parks, recreation, and cultural programs.

Dominion also pays annual property taxes to Spotsylvania County on behalf of North Anna and other Dominion property located in the county (assessed value $167 million). Dominion's property tax payments to Spotsylvania County in Table 3-27 are based on the assessed valuation for North Anna alone and do not include the total property tax payment for Dominion property in Spotsylvania County. Dominion's property tax payment to Spotsylvania County in 2019 was $55,129, representing less than 1 percent of the total county property tax revenue.

Dominion's property tax payments remained relatively consistent between 2015 and 2019, with no adjustments to payments caused by reassessments or other actions that could have resulted in notable increases or decreases. Dominion does not anticipate any future changes in tax laws, rates, assessed property value, or any other adjustments that could result in a notable future increase or decrease in property taxes or other payments to Louisa County or Spotsylvania County (Dominion 2020b).

Dominion also provides pass-through funds (e.g., approximately $500,000 to $600,000) to the Commonwealth of Virginia for emergency response support (Dominion 2020b).

Table 3-27. Dominion Energy Virginia Property Tax Payments, 2015–2019

Year	Dominion Energy Virginia Property Tax Payments (in millions of dollars)	Property Tax Revenues (in millions of dollars)	Percent of County Property Tax Revenue
Louisa County			
2015	13.0	52.2	25
2016	12.5	55.0	23
2017	12.6	58.4	22
2018	11.9	60.5	20
2019	11.5	60.9	19
Spotsylvania County			
2015	0.054	156.7	0.03
2016	0.052	161.7	0.03
2017	0.050	167.5	0.03
2018	0.052	172.3	0.03
2019	0.055	178.2	0.03

Source: Dominion 2020b.

3.10.6 Local Transportation

The primary road network surrounding North Anna is shown in Figure 2-1. A major east coast highway, Interstate 95 (I–95), which runs north to Maine, and south to Florida through Richmond, VA, and Interstate 64 (I–64), which runs west to Missouri and east to Chesapeake, VA, traverse approximately 16 and 15 mi (26 and 24 km) east of North Anna. Virginia State Route (SR) 601 and SR 652 run parallel with the Lake Anna shoreline and pass about 2.2 mi (4 km) northeast and 1.5 mi (2 km) south of the plant site, respectively. Virginia SR 208 crosses Lake Anna at a point about 2 mi (3 km) northwest of the site and joins US Highway 522 about 5 mi (8 km) west-northwest of North Anna (Dominion 2020b).

The primary access to North Anna Units 1 and 2 is from Virginia SR 700. Virginia SR 700 (Haley Drive) provides access to the plant site by a two-lane, predominantly southwest-northeast paved road. Virginia SR 652 (Kentucky Springs Road) is also a two-lane paved road and provides commuter traffic access to the North Anna site by SR 700 at an intersection located approximately 1.5 mi (2 km) southwest of the plant site. Neither SR 700 nor SR 652 are primary arterials in the area. Over the years, the traffic volume counts taken on SR 652 and SR 700 have revealed little fluctuation in traffic flow. The most recent average annual daily traffic (AADT) count in September 2013 for SR 700 (Haley Drive) east of SR 652 was 3,600, and the 2017 AADT county for SR 700 (Johnson Road) west of SR 652 was 1,300. The 2017 AADT count on SR 652 (Kentucky Springs Road) south of SR 700 was 3,100; the AADT count was 3,900 north of SR 700 (Dominion 2020b).

Table 3-28 lists the Virginia Department of Transportation AADT volumes for these State roads with plant access. The AADT values represent traffic volumes for a 24-hour period factored by both day of week and month of year.

Table 3-28. Virginia State Routes in the Vicinity of North Anna: 2017 Annual Average Daily Traffic Volume Estimates

Roadway and Location	Annual Average Daily Traffic Volume Estimates
SR 652 Kentucky Springs Road	
South of SR 700, SR 1205 Ordinary Road to SR 700 Johnson Road	3,100
North of SR 700, SR 700 Johnson Road to SR 790 Michell Point Road	3,900
SR 700 Johnson Road	
West of SR 652, SR 618 Fredericks Hall Road to SR 652 Kentucky Springs Road	1,300
East of SR 652, SR 652 Kentucky Springs Road to Dead End (North Anna Power Station entrance)	3,600 [(a)]

[(a)] Count as of September 24, 2013.

Source: Dominion 2020b.

3.10.7 Proposed Action

Socioeconomic effects of ongoing reactor operations at North Anna have become well established as regional socioeconomic conditions have adjusted to the presence of the nuclear power plant. Changes in employment and tax revenue could impact the availability of community services and housing, as well as traffic on roads near the nuclear power plant.

Dominion indicated in its ER that it has no plans to add non-outage workers during the SLR term and that it could manage increased maintenance and inspection activities using the current workforce (Dominion 2020b). Consequently, people living near North Anna Units 1 and 2 would not experience any changes in socioeconomic conditions during the LR term beyond what is currently being experienced. Therefore, the impact of continued reactor operations during the subsequent license renewal term would not exceed the generic socioeconomic impacts predicted in the 2013 GEIS. For these issues, the GEIS predicted socioeconomic impacts would be SMALL for all nuclear plants.

3.10.8 No-Action Alternative

3.10.8.1 Socioeconomics

Under the no-action alternative, the NRC would not renew the operating license, and North Anna Units 1 and 2 would shut down on or before the expiration of the current facility operating license. This would have a noticeable impact on socioeconomic conditions in the counties and communities near North Anna. The loss of jobs, income, and tax revenue would have an immediate socioeconomic impact. As jobs are eliminated, some, but not all, of the over 900 workers could leave. Income from the buying and selling of goods and services needed to maintain the power plant would also be reduced. In addition, loss of tax revenue could affect the availability of public services.

If workers and their families move away, increased vacancies and reduced demand for housing would likely cause property values to fall. The greatest socioeconomic impact would be experienced in the communities located nearest to North Anna, in Louisa and Spotsylvania counties. However, the loss of jobs, income, and tax revenue may not be as noticeable in larger communities, due to the time and steps required to prepare the nuclear plant for decommissioning. Also, while property tax revenue would decline, both Louisa and Spotsylvania counties have other significant sources of revenue, and property tax would still be collected (in a lesser amount) for the North Anna site. Therefore, depending on the jurisdiction, socioeconomic impacts from not renewing the operating license and terminating reactor operations at North Anna Units 1 and 2 could range from SMALL to MODERATE.

3.10.8.2 Transportation

Traffic volume on roads near North Anna Units 1 and 2 may be noticeably reduced after the termination of reactor operations. Any reduction in traffic volume would coincide with workforce reductions at North Anna. The number of truck deliveries and shipments would also be reduced until active decommissioning. Therefore, due to the time and steps required to prepare the nuclear plant for decommissioning, traffic-related transportation impacts would be SMALL.

3.10.9 Replacement Power Alternatives: Common Impacts

Workforce requirements for replacement power alternatives were evaluated to measure their possible effects on current socioeconomic and transportation conditions. Table 3-29 summarizes socioeconomic and transportation impacts of replacement power alternatives. The following discusses the common socioeconomic and transportation impacts during construction and operation of replacement power generating facilities.

3.10.9.1 Socioeconomics

Socioeconomic impacts are defined in terms of changes in the social and economic conditions of a region. For example, the creation of jobs and the purchase of goods and services during the construction and operation of a replacement power plant could affect regional employment, income, and tax revenue. For each alternative, two types of jobs would be created: (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.

The selection of a replacement power alternative could create opportunities for employment and income and generate tax revenue in the local economy; at the same time, employment, income, and tax revenue could be greatly reduced or eliminated in communities near the nuclear power plant if the replacement units are sited in other counties. These impacts would be similar to those described in the “No-Action Alternative” (Section 3.10.8).

<u>Construction</u>

The relative economic effect of an influx of workers on the local economy and tax base would vary, with the greatest impacts occurring in the communities where most construction workers would reside and spend their income. As a result, some local communities could experience an economic boom during construction from increased tax revenue and income generated by expenditures for goods and services and increased demand for temporary (rental) housing. After construction, local communities would likely experience a return to preconstruction economic conditions.

<u>Operation</u>

Before the commencement of startup and operations, local communities would see an influx of operations workers and their families and increased demand for permanent housing and public services. These communities would also experience the economic benefits from increased income and tax revenue generated by the purchase of goods and services needed to operate a new replacement power plant. Consequently, power plant operations would have a greater potential than power plant construction for effecting permanent, long-term socioeconomic impacts on the region.

3.10.9.2 Transportation

Transportation impacts are defined in terms of changes in level of service conditions on local roads. Additional vehicles during construction and operations could lead to traffic congestion and level of service impacts on local roadways and delays at intersections.

Construction

Transportation impacts would consist of commuting workers and truck deliveries of equipment and material to the construction site. Traffic volumes would increase substantially during shift changes. Trucks would deliver equipment and material to the construction site and remove waste material, thereby increasing the amount of traffic on local roads. The increase in traffic volumes could result in level of service impacts and delays at intersections during certain hours of the day. In some instances, construction material could also be delivered and removed by rail or barge.

Operation

Traffic volumes would be greatly reduced after construction because of the smaller size of the operations workforce. Transportation impacts would consist of commuting operations workers and truck deliveries of equipment and material and removal of waste material.

Table 3-29. Socioeconomic and Transportation Impacts of Replacement Power Alternatives

Alternative	Resource Requirements	Impacts	Discussion
New Nuclear (small modular reactors)	Construction: peak 2,600 workers for several months	MODERATE to LARGE	If all five small modular reactors are constructed/installed at the same time. Some nuclear workers could transfer from North Anna.
	Operations: 1,200 workers	MODERATE to LARGE	
Combination, Solar, Offshore Wind, Small Modular Reactor, and Demand-Side Management	Construction: peak 2,200 (Solar), 300 (Wind), and 600 (Nuclear) workers for several months	MODERATE to LARGE	The demand-side management component could generate additional employment, depending on the nature of the conservation and energy efficiency programs and the need for direct measure installations in homes and office buildings. Jobs would likely be few and scattered throughout the region and would not have a noticeable effect on the local economy. The demand-side management component would not cause an increase in traffic volumes on local roads and would therefore have no transportation impacts.
	Operations: 100 (Solar), 140 (Wind), and 250 (Nuclear) workers	MODERATE	

Source: AWEA 2020, BLM 2019, DOE 2011b; NRC 2018a.

3.11 Human Health

North Anna is both an industrial facility and a nuclear power plant. Similar to any industrial facility or nuclear power plant, the operation of North Anna over the subsequent license renewal period will produce various human health risks for workers and members of the public. This section describes the human health risks resulting from the operation of North Anna, including from radiological exposure, chemical hazards, microbiological hazards, electromagnetic fields, and other hazards. The description of these risks is followed by the staff's analysis of the potential impacts on human health from the proposed action (SLR) and alternatives to the proposed action.

3.11.1 Radiological Exposure and Risk

Operation of a nuclear power plant involves the use of nuclear fuel to generate electricity. Through the fission process, the nuclear reactor splits uranium atoms, resulting generally in (1) the production of heat which is then used to produce steam to drive the plant's turbines and generate electricity and (2) the creation of radioactive byproducts. As required by NRC regulations at 10 CFR 20.1101, "Radiation Protection Programs," Dominion designed a radiation protection program to protect onsite personnel (including employees and contractor employees), visitors, and offsite members of the public from radiation and radioactive material at North Anna. The North Anna radiation protection program is extensive and includes, but is not limited to, the following:

- Organization and Administration (e.g., a radiation protection manager who is responsible for the program and who ensures there are trained and qualified workers for the program)
- Implementing Procedures
- ALARA Program to minimize dose to workers and members of the public
- Dosimetry Program (i.e., measure radiation dose of plant workers)
- Radiological Controls (e.g., protective clothing, shielding, filters, respiratory equipment, and individual work permits with specific radiological requirements)
- Radiation Area Entry and Exit Controls (e.g., 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)
- Recordkeeping and Reporting (e.g., documentation of worker dose and radiation survey data)
- Radiation Safety Training (e.g., classroom training and use of mockups to simulate complex work assignments)
- Radioactive Effluent Monitoring Management (i.e., controlling and monitoring radioactive liquid and gaseous effluents released into the environment)
- Radioactive Environmental Monitoring (e.g., sampling and analysis of environmental media, such as direct radiation, air, water, groundwater, milk, food products (corn, soybeans, and peanuts), fish, oysters, clams, crabs, silt,

and shoreline sediment to measure the levels of radioactive material in the environment that may impact human health)

- Radiological Waste Management (i.e., controlling, monitoring, processing, and disposing of radioactive solid waste)

For radiation exposure to North Anna personnel, the NRC staff reviewed the data contained in NUREG-0713, Volume 40, *Occupational Radiation Exposure at Commercial Nuclear Power Reactors and other Facilities 2018: Fifty-First Annual Report* (NRC 2020c). The 51st annual report was the most recent annual report available at the time of this environmental review. It summarizes the occupational exposure data in the NRC's Radiation Exposure Information and Reporting System database through 2018. These data are reported by nuclear power plant operators, as required by 10 CFR 20.2206, "Reports of Individual Monitoring," which requires them to report their occupational exposure data to the NRC annually.

NUREG-0713 calculates a 3-year average collective dose per reactor for workers at 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 applicant'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 1-year period. There are no NRC or EPA standards for collective dose. Based on the data for operating pressurized-water reactors like the reactors at North Anna, the average annual collective dose per reactor year was 37 person-rem. In comparison, North Anna had a reported annual collective dose per reactor year of 48 person-rem.

In addition, as reported in NUREG-0713, for 2018, no worker at North Anna received an annual dose greater than 0.75 rem (0.0075 sievert (Sv)), which is much less than the NRC occupational dose limit of 5.0 rem (0.05 Sv) in 10 CFR 20.1201, "Occupational Dose Limits for Adults."

Section 2.1.4, "Radioactive Waste Management Systems," of this SEIS discusses offsite dose to members of the public.

3.11.2 Chemical Hazards

State and Federal environmental agencies regulate the use, storage, and discharge of chemicals, biocides, and sanitary wastes. Such environmental agencies also regulate how facilities like North Anna manage minor chemical spills. Chemical and hazardous wastes can potentially impact workers, members of the public, and the environment.

Dominion currently controls the use, storage, and discharge of chemicals and sanitary wastes at North Anna Units 1 and 2 in accordance with its chemical control procedures, waste management procedures, and North Anna site-specific chemical spill prevention plans. Dominion monitors and controls discharges of chemical and sanitary wastes through North Anna's VPDES permit process, discussed in Section 3.5.1.3, "Surface Water Quality and Effluents," of this report. These plant procedures, plans, and processes are designed to prevent and minimize the potential for a chemical or hazardous waste release and, in the event of such a release, minimize impact on workers, members of the public, and the environment (Dominion 2020b).

3.11.3 Microbiological Hazards

Thermal effluents associated with nuclear plants that discharge to a cooling pond or lake, such as North Anna, have the potential to promote the growth of certain thermophilic microorganisms linked to adverse human health effects. Microorganisms of particular concern include several types of bacteria (*Legionella* species, *Salmonella* species, *Shigella* species, and *Pseudomonas aeruginosa*) and the free-living amoeba *Naegleria fowleri*.

The public can be exposed to the thermophilic microorganisms *Salmonella*, *Shigella*, *P. aeruginosa*, and *N. fowleri* during swimming, boating, or other recreational uses of freshwater. If these organisms are naturally occurring and a nuclear plant's thermal effluent enhances their growth, the public could experience an elevated risk of infection when recreating in the affected waters.

Nuclear plant workers can be exposed to *Legionella* when performing cooling system maintenance through inhalation of cooling tower vapors because these vapors are often within the optimum temperature range for *Legionella* growth. Plant personnel most likely to come in contact with aerosolized *Legionella* are workers who clean and maintain cooling towers and condenser tubes. Public exposure to *Legionella* from nuclear plant operation is generally not a concern because exposure risk is confined to cooling towers and related components and equipment, which are typically within the protected area of the site and, therefore, are not accessible to the public.

Thermophilic Microorganisms of Concern

Salmonella typhimurium and *S. enteritidis* are two species of enteric bacteria that cause salmonellosis, a disease more common in summer than winter. Salmonellosis is transmitted through contact with contaminated human or animal feces and may be spread through water transmission, contact with infected animals or food, or contamination in laboratory settings (CDC 2015). These 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* species outside of a host found that the bacteria can survive for several months in water and in aquatic sediments (Moore et al. 2003). The Centers for Disease Control and Prevention (CDC) reports no outbreaks or cases of waterborne *Salmonella* infection from recreational waters in the United States within the past 10 years (2010–2019) (CDC 2019a). All reported *Salmonella* outbreaks during this period were associated with contaminated foods, contact with contaminated domestic animals, or laboratory exposure (CDC 2019a).

Shigella species causes the infection shigellosis, which can be contracted through contact with contaminated food, water, or feces. When ingested, the bacteria release toxins that irritate the intestines. Like salmonellosis, shigellosis infections are more common in summer than in winter because the bacteria optimally grow at temperatures between 77 and 99 °F (25 and 37 °C) (PHAC 2011). Shigellosis outbreaks related to recreational uses of water are rare; almost all cases are related to food contamination.

Pseudomonas aeruginosa can be found in soil, hospital respirators, water, and sewage, and on the skin of healthy individuals. It is most commonly linked to infections transmitted in healthcare settings. Infections from exposure to *P. aeruginosa* in water can lead to the development of mild respiratory illnesses in healthy people. These bacteria optimally grow at 98.6 °F (37 °C) and can survive in high-temperature environments up to 107.6 °F (42 °C) (Todar 2004). In the past 5 years of available data (2009–2014), the CDC reported five cases of *P. aeruginosa* infection, all of which occurred in March 2012 and were associated with a private spa (CDC 2018a).

The free-living amoeba *N. fowleri* prefers warm freshwater habitats and is the causative agent of human primary amebic meningoencephalitis (PAM). 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. This free-swimming amoeba species grows best at higher temperatures of up to 115 °F (46 °C) (CDC 2021). It is typically not present in waters below 95 °F (35 °C) (Tyndall et al. 1989). The *N. fowleri*-caused disease PAM is rare in the United States. From 1962 through 2019, the CDC reports an average of 2.5 cases of PAM annually nationwide. Only seven cases have been reported from Virginia over that period (CDC 2018b).

Legionella is a genus of common warm water bacteria that occurs in lakes, ponds, and other surface waters, as well as some groundwater sources and soils. The bacteria thrive in aquatic environments as intracellular parasites of protozoa and are only pathogenic to humans when aerosolized and inhaled into the lungs. Approximately 2 to 5 percent of those exposed in this way develop an acute bacterial infection of the lungs known as Legionnaires' disease (Pearson 2019). Legionella optimally grow in stagnant surface waters containing biofilms or slimes that range in temperature from 95 to 113 °F (35 to 45 °C), although the bacteria can persist in waters from 68 to 122 °F (20 to 50 °C) (Pearson 2019). As such, human infection is often associated with complex water systems within buildings or structures, such as cooling towers (CDC 2016). Potential adverse health effects related to *Legionella* would generally not be of concern at North Anna because the plant does not use cooling towers. The CDC issues biannual surveillance summary reports concerning Legionnaires' disease. According to the most recently available data from these reports, no cases within Virginia were attributable to cooling systems, recreational uses of reservoirs or lakes, or other categories that could be attributable to nuclear plant operation over the period 2014–2017 (CDC 2019b; CDC 2020).

<u>Baseline Conditions in Lake Anna</u>

Lake Anna is typical of many shallow reservoirs in the southern and mid-Atlantic region. It contains an upper eutrophic layer, a lower oligotrophic layer, and a mid-layer that is a blend of the two, and it remains hydrologically connected to the North Anna River via the North Anna Dam. Lake Anna contains appropriate ecological conditions to support thermophilic microorganisms; however, lake temperatures are generally below the optimum growth range for the microorganisms of concern, even within the area affected by the North Anna thermal discharge. In the summer months, surface water temperatures often range from the mid-80s °F to low 90s °F (approximately 29 to 34 °C).

The thermal effluent from North Anna enters the waste heat treatment facility (WHTF) before remixing with the lake. Within the WHTF, water moves through a series of three lagoons before it returns to the North Anna Reservoir at Dike 3. VDEQ regulates discharge at Dike 3 as Outfall 001 in the North Anna VPDES permit. VDEQ limits waste heat rejected to the lake at this location to 13.54×10^9 BTU per hour (VDEQ 2014).

As part of its Lake Anna ecological monitoring, Dominion measures Lake Anna water temperatures in the Lake Anna Reservoir and the WHTF using fixed temperature recorders. Temperatures are reported by monitoring station as monthly maximum, mean, and minimum temperatures and compared with historical data. Within the WHTF, temperatures are recorded at three stations at a depth of 1 m (3.2 ft). Within the past 5 years of available data (2015–2019), the maximum hourly temperature recorded in the WHTF at the end of the discharge canal (Station NADISC1, the closest station to where heated effluent returns to Lake Anna) has ranged from 101.12 to 105.26 °F (38.4 to 40.7 °C) (see Table 3-30) (Dominion 2016a, 2017, 2018c, 2019b, 2020b).

Table 3-30. Maximum Hourly Temperatures Recorded at Waste Heat Treatment Facility Station NADISC1, 2015–2019

Year	Maximum Hourly Temp. in ºF (ºC)
2015	101.1 (38.4)
2016	105.3 (40.7)
2017	103.8 (39.9)
2018	102.6 (39.2)
2019	105.3 (40.7)

Sources: Dominion 2016a, 2017, 2018c, 2019b, 2020b.

From 1975 through 1985, Dominion collected pre- and post-operational temperature data in Lake Anna in connection with a Clean Water Act (CWA) Section 316(a) demonstration. As part of this effort, Dominion monitored water temperatures at seven Lake Anna stations. Researchers recorded temperatures hourly at most locations. The highest hourly average temperatures recorded in June, July, and August over this period were 91.8 °F (33.2 °C) (at an upper lake station in 1984), 92.7 °F (33.7 °C) (at an upper lake station in 1977), and 91.6 °F (33.1 °C) (at a lower lake station in 1980). The highest hourly average water temperature measured in an operational year was 92.3 °F (33.5 °C) in 1983 (Dominion 2020b).

<u>Thermophilic Microorganism Occurrence in Lake Anna</u>

The free-living amoeba *N. fowleri* that causes the infection human primary amebic meningoencephalitis (PAM) occurs within Lake Anna. *N. fowleri* was first identified in the lake in June 1978. In 1982, Dominion personnel worked with the State epidemiologist and relevant Federal and State agencies to determine whether the pathogen represented a public health risk. As a result of this coordination, the agencies determined that the risk to the public was too low to justify any action by Dominion or State agencies (Dominion 2020b).

In 2007, researchers found *N. fowleri* at 9 of 16 test sites during summer lake sampling. However, total amoeba count, inclusive of *N. fowleri* and other amoeba species, was low (less than 12 amebae per 50 mL) (Jamerson et al. 2009; Marciano-Cabral 2007).

In 2012, the Virginia Department of Health (VDH) participated in a multistate environmental study of N. *fowleri* with the CDC. Of the samples collected at Lake Anna, no water samples tested positive for the amoeba (Dominion 2020b). One sediment sample collected at the shore of the WHTF tested positive. Access to this area is restricted to adjacent private property owners (Dominion 2020b).

The CDC, VDH, and Dominion report no occurrences of *N. fowleri* human infection in Lake Anna since the amoeba was identified in 1972. Additionally, the NRC staff identified no records indicating increased concentrations or growth of *N. fowleri* in association with the North Anna thermal effluent.

During the most recent VPDES permit renewal process, VDH recommended that Dominion make WHTF temperature measurements publicly available to allow the public to make temperature-informed decisions about recreational use of Lake Anna, especially during warmer months. In response to the VDH recommendation, Dominion now posts WHTF lagoon temperatures online at: https://www.dominionenergy.com/company/making-energy/nuclear/north-anna-power-station/waste-heat-treatment-facility. Dominion also maintains links to thermophilic microorganism health risk information on that Web page.

The NRC staff identified no records of either increased growth of or human infection caused by any of the other thermophilic microorganisms of concern (i.e., *Salmonella typhimurium, S. enteritidis*, *Shigella* species, *Pseudomonas aeruginosa*, and *Legionella* species).

Virginia Department of Health Consultation

In August 2019, Dominion contacted VDH concerning the potential existence and perceived health risks that may be present in the portion of Lake Anna that receives the cooling water discharge from North Anna. In its response, VDH mentioned no specific concerns relating to the microorganisms in question. In addition to addressing the thermophilic microorganisms of concern, VDH described numerous reports of algal blooms in Lake Anna in 2019. It expressed concern that continued algae blooms could impact water quality at a downstream North Anna River drinking water intake used by Hanover County's Suburban Waterworks (VDH 2020a).

Dominion's subsequent response to VDH explained that the harmful algal blooms referenced by VDH were located in an upper arm of Lake Anna many miles from Outfall 001 and outside the reaches of the North Anna thermal plume. The 2019 algal blooms were not associated with North Anna operations and did not affect the North Anna River (Dominion 2019d). However, due to the VDH concerns and because algal blooms have also occurred in the WHTF, the NRC staff addresses this topic in more detail below.

Harmful Algal Blooms in Lake Anna

Cyanobacteria is a harmful algae that can cause skin rash and gastrointestinal illnesses. Since 2018, seasonal cyanobacteria blooms have been reported from several different areas of Lake Anna. The blooms typically appear between July and September when elevated temperatures, reduced water clarity, and elevated phosphorus and nitrogen concentrations combine to create favorable growth conditions. People can be exposed to the toxins from swimming in or drinking water that is affected by the algal bloom. The cyanobacteria that dominates fresh water algal blooms produces a liver toxin that can cause gastrointestinal illness as well as liver damage (NIEHS 2021).

Beginning in 2018 when the issue first appeared, VDH initiated monitoring of lake conditions and cyanobacteria concentrations. When VDH deems concentrations to be at or above levels harmful to human health, it issues no-swim advisories for the affected areas through a press release on its Web site at: https://www.vdh.virginia.gov/news/.

Following VDH guidelines, Dominion also developed its own cyanobacteria sampling plan in 2018 for the WHTF. On its Web site, Dominion issues no-swim advisories for areas within the WHTF when harmful algal blooms are present (see https://www.dominionenergy.com/projects-and-facilities/nuclear-facilities/north-anna-power-station/waste-heat-treatment-facility). Dominion lifted its last no-swim advisory on July 25, 2019, and has issued no advisories since then (Dominion 2021b).

Table 3-31 lists the areas of Lake Anna for which VDH or Dominion have issued advisories since 2018. Before 2018, no blooms were reported from Lake Anna.

Table 3-31. Harmful Algal Bloom Advisories in Lake Anna, 2018–Present

Year	Affected Branches of Lake Anna
2018	Lower Pamunkey—Upper, Middle, and Lower North Anna—Upper, Middle, and Lower Fisherman's Cove WHTF—Beaver Creek, Elk Creek, Millpond Creek, and Moody Creek[a]
2019	Pamunkey—Upper, Middle, and Lower North Anna—Upper, Middle, and Lower Lake Anna State Park Beach Main Branch WHTF—Beaver Creek[a][b]
2020	Pamunkey—Upper and Middle Terry's Run North Anna—Upper
2021	None to date

[a] Thermally affected by North Anna effluent discharges.

[b] Subsequent to Dominion issuing this swim advisory, VDH revised its guidance for harmful algal bloom advisories. Under the revised criteria, the WHTF samples did not exceed the VDH threshold, and Dominion lifted the swim advisory (Dominion 2021c).

Sources: Dominion 2020b, Dominion 2021c, VDH 2018, VDH 2019, VDH 2020b.

3.11.4 Electromagnetic Fields

Based on its evaluation in the license renewal GEIS (NUREG-1437), the NRC has not found electric shock resulting from direct access to energized conductors or from induced charges in metallic structures to be a problem at most operating plants. Generally, the NRC staff also does not expect electric shock from such sources to be a human health hazard during the subsequent license renewal period. 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. Transmission lines that are within the scope of the NRC's subsequent license renewal environmental review are limited to: (1) those transmission lines that connect the nuclear plant to the substation where electricity is fed into the regional distribution system and (2) those transmission lines that supply power to the nuclear plant from the grid (NRC 2013a).

As discussed in Section 2.1.6.5, "Power Transmission Systems," of this SEIS, the only transmission lines that are in scope for North Anna subsequent license renewal are onsite. Specifically, there are seven in-scope transmission lines of which three have been placed underground. The plant is connected to the switchyard by two overhead 500 kilovolt (kV) transmission lines, three 34.5 kV underground lines, and two 34.5 kV overhead lines (Dominion 2020b). There is no potential shock hazard to offsite members of the public from these onsite transmission lines. As discussed in Section 3.11.5, "Other Hazards," of this SEIS, North Anna maintains an occupational safety program, which includes protection from acute electrical shock and is in accordance with Occupational Safety and Health Administration (OSHA) regulations.

3.11.5 Other Hazards

This section addresses two additional human health hazards: (1) physical occupational hazards and (2) occupational 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. Nuclear power plant workers may perform electrical work, electric power line maintenance, repair work, and maintenance activities and may be exposed to potentially hazardous physical conditions (e.g., falls, excessive heat, cold, noise, electric shock, and pressure).

OSHA is responsible for developing and enforcing workplace safety regulations. Congress created OSHA by enacting the Occupational Safety and Health Act of 1970, as amended (29 U.S.C. 651 et seq.) 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 (NRC 2013c) between the NRC and OSHA. Occupational hazards are reduced when workers adhere to safety standards and use appropriate protective equipment; however, fatalities and injuries from accidents may still occur. Dominion maintains an occupational safety program for its workers in accordance with OSHA regulations (Dominion 2020b). For occupational electric shock hazards, OSHA implemented the regulation in 29 CFR 1926.964, “Overhead Lines and Live-Line Barehand Work,” in April 2014 (79 FR 20315) for work performed on or near overhead lines and equipment and for live-line barehand work. A note to 29 CFR 1926.964(b)(4), “Induced Voltage,” sets specific overhead line safety limits:

> If the employer takes no precautions to protect employees from hazards associated with involuntary reactions from electric shock, a hazard exists if the induced voltage is sufficient to pass a current of 1 milliampere through a 500-ohm resistor. If the employer protects employees from injury due to involuntary reactions from electric shock, a hazard exists if the resultant current would be more than 6 milliamperes.

As stated in Section E3.10.2, “Electric Shock Hazards,” of the ER, Dominion adheres to the National Electric Safety Code (NESC) compliance requirements for occupational shock hazard avoidance through implementation of the Dominion engineering manual and the Dominion Blue Book (Dominion 2020b). Dominion must also adhere to OSHA’s occupational safety regulations. These regulations and guidance documents ensure all necessary mitigation measures are incorporated for maintaining worker and visitor safety through design ground clearances and other shock prevention measures applicable to the in-scope transmission lines. Additionally, in October 2018, Dominion Energy Electric Transmission personnel investigated the potential for electrical shock by induced current in the vicinity of the four overhead transmission lines and found the worst-case situation would be less than the 2012 NESC standard of 5 milliamperes root mean square (Dominion 2021c) and OSHA regulation of 6 milliamperes as incorporated into Dominion safety documents.

3.11.6 Proposed Action

According to the GEIS (NRC 1996 and NRC 2013a), the generic issues related to human health as identified in Table 3-1 of this report would have SMALL impacts resulting from license renewal. As discussed in Section 3.11 above, the NRC staff identified no new and significant information for these issues. Thus, as concluded in the GEIS, the impacts of those generic issues related to human health would be SMALL.

Table 3-2 identifies one uncategorized issue (chronic exposure to electromagnetic fields (EMFs)) and two site-specific (Category 2) issues (electric shock hazards and microbiological hazards to the public) related to human health applicable to North Anna subsequent license renewal. These issues are analyzed below.

3.11.6.1 Microbiological Hazards to the Public

In the GEIS (NRC 2013a), the NRC staff determined that effects of thermophilic microorganisms on the public for plants using cooling ponds, lakes, or canals or cooling towers that discharge to a river is a Category 2 issue that requires site-specific evaluation during each license renewal review.

Based on the information presented in Section 3.11.3, "Microbiological Hazards," the thermophilic organisms most likely to be of potential concern in Lake Anna are *N. fowleri*, a free-living amoeba that causes the infection human primary amebic meningoencephalitis (PAM), and cyanobacteria, which can cause harmful algal blooms that can result in skin rash and gastrointestinal illnesses in exposed individuals. The public could be exposed to these microorganisms during swimming, boating, fishing, and other recreational uses of Lake Anna.

As explained in Section 3.11.3, all other thermophilic microorganisms identified in the GEIS that may be associated with thermal effluents of nuclear plants are not specifically of concern at North Anna or within Lake Anna. These include *Salmonella typhimurium, S. enteritidis*, *Shigella* species, *Pseudomonas aeruginosa*, and *Legionella* species.

<u>*Naegleria fowleri*</u>

With respect to *N. fowleri*, this organism is known to be present in Lake Anna. However, North Anna's thermal effluent discharge is below the organism's optimal growth temperature of 115 °F (46 °C) (see Table 3-30), and public access to the waste heat treatment facility (WHTF), where temperatures are highest, is restricted to adjacent private property owners. Thus, the North Anna thermal discharges are not high enough in temperature to facilitate proliferation of this microorganism or to cause a public health concern. There have been no known occurrences of PAM from Lake Anna over the 42-year period since the organism was discovered, and the proposed action would not result in any operational changes that would affect thermal effluent temperature or otherwise create favorable conditions for *N. fowleri* growth. Additionally, to better inform the public and to mitigate the potential health risk associated with *N. fowleri* and other thermophilic microorganisms, Dominion began posting WHTF lagoon temperatures online at the recommendation of VDH. The ability of the public to make temperature-informed water recreation decisions would mitigate the already small risk of exposure to *N. fowleri*. During the proposed license renewal term, Dominion would continue monitoring and posting WHTF lagoon temperatures, which would ensure that the public health risk from *N. fowleri* exposure remains low.

<u>Harmful Algal Blooms</u>

With respect to cyanobacteria, the appearance of harmful algal blooms in Lake Anna is a relatively new issue that first occurred in the summer of 2018. Blooms have been reported within the WHTF as well as from multiple arms of Lake Anna that are not influenced by North Anna thermal discharges. The widespread occurrence of these blooms indicates that there are contributing factors beyond North Anna operations. North Anna thermal discharges may contribute to favorable bloom conditions within and near the WHTF, but other conditions must also be present for blooms to occur. These include reduced water clarity and increased nutrient concentrations, which are factors that would not be associated with North Anna operations. North Anna operations are unlikely to contribute to blooms that occur beyond the reach of the

North Anna thermal plume, such as the various arms of Lake Anna identified in Table 3-31, many of which are several miles from North Anna.

VDH and Dominion have developed monitoring programs to sample suspected blooms and issue no-swim advisories when necessary. VDH performs monitoring in the North Anna Reservoir, and Dominion performs sampling in the WHTF. Dominion posts advisory information online and also physically posts advisory signs at the access gates to the common areas of nearby residential subdivisions to warn members of the public recreating near affected areas (Dominion 2021c). As indicated in the preceding paragraph, Dominion also posts WHTF lagoon temperatures on its Web site. These measures collectively minimize the risk that members of the public would be exposed to cyanobacteria in concentrations that could pose a health risk. During the proposed license renewal term, Dominion would continue monitoring cyanobacteria, issuing advisories, and coordinating with VDH on harmful algal blooms (Dominion 2021c), all of which would ensure that the public health risk from cyanobacteria exposure remains low.

<u>Conclusion</u>

The thermophilic microorganisms *N. fowleri* and cyanobacteria can pose public health concerns in recreational-use waters such as Lake Anna when these organisms are present in high enough concentrations to cause infection. Based on the NRC staff's preceding analysis, continued thermal effluent discharges from North Anna during the proposed license renewal term would not contribute to the proliferation of *N. fowleri*. No infections are known to have occurred from Lake Anna, and none are expected during the proposed subsequent license renewal term.

Thermal effluent discharges may contribute to the growth of cyanobacteria in the WHTF. Notably, however, temperature is only one of several factors necessary for a harmful algal bloom to occur. Dominion has instituted monitoring and mitigation strategies to limit public exposure to potentially harmful conditions when blooms are present. Dominion also coordinates with VDH concerning this issue, and the NRC staff assumes that VDH would use its authority to implement any further mitigation it deems necessary to protect the public.

The NRC staff concludes that the impacts of thermophilic microorganisms on the public are SMALL for the proposed North Anna subsequent license renewal.

3.11.6.2 Uncategorized Issue Relating to Human Health: Chronic Effects of Electromagnetic Fields

The GEIS (NRC 2013a) and 10 CFR Part 51, Subpart A, Appendix B do not designate the chronic effects of 60-hertz EMFs from power lines as either a Category 1 or Category 2 issue. Until a scientific consensus is reached on the health implications of electromagnetic fields, the NRC will not include them as either a Category 1 or a Category 2 issue.

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 NIEHS (1999) report 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

> noncancer health outcomes provide sufficient evidence of a risk to currently warrant concern.

This statement did not cause the NRC to change its position with respect to the chronic effects of EMFs. The NRC staff considers the GEIS finding of "UNCERTAIN" to still be appropriate and will continue to follow developments on this issue.

3.11.6.3 Category 2 Issue Related to Human Health: Electric Shock Hazards

Based on the GEIS (NRC 2013a), the Commission found that electric shock resulting from direct access to energized conductors or from induced charges in metallic structures has not been identified as 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 North Anna license renewal review.

As discussed in Section 3.11.4, "Electromagnetic Fields," there are no offsite transmission lines that are in scope for this SEIS. Therefore, there are no potential impacts on members of the public. There are four onsite overhead transmission lines with the potential for electric shock to workers through induced currents. To address this occupational hazard, Dominion adheres to NESC code and OSHA compliance requirements for shock hazard avoidance, as supported by a corresponding investigation of the before-mentioned overhead transmission lines. As discussed in Section 3.11.5, North Anna maintains an occupational safety program for its workers in accordance with OSHA regulations, which includes protection from acute electric shock. Therefore, the NRC staff concludes that the potential impacts from acute electric shock during the SLR term would be SMALL.

3.11.6.4 Environmental Consequences of Postulated Accidents

The GEIS (NRC 2013a) evaluates the following two classes of postulated accidents as they relate to license renewal:

- Design-Basis Accidents: Postulated accidents that a nuclear facility must be designed and built to withstand without loss to the systems, structures, and components necessary to ensure public health and safety.
- Severe Accidents: Postulated accidents that are more severe than design-basis accidents because they could result in substantial damage to the reactor core.

As shown in Table 3-1 of this report, the GEIS (NRC 2013a) addresses design-basis accidents as a Category 1 issue and concludes that the environmental impacts of design-basis accidents are of SMALL significance for all nuclear power plants.

As shown in Table 3-2 of this report, the GEIS (NRC 2013a) designates severe accidents as a Category 2 issue requiring site-specific analysis. Based on information in the 2013 GEIS, the NRC staff determined in 10 CFR Part 51, Subpart A, Appendix B, that for all nuclear power plants, the environmental impacts of severe accidents associated with license renewal are SMALL, with a caveat:

> 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. [NRC 2013a]

Dominion's 2001 ER, submitted as part of its initial license renewal application, included an assessment of SAMAs for North Anna (Dominion 2001). The NRC staff at that time reviewed

Dominion's 2001 analysis of SAMAs for North Anna and documented this review in its SEIS for the initial license renewal, which the NRC published in 2002, as Supplement 7 to NUREG-1437 (NRC 2002b). Because the NRC staff has previously considered SAMAs for North Anna, Dominion is not required to perform another SAMA analysis for its subsequent license renewal application (10 CFR 51.53(c)(3)(ii)(L)).

However, the NRC's regulations at 10 CFR Part 51, which implement NEPA Section 102(2), require that (a) all applicants for license renewal submit an ER to the NRC and (b) in the ER, the applicant is to identify any "new and significant information regarding the environmental impacts of license renewal of which the applicant is aware" (10 CFR 51.53(c)(3)(iv)). This includes new and significant information that could affect the environmental impacts related to postulated severe accidents or that could affect the results of a previous SAMA assessment. Accordingly, in its subsequent license renewal application ER, Dominion evaluated areas of new and potentially significant information that could affect the environmental impact of postulated severe accidents during the SLR period. The NRC staff discusses new information pertaining to SAMAs in Appendix F, "Environmental Impacts of Postulated Accidents," in this SEIS.

Based on the NRC staff's review and evaluation of Dominion's analysis of new and potentially significant information regarding SAMAs and the staff's independent analyses as documented in Appendix F to this SEIS, the staff finds that there is no new and significant information for North Anna related to SAMAs.

3.11.7 No-Action Alternative

Under the no-action alternative, the NRC would not issue subsequent renewed licenses, and North Anna would shut down on or before the expiration of the current renewed licenses. Human health risks would be smaller following plant shutdown. The reactor units, which currently operate 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 3.11.6, "Proposed Action," the NRC staff concluded that the impacts of continued plant operation on human health would be SMALL, except for "Chronic effects of electromagnetic fields (EMFs)," for which the impacts are UNCERTAIN. In Section 3.11.6.4, "Environmental Consequences of Postulated Accidents," the NRC staff concluded that the impacts of accidents during operation are SMALL. Therefore, as radioactive emissions to the environment decrease, and as the likelihood and types of accidents decrease following shutdown, the NRC staff concludes that the risk to human health following plant shutdown would be SMALL.

3.11.8 Replacement Power Alternatives: Common Impacts

Impacts on human health from construction of a replacement power station would be similar to impacts associated with the construction of any major industrial facility. Compliance with worker protection rules, the use of personal protective equipment, training, and placement of engineered barriers would limit those impacts on workers to acceptable levels.

The human health impacts from the operation of a power station include public risk from inhalation of gaseous emissions. Regulatory agencies, including EPA and Virginia State agencies, base air emission standards and requirements on human health impacts. These agencies also impose site-specific emission limits to protect human health.

3.11.9 New Nuclear (Small Modular Reactor) Alternative

The construction impacts of the new nuclear alternative would include those identified in Section 3.11.8 above as common to all replacement power alternatives. Because the NRC staff expects that the licensee would limit access to active construction areas to only authorized individuals, the impacts on human health from the construction of five new SMRs would be SMALL.

The human health effects from the operation of the new nuclear alternative would be similar to those of operating the existing North Anna Units 1 and 2. Small modular reactor designs would use the same type of fuel (i.e., form of the fuel, enrichment, burnup, and fuel cladding) as those plants considered in the NRC staff's evaluation in the GEIS (NRC 2013a). As such, their impacts would be similar to North Anna Units 1 and 2. As presented in Section 3.11.6, impacts on human health from the operation of North Anna would be SMALL, except for "chronic effects of electromagnetic fields (EMFs)," for which the impacts are UNCERTAIN. Therefore, the NRC staff concludes that the impacts on human health from the operation of the new nuclear alternative would be SMALL.

3.11.10 Combination Alternative (Solar, Offshore Wind, Small Modular Reactor, and Demand-Side Management)

Impacts on human health from construction of the combination alternative would include those identified in Section 3.11.8 as common to the construction of all replacement power alternatives. Since the NRC staff expects that the builder will limit access to the active construction area to only authorized individuals, the impacts on human health from the construction of the combination SMR and solar alternative would be SMALL.

Solar photovoltaic (PV) panels are encased in heavy-duty glass or plastic. Therefore, there is little risk that the small amounts of hazardous semiconductor material that they contain would be released into the environment. In the event of a fire, hazardous particulate matter could be released to the atmosphere. Given the short duration of fires and the high melting points of the materials found in the solar PV panels, the impacts from inhalation are minimal. Also, the risk of fire at ground-mounted solar installations is minimal due to precautions taken during site preparation, such as the removal of fuels and the lack of burnable materials contained in the solar PV panels. Another potential risk associated with PV systems and fire is the potential for shock or electrocution from contact with a high-voltage conductor. Proper procedures and clear marking of system components should be used to provide emergency responders with appropriate warnings to diminish the risk of shock or electrocution (OIPP 2010).

PV solar panels do not produce EMFs at levels considered harmful to human health, as established by the International Commission on Non-Ionizing Radiation Protection. These small EMFs diminish significantly with distance and are indistinguishable from normal background levels within several yards (OIPP 2010).

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. Adherence to safety standards and the use of appropriate protective equipment through implementation of an OSHA-approved worker safety program would minimize occupational hazards. Potential impacts on workers and the public include ice thrown from rotor blades and broken blades thrown as a result of mechanical failure. Adherence to proper worker safety procedures and limiting public access to wind turbine sites would minimize the impacts from ice thrown and broken rotor blades. Potential impacts also include EMF exposure, aviation safety hazards, and exposure to noise and vibration from the rotating blades. Impacts from EMF exposure would be minimized by adherence to proper worker safety procedures and limiting public access to any components that could create an EMF. Aviation safety hazards would be minimized by proper siting of the wind turbine facilities and maintaining all proper safety warning devices, such as indicator lights, for pilot visibility. Offshore installation of wind facilities would preclude any potential human health effects from noise and vibration. Furthermore, the NRC staff has identified no epidemiologic studies on noise and vibration from wind turbines that would suggest any direct human health impact. Based on this information, the human health impacts from the operation of the wind component for the combination alternative would be SMALL.

Construction impacts for the demand-side management portion of this alternative would be minimal and localized to activities such as weatherization efficiency of an end-user's home or facility (NRC 2013a). Impacts on human health from the construction activities involved in the demand-side management portion of this alternative would be SMALL.

Operational hazard impacts for the demand-side management portion of this alternative would be minimal and localized to activities such as weatherization efficiency of an end-user's home or facility. The GEIS notes that the environmental impacts are likely to center on indoor air quality (NRC 2013a). This is because of increased weatherization of the home in the form of extra insulation and reduced air turnover rates from the reduction in air leaks. However, the actual impact is highly site specific and not yet well established. Impacts on human health from the operational hazard activities involved in the demand-side management portion of this alternative would be SMALL.

Therefore, given the expected compliance with worker and environmental protection rules and the use of personal protective equipment, training, and engineered barriers, the NRC staff concludes that the potential human health impacts for the combination alternative would be SMALL.

3.12 <u>Environmental Justice</u>

3.12.1 Background

Under Executive Order 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. Independent agencies, such as the NRC, are not bound by the terms of EO 12898 but are "requested to comply with the provisions of [the] order." In 2004, the Commission issued the agency's "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 EO 12898, and strives to meet those goals as part of its NEPA review process."

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

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

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.

This 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 continued operation of North Anna Units 1 and 2 associated with the proposed action (license renewal) and alternatives to the proposed action. In assessing the impacts, the following definitions of minority individuals, minority 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, White 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.

<u>Minority Population</u>

According to the Census Bureau’s 2010 Census data, approximately 37 percent of the population residing within a 50-mi (80-km) radius of North Anna identified themselves as minority individuals. The largest minority populations were Black or African American (approximately 23 percent), and Hispanic, Latino, or Spanish origin of any race (approximately 8 percent) (MCDC 2021).

According to the CEQ definition, a minority population exists if the percentage of the minority population of an area (e.g., census block group) exceeds 50 percent or is meaningfully greater than the minority population percentage in the general population. This environmental justice analysis applied the meaningfully greater threshold in identifying higher concentrations of minority populations; meaningfully greater threshold is any percentage greater than the minority population within the 50-mi (80-km) radius. Therefore, for the purposes of identifying higher concentrations of minority populations, census block groups within the 50-mi (80-km) radius of North Anna were identified as minority population block groups if the percentage of the minority population in the block group exceeded 37 percent, the percent of the minority population within the 50-mi (80-km) radius of North Anna.

As shown in Figure 3-6, high-population minority block groups (race and ethnicity) are predominantly clustered north-northeast towards Washington, DC, and Fredericksburg, VA, and south-southeast of North Anna around Richmond, VA. Based on this analysis, North Anna Units 1 and 2 are not located in a minority population block group.

According to 2010 Census data, minority populations in the socioeconomic region of influence (Louisa and Orange counties) comprised 20.7 percent of the total two-county population (Table 3-25). Figure 36 shows predominantly minority population block groups, using 2010 Census data for race and ethnicity, within a 50-mi (80-km) radius of North Anna.

According to the Census Bureau's 2015–2019 American Community Survey 5-Year Estimates (USCB 2021), since 2010, minority populations in the region of influence increased by nearly 2,400 persons and now comprise approximately 22 percent of the population (Table 3-26).

<u>Low-Income Population</u>

The Census Bureau's 2015–2019 American Community Survey data identify approximately 10 percent of individuals and 6 percent of families residing within a 50-mi (80-km) radius of North Anna as living below the Federal poverty threshold in 2019 (MCDC 2021). The 2019 Federal poverty threshold was $26,172 for a family of four (USCB 2021).

Figure 3-7 shows the location of low-income block groups within a 50-mi (80-km) radius of North Anna. Census block groups were considered low-income population block groups if the percentage of individuals living below the Federal poverty threshold within the block group exceeded 10 percent, which is the percent of individuals living below the Federal poverty threshold within the 50-mi (80-km) radius of North Anna.

As shown in Figure 3-7, high-population low-income block groups are predominantly clustered north-northeast towards Washington, DC, and Fredericksburg, VA, and south-southeast of North Anna in Richmond, VA.

According to the Census Bureau's 2015–2019 American Community Survey 5-Year Estimates, 7.1 percent of families and 10.6 percent of people in Virginia were living below the Federal poverty threshold and the median household and per capita incomes for Virginia were $74,222 and $39,278, respectively (USCB 2021). In the socioeconomic region of influence, people living in Louisa County have lower median household and per capita incomes ($60,975 and $34,041, respectively), with similar percentages of families and people (7.9 percent and 11.8 percent, respectively) living below the poverty level. People living in Orange County also have lower median household and per capita incomes ($71,548 and $32,292, respectively), with lower percentages of families and people (5.1 percent and 8.2 percent, respectively) living below the official poverty level (USCB 2021).

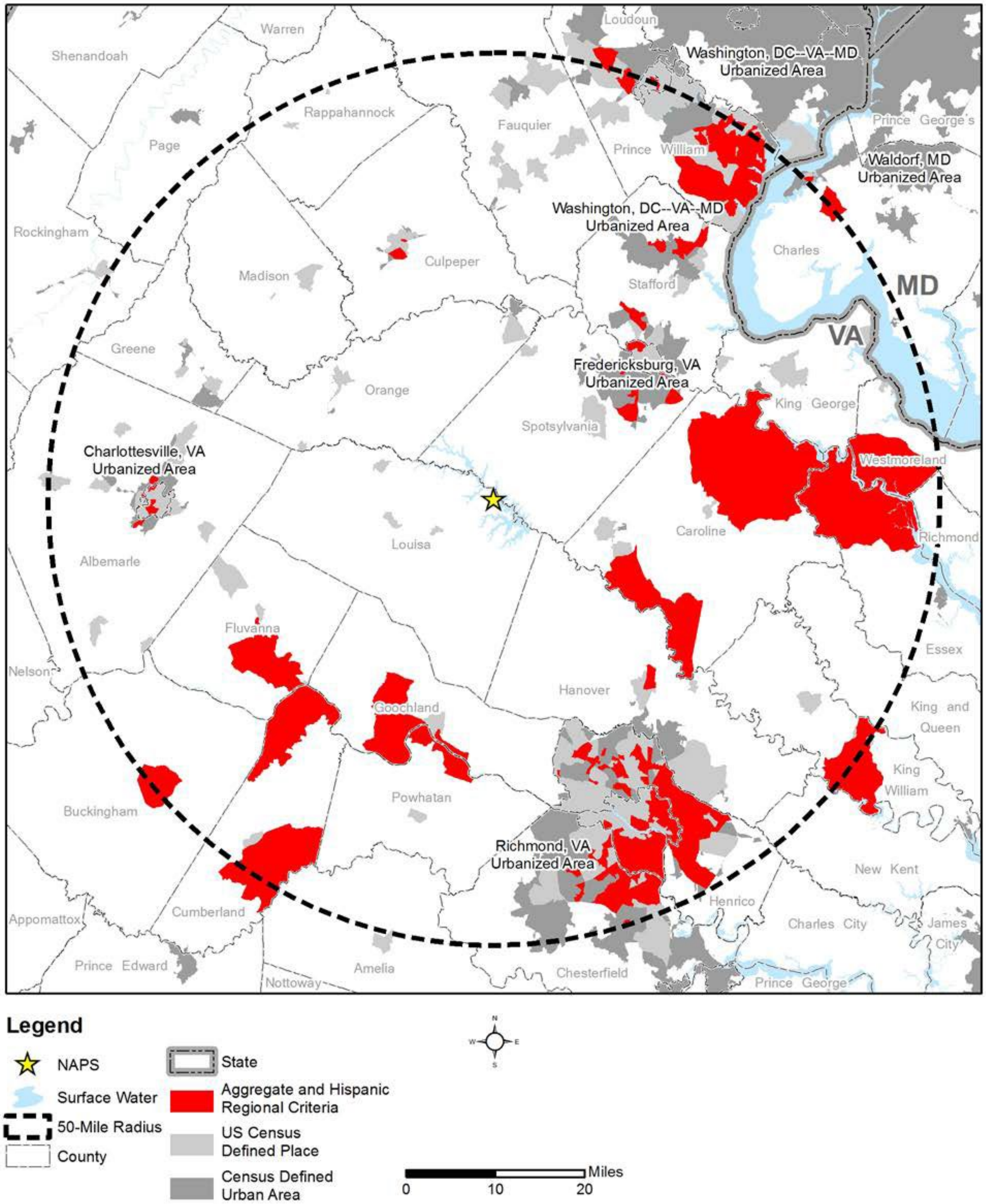


Figure 3-7. 2010 Census—Minority Block Groups Within a 50-mi (80-km) Radius of North Anna

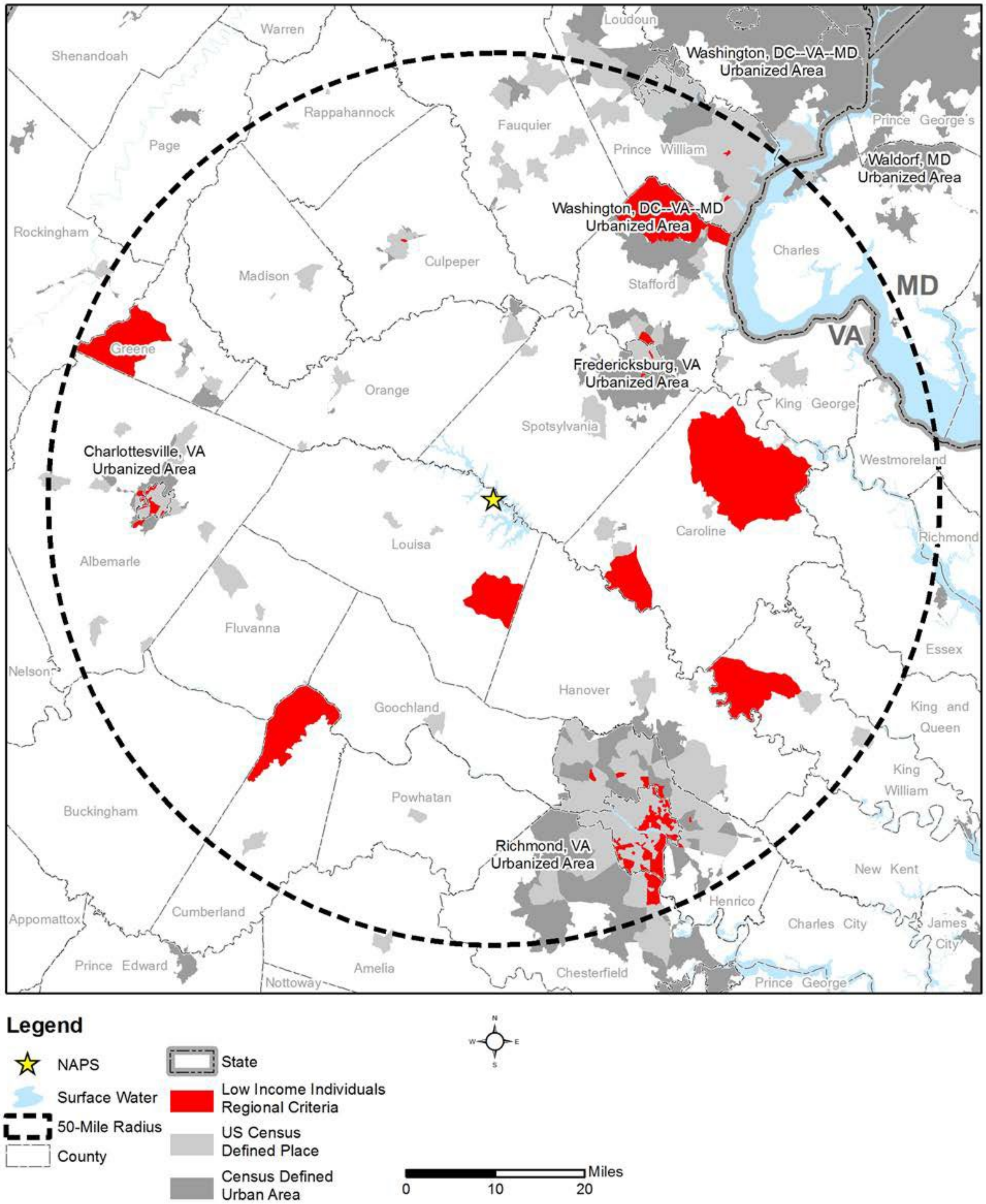


Figure 3-8. 2012–2016, American Community Survey 5-Year Estimates—Low-Income Block Groups Within a 50-mi (80-km) Radius of North Anna

3.12.2 Proposed Action

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 LR term, (2) determining whether there would be any potential human health or environmental effects on these populations and special pathway receptors (groups or individuals with unique consumption practices and interactions with the environment), and (3) determining whether 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 3-6 and 3-7 show the location of predominantly minority and low-income population block groups residing within a 50-mi (80-km) radius of North Anna Units 1 and 2. This area of impact is consistent with the 50-mi (80-km) impact analysis for public and occupational health and safety. This chapter of the SEIS 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 SLR term are expected to continue at current levels, and they would remain within regulatory limits. Section 3.11.6.4 discusses the environmental impacts from postulated accidents that might occur during the LR term, which include both design-basis and severe accidents. In both cases, the Commission has generically determined that impacts associated with design-basis accidents are small because nuclear plants are designed and operated to 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 this chapter, there would be no disproportionately high and adverse human health and environmental effects on minority and low-income populations from the continued operation of North Anna Units 1 and 2 during the renewal term.

<u>Subsistence Consumption of Fish and Wildlife</u>

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 interactions with the environment, including the subsistence consumption of fish and wildlife; consumption of native vegetation; contact with 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. 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. The results of this analysis are presented here.

Section 4–4 of Executive Order 12898, "Federal actions to address environmental justice in minority populations and low-income populations" (1994) (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 wildlife for subsistence and to communicate the risks of these consumption patterns to the public. In this SEIS, the NRC staff considered whether there were any means for minority or low-income populations to be disproportionately affected by examining impacts on American Indians, Hispanics, migrant workers, and other traditional lifestyle special pathway receptors. The assessment of special pathways considered the levels of radiological and nonradiological contaminants in fish, sediments, water, milk, and food products on or near North Anna Units 1 and 2.

Radionuclides released to the atmosphere may deposit on soil and vegetation and may therefore eventually be incorporated into the human food chain. To assess the impact of reactor operations on humans from the ingestion pathway, Dominion collects and analyzes samples of air, water, silt, shoreline sediment, aquatic biota, leafy vegetation, and direct exposure for radioactivity as part of its ongoing comprehensive radiological environmental monitoring program.

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 samples were higher than background levels. Two types of samples are collected. The first type, a control sample, is collected from areas beyond the influence of the nuclear power plant or any other nuclear facility. These control samples are used as reference data to determine normal background levels of radiation in the environment. The second type of samples, indicator samples, are collected near the nuclear power plant from areas where any radioactivity contribution from the nuclear power plant would be at its highest concentration. These indicator samples are then compared to the control samples 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 were larger or higher than the control sample or background levels.

Dominion collects samples from the aquatic and terrestrial environment near North Anna Units 1 and 2. The aquatic environment includes precipitation, surface, river and well water, silt and shoreline sediments, and fish from Lake Anna and Lake Orange (e.g., bass, sunfish, catfish), and shoreline sediment (Lake Anna). Aquatic monitoring results for 2018 showed only naturally occurring radioactivity and radioactivity associated with fallout from past atmospheric nuclear weapons testing and were consistent with levels measured before North Anna Units 1 and 2 began operating. Dominion detected no radioactivity greater than the minimum detectable activity in any aquatic sample during 2018 and identified no adverse long-term trends in aquatic monitoring data (VEPCO 2019b).

The terrestrial environment includes airborne particulates, food products, and broad leaf vegetation. Terrestrial monitoring results for 2018 showed only naturally occurring radioactivity. The radioactivity levels detected were consistent with levels measured prior to the operation of North Anna Units 1 and 2. Dominion detected no radioactivity greater than the minimum detectable activity in any terrestrial samples during 2018. The terrestrial monitoring data also showed no adverse trends in the terrestrial environment (VEPCO 2019b).

Analyses performed on all samples collected from the environment at North Anna in 2018 showed no significant measurable radiological constituent above background levels. Overall, radioactivity levels detected in 2018 were consistent with previous levels as well as radioactivity levels measured prior to the operation of North Anna Units 1 and 2. Radiological environmental monitoring program sampling in 2018 did not identify any radioactivity above background or the minimum detectable activity (VEPCO 2019b).

Based on the radiological environmental monitoring data, the NRC finds that no disproportionately high and adverse human health impacts would be expected in special pathway receptor populations in the region because of subsistence consumption of water, local food, fish, or wildlife. In addition, the continued operation of North Anna Units 1 and 2 would not have disproportionately high and adverse human health and environmental effects on these populations.

3.12.3 No-Action Alternative

Under the no-action alternative, the NRC would not renew the operating licenses, and North Anna Units 1 and 2 would shut down on or before the expiration of the current facility operating license. Impacts on minority and low-income populations would depend on the number of jobs and the amount of tax revenues lost in communities located near the power plant after reactor operations cease. Not renewing the operating licenses and terminating reactor operations could have a noticeable impact on socioeconomic conditions in the communities near North Anna. The loss of jobs and income could have an immediate socioeconomic impact.

Some, but not all, of the over 900 employees could leave the area. In addition, less tax revenue could reduce the availability of public services. This could disproportionately affect minority and low-income populations that may have become dependent on these services. See also Appendix J, “Socioeconomics and Environmental Justice Impacts Related to the Decision to Permanently Cease Operations,” of NUREG-0586, Supplement 1, Volume 1, *Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities: Regarding the Decommissioning of Nuclear Power Reactors* (NRC 2002a), for additional discussion of these impacts.

3.12.4 Replacement Power Alternatives: Common Impacts

<u>Construction</u>

Potential impacts on minority and low-income populations from the construction of a replacement power plant would mostly consist of environmental and socioeconomic effects (e.g., noise, dust, traffic, employment, and housing impacts). The extent of the effects experienced by these populations is difficult to determine because the effects would depend on the location of the power plant units and transportation routes. 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 truck and commuter vehicular traffic during construction, especially during shift changes. However, these effects would be temporary, limited to certain hours of the day, and would not likely be high and adverse. Increased demand for rental housing during construction could disproportionately affect low-income populations reliant on low-cost housing. However, given the proximity of North Anna to the Richmond, VA and Washington, DC, metropolitan areas, construction workers could commute to the site from those or other areas, thereby reducing the potential demand for local rental housing.

<u>Operation</u>

Low-income populations living near the new power plant that rely on subsistence consumption of fish and wildlife could be disproportionately affected. Emissions during power plant operations could also disproportionately affect nearby minority and low-income populations, depending on the type of replacement power. However, permitted air emissions are expected to remain within regulatory standards during operations.

Conclusion

Based on this information and the analysis of human health and environmental impacts presented in this SEIS, it is not likely that the construction and operation of a new replacement power plant and energy savings from demand-side management would have any disproportionately high and adverse human health and environmental effects on minority and low-income populations. However, this determination would depend on the location, plant design, and operational characteristics of new replacement power plants. Therefore, the NRC staff cannot determine whether any of the replacement power alternatives would result in disproportionately high and adverse human health and environmental effects on minority and low-income populations.

3.12.5 New Nuclear (Small Modular Reactor) Alternative

Potential impacts on minority and low-income populations during the construction and operation of new nuclear small modular power plant units would be similar to the construction impacts described above in Section 3.12.4. Potential impacts during operations would mostly consist of radiological effects; however, radiation doses would be well within regulatory limits.

3.12.6 Combination Alternative (Solar, Offshore Wind, Small Modular Reactor, and Demand-Side Management)

Potential impacts on minority and low-income populations from the construction and operation of a new SMR and the installation of solar PV units would be similar to the construction and operation impacts described above in Section 3.12.4. Low-income populations could benefit from weatherization and insulation programs in a demand-side management energy conservation program. This could have a greater effect on low-income populations than the general population, as low-income households generally experience greater home energy burdens than the average household. Conversely, more costly utility bills due to increasing power costs could disproportionately affect low-income populations. However, programs such as the Federal Low Income Home Energy Assistance Program and the Virginia Energy Assistance Program are available to assist low-income families in paying for electricity.

3.13 Waste Management and Pollution Prevention

Like any operating nuclear power plant, North Anna will produce both radioactive and nonradioactive waste during the SLR period. This section describes waste management and pollution prevention at North Anna. The description of these waste management activities is followed by the staff's analysis of the potential impacts of waste management activities from the proposed action (SLR) and alternatives to the proposed action.

3.13.1 Radioactive Waste

As discussed in Section 2.1.4, "Radioactive Waste Management Systems," of this SEIS, North Anna uses liquid, gaseous, and solid waste processing systems to collect and treat, as needed, radioactive materials produced as a byproduct of plant operations. Each of the liquid, solid, and gaseous waste disposal systems is designed to serve both reactor units. Radioactive materials in liquid, gaseous, and solid effluents are reduced prior to 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 prior to 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. Licensees are required to consider pollution prevention measures as dictated by the Pollution Prevention Act (Public Law 101-5084) and the Resource Conservation and Recovery Act of 1976, as amended (Public Law 94-580) (NRC 2013a).

The Resource Conservation and Recovery Act governs the disposal of solid waste. VDEQ, the Virginia Waste Management Board, and EPA regulate solid and hazardous waste in Virginia. As described in Section 2.1.5, “Nonradioactive Waste Management System,” North Anna has a nonradioactive waste management program to handle nonradioactive waste in accordance with Federal, State, and corporate regulations and procedures. North Anna maintains a waste minimization program that uses material control, process control, waste management, recycling, and feedback to reduce waste.

The North Anna stormwater pollution prevention plan (SWPPP) identifies potential sources of pollution that may affect the quality of stormwater discharges from permitted outfalls. The SWPPP also describes BMPs for reducing pollutants in stormwater discharges and assuring compliance with the site’s NPDES permit.

North Anna also has an environmental management system (Dominion 2020b). Procedures are in place to monitor areas within the site that have the potential to discharge oil into or upon navigable waters, in accordance with the regulations in 40 CFR Part 112, “Oil Pollution Prevention.” The Pollution Incident/Hazardous Substance Spill Procedure identifies and describes the procedures, materials, equipment, and facilities that Dominion uses to minimize the frequency and severity of oil spills at North Anna.

North Anna is subject to the EPA reporting requirements in 40 CFR Part 110, “Discharge of Oil,” under Section 311(b)(4) of the Federal Water Pollution Control Act. Under these regulations, North Anna must report to the National Response Center any discharges of oil if the quantity may be harmful to the public health or welfare or to the environment. Based on the staff’s review of Section E9.5.3.6 of the ER (Dominion 2020b) and a review of records from 2013 through 2018, no spills reportable under 40 CFR Part 110 occurred. In addition, the applicant confirmed that no reportable spills have triggered this notification requirement since the ER was written (Dominion 2021a).

North Anna is also subject to the reporting provisions of the State Water Control Law Section 62.1-44.34:19, “Reporting of Discharge” (Article 11, “Discharge of Oil into Waters”). This reporting provision requires that any release of oil in a quantity of 25 gallons (95 liters) or greater to the environment be reported to VDEQ, the coordinator of emergency services of the locality that could reasonably be expected to be affected, and appropriate Federal authorities. Based on the staff’s review of Section E9.5.12.6 of the ER (Dominion 2020b), the only reportable spill occurring between 2013 and 2018 was an underground fuel oil leak from the leaking 2H B fuel oil feed line, which occurred in December 2016, for which the amount of fuel oil that leaked was not quantified. In addition, the applicant confirmed that there have been no reportable spills that would trigger this notification requirement since the ER was written (Dominion 2021a).

3.13.3 Proposed Action

According to the GEIS (NRC 1996, NRC 2013a), the generic issues related to waste management as identified in Table 3-1 would not be affected by continued operations associated with license renewal. As discussed in Chapter 3, the NRC staff identified no new and significant information for these issues. Thus, as concluded in the GEIS, the impacts of those generic issues related to waste management would be SMALL.

As shown in Table 3-2 of this report, the NRC staff did not identify any site-specific (Category 2) waste management issues for an additional 20 years of operations.

3.13.4 No-Action Alternative

Under the no-action alternative, North Anna would cease operation at the end of the term of the current operating licenses or sooner and enter decommissioning. After entering decommissioning, the plant would generate less spent nuclear fuel, emit less gaseous and liquid radioactive effluents into the environment, and generate less low-level radioactive and nonradioactive wastes. In addition, following shutdown, the variety of potential accidents at the plant (radiological and industrial) would be reduced to a limited set associated with shutdown events and fuel handling and storage. Therefore, as radioactive emissions to the environment decrease, and the likelihood and variety of accidents decrease following shutdown and decommissioning, the NRC staff concludes that impacts resulting from waste management from implementation of the no-action alternative would be SMALL.

3.13.5 Replacement Power Alternatives: Common Impacts

Impacts from waste management common to all analyzed replacement power alternatives would be from construction-related nonradiological debris generated during construction activities. This waste would be recycled or disposed of in approved landfills.

3.13.6 New Nuclear (Small Modular Reactor) Alternative

Impacts from the waste generated during the construction of the new nuclear alternative would include those identified in the previous paragraph, Section 3.13.5, as common to all replacement power alternatives.

During normal plant operations, routine plant maintenance and cleaning activities would generate radioactive low-level waste, spent nuclear fuel, high-level waste, and nonradioactive waste. Sections 2.1.4 and 2.1.5 of this SEIS discuss radioactive and nonradioactive waste management at North Anna. Small modular reactor designs would use the same type of fuel (i.e., form of the fuel, enrichment, burnup, and fuel cladding) as those plants considered in the NRC staff's evaluation in the GEIS (NRC 2013a), and as such, all wastes generated would be similar to those generated at North Anna Units 1 and 2. As discussed in the GEIS, the NRC does not expect the generation and management of solid radioactive and nonradioactive waste during the subsequent license renewal term to result in significant environmental impacts. Based on this information, the waste impacts would be SMALL for the new nuclear alternative.

3.13.7 Combination Alternative (Solar, Offshore Wind, Small Modular Reactor, and Demand-Side Management)

Impacts from the waste generated during construction of replacement power alternatives would include those identified in Section 3.13.5 as common to all replacement power alternatives.

The construction of the solar PV facilities would create sanitary and industrial waste, although it would be of smaller quantity, compared to the SMR. This waste could be recycled or shipped to an offsite waste disposal facility. All the waste would be handled in accordance with appropriate VDEQ regulations. Impacts on waste management resulting from the construction and operation of the solar PV facilities of the combination alternative would be minimal, and of a smaller quantity, compared to the SMR. In summary, the waste management impacts resulting from the construction and operation of the PV facilities would be SMALL.

During construction of offshore wind facilities as part of the combination alternative, waste materials or the accidental release of fuels are expected to be negligible because of the very limited amount of vessel traffic and construction activity that might occur with construction, installation, operation, and decommissioning of offshore turbine generators. Therefore, the waste management impacts would be SMALL.

Waste generation associated with construction and operation of the new nuclear component of the combination alternative would be similar to, but less than, those associated with the new nuclear alternative discussed in Section 3.13.6. This is because the SMR portion of this combination alternative would entail construction and operation of a single unit, a 400-MWe plant.

For the demand-side management component, there may be an increase in wastes generated during installation or implementation of energy conservation measures, such as appropriate disposal of old appliances, installation of control devices, and building modifications. New and existing recycling programs would help minimize the amount of generated waste. Impacts from the demand-side management portion of this alternative would be SMALL.

Overall, the NRC staff concludes that waste impacts for the combination alternative would be SMALL.

3.14 Evaluation of New and Significant Information

As stated in Section 3.1 of this SEIS, for Category 1 (generic) issues, the NRC staff can rely on the analysis in the GEIS (NRC 2013a) unless otherwise noted. Table 3-1 lists the Category 1 issues that apply to North Anna during the proposed SLR period. For these issues, the NRC staff did not identify any new and significant information based on its review of the applicant's ER, the environmental site audits, the review of available information as cited in this SEIS, or arising through the environmental scoping process, that would change the conclusions presented in the GEIS.

New and significant information must be new, based on a review of the GEIS (NRC 2013a), as codified in Table B-1 of Appendix B to Subpart A of 10 CFR Part 51. Such information must also 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).

The NRC defines new and significant information in Regulatory Guide 4.2, Supplement 1, "Preparation of Environmental Reports for Nuclear Power Plant License Renewal Applications" (NRC 2013d), as (1) information that identifies a significant environmental impact issue that was not considered or addressed in the GEIS and, consequently, not codified in Table B-1, in Appendix B to Subpart A of 10 CFR Part 51, or (2) information not considered in the assessment of impacts evaluated in the GEIS leading to a seriously different picture of the environmental consequences of the action than previously considered, such as an environmental impact finding different from that codified in Table B-1. Further, a significant environmental issue includes, but is not limited to, any new activity or aspect associated with the nuclear power plant that can act upon the environment in a manner or with an intensity or scope (context) not previously recognized.

In accordance with 10 CFR 51.53(c), "Operating License Renewal Stage," the applicant's ER must analyze the Category 2 (site-specific) issues in Table B-1 of 10 CFR Part 51, Subpart A,

Appendix B. Additionally, the applicant's ER 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 applicant's ER does not need to analyze any Category 1 issue unless there is new and significant information on a specific issue.

NUREG-1555, Supplement 1, Revision 1, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants for Operating License Renewal*, describes the NRC process for identifying new and significant information (NRC 2013e). The search for new information includes:

- review of an applicant's ER (Dominion 2020b) 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
- review of technical literature as documented through this SEIS

New information that the staff discovers is evaluated for significance using the criteria set forth in the GEIS. For Category 1 issues for 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 conducted its own independent review, including a public involvement process (e.g., public meetings and comments) to identify new and significant issues for the North Anna SLR environmental review. The assessment of new and significant information for each resource is addressed within each resource area discussion.

3.15 Impacts Common to All Alternatives

This section describes the impacts that the NRC staff considers common to all alternatives discussed in this SEIS, including the proposed action and replacement power alternatives. In addition, the following sections discuss termination of operations, the decommissioning of a nuclear power plant and potential replacement power facilities, and greenhouse gas emissions.

3.15.1 Fuel Cycle

This section describes the environmental impacts associated with the fuel cycles of both the proposed action and all replacement power alternatives that are analyzed in detail in this SEIS.

3.15.1.1 Uranium Fuel Cycle

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. Section 4.12.1.1 of the 2013 GEIS describes in detail the generic potential impacts of the radiological and nonradiological environmental impacts of the uranium fuel cycle and transportation of nuclear fuel and wastes (NRC 2013a). The staff incorporates the information in NUREG-1437, Revision 1, Section 4.12.1.1 (NRC 2013a: 4-183–4-197), here by reference. The GEIS does not identify any site-specific (Category 2) uranium fuel cycle issues.

As stated in the GEIS (NRC 1996, 2013a), the generic issues related to the uranium fuel cycle as identified in Table 3-1 would not be affected by continued operations associated with license renewal. The NRC staff identified no new and significant information for these issues for North Anna SLR. Thus, as concluded in the GEIS, the impacts of generic issues related to the uranium fuel cycle would be SMALL.

3.15.1.2 Replacement Power Plant Fuel Cycles

<u>New Nuclear Energy Alternatives</u>

Uranium 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 referenced above in Section 3.15.1.1.

<u>Renewable Energy Alternatives</u>

For renewable energy technologies that rely on the extraction of a fuel source (e.g., biomass), such alternatives may have fuel cycle impacts with some similarities to those associated with the uranium fuel cycle. However, as stated in Section 4.12.1.2 of the GEIS (NRC 2013a) (subsection, “Renewable Energy Alternatives”), the fuel cycle for renewable technologies such as wind, solar, geothermal, and ocean wave and current is difficult to define. This is because the associated natural resources would exist (i.e., the resource is not consumed or irreversibly committed) regardless of any effort to harvest them for electricity production. Impacts from the presence or absence of these renewable energy technologies are often difficult to determine (NRC 2013a).

3.15.2 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 at North Anna, subsequent license renewal would delay this eventuality for an additional 20 years beyond the current license periods, until 2058 (Unit 1) and 2060 (Unit 2).

3.15.2.1 Existing Nuclear Power Plant

Decommissioning would occur whether North Anna is shut down at the end of the current renewed licenses or at the end of the SLR term. NUREG-0586 evaluates the environmental impacts from the activities associated with the decommissioning of any reactor before or at the end of an initial or renewed license (NRC 2002a). Additionally, Section 4.12.2.1 of the GEIS (NRC 2013a) summarizes the incremental environmental impacts associated with nuclear power plant decommissioning activities. As noted in Table 3-1, there is one Category 1 issue, “Termination of plant operations and decommissioning,” applicable to North Anna decommissioning following the subsequent license renewal term. The license renewal GEIS did not identify any site-specific (Category 2) decommissioning issues.

3.15.2.2 Replacement Power Plants

<u>New Nuclear Alternatives</u>

The environmental impacts from the termination of power plant operations and decommissioning of a power generating facility are dependent on the facility’s decommissioning plan. The decommissioning plan outlines the actions necessary to restore the site to a condition equivalent in character and value to the site on which the facility was first constructed (NRC 2013a). General elements and requirements for a thermoelectric power plant decommissioning plan are discussed in Section 4.12.2.2 of the license renewal GEIS (NRC 2013a) and can include the removal of structures to at least 3 ft (1 m) below grade, the removal of all accumulated waste materials, the removal of intake and discharge structures, and the cleanup and remediation of incidental spills and leaks at the facility. The staff incorporates the information in NUREG-1437, Revision 1, Section 4.12.2.2 (NRC 2013a: 4-224, 4-225), here by reference.

Activities that are unique to the termination of operations and decommissioning of a nuclear power generating facility include 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 the license.

Renewable Energy Alternatives

Termination of power plant operation and decommissioning for renewable energy facilities would generally be similar to the impacts discussed for new nuclear alternatives above. Decommissioning would involve the removal of facility components and operational wastes and residues to restore sites to a condition equivalent in character and value to the site on which the facility was first constructed (NRC 2013a). The range of possible decommissioning impacts, depending on the renewal energy alternative considered, are discussed in Section 4.12.2.2 of the GEIS (see subsection, “Renewable Alternatives”) (NRC 2013a).

3.15.3 Greenhouse Gas Emissions and Climate Change

The following sections discuss greenhouse gas (GHG) emissions and climate change impacts. Section 3.15.3.1 evaluates GHG emissions associated with the operation of North Anna and replacement power alternatives. Section 3.15.3.2 discusses the observed changes in climate and potential future climate change during the subsequent license renewal term, based on climate model simulations under future global GHG emissions scenarios. In Section 3.16, “Cumulative Impacts,” of this SEIS, the NRC staff considers the potential cumulative, or overlapping, impacts from climate change on environmental resources where there are incremental impacts of the proposed action (subsequent license renewal).

3.15.3.1 Greenhouse Gas Emissions from the Proposed Project and Alternatives

Gases found in the Earth’s atmosphere that trap heat and play a role in the Earth’s climate are collectively termed greenhouse gases (GHGs). GHGs include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), water vapor (H_2O), and fluorinated gases, such as hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). The Earth’s climate responds to changes in concentrations of GHGs in the atmosphere because these gases affect the amount of energy absorbed and heat trapped by the atmosphere. Increasing concentrations of these gases in the atmosphere generally increase the Earth’s surface temperature. Atmospheric concentrations of carbon dioxide, methane, and nitrous oxide have significantly increased since 1750 (IPCC 2007, IPCC 2013). Carbon dioxide, methane, nitrous oxide, and fluorinated gases (termed long-lived GHGs) are well mixed throughout the Earth’s atmosphere, and their impact on climate is long lasting and cumulative in nature as a result of their long atmospheric lifetime (EPA 2016). Therefore, the extent and nature of climate change is not specific to where GHGs are emitted. Carbon dioxide is of primary concern for global climate change because it is the primary gas emitted as a result of human activities. 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 the atmosphere resulting from human activities (IPCC 2013; USGCRP 2014, USGCRP 2017, USGCRP 2018). EPA has determined that GHGs "may reasonably be anticipated both to endanger public health and to endanger public welfare" (74 FR 66496).

Proposed Action

The operation of North Anna results in both direct and indirect GHG emissions. Dominion has calculated direct (i.e., stationary and portable combustion sources) and indirect (i.e., workforce commuting) GHG emissions, which are reported in Table 3-32. Dominion does not maintain an inventory of GHG emissions resulting from visitor and delivery vehicles (Dominion 2020b). Fluorinated gas emissions from refrigerant sources and from electrical transmission and distribution systems can result from leakage, servicing, repair, or disposal of sources. In addition to being GHGs, chlorofluorocarbons and hydrochlorofluorocarbons are ozone-depleting substances that are regulated by the Clean Air Act (42 U.S.C. 7401 et seq.) under Title VI, "Stratospheric Ozone Protection." Dominion maintains a program to manage stationary refrigeration appliances at North Anna to recycle, recapture, and reduce emissions of ozone-depleting substances. Therefore, Table 3-32 below does not account for any potential emissions from stationary refrigeration sources at North Anna (Dominion 2020b). In addition, Dominion uses mineral oil in electrical equipment (e.g., transformers) and does not purchase electrical equipment containing perfluorocarbon liquids (Dominion 2020b).

Table 3-32. Annual Greenhouse Gas Emissions from Operation at North Anna, Units 1 and 2

Year	Onsite Combustion Sources[a] (in tons)	Workforce Commuting[b] (in tons)	Total Carbon Dioxide Equivalents (CO_{2eq}) (in tons)
2013	620	4,490	5,110
2014	430	4,490	4,920
2015	560	4,490	5,050
2016	690	4,490	5,180
2017	480	4,490	4,970

Note: GHG emissions are reported in metric tons and converted to short tons. All reported values are rounded. To convert tons per year, multiply by 0.90718. Expressed in carbon dioxide equivalents (CO2eq), a metric used to compare the emissions of greenhouse gases (GHG) based on their global warming potential (GWP). The GWP is a measure used to compare how much heat a GHG traps in the atmosphere. The GWP is the total energy that a gas absorbs over a period of time compared to carbon dioxide. CO_2eq is obtained by multiplying the amount of the GHG by the associated GWP. For example, the GWP of methane is 21; therefore, 1 ton of methane emission is equivalent to 21 tons of carbon dioxide emissions.

[a] Onsite combustion sources include the North Anna blackout diesel generator and four emergency generators.

[b] Emissions consider North Anna permanent full-time employees and contract workers (866 passenger vehicles per day based on a 4.1 percent carpool rate for 903 employees) and does not include additional contractor workers during refueling outages. Refueling outages occur on a staggered, 18-month schedule and last approximately 30 days per unit.

Source: Dominion 2020b

No-Action Alternative

Under the no-action alternative, the NRC would not issue subsequent renewed licenses, and North Anna would shut down on or before the expiration of the current renewed licenses. At some point, all nuclear plants will terminate operations and undergo decommissioning. The

Decommissioning GEIS (NUREG-0586, NRC 2002a) considers the environmental impacts from decommissioning. Therefore, the scope of impacts considered under the no-action alternative includes the immediate impacts resulting from activities at North Anna that would occur between plant shutdown and the beginning of decommissioning (i.e., activities and actions necessary to cease operation of North Anna). Facility operations would terminate at or before the expiration of the current renewed licenses. When the facility stops operating, a reduction in GHG emissions from activities related to plant operation, such as the use of diesel generators and employee vehicles, would occur. The NRC staff anticipates that GHG emissions for the no-action alternative would be less than those presented in Table 3-32.

Since the no-action alternative would result in a loss of power-generating capacity due to plant shutdown, the sections below discuss GHG emissions associated with replacement baseload power generation for each replacement power alternative analyzed.

<u>New Nuclear Alternative (Small Modular Reactor)</u>

The license renewal GEIS (NUREG-1437) presents life-cycle GHG emissions associated with nuclear power generation. As presented in Tables 4.12-4 through 4.12-6 of the GEIS (NRC 2013a), life cycle GHG emissions from nuclear power generation can range from 1 to 288 grams of carbon equivalent per kilowatt-hour (g Ceq/kWh). Nuclear power plants do not burn fossil fuels to generate electricity. Sources of GHG emissions from the new nuclear alternative would include stationary combustion sources such as emergency diesel generators, boilers, and pumps similar to existing sources at North Anna (see Section 3.3.2, “Air Quality,” of this SEIS). The NRC staff estimates that GHG emissions from a new nuclear alternative would be similar to those from North Anna.

<u>Combination Alternative</u>

For the combination alternative, GHGs would primarily be emitted from the new nuclear alternative component and offshore wind portion of this alternative. GHG sources for the new nuclear portion are discussed above. GHG sources for the offshore wind component would include diesel generators supporting meteorological data collection facilities. GHG emissions for the combination alternative would be similar and comparable to those from North Anna.

<u>Summary of Greenhouse Gas Emissions from the Proposed Action and Alternatives</u>

The proposed action, the no-action alternative, new nuclear alternative, and combination alternative would have similar and comparable GHG emissions. If North Anna’s generating capacity were to be replaced by either the new nuclear alternative or the combination alternative, there would be no significant increase or decrease in GHG emissions.

3.15.3.2 Climate Change

Climate change is the decades or longer change in climate measurements (e.g., temperature and precipitation) that has been observed on a global, national, and regional level (IPCC 2007; EPA 2016; USGCRP 2014). Climate change can vary regionally, spatially, and seasonally, depending on local, regional, and global factors. Just as regional climate differs throughout the world, the impacts of climate change can vary among locations.

<u>Observed Trends in Climate Change Indicators</u>

On a global level, from 1901 to 2016, the average temperature has increased by 1.8 °F (0.9 °C) (USGCRP 2018). The year 2019 was the second warmest year in a 140-year climate record; the top five warmest years (in order) are 2016, 2019, 2015, 2017, and 2018 (NOAA 2020a; NOAA 2020b). Section 4.15.3.2, “Observed Trends in Climate Change Indicators,” of NUREG-1437, Supplement 6, Second Renewal (NRC 2020b), the SEIS for subsequent license renewal of Surry Power Station, Units 1 & 2, describes in detail observed changes in average temperature and precipitation on a global level and across the United States and the Southeast region. Unlike Surry Power Station, North Anna is not located on a tidal river, and Lake Anna Reservoir is not directly affected by sea level changes along the Atlantic coast. See section 3.16.2 below for a discussion of how climate change can impact surface water resources in the vicinity of North Anna. Therefore, with the exception of information related to sea level rise, the NRC staff incorporates the observed trends described in Section 4.15.3.2 of NUREG-1437, Supplement 6, Second Renewal by reference (NRC 2020b: 4.15.3.2, 4-127–4-129), with key information summarized below.

The Southeast is one of the few places in the world where there has not been an overall increase in daily maximum temperatures since 1900 (NOAA 2013a; USGCRP 2018); however, since the early 1960s, the Southeast has been warming at a similar rate as the rest of the United States and has been accompanied by an increase in the number of hot days with maximum temperatures above 95 °F (35 °C) in the daytime and above 75 °F (23.9 °C) in the nighttime (NOAA 2013a; USGCRP 2009, 2014, 2018: Fig. 19.1). Average annual precipitation data for the Southeast region does not exhibit an increasing or decreasing trend overall for the long-term period (1895–2011) (NOAA 2013b). Precipitation in the Southeast region varies considerably throughout the seasons, and average precipitation has generally increased in the fall and decreased in the summer (NOAA 2013b; USGCRP 2009).

The NRC staff used the National Oceanic and Atmospheric Administration (NOAA) Climate at a Glance tool to analyze temperature and precipitation trends for the period of 1895–2020 in the Eastern Piedmont Climate Division. A trend analysis shows that the average annual temperature has increased at a rate of 0.1 °F (0.06 °C) per decade, while average annual precipitation has increased at a rate of 0.24 in. (0.6 cm) per decade (NOAA 2020c).

<u>Climate Change Projections</u>

Future global GHG emission concentrations (emission scenarios) 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 emission concentrations in the atmosphere (USGCRP 2014). This is because it takes time for Earth's climate system to respond to changes in GHG concentrations; if GHG concentrations were to stabilize at current levels, this would still result in at least an additional 1.1 °F (0.6 °C) of warming (USGCRP 2018). Over the longer term, the magnitude of temperature increases and climate change effects will depend on future global GHG emissions (IPCC 2007, IPCC 2013; USGCRP 2009, 2014, 2018). Climate model simulations often use GHG emission scenarios to represent possible future social, economic, technological, and demographic development that, in turn, drive future emissions. Consequently, the GHG emission scenarios, their supporting assumptions, and the projections of possible climate change effects entail substantial uncertainty.

Section 4.15.3.2 of NUREG-1437, Supplement 6, Second Renewal (NRC 2020b), describes in detail annual mean temperature and precipitation projections for Virginia based on climate model simulations and future GHG scenarios. As discussed in NUREG-1437, Supplement 6, Second Renewal (NRC 2020b), the SEIS for subsequent license renewal of Surry Power Station, Units 1 & 2, increases in temperature are projected to occur across the majority of the Southeast region under a low- and high-emissions scenario. With the exception of the information related to sea level rise, the NRC staff incorporates the discussion contained in Section 4.15.3.2, " Climate Change Projections," of NUREG-1437, Supplement 6, Second Renewal, into this SEIS by reference (NRC 2020b: Section 4.15.3.2, 4-129–4-132), with key information summarized in this section. Climate model simulations suggest spatial differences in annual mean precipitation change across the Southeast, with some areas experiencing an increase and others a decrease in precipitation. For the period 2041–2070 (2055 midpoint), a

0 to 3-percent increase in annual mean precipitation is projected for both a low- and high-emission modeled scenario across the northern reaches of the Southeast region, encompassing Virginia. Increases are projected to occur in the winter, spring, and fall, with decreases during the summer (NOAA 2013a).

The effects of climate change on North Anna structures, systems, and components are outside the scope of the NRC staff's subsequent license renewal environmental review. The environmental review documents the potential effects from continued nuclear power plant operation on the environment. Site-specific environmental conditions are considered when siting nuclear power plants. This includes the consideration of meteorological and hydrologic siting criteria as set forth in 10 CFR Part 100, "Reactor Site Criteria." NRC regulations require that plant structures, systems, and components important to safety be designed to withstand the effects of natural phenomena, such as flooding, without loss of capability to perform safety functions. Further, nuclear power plants are required to operate within technical safety specifications in accordance with the plants' NRC operating license, including coping with natural phenomena hazards. The NRC conducts safety reviews before allowing licensees to make operational changes due to changing environmental conditions. Additionally, the NRC evaluates nuclear power plant operating conditions and physical infrastructure to ensure safe operation under the plant's initial and renewed operating licenses through the NRC's Reactor Oversight Program. If new information about changing environmental conditions that threaten safe operating conditions or challenge compliance with the plant's technical specifications becomes available, the NRC will evaluate the new information to determine if any safety-related changes are needed at licensed nuclear power plants. This is a separate and distinct process from the NRC staff's subsequent license renewal environmental review conducted in accordance with NEPA. Nonetheless, as discussed below in Section 3.16, the NRC staff considers the impacts of climate change in combination with the effects of subsequent license renewal in assessing cumulative impacts.

3.16 Cumulative Impacts

Cumulative impacts may result when the environmental effects associated with the proposed action (subsequent license renewal) are added to the environmental effects from other past, present, and reasonably foreseeable future actions. Cumulative impacts can result from individually minor, but collectively significant, actions taking place over a period of time. As explained in the license renewal GEIS (NRC 2013a), the effects of the license renewal action, combined with the effects of other actions, could generate cumulative impacts on a given resource.

For the purposes of this analysis, past actions are those that occurred since the commencement of North Anna reactor operations and before the submittal of the subsequent license renewal application. Older actions are considered as part of the affected environment analyses presented in Sections 3.2 through 3.13 of this SEIS. Present actions are those that are occurring during current power plant operations. Reasonably foreseeable future actions are those that would occur through the end of power plant operation, including the period of extended operation. In response to Dominion's application for a COL for Unit 3, the NRC issued a final SEIS in support of its review in 2010 (NUREG-1917) and issued the COL to Dominion in 2017 (NRC 2010, NRC 2017b). Although Dominion stated in its ER for subsequent license renewal that it has not decided whether to proceed with Unit 3 project activities, it did include Unit 3 as a reasonably foreseeable action in its ER (Dominion 2020b, 2021a). Accordingly, the NRC staff considers Unit 3 to be a reasonably foreseeable future action in this SEIS. Therefore, the associated construction and operation impacts of Unit 3 have been factored into the cumulative impacts analysis below, where appropriate, for informational purposes. In this cumulative impacts analysis, the NRC staff considers potential effects through the end of the current license term, as well as through the end of the 20-year subsequent license renewal term.

The cumulative impacts analysis accounts for both geographic (spatial) and time (temporal) considerations of past, present, and reasonably foreseeable future actions to determine whether other potential actions are likely to contribute to the total environmental impact. In addition, because cumulative impacts accrue to resources and focus on overlapping impacts with the proposed action, no cumulative impacts analysis was performed for resource areas where the proposed action is unlikely to have any incremental impacts on that resource. Consequently, no cumulative impacts analysis was performed for the following resource areas: land use, noise, geology and soils, terrestrial resources, aquatic resources, and historic and cultural resources.

As noted in Section 3.15.3.2, “Climate Change,” of this SEIS, changes in climate could have broad implications for certain resource areas. Accordingly, a climate change impact discussion is provided for those resource areas that could be incrementally affected by the proposed action (subsequent license renewal). It is also important to note that the potential effects of climate change could occur irrespective of the proposed action.

Information from Dominion’s ER (Dominion 2020b); responses to requests for additional information; information from other Federal, State, and local agencies; scoping comments; and information gathered during the environmental site audit at North Anna were used to identify past, present, and reasonably foreseeable future actions in the cumulative impacts analysis. To evaluate cumulative impacts resulting from the continued operation of North Anna Units 1 and 2, the incremental impacts of the proposed action, as described in Sections 3.2 to 3.13 of this chapter, are combined with the impacts of other past, present, and reasonably foreseeable future actions, regardless of which agency (Federal or non-Federal) or person undertakes such actions. In general, the effects of past actions have already been described and accounted for in each resource-specific description of the existing (i.e., affected) environment, which serves as the environmental baseline for the cumulative impacts analysis.

Appendix E, “Projects and Actions Considered in the Cumulative Impacts Analysis,” describes other actions, including new and continuing activities and specific projects that the NRC staff identified during this environmental review and that were considered in the analysis of potential cumulative impacts.

3.16.1 Air Quality

The region of influence the NRC staff considered in the cumulative air quality analysis consists of Louisa and Spotsylvania counties, because air quality designations in Virginia are made at the county level. North Anna is located primarily in Louisa County, with a portion of the site extending into neighboring Spotsylvania County, VA. Dominion has not proposed any refurbishment-related activities during the subsequent license renewal term. As a result, the NRC staff expects that air emissions from the plant during the SLR term would be similar to those presented in Section 3.3, “Meteorology, Air Quality, and Noise.” Appendix E identified present and reasonably foreseeable projects that could contribute to the cumulative impacts on air quality in Louisa and Spotsylvania counties. Current air emission sources operating in Louisa and Spotsylvania counties have not resulted in long-term NAAQS violations, given the designated in attainment status for all criteria pollutants. Consequently, cumulative changes to air quality in Louisa and Spotsylvania counties would be the result of future projects and actions that change present-day emissions within the counties.

Development and construction activities identified in Appendix E could increase air emissions during their respective construction periods, but those air emissions would be temporary and localized. Air emissions associated with the operation of future solar PV facilities would be negligible because no fossil fuels would be directly burned to generate electricity. However, future operation of facilities can result in an increase in vehicular traffic and in overall long-term air emissions that contribute to cumulative air quality impacts. Any entity establishing new stationary sources of emissions in the region of influence would be required to apply for an air permit from VDEQ and would also be required to operate in accordance with applicable Federal, State, and local regulatory requirements.

Climate change can impact air quality as a result of changes in meteorological conditions. The formation, transport, dispersion, and deposition of air pollutants depend, in part, on weather conditions (IPCC 2007). Ozone is particularly sensitive to climate change (IPCC 2007; EPA 2009a). Ozone is formed by the chemical reaction of nitrogen oxides and volatile organic compounds in the presence of heat and sunlight. Sunshine, high temperatures, and air stagnation are favorable meteorological conditions for higher levels of ozone (IPCC 2007; EPA 2009b). The emission of ozone precursors also depends on temperature, wind, and solar radiation (IPCC 2007). According to EPA, both nitrogen oxide and biogenic VOC emissions are expected to be higher in a warmer climate (EPA 2009a). Although surface temperatures are expected to increase in the Southeast region of the United States (where North Anna is located), this may not necessarily result in an increase in ozone. While some climate models project seasonal, short-term increases of ozone concentrations during summer months in the Southeast United States (e.g., Wu et al. 2008), others (e.g., Tao et al. 2007; Nolte et al. 2018; Meehl et al. 2018) found differences in future changes in ozone for the Southeast with decreases in ozone concentrations under a low-emission modelled scenario, increases under a high-emission modelled scenario, or decreases in ozone on heat wave days. Among modelled studies of climate-related ozone changes, model simulations for the Southeast region have the least consensus. Therefore, the potential cumulative impact on air quality ozone levels in the vicinity of North Anna due to climate change is unknown.

3.16.2 Water Resources

3.16.2.1 Surface Water Resources

The description of the affected environment in Section 3.5.1, "Surface Water Resources," of this SEIS serves as the baseline for the NRC staff's cumulative impacts assessment for surface water resources. North Anna withdraws cooling water directly from the North Anna Reservoir and discharges return flows and comingled effluents to the dedicated WHTF and ultimately to the reservoir. As such, this cumulative impact review focuses on those projects and activities that would withdraw water from, or discharge effluents to, the North Anna Reservoir and its tributaries (see Figure 3-4).

<u>Water Use and Water Quality Considerations</u>

The NRC staff previously considered the cumulative impacts on surface water resources at North Anna in Section 7.3, "Water Use and Quality," of the NRC's supplemental EIS for the combined license for proposed Unit 3 at North Anna (NUREG-1917) (NRC 2010). In that analysis, the staff considered the combined impacts on Lake Anna's hydrology and water quality associated with existing Units 1 and 2, along with the incremental impacts of construction and operations of proposed Unit 3. In NUREG-1917, the staff also independently reviewed Dominion's water budget model of Lake Anna and proposed Unit 3 operational parameters and their effect on consumptive water use. In summary, the staff concluded in NUREG-1917 that the cumulative impacts on water use, to include the construction and operation of the proposed Unit 3, would remain SMALL except during drought periods, when the impacts would be MODERATE. The NRC staff incorporates the cumulative impacts analysis in Section 7.3 of

NUREG-1917 by reference (NRC 2010: Section 7.3, p. 7-2– 7-4), to present an analysis of cumulative impacts if Dominion were to construct and operate Unit 3 during the SLR period of extended operation.

The North Anna Reservoir was created to provide a source of cooling water for the North Anna nuclear generating units. As discussed in Section 3.5.1.2, with the exception of a small fraction of water being lost to evaporation, surface water withdrawn by North Anna is returned to the North Anna Reservoir. Dominion has not proposed to increase North Anna Unit 1 and 2 surface water withdrawals or consumptive water use during the SLR term. In addition, as referenced in Section 3.5.1.1, Dominion has a Virginia water protection permit (number 10-2001) for operation of proposed Unit 3. This permit, in conjunction with the release schedule for the North Anna Dam included in Dominion's VPDES permit for Units 1 and 2 (VDEQ 2014), will help to ensure that minimum instream flows are maintained in the North Anna River to minimize water use conflicts and to safeguard designated uses. The staff has identified no new or proposed projects (see Appendix E, Table E-1) that have the potential to substantially impact surface water withdrawals or consumptive water use in the Lake Anna watershed. The NRC staff continues to recognize that resolution of any future conflicts over water availability would fall within the regulatory authority of the Commonwealth of Virginia.

In Section 7.3 of NUREG-1917 (NRC 2010), the staff also evaluated the potential cumulative impacts on water quality associated with the operation of proposed Unit 3 combined with existing Units 1 and 2. The staff considered the presence of two pollutants (copper and tributyltin) and the potential for the pollutants to be concentrated by the operation of proposed Unit 3's cooling system. Based on its analysis, the staff concluded that cumulative water-quality impacts associated with the proposed Unit 3 would remain SMALL, as all effluent discharges would be regulated under the VPDES permit program. The NRC staff incorporates the analysis in Section 7.3 of NUREG-1917 by reference (NRC 2010: Section 7.3, p. 7-2–7-4), to address the cumulative impacts on water resources if Dominion were to decide to construct and operate North Anna Unit 3 during the Units 1 and 2 SLR period of extended operation.

In Appendix E, Table E-1 of this SEIS, the staff has identified a number of ongoing and reasonably foreseeable future actions that could impact surface water quality in affected watersheds. Specific to the Lake Anna region, the primary impact driver is likely to be continued residential and mixed-use development.

Future development can result in water quality degradation if those projects increase sediment loading and the discharge of other pollutants to nearby surface water bodies. On an individual facility basis, State-issued permits (i.e., the VPDES in Virginia) under CWA Section 402 set limits on wastewater, stormwater associated with construction and industrial activity, and other point source discharges. As previously discussed, Section 303(d) of the Federal CWA requires states to identify all "impaired" waters for which effluent limitations and pollution control activities are not sufficient to attain water quality standards and to establish total maximum daily loads to ensure future compliance with water quality standards. Consequently, a substantial regulatory framework exists to address current and potential future sources of water quality degradation within the watershed of Lake Anna Reservoir with respect to potential cumulative impacts on surface water quality.

<u>Climate Change and Related Considerations</u>

Climate change can impact surface water resources as a result of changes in temperature, precipitation, and other parameters, as discussed in Section 3.15.3.2, "Greenhouse Gas Emissions and Climate Change."

The U.S. Global Change Research Program (USGCRP) projects that water demand across Virginia will increase by 10 to 25 percent by 2060, relative to 2005, based on combined changes in population, socioeconomic conditions, and climate (USGCRP 2014, Figure 3.11).

Elevated surface water temperatures can decrease the cooling efficiency of thermoelectric power generating facilities and plant capacity. Therefore, as intake water temperatures warm, the volume of surface water needed for power plant cooling can increase (USGCRP 2014). Power plants would have to account for any changes in water temperature in operational practices and procedures.

Since 1958, heavy precipitation (i.e., the amount of annual precipitation falling in the heaviest 1 percent of events) has increased by an average of 27 percent across the Southeast region (USGCRP 2018: Fig 2.6). Observed increases in heavy precipitation events are projected to continue across the Southeast, including Virginia. Increases in annual precipitation and heavy precipitation events can result in greater runoff from the land while increasing the potential for riverine flooding. In turn, these changes can result in the transport of a higher sediment load and other contaminants to surface waters with potential degradation of ambient water quality.

3.16.2.2 Groundwater Resources

Section 3.5.2, “Groundwater Resources,” describes regional groundwater supply systems. In the North Anna region, over the period of license renewal, the groundwater within the aquifer should continue to be affected by human activities and natural processes. Surrounding aquifer resources may continue to be subject to depletion and water quality degradation; however, the hydraulically isolated nature of the North Anna site groundwater aquifer with respect to the surrounding area precludes impacts on the surrounding region and users. In addition, the North Anna site has approved waste management and spill prevention practices and stormwater BMPs in place to prevent or minimize surface source releases from migrating to the groundwater flow system. Therefore, continued pumping of groundwater at the North Anna site during the SLR term is anticipated to have a negligible impact on groundwater contamination, groundwater use conflicts, and groundwater degradation impacts.

The NRC staff incorporates the information in NUREG-1811, Section 7.3 (NRC 2006: Section 7.3, p. 7-2, 7-3) on cumulative impacts, here by reference. If North Anna Unit 3 is constructed and operated, up to five additional domestic wells would be developed for Unit 3 construction and operation (Dominion 2016b; NRC 2010) under the purview of VDEQ and VDH permitting requirements. Withdrawals related to construction dewatering for Unit 3 foundations and basemats would cause aquifer drawdowns; however, drawdown due to well withdrawals during construction and operation would be mitigated by the hydraulic boundaries of Lake Anna and the discharge canal.

Based on the NRC staff’s review of Dominion’s annual radioactive effluent release report data (VEPCO 2016, 2017, 2018, 2019, 2020), the staff determined that the North Anna site monitoring program is consistent with the groundwater protection procedures as described in ER Section E3.6.2.4 (Dominion 2020b). During the past 5 years, the monitoring well network has detected tritium in groundwater, while no plant-related gamma isotopes or residual radionuclides have been detected. As described in Section 3.5.2.3 above, GWP-18 tritium concentrations were indicative of surface water leaking into the pipe tunnel and subsequent leaching of tritium from the concrete of the tunnel to the ground. After excess water was removed from the tunnel, GWP-18 concentrations returned to historical threshold values. Pipe tunnel surface water ingress points were sealed during 2020 and the tunnel remains dry to preclude leaching of residual tritium in tunnel concrete to groundwater (Haley & Aldrich 2020).

Groundwater well permitting and withdrawals are within the purview of VDEQ and VDH permitting requirements. Based on the hydrogeologic setting, compliance with groundwater permitting, adherence to the groundwater protection initiative (NEI 2007), and the staff's 2006 review of Unit 3 groundwater use impacts (NUREG-1811, Section 7.3), the cumulative impact from Unit 1 and Unit 2 during the SLR period of operation would be SMALL.

3.16.3 Socioeconomics

This section addresses socioeconomic factors that have the potential to be affected by changes in operations at North Anna, in addition to the aggregate effects of other past, present, and reasonably foreseeable future actions. As discussed in Section 3.10.7, continued operation of North Anna during the SLR term would have no impact on socioeconomic conditions in the region beyond what is already being experienced.

Because Dominion has no plans to hire additional workers during the SLR term, overall expenditures and employment levels at North Anna Units 1 and 2 would remain relatively unchanged with no new or increased demand for housing and public services. Based on this and other information presented in this chapter, there would be no contributory effect on socioeconomic conditions in the region during the SLR term from the continued operation of North Anna beyond what is currently being experienced. Therefore, the only contributory effects would come from reasonably foreseeable future planned activities at North Anna unrelated to the proposed action and other planned offsite activities.

In the supplemental EIS for the Unit 3 combined license (NUREG-1917 (NRC 2010)), the NRC staff evaluated the potential socioeconomic impacts from construction and operation of proposed Unit 3, if built, at the North Anna site. As summarized in Section 7.6 of NUREG-1917, the NRC staff determined that construction and operation of proposed Unit 3 could make detectable adverse contributions to the cumulative effects associated with some socioeconomic issues, including aesthetics and recreation, with individual impacts ranging from MODERATE adverse to LARGE beneficial. Specifically, as presented in Section 4.5 of NUREG-1917, the staff found that adverse construction impacts could be MODERATE for regional transportation and recreational use of Lake Anna, area housing, and school enrollment. These impacts would be temporary. Construction could have MODERATE beneficial impacts on the regional economy and tax revenue. All other socioeconomic impacts would be SMALL. For operations, as presented in Section 5.5 of NUREG-1917, the staff projected that there could be MODERATE adverse impacts on visual aesthetics and on recreational use of Lake Anna on a periodic basis. Operations could have MODERATE to LARGE beneficial impacts on the regional economy and tax revenue (NRC 2010: Sections 4.5, 5.5, 7.6, p. 4-13–4-20, p. 5-17–5-28, p. 7-6). The NRC staff incorporates those impact analyses from NUREG-1917 into this SEIS by reference.

3.16.4 Human Health

The NRC and EPA have established radiological dose limits to protect the public and workers from both acute and long-term exposure to radiation and radioactive materials. These dose limits are specified in 10 CFR Part 20 and 40 CFR Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations." As discussed in Section 3.11.6 et seq., "Human Health," of this SEIS, the impacts on human health from continued plant operations during the SLR term would be SMALL.

For the purposes of this cumulative impacts analysis, the geographical area considered is the area within a 50-mi (80-km) radius of North Anna. There are no other nuclear power plants within this 50-mi (80-km) radius. However, that radius does overlap with the 50-mi (80-km) radius around the Surry Power Station and the Calvert Cliffs Nuclear Power Station, which are located approximately 86 mi (138 km) and 78 mi (125 km) from North Anna, respectively. Like North Anna, both nuclear power stations comply with all NRC and EPA regulations on radiation and radioactive materials exposure. As discussed in Section 2.1.4.4, “Radioactive Waste Storage,” of this SEIS, Dominion stores spent nuclear fuel from Units 1 and 2 in a storage pool and in an onsite independent spent fuel storage installation (ISFSI). Currently, the ISFSI consists of three separate spent fuel storage pads. Dominion stated in the ER that it has no current plans to add additional storage pads (Dominion 2020b).

As referenced in Section 3.16, the staff provides the following evaluation regarding the likely cumulative impacts on human health if Dominion were to construct and operate North Anna Unit 3 during the SLR period of extended operation. In this regard, the NRC staff notes that the operation of North Anna Unit 3, if built, would result in radiological releases and dose impacts to workers and the public, in addition to the impacts resulting from operation of Units 1 and 2. Also, spent fuel would accumulate onsite as a result of the operation of Unit 3, in addition to the spent fuel produced by continued operations of Units 1 and 2. Section 5.9.2.3, “External Radiation Pathway“; Section 5.9.3, ”Impacts to Members of the Public”; Section 5.9.4, ”Occupational Doses to Workers”; and Section 6.1, “Fuel Cycle Impacts and Solid Waste Management” of NUREG-1917 (NRC 2010) describe the projected operational impacts of proposed Unit 3 in detail. As summarized in Section 7.8 of the NRC staff’s supplemental EIS for the Unit 3 combined license (NUREG-1917), the staff projected that cumulative public and occupational doses from the operation of Units 1 and 2 and proposed Unit 3 would be well below regulatory limits and standards. In NUREG-1917, the NRC staff determined that the radiological health, fuel cycle, and waste management impacts of Unit 3 operation, alone or combined with Units 1 and 2, would be SMALL (NRC 2010: Sections 5.9.2.3, 5.9.3, 5.9.4, 6.1, 7.8, p. 5-41–5-48, 6-1–6-3, 7-7). The NRC staff incorporates those impact analyses from NUREG-1917 into this SEIS by reference, to describe these cumulative impacts if Unit 3 were to be built.

The EPA regulations at 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 2.1.4.5, “Radiological Environmental Monitoring Program,” in this SEIS, Dominion has a radiological environmental monitoring program that measures radiation and radioactive materials in the environment from North Anna, its ISFSI, and all other sources. The NRC staff reviewed the radiological environmental monitoring results for the 5-year period from 2015 through 2019 as part of this cumulative impacts assessment. The review of Dominion’s data showed no indication of an adverse trend in radioactivity levels in the environment from either North Anna or the ISFSI. The data showed that there was no measurable radiological impact on the environment from operations at North Anna.

In summary, the NRC staff concludes that there is no significant cumulative radiological effect on human health resulting from the proposed action of subsequent license renewal, in combination with cumulative impacts from other sources. The NRC staff bases this conclusion on its review of radiological environmental monitoring program data, radioactive effluent release data, and worker dose data; the expectation that North Anna would continue to comply with Federal radiation protection standards during the period of extended operation; and the continued regulation of any future development or actions in the vicinity of the North Anna site by the NRC and the Commonwealth of Virginia.

3.16.5 Environmental Justice

This cumulative impact analysis evaluates the potential for disproportionately high and adverse human health and environmental effects on minority and low-income populations that could result from past, present, and reasonably foreseeable future actions, including the continued operational effects of North Anna Units 1 and 2 during the renewal term. As discussed in Section 3.12.1, there would be no disproportionately high and adverse impacts on minority and low-income populations from the continued operation of North Anna Units 1 and 2 during the SLR term.

Everyone living near North Anna, including minority and low-income populations, currently experiences its operational effects. The NRC addresses environmental justice matters for license renewal by identifying the location of minority and low-income populations, determining whether there would be any potential human health or environmental effects, and whether any of the effects may be disproportionately high and adverse on these populations.

Adverse health effects are measured in terms of the risk and rate of fatal or non-fatal 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 in 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 chapter of the SEIS. As previously discussed in this chapter, the impact from license renewal for all resource areas (e.g., land, air, water, and human health) would be SMALL.

As discussed in Section 3.12.1, there would be no disproportionately high and adverse impacts on minority and low-income populations from the continued operation of North Anna Units 1 and 2 during the SLR term. Because Dominion has no plans to hire additional workers during the SLR term to support continued operation of North Anna Unit 1 and 2 (Dominion 2020b), employment levels at North Anna would remain relatively constant, and there would be no additional demand for housing or increase in traffic due to subsequent license renewal of Units 1 and 2. Based on this information and the analysis of human health and environmental impacts presented in the preceding sections, it is not likely that there would be any disproportionately high and adverse contributory effects on minority and low-income populations from the continued operation of North Anna Units 1 and 2 during the SLR term. Therefore, the only contributory effects would come from the other reasonably foreseeable future planned activities at North Anna, unrelated to the proposed action (license renewal), and other reasonably foreseeable planned offsite activities.

If Dominion were to proceed to construct and operate Unit 3, the staff would not expect any cumulative adverse impact on environmental justice populations. In the supplemental EIS for the Unit 3 combined license (NUREG-1917 (NRC 2010)), the NRC staff evaluated the potential for disproportionately high and adverse human health and environmental effects on minority and low-income populations from construction and operation of proposed Unit 3. As summarized in Section 7.6 of NUREG-1917, and detailed in Sections 4.7 and 5.7, the staff determined that there would be no disproportionate and adverse impacts on minority and low-income populations from construction and operation of proposed Unit 3, either alone or in combination with operation of Units 1 and 2 (NRC 2010: Sections 4.4, 5.7, 7.6, p. 4-22–4-23, 5-29–5-31, 7-5–7-6). For informational purposes, the NRC staff incorporates those impact analyses from

NUREG-1917 into this SEIS by reference, to address the likely environmental justice impacts if Dominion were to proceed to construct and operate North Anna Unit 3.

In sum, when combined with other past, present, and reasonably foreseeable future activities, the contributory effects of continuing reactor operations and maintenance at North Anna would not likely cause disproportionately high and adverse human health and environmental effects on minority and low-income populations residing near North Anna.

3.16.6 Waste Management and Pollution Prevention

This section considers the incremental waste management impacts of the SLR term when added to the aggregate effects of other past, present, and reasonably foreseeable future actions. In Section 3.13.3, the NRC staff concluded that the potential waste management impacts from North Anna Units 1 and 2 continued operations during the SLR term would be SMALL.

The construction and operation of Unit 3 would generate additional radioactive and nonradioactive waste. In the supplemental EIS for the Unit 3 combined license (NUREG-1917 (NRC 2010)), the NRC staff evaluated the potential waste management impacts resulting from Unit 3 operations, either alone or in combination with Units 1 and 2. Cumulative waste impacts were addressed in Section 7.10, “Fuel Cycle, Transportation, and Decommissioning,” and Unit 3 waste impacts were evaluated in Section 6.1,”Fuel Cycle Impacts and Solid Waste Management” of NUREG-1917. In sum, the NRC staff determined that uranium fuel cycle and solid waste management impacts of Unit 3 operation, either alone or in combination with Units 1 and 2, would be SMALL (NRC 2010: Sections 6.1, 7.10, p. 6-1–6-3, 7-8). For informational purposes, the NRC staff incorporates those impact analyses from NUREG-1917 into this SEIS by reference.

As discussed in Sections 2.1.4 and 2.1.5 of this draft SEIS, Dominion maintains waste management programs for radioactive and nonradioactive waste generated at North Anna and is required to comply with Federal and State permits and other regulatory waste management requirements. All industrial facilities, including nuclear power plants and other facilities within a 30-mi (48-km) radius of North Anna, are also required to comply with appropriate NRC, EPA, and State requirements for the management of radioactive and nonradioactive waste. Current, ongoing waste management activities at North Anna would likely remain unchanged during the SLR term, and continued compliance with Federal and State requirements for radioactive and nonradioactive waste is expected.

In summary, the NRC staff concludes that there is no significant cumulative effect from the proposed action due to continued radioactive and nonradioactive waste generation. This is based on North Anna’s expected continued compliance with Federal and Commonwealth of Virginia requirements for radioactive and nonradioactive waste management and the expected regulatory compliance of other waste producers in the area.

3.17 Resource Commitments Associated with the Proposed Action

This section describes the NRC staff’s consideration of potentially unavoidable adverse environmental impacts that could result from implementation of the proposed action and alternatives; the relationship between short-term uses of the environment and the maintenance and enhancement of long-term productivity; and the irreversible and irretrievable commitments of resources.

3.17.1 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 replacement 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 the 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 Federal EPA and State emissions standards. 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 low levels of radiation as well as 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 are not expected to exceed regulatory 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, for 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 some 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, the NRC staff expects that power plant operators would optimize all waste management activities and operations in a way that generates the smallest possible amount of waste.

3.17.2 Relationship between Short-Term Use of the Environment and Long-Term Productivity

The operation of power generating facilities would result in short-term uses of the environment, as described in Sections 3.2 through 3.13 (see subsections titled, “Proposed Action,” “No-Action Alternative,” and “Replacement Power Alternatives: Common Impacts”). 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 nuclear power plant operations introduce small amounts of radiological and nonradiological emissions to the region around the plant site. Over time, these emissions would result in increased concentrations and exposure, but the NRC staff does not expect that these emissions would impact air quality or radiation exposure to the extent that they would impair public health and long-term productivity of the environment.

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 require an increase in energy and consume 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 these facilities are decommissioned and the area restored, the land could be available for other future productive uses.

3.17.3 Irreversible and Irretrievable Commitment of Resources

Resource commitments are irreversible when primary or secondary impacts limit the future options for a resource. For example, the consumption or loss of nonrenewable resources is irreversible. An irretrievable commitment refers to the use or consumption of resources for a period of time (e.g., for the duration of the action under consideration) that are neither renewable nor recoverable for future use. Irreversible and irretrievable commitments 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 commitments of capital, energy, labor, and material resources are also irreversible.

The implementation of any of the replacement energy alternatives considered in this SEIS would entail the irreversible and irretrievable commitments 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 or withdrawn from surface water or groundwater. These resources are readily available, and the NRC staff does not expect that the amounts required would deplete available supplies or exceed available system capacities.

4.0 CONCLUSION

This draft supplemental environmental impact statement (DSEIS) contains the NRC staff's environmental review of the Dominion Energy Virginia (Dominion) application for subsequent renewed operating licenses for North Anna Power Station, Units 1 and 2 (North Anna), as required by Title 10 of the *Code of Federal Regulations* (10 CFR) Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions." The regulations in 10 CFR Part 51 implement the National Environmental Policy Act of 1969, as amended (42 U.S.C. 4321 et seq.). This chapter briefly summarizes the environmental impacts of subsequent license renewal, lists and compares the environmental impacts of alternatives to subsequent license renewal, and presents the NRC staff's preliminary conclusions and recommendation.

4.1 Environmental Impacts of License Renewal

After reviewing the site-specific (Category 2) environmental issues in this DSEIS, the NRC staff concluded that issuing subsequent renewed licenses for North Anna would have SMALL impacts for the Category 2 issues applicable to the license renewal at North Anna. The NRC staff considered mitigation measures for each Category 2 issue, as applicable. The NRC staff concluded that no additional mitigation measure is warranted.

4.2 Comparison of Alternatives

In Chapter 3 of this DSEIS, the NRC staff considered the following alternatives to issuing renewed operating licenses to North Anna:

- no-action alternative
- new nuclear (small modular reactor) alternative
- combination alternative

Based on the review presented in this DSEIS, the NRC staff concludes that the environmentally preferred alternative is the proposed action. The NRC staff recommends that subsequent renewed North Anna operating licenses be issued. As shown in Table 2-2, all other power-generation alternatives have impacts in at least four resource areas that are greater than subsequent license renewal, in addition to the environmental impacts inherent with new construction projects. To make up the lost power generation if the NRC does not issue subsequent renewed licenses for North Anna (i.e., the no-action alternative), energy decisionmakers may implement one of the replacement power alternatives discussed in Chapter 3, or a comparable alternative capable of replacing the power generated by North Anna Units 1 and 2.

4.3 Recommendation

The NRC staff's preliminary recommendation is that the adverse environmental impacts of subsequent license renewal for North Anna are not so great that preserving the option of subsequent license renewal for energy-planning decisionmakers would be unreasonable. This preliminary 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 Dominion
- the NRC staff's consultation with Federal, State, Tribal, and local agencies
- the NRC staff's independent environmental review
- the NRC staff's consideration of public comments

5.0 REFERENCES

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

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

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

10 CFR Part 54. *Code of Federal Regulations*. Title 10, *Energy*, Part 54, "Requirements for Renewal of Operating Licenses for Nuclear Power Plants."

10 CFR Part 72. Code of Federal Regulations. Title 10, *Energy*, Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater than Class C Waste."

10 CFR Part 100. *Code of Federal Regulations*. Title 10, *Energy*, Part 100, "Reactor Site Criteria."

15 CFR Part 930. *Code of Federal Regulations*. Title 15, *Commerce and Foreign Trade,* Part 930, "Federal Consistency with Approved Coastal Management Programs."

29 CFR 1926. *Code of Federal Regulations*. Title 29, *Labor*, Part 1926, "Safety and Health Regulations for Construction."

33 CFR Part 320. *Code of Federal Regulations*. Title 33, *Navigation and Navigable Waters*, Part 320, "General Regulatory Policies."

33 CFR Part 322. *Code of Federal Regulations*. Title 33, *Navigation and Navigable Waters,* Part 322, "Permits for Structures or Work in or Affecting Navigable Waters of the United States."

33 CFR Part 323. *Code of Federal Regulations*. Title 33, *Navigation and Navigable Waters,* Part 323, "Permits for Discharges of Dredged or Fill Material into Waters of the United States."

33 CFR Part 328. *Code of Federal Regulations*. Title 38, *Navigation and Navigable Waters,* Part 328, "Definition of Waters of the United States."

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

40 CFR Part 50. *Code of Federal Regulations*. Title 40, *Protection of Environment*, Part 50, "National Primary and Secondary Ambient Air Quality Standards."

40 CFR Part 51. *Code of Federal Regulations*. Title 40, *Protection of Environment*, Part 51, "Regional Haze Program Requirements."

40 CFR Part 81. *Code of Federal Regulations*. Title 40, *Protection of Environment*, Part 81, "Designation of Areas for Air Quality."

40 CFR Part 110. *Code of Federal Regulations*. Title 40, *Protection of Environment*, Part 110, "Discharge of Oil."

40 CFR Part 112. *Code of Federal Regulations*. Title 40, *Protection of Environment*, Part 112, "Oil Pollution Prevention."

40 CFR Part 122. *Code of Federal Regulations*. Title 40, *Protection of Environment*, Part 122, "EPA Administered Permit Programs: The National Pollutant Discharge Elimination System."

40 CFR Part 125. *Code of Federal Regulations*. Title 40, *Protection of Environment*, Part 125, "Criteria and Standards for the National Pollutant Discharge Elimination System."

40 CFR Part 131. *Code of Federal Regulations*. Title 40, *Protection of Environment,* Part 131, "Water Quality Standards."

40 CFR Part 141. *Code of Federal Regulations*. Title 40, *Protection of Environment*, Part 141, "National Primary Drinking Water Regulations."

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

40 CFR Part 401. *Code of Federal Regulations*. Title 40, *Protection of Environment,* Part 401, "General Provisions."

50 CFR Part 402. *Code of Federal Regulations*. Title 50, *Wildlife and Fisheries,* Part 402, "Interagency Cooperation—Endangered Species Act of 1973, as Amended."

59 FR 7629. Executive Order No. 12898. "Federal actions to address environmental justice in minority populations and low-income populations." *Federal Register* 59(32):7629–7634. February 11, 1994.

64 FR 6183. Executive Order No. 13112. "Invasive species." *Federal Register* 64(25): 6183–6186. February 3, 1999

69 FR 52040. U.S. Nuclear Regulatory Commission. "Policy statement on the treatment of environmental justice matters in NRC regulatory and licensing actions." *Federal Register* 69(163):52040–52048. August 24, 2004.

70 FR 39104. U.S. Environmental Protection Agency. "Regional haze regulations and guidelines for best available retrofit technology (BART) determinations." *Federal Register* 70(128):39104–39172. July 6, 2005.

74 FR 66496. U.S. Environmental Protection Agency. "Endangerment and cause or contribute findings for greenhouse gases under section 202(a) of the Clean Air Act." *Federal Register* 74(239):66496–66546. December 15, 2009.

79 FR 20315. U.S. Department of Labor. Occupational Safety and Health Administration. "Electric power generation, transmission, and distribution; electrical protective equipment; final rule." *Federal Register* 79(70):20315–20743. April 11, 2014.

79 FR 48300. U.S. Environmental Protection Agency. "National Pollutant Discharge Elimination System—final regulations to establish requirements for cooling water intake structures at existing facilities and amend requirements at Phase I facilities." *Federal Register* 79(158):48300–48439. August 15, 2014.

80 FR 17974. U.S. Fish and Wildlife Service. "Endangered and threatened wildlife and plants; threatened species status for the northern long-eared bat with 4(d) rule." *Federal Register* 80(63):17974–18033. April 2, 2015.

81 FR 1900. U.S. Fish and Wildlife Service. "Endangered and threatened wildlife and plants; 4(d) rule for Northern Long-Eared Bat." *Federal Register* 81(9):1900–1922. January 14, 2016.

81 FR 24707. U.S. Fish and Wildlife Service. "Endangered and threatened wildlife and plants; determination that designation of critical habitat is not prudent for the Northern Long-Eared Bat." *Federal Register* 81(81):24707–24714. April 27, 2016.

81 FR 88609. Executive Order No. 13751. "Safeguarding the Nation from the Impacts of Invasive Species." Federal Register 81(236):88609-88614. December 5, 2016.

83 FR 4932. U.S. Nuclear Regulatory Commission. "North Anna Power Station Independent Spent Fuel Storage Installation, Environmental assessment and finding of no significant impact; issuance." *Federal Register* 83(23):4932–4934. February 2, 2018.

83 FR 6242. U.S. Nuclear Regulatory Commission. "Virginia Electric and Power Company, Old Dominion Electric Cooperative, North Anna Power Station Independent Spent Fuel Storage Installation, License renewal; issuance. *Federal Register* 83(30):6242–6243. February 13, 2018.

[9 VAC 25-31] Virginia Administrative Code, Title 9, Environment, Agency 25, State Water Control Board, Chapter 31, Virginia Pollutant Discharge Elimination System (VPDES) Permit Regulation. Commonwealth of Virginia, Division of Legislative and Automated Systems. Available at <https://law.lis.virginia.gov/admincode/> (accessed November 11, 2020).

[9 VAC 25-210-310] Virginia Administrative Code, Title 9, Environment, Agency 25, State Water Control Board, Chapter 210, Virginia Water Protection Permit Program, Part V, Surface Water Withdrawals, Section 310, Exclusions from permits for surface water withdrawals. Commonwealth of Virginia, Division of Legislative and Automated Systems. Available at <https://law.lis.virginia.gov/admincode/> (accessed November 11, 2020).

[9 VAC 25-260] Virginia Administrative Code, Title 9, Environment, Agency 25, State Water Control Board, Chapter 260, Water Quality Standards, Part I, Surface Water Standards with General, Statewide Application, Sections 5-550. Commonwealth of Virginia, Division of Legislative and Automated Systems. Available at <https://law.lis.virginia.gov/admincode/> (accessed November 11, 2020).

[9 VAC 25-880] Virginia Administrative Code, Title 9, Environment, Agency 25, State Water Control Board, Chapter 880, General VPDES Permit for Discharges of Stormwater from Construction Activities. Commonwealth of Virginia, Division of Legislative and Automated Systems. Available at <https://law.lis.virginia.gov/admincode/> (accessed November 11, 2020).

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

[AWEA] American Wind Energy Association. 2020. *U.S. Offshore Wind Power Economic Impact Assessment.* Washington, DC: AWEA March 2020. 19 p. Available at <https://supportoffshorewind.org/wp-content/uploads/sites/6/2020/03/AWEA_Offshore-Wind-Economic-ImpactsV3.pdf> (accessed January 21, 2021).

Bald and Golden Eagle Protection Act. 16 U.S.C. § 668 et seq.

Birdlife International. 2021. "Species factsheet: *Morus bassanus."* Available at <http://datazone.birdlife.org/species/factsheet/northern-gannet-morus-bassanus> (accessed March 14, 2021).

[BLM] U.S. Department of the Interior, Bureau of Land Management. 2019. *Gemini Solar Project, Final Resource Management Plan Amendment and Environmental Impact Statement, Volume 1: Chapters 1 – 4*. doi:BLM-NV-S010-2018-0051-EIS. December. Available at <https://blm.gov/public-room> (accessed January 21, 2021).

[BOEM] U.S. Department of the Interior, Bureau of Ocean Energy Management. 2012. *Commercial Wind Lease Issuance and Site Assessment Activities on the Atlantic Outer Continental Shelf Offshore New Jersey, Delaware, Maryland, and Virginia: Final Environmental Assessment*. January 2012. OCS EIS/EA BOEM 2012-003. 366 p. Available at <https://www.boem.gov/sites/default/files/uploadedFiles/BOEM/Renewable_Energy_Program/Smart_from_the_Start/Mid-Atlantic_Final_EA_012012.pdf> (accessed January 21, 2021).

[BOEM] U.S. Department of the Interior, Bureau of Ocean Energy Management. 2013. *Virginia Commercial Lease Area (OCS-A 0483.) Map ID: PACB-2013-1019.* 1 p. Available at <https://www.boem.gov/sites/default/files/renewable-energy-program/State-Activities/VA/Map-of-the-Virginia-Commercial-Lease-Area.pdf> (accessed January 21, 2021).

[BOEM] U.S. Department of the Interior, Bureau of Ocean Energy Management. 2015. *Virginia Offshore Wind Technology Advancement Project on the Atlantic Outer Continental Shelf Offshore Virginia: Revised Environmental Assessment.* July 2015. OCS EIS/EA BOEM 2015-031. 218 p. Available at <https://www.energy.gov/sites/prod/files/2016/03/f30/EA-1985-FEA-2015_1.pdf> (accessed January 21, 2021).

[BOEM] U.S. Department of the Interior, Bureau of Ocean Energy Management. 2018. *Vineyard Wind Offshore Wind Energy Project: Draft Environmental Impact Statement.* OCS EIS/EA, BOEM 2018-060. December 2018. 478 p. Available at <https://www.boem.gov/sites/default/files/renewable-energy-program/State-Activities/MA/Vineyard-Wind/Vineyard_Wind_Draft_EIS.pdf> (accessed January 21, 2021).

[BOEM] U.S. Department of the Interior, Bureau of Ocean Energy Management. 2020. *Vineyard Wind 1 Offshore Wind Energy Project: Supplement to the Draft Environmental Impact Statement.* June 2020. OCS EIS/EA BOEM 2020-025. 420 p. Available at <https://www.boem.gov/sites/default/files/documents/renewable-energy/Vineyard-Wind-1-Supplement-to-EIS.pdf> (accessed January 21, 2021).

[BOEM] U.S. Department of the Interior, Bureau of Ocean Energy Management. 2021. "Commercial Lease for Wind Energy Offshore Virginia." Available at <https://www.boem.gov/renewable-energy/state-activities/commercial-lease-wind-energy-offshore-virginia> (accessed February 2, 2021).

[BOEM] U.S. Department of the Interior, Bureau of Ocean Energy Management. Undated. "Renewable Energy on the Outer Continental Shelf: Ocean Wave Energy." Available at <https://www.boem.gov/Renewable-Energy-Program/Renewable-Energy-Guide/Ocean-Wave-Energy.aspx> (accessed March 20, 2021).

Carter T.C., Feldhamer G.A. 2005. Roost tree use by maternity colonies of Indiana Bats and Northern Long-Eared Bats in southern Illinois. *Forest Ecology and Management*. 219(2–3):259–268. doi:10.1016/j.foreco.2005.08.049.

[CCB] The Center for Conservation Biology. 2018 . "CCB Mapping Portal: VA Eagle Nest Locator." Available at <http://www.ccbbirds.org/maps/> (accessed March 9, 2021).

[CDC] Centers for Disease Control and Prevention. 2015. "Salmonella: Information for Healthcare Professionals and Laboratories." October 24, 2018. Available at <http://www.cdc.gov/salmonella/general/technical.html> (accessed January 31, 2019).

[CDC] Centers for Disease Control and Prevention. 2016. "Legionnaires' Disease." July 18, 2016. 1 p. Available at <https://www.cdc.gov/legionella/downloads/fs-legionnaires.pdf> (accessed December 16, 2020).

[CDC] Centers for Disease Control and Prevention. 2018a. "Waterborne Disease & Outbreak Surveillance Reporting: 2013–2014 Recreational Water–associated Outbreak Surveillance Report Supplemental Tables." Available at <https://www.cdc.gov/healthywater/surveillance/recreational/2013-2014-tables.html> (accessed December 16, 2020).

[CDC] Centers for Disease Control and Prevention. 2018b. "Parasites — *Naegleria fowleri* — Primary Amebic Meningoencephalitis (PAM) — Amebic Encephalitis." September 29, 2020. Available at <https://www.cdc.gov/parasites/naegleria/state-map.html> (accessed December 16, 2020).

[CDC] Centers for Disease Control and Prevention. 2019a. "Salmonella: Reports of *Salmonella* Outbreak Investigations from 2019." December 11, 2019. Available at <https://www.cdc.gov/salmonella/outbreaks-2019.html> (accessed December 16, 2020).

[CDC] Centers for Disease Control and Prevention. 2019b. *Legionnaires' Disease Surveillance Summary Report, United States: 2014-2015.* July 2019. 48 p. Available at <https://www.cdc.gov/legionella/health-depts/surv-reporting/2014-15-surv-report-508.pdf> (accessed December 16, 2020).

[CDC] Centers for Disease Control and Prevention. 2020. *Legionnaires' Disease Surveillance Summary Report, United States: 2016–2017.* February 2020. 50 p. Available at <https://www.cdc.gov/legionella/health-depts/surv-reporting/2016-17-surv-report-508.pdf> (accessed December 16, 2020).

[CDC] Centers for Disease Control and Prevention. 2021. "Parasites — *Naegleria fowleri* — Primary Amebic Meningoencephalitis (PAM) — Amebic Encephalitis." Available at <https://www.cdc.gov/parasites/naegleria/general.html> (accessed January 6, 2021).

[CEQ] Council on Environmental Quality. 1997. "Environmental Justice: Guidance under the National Environmental Policy Act." Washington, DC: CEQ. December 10, 1997. Available at <https://ceq.doe.gov/nepa-practice/justice.html> (accessed February 26, 2021).

[CISEH] University of Georgia, Center for Invasive Species and Ecosystem Health. 2020. "Early Detection and Distribution Mapping System [online database]." [Search: Virginia, Invasives by County]. Available at <https://www.eddmaps.org/tools/statereport.cfm?id=us_va> (accessed December 9, 2020).

Clean Air Act of 1970. 42 U.S.C. § 7401 et seq.

Conner A.M., Francfort J.E., Rinehart B.N. 1998. *U.S. Hydropower Resource Assessment, Final Report.* Idaho Falls, ID: Idaho National Engineering and Environmental Laboratory. DOE/ID 10430.2. December 1998. 56 p. Available at <https://www.osti.gov/servlets/purl/771504> (accessed March 19, 2021).

[CVOW] Dominion Energy, Coastal Virginia Offshore Wind. 2021. "About Delivering Wind Power, Frequently Asked Questions." Available at <https://coastalvawind.com/about-offshore-wind/delivering-wind-power.aspx#sec3> (accessed March 12, 2021).

Coastal Zone Management Act of 1972. 16 U.S.C. § 1451 et seq.

Crawford R.L., Baker W.W. 1981. Bats killed at a north Florida television tower: a 25-year record. *Journal of Mammalogy* 62(3):651-652. doi:10.2307/1380421.

Cryan, P.M., Brown A.C. 2007. Migration of bats past a remote island offers clues toward the problem of bat fatalities at wind turbines. *Biological Conservation* 139(1–2):1–11. Available at <https://www.fws.gov/uploadedFiles/cryan_brown_2007_biocon.pdf> (accessed February 26, 2021).

[DOE] U.S. Department of Energy. 2011a. *2010 Solar Technologies Market Report.* Washington, DC: DOE. November 2011. 136 p. Available at <https://www.nrel.gov/docs/fy12osti/51847.pdf> (accessed March 18, 2021).

[DOE] U.S. Department of Energy. 2011b. *Final Environmental Impact Statement: Volume 1 Department of Energy Loan Guarantee to Royal Bank of Scotland for Construction and Startup of the Topaz Solar Farm, San Luis Obispo County, California.* Washington, DC: DOE. August 2011. 540 p. Available at <http://energy.gov/sites/prod/files/Topaz-FEIS-Volume-I-PDF-Version.pdf> (accessed March 18, 2021).

[DOE] U.S. Department of Energy. 2013a. “Fuel Cell Basics: Hydrogen and Fuel Cell Technologies Office.” August 14, 2013. Available at <https://www.energy.gov/eere/fuelcells/fuel-cell-basics> (accessed March 17, 2021).

[DOE] U.S. Department of Energy. 2013b. “Geothermal Basics: Geothermal.” August 14, 2013. Available at <https://www.energy.gov/eere/geothermal/geothermal-basics> (accessed March 17, 2021).

[DOE] U.S. Department of Energy. 2019. “WINDExchange: Wind Energy State Information [online database].” Office of Energy Efficiency and Renewable Energy. Available at <https://windexchange.energy.gov/states> (accessed March 21, 2021).

[DOE] U.S. Department of Energy. 2020. “Advanced Small Modular Reactors (SMRs): Office of Nuclear Energy.” Available at <http://energy.gov/ne/nuclear-reactor-technologies/small-modular-nuclear-reactors> (accessed March 12, 2021).

[DOE] U.S. Department of Energy. 2021. “Hydrogen Shot: An Introduction.” Office of Energy Efficiency and Renewable Energy, Hydrogen and Fuel Cells Technology Office. June 22, 2021. Available at <https://www.energy.gov/eere/fuelcells/articles/hydrogen-shot-introduction> (accessed July 7, 2021).

[Dominion] Dominion Energy Virginia. 2001. *North Anna Power Station, Units 1 and 2, License Renewal Application, Appendix E, Applicant’s Environmental Report.* May 2001. 238 p. ADAMS Accession No. ML011500475.

[Dominion] Dominion Electric Environmental Services. 2009. *Environmental Study of Lake Anna and the Lower North Anna River, Annual Report for 2008*. 53 p. ADAMS Package Accession No. ML21033A301.

[Dominion] Dominion Electric Environmental Services. 2014. *A Monitoring Plan for Lake Anna, Waste Heat Treatment Facility and the North Anna River*. 15 p. ADAMS Package Accession No. ML21033A301.

[Dominion] Dominion Energy. 2015. “Virginia Offshore Wind Technology Advancement Project (VOWTAP) Research Activities Plan (revised).” April. Available at <https://www.boem.gov/renewable-energy/state-activities/research-activities-plan> (accessed January 21, 2021)

[Dominion] Dominion Electric Environmental Services. 2016a. *Environmental Study of Lake Anna and the Lower North Anna River, Annual Report for 2015*. 47 p. ADAMS Package Accession No. ML21033A301.

[Dominion] Dominion Energy Virginia. 2016b. *North Anna 3 Combined License Application, Part 3: Applicant’s Environmental Report – Combined License Stage*. Revision 8. June 2016. 417 p. ADAMS Accession No. ML16218A026.

[Dominion] Dominion Electric Environmental Services. 2017. *Environmental Study of Lake Anna and the Lower North Anna River, Annual Report for 2016*. 46 p. ADAMS Package Accession No. ML21033A301.

[Dominion] Dominion Energy Virginia. 2018a. *North Anna Power Station Updated Final Safety Analysis Report.* Revision 54. September 27, 2018. ADAMS Package Accession No. ML18285A084.

[Dominion] Dominion Energy. 2018b. *Dominion Energy, North Anna Power Station VPDES Permit No. VA0052451 Application for Permit Reissuance.* October 15, 2018. 663 p. In ADAMS Package Accession No. ML21033A301.

[Dominion] Dominion Electric Environmental Services. 2018c. *Environmental Study of Lake Anna and the Lower North Anna River, Annual Report for 2017*. 52 p. ADAMS Package Accession No. ML21033A301.

[Dominion] Dominion Electric Environmental Services. 2019a. Letter from J. Williams, Director, Environmental Services, Dominion, to S. Mackert, Virginia Department of Environmental Quality. Subject: Dominion Energy North Anna Power Station VPDES Permit No. VA0052451: Application for Permit Reissuance – 316(b) 40 CFR § 122.21(r)(10)-(13). March 12, 2019. 3 p. *In* ADAMS Package Accession No. ML21033A301.

[Dominion] Dominion Electric Environmental Services. 2019b. *Environmental Study of Lake Anna and the Lower North Anna River, Annual Report for 2018*. 54 p. ADAMS Package Accession No. ML21033A301.

[Dominion] 2019c. (Intentionally left blank).

[Dominion] Dominion Electric Environmental Services. 2019d. Email from K. Roller, Environmental Manager, to A. Warren, GIS Program Support Technician, Virginia Department of Health. Subject: Thermophilic Microorganisms in Lake Anna. August 14, 2019. *In* Appendix F of Dominion 2020b.

[Dominion] Dominion Virginia Power. 2020a. *North Anna Power Station, Units 1 and 2 Application for Subsequent License Renewal.* August 2020. ADAMS Package Accession No. ML20246G703.

[Dominion] Dominion Virginia Power. 2020b. Appendix E, Applicant's Environmental Report, Subsequent Operating License Renewal Stage, North Anna Power Station, Units 1 and 2. August 2020. ADAMS Accession No. ML20246G698.

[Dominion] DominionEnergy.com. 2020c. "Lake Anna, VA." Available at <https://www.dominionenergy.com/lakes-and-recreation/lake-anna-va> (accessed March 10, 2021).

[Dominion] Dominion Energy. 2020d. Virginia Electric and Power Company's Report of its Integrated Resource Plan Before the Virginia State Corporation Commission and North Carolina Utilities Commission. Public Version. May 1, 2020. 298 p. Available at <https://www.dominionenergy.com/-/media/pdfs/global/2020-va-integrated-resource-plan.pdf?la=en&rev=fca793dd8eae4ebea4ee42f5642c9509> (accessed October 16, 2020).

[Dominion] Dominion Energy, Inc. 2020e. "News Releases: Dominion Energy Files Construction and Operations Plan for Coastal Virginia Offshore Wind Project." December 18. Available at <https://news.dominionenergy.com/2020-12-18-Dominion-Energy-Files-Construction-and-Operations-Plan-for-Coastal-Virginia-Offshore-Wind-Project> (accessed February 2, 2021).

[Dominion] Dominion Electric Environmental Services. 2020f. *Environmental Study of Lake Anna and the Lower North Anna River, Annual Report for 2019.* 52 p. ADAMS Package Accession No. ML21033A301.

[Dominion] Dominion Virginia Power. 2021a. Letter from M. D. Sartain, Vice President – Nuclear Engineering and Fleet Support, to NRC. Subject: Virginia Electric and Power Company, North Anna Power Station (NAPS) Units 1 and 2, Subsequent License Renewal Application (SLRA), Response to Request for Confirmation of Information for the Environmental Review. February 11, 2021. 14 p. ADAMS Accession No. ML21042B904.

[Dominion] Dominion Electric Environmental Services. 2021b. "Waste Heat Treatment Facility." Available at <https://www.dominionenergy.com/projects-and-facilities/nuclear-facilities/north-anna-power-station/waste-heat-treatment-facility> (accessed January 6, 2021).

[Dominion] Dominion Virginia Power. 2021c. Letter from M.D. Sartain, Vice President – Nuclear Engineering and Fleet Support, to NRC. Subject: Virginia Electric and Power Company, North Anna Power Station Units 1 and 2, Subsequent License Renewal Application, Environmental Review, Response to Request for Additional Information. February 22, 2021. 21 p. ADAMS Accession No. ML21053A433.

[EIA] U.S. Energy Information Administration. 2013. *Annual Energy Outlook 2013 with Projections to 2040*. DOE/EIA-0383 (2013). Washington, DC: EIA. April 2013. 244 p. Available at <http://www.eia.gov/forecasts/aeo/pdf/0383(2013).pdf> (accessed March 18, 2021).

[EIA] U.S. Energy Information Administration. 2015a. *Annual Energy Outlook 2015 with Projections to 2040.* DOE/EIA–0383 (2015). Washington, DC: EIA. April 2015. 154 p. Available at <http://www.eia.gov/forecasts/aeo/pdf/0383(2015).pdf> (accessed March 20, 2021).

[EIA] U.S. Energy Information Administration. 2015b. *Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2015.* Washington, DC: EIA. June 2015. 12 p. Available at <https://www.eia.gov/outlooks/archive/aeo15/pdf/electricity_generation_2015.pdf> (accessed March 21, 2021).

[EIA] U.S. Energy Information Administration. 2020a. *Annual Energy Outlook 2020 with Projections to 2050*. Washington, DC: EIA. January 2020. 161 p. Available at <https://www.eia.gov/outlooks/archive/aeo20/> (accessed March 18, 2021).

[EIA] U.S. Energy Information Administration. 2020b. "Virginia State Profile and Energy Estimates—Analysis." Washington, DC: EIA. Last updated: October 15, 2020. Available at <https://www.eia.gov/state/analysis.php?sid=VA> (accessed March 12, 2021).

[EIA] U.S. Energy Information Administration. 2021a. *Annual Energy Outlook 2021 with Projections to 2050.* Washington, DC: EIA. February 2021. 31 p. Available at <https://www.eia.gov/outlooks/aeo/> (accessed March 18, 2021).

[EIA] U.S. Energy Information Administration. 2021b. "State Electricity Profiles. Table 4. Electric Power Industry Capability by Primary Energy Source, 1990 through 2019." Available at <https://www.eia.gov/electricity/state/virginia/index.php> (accessed March 12, 2021).

[EIA] U.S. Energy Information Administration. 2021c. "State Electricity Profiles. Table 5. Electric Power Industry Generation by Primary Energy Source, 1990 through 2019." Available at <https://www.eia.gov/electricity/state> (accessed March 7, 2021).

[EIA] U.S. Energy Information Administration. 2021d. "Electric Power Monthly, Table 6.07.B: Capacity Factors for Utility Scale Generators Primarily Using Non-Fossil Fuels." Washington, DC: EIA. Available at <https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_6_07_b> (accessed March 18, 2021).

[EIA] U.S. Energy Information Administration. 2021e. "Electric Power Annual 2020, Table 1.2. Summary Statistics for the United States, 2009–2019. Utility Scale Capacity: Solar Photovoltaic." Washington, DC: EIA. October 2020; Revised February 2021. Available at <https://www.eia.gov/electricity/annual/> (accessed March 18, 2021).

[EIA] U.S. Energy Information Administration. 2021f. *Cost and Performance Characteristics of New Generating Technologies, Annual Energy Outlook 2021.* Washington, DC: EIA. February 2021. 4 p. Available at <https://www.eia.gov/outlooks/aeo/assumptions/pdf/table_8.2.pdf> (accessed March 20, 2021).

[EIA] U.S. Energy Information Administration. 2021g. "Today in Energy: Less electricity was generated by coal than nuclear in the United States in 2020." Washington, DC: EIA. March 18, 2021. Available at <https://www.eia.gov/todayinenergy/detail.php?id=47196> (accessed March 21, 2021).

[EIA] U.S. Energy Information Administration. 2021h. "Hydrogen explained." Washington, DC: EIA. January 7, 2021. Available at <https://www.eia.gov/energyexplained/hydrogen/use-of-hydrogen.php> (accessed July 7, 2021).

[Energy Daily] IHS The Energy Daily. 2016. "First U.S. Offshore Wind Farm Delivers Power to Grid." *The Energy Daily* 44(238). December 13, 2016. Available at <http://www.theenergydaily.com> (accessed December 16, 2020).

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

[Enercon et al.] Enercon Services, Inc., Normandeau Associates, Inc., and NERA Economic Counseling. 2019. *Dominion North Anna Power Station National Pollutant Discharge Elimination System (NPDES) Permit No. VA0052451, Draft Updated Final 316(b) Rule Information, 40 CFR 122.21(r)(10)-(r)(12) Submittals.* Prepared for Dominion Energy. January 2019. 572 p. ADAMS Package Accession No. ML21033A301.

[EPA] Environmental Protection Agency. 1981. *Noise Effects Handbooks: A Desk Reference to Health and Welfare Effects of Noise.* Available at <https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=9100OOAJ.TXT> (accessed December 30, 2020).

[EPA] U.S. Environmental Protection Agency. 2002. *EPA Facts about Tritium*. July 2002. 2 p. Available at <https://semspub.epa.gov/work/HQ/175261.pdf> (accessed May 13, 2019).

[EPA] U.S. Environmental Protection Agency. 2009a. *Assessment of the Impacts of Global Change on Regional U.S. Air Quality: A Synthesis of Climate Change Impacts on Ground-Level Ozone (An Interim Report of the U.S. EPA Global Change Research Program)*. Washington, DC: EPA. EPA/600/R-07/094F. April 2009. 131 p. Available at <https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=203459> (accessed March 3, 2021).

[EPA] U.S. Environmental Protection Agency. 2009b. "Greenhouse Gas Emissions: Endangerment and Cause for Contribute Findings for Greenhouse Gases under the Section 202(a) of the Clean Air Act." Last updated: July 11, 2017. Available at <https://www.epa.gov/ghgemissions/endangerment-and-cause-or-contribute-findings-greenhouse-gases-under-section-202a-clean> (accessed March 3, 2021).

[EPA] U.S. Environmental Protection Agency. 2013 "Primary Distinguishing Characteristics of Level III Ecoregions of the Continental United States." September 2013. 20 p. Available at <https://www.epa.gov/eco-research/level-iii-and-iv-ecoregions-continental-united-states> (accessed February 26, 2021).

[EPA] U.S. Environmental Protection Agency. 2016. *Climate Change Indicators in the United States, 2016*. Fourth Edition. EPA 430-R-16-004. Washington, DC. August 2016. 96 p. Available at <https://www.epa.gov/climate-indicators> (accessed December 23, 2020).

[EPA] Environmental Protection Agency. 2020a. “2017 National Emissions Inventory (NEI) Data.” Available at <https://www.epa.gov/air-emissions-inventories/2017-national-emissions-inventory-nei-data> (accessed October 19, 2020).

[EPA] U.S. Environmental Protection Agency. 2020b. “Enforcement and Compliance History Online. [Detailed Facility Report, Effluent Charts, Effluent Limit Exceedances Reports, for Virginia Electric-North Anna Power Station.]” Available at <https://echo.epa.gov/detailed-facility-report?fid=VA0052451&sys=ICP> (accessed December 4, 2020).

[EPA] U.S. Environmental Protection Agency. 2020c. “Map of Sole Source Aquifer Locations.” 2020. Available at <https://www.epa.gov/dwssa/map-sole-source-aquifer-locations> (accessed January 11, 2021).

[EPA] U.S. Environmental Protection Agency. 2020d. “Energy Recovery from the Combustion of Municipal Solid Waste (MSW).” Last updated: July 31, 2020. Available at <https://www.epa.gov/smm/energy-recovery-combustion-municipal-solid-waste-msw#EnergyRecovery> (accessed March 19, 2021).

[EPA] U.S. Environmental Protection Agency. 2020e. “Mercury and Air Toxics Standards (MATS).” Last updated: October 22, 2020. Available at <https://www.epa.gov/mats> (accessed March 20, 2021).

[EPA] Environmental Protection Agency. 2021. “Enforcement and Compliance History Online: Detailed Facility Report: VIRGINIA ELECTRIC – NORTH ANNA POWER STATION.” Available at <https://echo.epa.gov/detailed-facility-report?fid=110001891114> (accessed March 3, 2021).

[EPA] Environmental Protection Agency. 2021b. “Sole Source Aquifers for Drinking Water.” Available at <https://www.epa.gov/dwssa> (accessed March 3, 2021).

[EPRI] Energy Power Research Institute. 2004. *Technical Evaluation of the Utility of Intake Approach Velocity as an Indicator of Potential Adverse Environmental Impact under Clean Water Act Section 316(b).* Technical Report ID: 1000731. Palo Alto, CA: EPRI. 166 p. Available at <https://www.epri.com/research/products/1000731> (accessed January 12, 2021).

[EPRI] Electric Power Research Institute. 2011. *Mapping and Assessment of the United States Ocean Wave Energy Resource*. Palo Alto, CA: EPRI. Technical Report ID: 1024637. December 2011. 176 p. Available at <https://www1.eere.energy.gov/water/pdfs/mappingandassessment.pdf> (accessed March 20, 2021).

Exo K-M., Hüppop O., Garthe S. 2003. Birds and offshore wind farms: a hot topic in marine ecology. *Wader Study Group Bulletin* 100:50–53. Available at <https://sora.unm.edu/sites/default/files/journals/iwsgb/v100/p00050-p00053.pdf> (accessed February 26, 2021)

Federal Water Pollution Control Act (Clean Water Act) of 1972, as amended. 33 U.S.C. § 1251 et seq.

[FEMA] Federal Emergency Management Agency. 2020. “FEMA Flood Map Service Center: Search by Address.” Available at <https://msc.fema.gov/portal/search?AddressQuery=1022%20haley%20drive%20mineral%2C%20VA%2023117#searchresultsanchor> (accessed November 18, 2020).

Foster R.W., Kurta A. 1999. Roosting ecology of the Northern Bat (*Myotis septentrionalis*) and comparisons with the endangered Indiana Bat (*Myotis sodalis*). *Journal of Mammalogy* 80(2):659–672.

Frick W.F., Puechmaille S.J., Hoyt J.R., Nickel B.A., Langwig K.E., Foster J.T., Barlow K.E., Bartonicka T., Feller D., Haarsma A-J., Herzog C., Horácek I., van der Kooij J., Mulkens B., Petrov B., Reynolds R., Rodrigues L., Stihler C.W., Turner G.G., Kilpatrick A.M. 2015. Disease alters macroecological patterns of North American Bats. *Global Ecology and Biogeography* 24:741-749. doi:10.1111/geb.12290.

[FWS] U.S. Fish and Wildlife Service. 2007. *Indiana Bat (Myotis sodalis) Draft Recovery Plan: First Revision*. April 2007. 260 p. Available at <https://www.fws.gov/Midwest/Endangered/mammals/inba/pdf/inba_fnldrftrecpln_apr07.pdf> (accessed January 20, 2021).

[FWS] U.S. Fish and Wildlife Service. 2010. *Programmatic Biological Opinion on the Effects of Ongoing and Future Military and Land Management Activities at the Camp Atterbury Joint Maneuver Training Center in Bartholomew, Brown, and Johnson Counties in Indiana on the Federally Endangered Indiana Bat (Myotis sodalis)*. October 21, 2010. Available at <https://www.fws.gov/midwest/endangered/section7/bo/10_IN_FinalAtterburyBO.pdf> (accessed January 20, 2021).

[FWS] U.S. Fish and Wildlife Service. 2014a. Letter from F. Clark, FWS, to D. Wrona, NRC. Subject: Concurrence with effect determinations for Davis-Besse license renewal. September 30, 2014. ADAMS Accession No. ML14296A559.

[FWS] U.S. Fish and Wildlife Service. 2014b. "Guidance for Preparing a Biological Assessment." 6 p. Available at <http://www.fws.gov/midwest/endangered/section7/pdf/BAGuidance.pdf> (accessed January 20, 2021).

[FWS] U.S. Fish and Wildlife Service. 2015a. Final Environmental Assessment for Final 4(d) Rule for the Northern Long-eared Bat. December 2015. 85 p. Available at <https://www.fws.gov/midwest/endangered/mammals/nleb/pdf/NLEB4dRuleEAFINALDec2015.pdf> (accessed January 20, 2021).

[FWS] U.S. Fish and Wildlife Service. 2015b. Letter from D. Stilwell, FWS, to D. Wrona, NRC. Subject: Concurrence with determination that Indian Point license renewal is not likely to adversely affect the Indiana bat or northern long-eared bat. July 14, 2015. ADAMS Accession No. ML15196A013.

[FWS] U.S. Fish and Wildlife Service. 2016. *Programmatic Biological Opinion on Final 4(d) Rule for the Northern Long-Eared Bat and Activities Excerpted from Take Prohibitions*. Bloomington, MN: FWS. January 5, 2016. 109 p. Available at <https://www.fws.gov/midwest/endangered/mammals/nleb/pdf/BOnlebFinal4d.pdf> (accessed January 20, 2021).

[FWS] U.S. Fish and Wildlife Service. 2018. Letter from T.R. Chapman, New England Field Office Supervisor, to B. Beasley, NRC. Subject: Concurrence on NRC Findings for Seabrook Station Unit 1 License Renewal, Seabrook NH. September 20, 2018. ADAMS Accession No. ML18263A200.

[FWS] U.S. Fish and Wildlife Service. 2019. Letter from Virginia Ecological Services Field Office, FWS, to B. Grange, NRC. Subject: Verification letter for the Surry Power Station, Units 1 and 2, subsequent license renewal project under the January 5, 2016, programmatic biological opinion on final 4(d) rule for northern long-eared bat and activities excepted from take prohibitions. April 9, 2019. ADAMS Accession No. ML19157A113.

[FWS] U.S. Fish and Wildlife Service. 2020a. "Migratory Bird Treaty Act Protected Species (10.13 List)." April 16, 2020. Available at <https://www.fws.gov/birds/management/managed-species/migratory-bird-treaty-act-protected-species.php> (accessed January 20, 2021).

[FWS] U.S. Fish and Wildlife Service. 2020b. Letter from Virginia Ecological Services Field Office, FWS, to B. Grange, NRC. Subject: Verification letter for the North Anna Power Station, Units 1 and 2, subsequent license renewal project under the January 5, 2016, programmatic biological opinion on final 4(d) rule for northern long-eared bat and activities excepted from take prohibitions. October 26, 2020. ADAMS Accession No. ML20300A512.

[FWS] U.S. Fish and Wildlife Service. 2021. Letter from Virginia Ecological Services Field Office, FWS, to B. Grange, NRC. Subject: North Anna Power Station, Units 1 and 2, subsequent license renewal updated list of threatened and endangered species that may occur in your proposed project location, and/or may be affected by your proposed project. January 20, 2021. ADAMS Accession No. ML21021A198.

[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. 219 p. Available at <http://www.fws.gov/endangered/esa-library/pdf/esa_section7_handbook.pdf> (accessed January 20, 2021).

[GAI] GAI Consultants, Inc. 2016. Bat Survey Report, Dominion Virginia Power North Anna Power Station Project, Louisa County, Virginia. Prepared for Dominion Virginia Power. GAI Project No.: C15158.00. July 2016. 58 p. ADAMS Accession No. ML16211A178.

Haley & Aldrich. 2020. Groundwater Protection Program, Five-Year Hydrogeological Review North Anna Power Station, Mineral, Virginia. June 4. 10 p. ADAMS Package Accession No. ML21033A301.

Hathcock, C. 2019. *Literature review on impacts to avian species from solar energy collection and suggested mitigations.* Department of Energy. Available at <https://www.energy.gov/sites/prod/files/2019/03/f61/Hathcock%202018.pdf> (accessed January 20, 2021).

[HDR] HDR Engineering, Inc. 2018a. *North Anna Power Station §316(b) Submittal Requirements: §122.21(r)(1)-(9) Reports, Appendix F, 2016-2017 Entrainment Characterization Study*. Prepared for Dominion Energy, Inc. June 30, 2018. 130 p. ADAMS Package Accession No. ML21033A301.

[HDR] HDR Engineering, Inc. 2018b. *North Anna Power Station §316(b) Submittal Requirements: §122.21(r)(2)-(9) Reports*. Prepared for Dominion Energy, Inc. June 27, 2018. 215 p. ADAMS Package Accession No. ML21033A301.

Horton J.W. Jr., Chapman M.C., Green R.A. 2015. The 2011 Mineral, Virginia, earthquake, and its significance for seismic hazards in eastern North America–Overview and synthesis. *Geological Society of America Special Paper.* 509:1–25. Available at <https://www.researchgate.net/publication/272504552_The_2011_Mineral_Virginia_earthquake_and_its_significance_for_seismic_hazards_in_eastern_North_America-Overview_and_synthesis> (accessed January 13, 2021).

Horváth G., Kriska G., Malik P., Robertson B. 2009. Polarized light pollution: a new kind of ecological photopollution. *Frontiers in Ecology and the Environment* 7(6):317-325. August 2009 Available at <https://esajournals.onlinelibrary.wiley.com/doi/full/10.1890/080129> (accessed January 20, 2021).

[IEA] International Energy Agency. 2007. *Biomass for Power Generation and CHP*. Paris, FR: IEA Energy Technology Essentials ETE03. January 2007. 4 p. Available at <https://www.iea.org/reports/biomass-for-power-generation-and-chp#:~:text=Biomass%20for%20Power%20Generation%20and%20CHP%20Biomass%20combustion,the%20most%20cost-effective%20biomass%20use%20for%20power%20generation> (accessed March 21, 2021).

[IPCC] Intergovernmental Panel on Climate Change. 2007. *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment* 35 *Report of the Intergovernmental Panel on Climate Change*. Solomon S., Qin D., et al. 36 (editors). Cambridge University Press, Cambridge, UK. 2007. 996 p. Available at <https://www.ipcc.ch/report/ar4/wg1/> (accessed March 3, 2021).

[IPCC] Intergovernmental Panel on Climate Change. 2013. *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Stocker T.F., Qin D., et al. Cambridge University Press, Cambridge, UK. 2013. 1535 p. Available at <https://www.ipcc.ch/report/ar5/wg1/> (accessed December 23, 2020).

[IUCN] International Union for the Conservation of Nature. 2018. "Northern Gannet: Morus bassanus." The IUCN Red List of Threatened Species. August 10, 2018. Available at <https://www.iucnredlist.org/species/22696657/132587285> (accessed February 26, 2021).

Jamerson M., Remmers K., Cabral G., Marciano-Cabral F. Survey for the presence of Naegleria fowleri amebae in lake water used to cool reactors at a nuclear power generating plant. *Parasitology Research* 104(5): 969–978. April 2009.

Johnson G.D., Strickland M.D. (Western Ecosystems Technology, Inc.). 2003. Biological Assessment for the Federally Endangered Indiana Bat (*Myotis sodalis*) and Virginia Big-eared Bat (*Corynorhinus townsendii virginianus*): NedPower Mount Storm Wind Project, Grant County, West Virginia. Chantilly, VA: Prepared for NedPower Mount Storm LLC. October 8, 2003. 48 p. Available at <https://tethys.pnnl.gov/sites/default/files/publications/JohnsonNedPower-2003.pdf> (accessed January 20, 2021).

Johnson G.D., Erickson W.P., Strickland M.D., Shepherd M.F., Shepherd D.A., Sarappo S.A. 2003. Mortality of Bats at a Large-scale Wind Power Development at Buffalo Ridge, Minnesota. *The American Midland Naturalist* 150(2):332–34.

[Lake Anna] Lake Anna Special Area Plan Committee. 2000. "*Lake Anna Special Area Plan*." March 2000. 113 p. Available at <https://www.lakeannavirginia.org/Lake-Anna-Special> (accessed March 9, 2021).

Loss S.R., Will T., Marra P.P. 2013. Estimates of bird collision mortality at wind facilities in the contiguous United States. *Biological Conservation* 168:201–09. Available at <https://www.fws.gov/migratorybirds/pdf/management/lossetal2013windfacilities.pdf> (accessed February 26, 2021).

Louisa County. 2019. *County of Louisa Comprehensive Plan 2040.* Adopted September 3, 2019. 37 p. Available at <https://www.louisacounty.com/DocumentCenter/View/5540/2040-Comprehensive-Plan-Web-posting> (accessed January 7, 2021).

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

Marciano-Cabral F. 2007. Studies to Identify Naegleria fowleri Amebae, Causative Agent of Primary Amebic Meningoencephalitis, in Lake Anna. A final report submitted to the Lake Anna Civic Association. December 2007. ADAMS Accession No. ML093210605.

Mayhew D.A., Jensen L.D., Hanson D.F., Muessig P.H. 2000. A comparative review of entrainment survival studies at power plants in estuarine environments. *Environmental Science & Policy.* 3(1):295–301. doi:10.1016/S1462-9011(00)00069-1.

[MCDC] Missouri Census Data Center, Circular Area Profiles (CAPS). 2021. “2010 Census Summary File 1, Aggregated Census Block Group Data on Hispanic, Latino or Spanish origin and Race, and 2015–2019 American Community Survey (ACS) data, Summary of aggregated Census Tract data on Poverty within a 50-mile (80-kilometer) radius around the North Anna Power Station Facility (38.060556 Lat., -77.789444 Long.).” Available at <https://mcdc.missouri.edu/applications/caps2010.html> (Accessed March 2021).

Meehl G.A., Tebaldi C., Tilmes S., Lamarque JF., Bates S., Pendergrass A., Lombardozzi D. 2018. Future heat waves and surface ozone. *Environmental Research Letters* 13(2018):06404. Available at <https://doi.org/10.1088/1748-9326/aabcdc> (accessed January 20, 2021).

Michaels T., Krishnan K. 2019. “Energy Recovery Council 2018 Directory of Waste-to-Energy Facilities.” October 2019. Available at <https://energyrecoverycouncil.org> (accessed March 20, 2021).

Migratory Bird Treaty Act of 1918, as amended. 16 U.S.C. § 703 et seq.

Moore B.C., Martinez E., Gay J.M., Rice D.H. 2003. Survival of *Salmonella enterica* in freshwater and sediments and transmission by the aquatic midge *Chironomus tentans* (Chironomidae: Diptera). *Applied and Environmental Microbiology* 69(8):4556–4560. Available at <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC169145/> (accessed December 16, 2020).

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

National Historic Preservation Act, as amended. 54 U.S.C. § 300101 et seq.

[NASS] National Agricultural Statistics Service, U.S. Department of Agriculture. 2021. “2017 Census of Agriculture,” Volume 1, Chapter 2, County and County Level, Table 7. “Hired Farm Labor – Workers and Payroll: 2017.” 2017 Census of Agriculture, Volume 1 Chapter 2, County Level Data for Maryland and County Level Data for Virginia. Last modified: 6/24/2019. Available at <https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Census_by_State/index.php> (accessed March 2021).

[NCDC] National Oceanic and Atmospheric Administration. 2020. “2019 Local Climatological Data Annual Summary with Comparative Data, Richmond, Virginia (KRIC).” Available at <https://www.ncdc.noaa.gov/IPS/lcd/lcd.html> (accessed February 26, 2021).

[NCEI] National Centers for Environmental Information. 2020. “Storms Events Database.” [Database search: Virginia, Louisa County, 01/1950–09/30/2020]. Available at <https://www.ncdc.noaa.gov/stormevents/choosedates.jsp?statefips=51%2CVIRGINIA> (accessed September 2020).

[NCES] National Center for Education Statistics. 2021. “Louisa County Public School Districts.” 2016-2017, 2017-2018 school years. Available at <http://nces.ed.gov/ccd/districtsearch/> (accessed March 2021).

[NEI] Nuclear Energy Institute. 2007. “Industry Ground Water Protection Initiative—Final Guidance Document.” NEI 07-07 [Final]. Washington, DC: NEI. August 2007. 27 p. ADAMS Accession No. ML072610036.

[NIEHS] National Institute of Environmental Health Sciences. 1999. *NIEHS Report on Health Effects from Exposure to Power-Line Frequency Electric and Magnetic Fields*. Research Triangle Park, NC: NIEHS. Publication No. 99-4493. May 4, 1999. 80 p. Available at <https://www.niehs.nih.gov/health/assets/docs_p_z/report_powerline_electric_mg_predates_508.pdf> (accessed June 10, 2018).

[NIEHS] National Institute of Environmental Health Sciences. 2021. “Algal Blooms.” Page updated January 21, 2021. Available at <https://www.niehs.nih.gov/health/topics/agents/algal-blooms/index.cfm#:~:text=What%20are%20the%20health%20effects,cause%20paralysis%20and%20even%20death> (accessed on February 2, 2021).

[NMFS] National Marine Fisheries Service. 2019. Email from J. Crocker, Endangered Fish Branch Chief, to O. Shehab-Dandan and T. Banks, Dominion. Subject: Federally listed species applicable to North Anna relicensing. July 18, 2019. *In:* Dominion 2020b, Attachment C: Threatened and Endangered Species Consultation Letters North Anna Power Station, Units 1 and 2. ADAMS Accession No. ML20246G698.

[NOAA] National Oceanic and Atmospheric Administration. 2013a. *Regional Climate* 1 *Trends and Scenarios for the U.S. National Climate Assessment, Part 2. Climate of the Southeast U.S.* Washington, DC: NOAA. NOAA Technical Report NESDIS 142-2. January 2013. 103 p. Available at <https://www.nesdis.noaa.gov/content/technical-reports> (accessed February 26, 2021).

[NOAA] National Oceanic and Atmospheric Administration. 2013b. *Regional Climate Trends and Scenarios for the U.S. National Climate Assessment, Part 9. Climate of the Contiguous United States*. Washington, DC: NOAA. NOAA Technical Report NESDIS 142-9. January 2013. 85 p. Available at <https://scenarios.globalchange.gov/report/regional-climate-trends-and-scenarios-us-national-climate-assessment-part-9-climate> (accessed December 23, 2020).

[NOAA] National Oceanic and Atmospheric Administration. 2020a. NOAA Study: Most of the years in next decade very likely to rank as Top 10 warmest years. Available at <https://www.ncei.noaa.gov/news/projected-ranks> (accessed December 28, 2020).

[NOAA] National Oceanic and Atmospheric Administration. 2020b. “2019 was 2nd hottest year on record for Earth say NOAA, NASA.” Available at <https://www.noaa.gov/news/2019-was-2nd-hottest-year-on-record-for-earth-say-noaa-nasa> (accessed December 28, 2020).

[NOAA] National Oceanic and Atmospheric Administration. 2020c. “Climate at a Glance: Divisional Time Series.” Search: average annual temperature and precipitation for Virginia Climate Division 2. Available at <https://www.ncdc.noaa.gov/cag/divisional/time-series> (December 23, 2020).

Nolte C.G., Spero T.L., Bowden J.H., Mallard M.S., Dolwick P.D. 2018. The potential effects of climate change on air quality across the conterminous US at 2030 under three Representative Concentration Pathways. *Atmospheric Chemistry and Physics* 18(20): 15471–15489. Available at <https://doi.org/10.5194/acp-18-15471-2018> (accessed August 21, 2019).

[NRC] U.S. Nuclear Regulatory Commission. 1996. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Final Report.* Washington, DC: NRC. NUREG-1437, Volumes 1 and 2. May 9, 1996. 1,204 p. ADAMS Accession Nos. ML040690705 and ML040690738.

[NRC] U.S. Nuclear Regulatory Commission. 1999. *Generic Environmental Impact Statement License Renewal of Nuclear Plants, Main Report, Section 6.3—Transportation, Table 9.1, Summary of findings on NEPA issues for license renewal of nuclear power plants.* NUREG-1437, Volume 1, Addendum 1. August 1999. 100 p. ADAMS Accession No. ML040690720.

[NRC] U.S. Nuclear Regulatory Commission. 2002a. *Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities: Supplement 1, Regarding the Decommissioning of Nuclear Power Reactors.* NUREG-0586, Volumes 1 and 2. November 30, 2002. 516 p. ADAMS Accession Nos. ML023470327, ML023500228, and ML023500295.

[NRC] U.S. Nuclear Regulatory Commission. 2002b. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants Regarding North Anna, Units 1 and 2.* Washington, DC: NRC. NUREG-1437, Supplement 7. Final Report. November 2002. 411 p. ADAMS Accession Nos. ML023380542 and ML023380567.

[NRC] U.S. Nuclear Regulatory Commission. 2006. *Environmental Impact Statement for and Early Site Permit (ESP) at the North Anna ESP Site*. Washington, DC: NRC. NUREG-1811, Volumes 1 and 2. Final Report. December 2006. 1,299 p. ADAMS Accession Nos. ML063470330 and ML063470332.

[NRC] U.S. Nuclear Regulatory Commission. 2007. North Anna Early Site Permit No. ESP-003. ADAMS Accession No. ML073180440.

[NRC] U.S. Nuclear Regulatory Commission. 2010. *Supplemental Environmental Impact Statement for Combined License (COL) for North Anna Power Station Unit 3*. Washington, DC: NRC. NUREG-1917. Final Report. February 2010. 728 p. ADAMS Accession No. ML100680117.

[NRC] U.S. Nuclear Regulatory Commission. 2010b. Tritium Database Report. ADAMS Accession No. ML101930417.

[NRC] U.S. Nuclear Regulatory Commission. 2011. *North Anna Power Station, Units 1 and 2, Technical Evaluation Related to Plant Restart After the Occurrence of An Earthquake Exceeding the Level of the Operating Basis and Design Basis Earthquakes*. Washington, DC: NRC. November 11, 2011. ADAMS Accession No. ML11308B406.

[NRC] U.S. Nuclear Regulatory Commission. 2012. *Request for Information Pursuant to Title 10 of the* Code of Federal Regulations *50.54(f) Regarding Recommendations 2.1,2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-Ichi Accident*. March 12, 2012. ADAMS Accession No. ML12053A340.

[NRC] U.S. Nuclear Regulatory Commission. 2013a. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants. Revision 1.* NUREG-1437, Volumes 1, 2, and 3. June 2013. 1,535 p. ADAMS Package Accession No. ML13107A023.

[NRC] U.S. Nuclear Regulatory Commission. 2013c. *Memorandum of Understanding Between NRC and OSHA for NRC-Regulated Facilities.* Final Report. October 2013. ADAMS Accession No. ML11354A432.

[NRC] U.S. Nuclear Regulatory Commission. 2013d. *Preparation of Environmental Reports for Nuclear Power Plant License Renewal Applications. Regulatory Guide 4.2, Supplement 1*, Revision 1. June 2013. ADAMS Accession No. ML13067A354.

[NRC] U.S. Nuclear Regulatory Commission. 2013e. *Standard Review Plans for Environmental Reviews for Nuclear Power Plants, Supplement 1: Operating License Renewal.* NUREG-1555, Revision 1. June 30, 2013. 325 p. ADAMS Accession No. ML13106A246.

[NRC] U.S. Nuclear Regulatory Commission. 2014a. *Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel.* NUREG-2157, Volumes 1 and 2. September 2014. 1,404 p. ADAMS Package Accession No. ML14198A440.

[NRC] U.S. Nuclear Regulatory Commission. 2014b. *Assessment of Impacts to Kirtland's Warbler* (*Setophaga kirtlandii*)*, Northern Long-Eared Bat (Myotis septentrionalis) and Red Knot (Calidris canutus rufa), Davis-Besse Nuclear Power Station Proposed License Renewal*. May 2014. 16 p. ADAMS Accession No. ML14168A616.

[NRC] U.S. Nuclear Regulatory Commission. 2015. *Biological Assessment on the Northern Long-Eared Bat (Myotis septentrionalis) and Indiana Bat* (Myotis sodalis) *for the Indian Point Nuclear Generating Units 2 and 3 Proposed License Renewal*. July 2015. 21 p. ADAMS Accession No. ML15161A086.

[NRC] U.S. Nuclear Regulatory Commission. 2016a. *Proposed Resolution of Remaining Tier 2 and 3 Recommendations Resulting from the Fukushima Dai-Ichi Accident*. Commission paper SECY-16-0144. December 29, 2016. ADAMS Accession No. ML16286A552.

[NRC] U.S. Nuclear Regulatory Commission. 2016b. *Event Notification Report for December 29, 2016.* Available at <https://www.nrc.gov/reading-rm/doc-collections/event-status/event/2016/20161229en.html> (accessed January 11, 2021).

[NRC] U.S. Nuclear Regulatory Commission. 2017. *Staff Requirements – Secy-16-0144 – Proposed Resolution of Remaining Tier 2 and 3 Recommendations Resulting from the Fukushima Dai-Ichi Accident.* May 3, 2017. ADAMS Accession No. ML17123A453.

[NRC] U.S. Nuclear Regulatory Commission. 2017b. *Issuance of Combined License for North Anna Unit 3*. Virginia Electric and Power Company (doing business as Dominion Virginia Power). Docket No. 52-017; License No. NPF 103. June 2, 2017. ADAMS Accession No. ML17128A500

[NRC] U.S. Nuclear Regulatory Commission. 2018a. *Environmental Impact Statement for an Early Site Permit (ESP) at the Clinch River Nuclear Site. Draft Report for Comment.* NUREG-2226, Volumes 1, and 2. April. ADAMS Accession No. ML18100A220.

[NRC] U.S. Nuclear Regulatory Commission. 2018b. *Biological Evaluation of Impacts to Northern Long-Eared Bat, Rufa Red Knot, Piping Plover, and Roseate Tern for the Seabrook Station, Unit 1, Proposed License Renewal*. July 2018. 45 p. ADAMS Accession No. ML18186A692.

[NRC] U.S. Nuclear Regulatory Commission. 2019a. "Backgrounder on Tritium, Radiation Protection Limits, and Drinking Water Standards." April 2019. 7 p. ADAMS Accession No. ML062020079. Also available at <https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/tritium-radiation-fs.html> (accessed January 21, 2021).

[NRC] U.S. Nuclear Regulatory Commission. 2020a. Letter from R. Bernardo, NRC, to D. Stoddard, Senior Vice President and Chief Nuclear Officer. Subject: North Anna Power Station, Units 1 And 2 – Documentation of the Completion of Required Actions Taken in Response to the Lessons Learned from the Fukushima Dai-Ichi Accident. June 9, 2020. ADAMS Accession No. ML20139A077.

[NRC] U.S. Nuclear Regulatory Commission. 2020b. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants Regarding Surry Power Station, Units 1 and 2*. Washington, DC: NRC. NUREG-1437, Supplement 6, Second Renewal. Final Report. April 2020. 523 p. ADAMS Accession No. ML20071D538.

[NRC] U.S. Nuclear Regulatory Commission. 2020c. *Occupational Radiation Exposure at Commercial Nuclear Power Reactors and other Facilities 2019: Fifty-First Annual Report.* NUREG-0713, Volume 40. March 2020. 236 p. ADAMS Accession No. ML20087J424.

[NRC] U.S. Nuclear Regulatory Commission. 2020d. *2020–2021 Information Digest.* NUREG-1350, Volume 32. October 2020. ADAMS Accession No. ML20282A632.

[NRC] U.S. Nuclear Regulatory Commission. 2020e. "Design Certification Application - NuScale." Page updated December 2, 2020. Available at <https://www.nrc.gov/reactors/new-reactors/design-cert/nuscale.html> (accessed March 12, 2021).

[NRC] U.S. Nuclear Regulatory Commission. 2021. "Radioactive Effluent and Environmental Reports." Page updated February 18, 2021. Available at <https://www.nrc.gov/reactors/operating/ops-experience/tritium/plant-info.html> (accessed January 26, 2021).

[NREL] National Renewable Energy Laboratory. 2013. *Land Use Requirements for Solar Power Plants in the United States.* Golden, CO: National Renewable Energy Laboratory. NREL/TP 6A20 56290. June 2013. 47 p. Available at <http://www.nrel.gov/docs/fy13osti/56290.pdf> (accessed March 18, 2021).

[NREL] National Renewable Energy Laboratory. Undated. "Concentrating Solar Power." Available at <https://www.nrel.gov/csp/index.html> (accessed March 18, 2021).

[NREL] National Renewable Energy Laboratory. 2016. *Geothermal Power Generation: Current and Planned Nameplate Capacity (MW) by State.* November 28, 2016. Available at <https://www.nrel.gov/gis/assets/images/geothermal-capacity.jpg> (accessed March 20, 2021).

[NREL] National Renewable Energy Laboratory. 2018. "Solar Resource Maps: Global Horizontal Irradiance." February 22, 2018. Available at <http://www.nrel.gov/gis/solar.html> (accessed March 18, 2021).

[NREL] National Renewable Energy Laboratory. 2020. *Electricity Annual Technology Baseline (ATB) Data – Wind: Offshore* Available at <https://atb.nrel.gov/electricity/2020/data.php> (accessed February 2, 2021).

[NRR] Natural Resource Report. 2010. *Federal Land Managers' Air Quality Related Values Work Group (FLAG): Phase 1 Report—Revised (2010)*. Denver, CO: National Park Service. Natural Resource Report NPS/NRPC/NRR—2010/232. October 2010. Available at <https://www.fws.gov/guidance/sites/default/files/documents/FLAG%20Air%20Quality%20Phase%201%20report.pdf> (accessed October 19, 2020).

[NuScale] NuScale Power, LLC. 2021a. "Environment - Minimizing Environmental Footprint." Available at <https://www.nuscalepower.com/environment/environmental-footprint> (accessed July 7, 2021).

[NuScale] NuScale Power, LLC. 2021b. “NuScale FAQs.” Available at <http://www.nuscalepower.com/about-us/faqs#p1a5> (accessed March 12, 2021).

Occupational Safety and Health Act of 1970, as amended. 29 U.S.C. § 651 et seq.

[OIPP] Office of Innovative Partnerships and Alternate Funding, Highway Division, Oregon Department of Transportation, State of Oregon. 2010. *Health and Safety Concerns of Photovoltaic Solar Panels.* Salem, OR: DOT. Available at <https://www.gusd.net/cms/lib/CA01000648/Centricity/Domain/53/6.%20OR%20PV%20health%20and%20safety.pdf> (accessed September 10, 2018).

[ORNL] Oak Ridge National Laboratory. 2012. *An Assessment of Energy Potential at Non Powered Dams in the United States.* Oak Ridge, TN: ORNL. April 2012. 44 p. Available at <https://www.energy.gov/sites/prod/files/2013/12/f5/npd_report_0.pdf> (accessed March 18, 2021).

Oscar T.P. 2009. Predictive Model for Survival and Growth of Salmonella typhimurium DT104 on Chicken Skin during Temperature Abuse. *Journal of Food Protection* 72(2):304–314.

Owen S.F., Menzel M.A., Ford M.W., Edwards J.W., Chapman B.R., Miller K.V., Wood P.B. 2002. *Roost Tree Selection by Maternal Colonies of Northern Long-eared Myotis in an Intensely Managed Forest*. U.S. Department of Agriculture Forest Service. General Technical Report NE-292. Available at <https://www.fs.usda.gov/treesearch/pubs/3172> (accessed January 20, 2021).

Pearson W.E. 2019. Legionella 2019: An Update and Statement by the Association of Water Technologies (AWT). Rockville, MD: Association of Water Technologies. June 2003. 33 p. Available at <https://www.awt.org/pub/035C2942-03BE-3BFF-08C3-4C686FB7395C> (accessed December 16, 2020).

[PHAC] Public Health Agency of Canada. 2011. “Pathogen Safety Data Sheets: Infectious Substances – Shigella spp.” Modified February 18, 2011. Available at <http://www.phac-aspc.gc.ca/lab-bio/res/psds-ftss/shigella-eng.php> (accessed December 16, 2020).

Porak, W., Tranquilli J.A. 1981. Impingement and entrainment of fishes at Kincaid Generating Station. *Illinois Natural History Survey Bulletin* 32(4):631–655.

Pollution Prevention Act of 1990. 42 U.S.C. § 13101 et seq.

Powell J.D., Abe J.M. 1985. *Availability and quality of ground water in the Piedmont Province of Virginia.* Richmond, VA: U.S. Geological Survey Water Resources Investigations Report 85-4235W. 38 p. Available at <https://pubs.er.usgs.gov/publication/wri854235> (accessed February 26, 2021).

[Power] POWER Magazine. 2018. “The Big Picture: Storage Mandates.” Volume 162, Number 3. March 2018.

[Power] POWER Magazine. 2019. “Waste-to-Energy: A Niche Market in Decline?” Volume 163, Number 6. June 2018.

POWER 2020a. “Big Lift for Newly Launched Siemens Gamesa 14-MW Offshore Wind Turbine”. POWER Magazine. June 24. Available at <https://www.powermag.com/big-lift-for-newly-launched-siemens-gamesa-14-mw-offshore-wind-turbine/> (accessed October 25, 2020).

POWER 2020b. Innovative Byproduct-Hydrogen Fuel Cell Power Plant Completed. POWER Magazine. August 13. Available at <https://www.powermag.com/innovative-byproduct-hydrogen-fuel-cell-power-plant-completed/> (accessed March 20, 2021).

Resource Conservation and Recovery Act of 1976, as amended. 42 U.S.C. § 6901 et seq.

Rivers and Harbors Appropriation Act of 1899, as amended. 33 U.S.C. § 403 Section 10.

Roble S.M. 2020. *Natural Heritage Resources of Virginia: Rare Animals*. Natural Heritage Rare Species Lists (2020-Fall). Richmond, VA: Virginia Department of Conservation and Recreation, Division of Natural Heritage 83 pp. Available at <https://www.dcr.virginia.gov/natural-heritage/document/anlistsep2020.pdf> (accessed December 3, 2020).

Runkle J., Kunkel K.E., Stevens L., Champion S., Stewart B.C., Frankson R., Sweet W. 2017. *Virginia State Climate Summary.* NOAA Technical Report NESDIS 149 VA. 5 p. Available at <https://statesummaries.ncics.org/> (accessed February 26, 2021).

Saunders W.E. 1930. Bats in migration. *Journal of Mammalogy* 11:2–225.

Schaub A., Ostwald J., Siemers B.M. 2008. Foraging Bats Avoid Noise. *Journal of Experimental Biology* 211:3174–3180.

Siemens Gamesa. Undated. *Wind Turbine Generator Model SG 14-222 DD Product Brochure.* Vizcaya, ES: Siemens Gamesa Renewable Energy, S.A. 3 p. Available at <https://www.siemensgamesa.com/en-int/products-and-services/offshore/wind-turbine-sg-14-222-dd> (accessed October 25, 2020).

Sjollema A.L., Gates J.E., Hilderbrand R.H., Sherwell J. 2014. Offshore Activity of Bats Along the Mid-Atlantic Coast. *Northeastern Naturalist* 21:154–63. June 1, 2014.

Spotsylvania County. 2018. *Spotsylvania County Comprehensive Plan.* 166 p. Available at <https://www.spotsylvania.va.us/DocumentCenter/View/2119/Comprehensive-Plan-PDF> (accessed January 7, 2021).

Sullivan R.G., Kirchler L.B., Cothren J., Winters S.L. 2013. Offshore Wind Turbine Visibility and Visual Impact Threshold Distances. Argonne National Laboratory. *Environmental Practice* 15(1): 33–49 Available at <https://blmwyomingvisual.anl.gov/docs/EnvPractice_Offshore%20Wind%20Turbine%20Visibility%20and%20Visual%20Impact%20Threshold%20Distances.pdf> doi: https://doi.org/10.1017/S1466046612000464.

Swain L.A., Mesko T.O., Hollyday E.F.. 2004. *Summary of the hydrogeology of the Valley and Ridge, Blue Ridge, and Piedmont Physiographic Provinces in the eastern United States.* Reston, VA: U.S. Geological Survey Professional Paper 1422-A. 23 p. Available at <https://pubs.er.usgs.gov/publication/pp1422A> (accessed February 26, 2021).

Tao Z., Williams A., Huang H., Caughey M., Liang X. 2007. Sensitivity of U.S. surface ozone to future emissions and climate changes. *Geophysical Research Letters* 34(8):L08811. doi:10.1029/2007GL029455.

Tarr A.C., Wheeler R.L. 2006. "Earthquakes in Virginia and Vicinity 1774–2004: U.S. Geological Survey Open-File Report 2006–1017." 1 p. Available at <https://pubs.usgs.gov/of/2006/1017/> (accessed January 3, 2021).

Taylor W.K., Anderson B.H. 1973. Nocturnal migrants killed at a central Florida TV tower: Autumns 1969–1971. *Wilson Bulletin* 85:42–51.

Todar K. 2004. "Pseudomonas." *In*: *Todar's Online Textbook of Bacteriology:* Available at <http://textbookofbacteriology.net/pseudomonas.html> (accessed December 16, 2020).

Tyndall R.L., Ironside K.S., Metler P.L., Tan E.L., Hazen T.C., Fliermans C.B. 1989. Effect of thermal additions on the density and distribution of thermophilic amoebae and pathogenic naegleria fowleri in a newly created cooling lake. *Applied and Environmental Microbiology* 55(3):722–732.

[U.S. Army] U.S. Army Garrison Fort Drum, Fish and Wildlife Management Program. 2014. *Biological Assessment on the Proposed Activities on Fort Drum Military Installation, Fort Drum, New York (2015–2017) for the Indiana Bat (Myotis sodalis) and Northern Long-Eared Bat (Myotis septentrionalis)*. September 2014. 176 p. Available at <https://fortdrum.isportsman.net/files/Documents%2FPublications%2FFortDrumBatBiologicalAssessment2015-2017.pdf> (accessed May 10, 2021).

[USCB] U.S. Census Bureau. 2021. Table DP03 – "Selected Economic Characteristics," 2015-2019, American Community Survey (ACS) 5 Year Estimates for Louisa and Orange Counties. "Poverty Thresholds for 2019 by Size of Family and Number of Related Children Under 18 Years." 1980–2010 Decennial Census: 1900 to 1990; Table DP-1 – "Profile of General Demographic Characteristics: 2000", and Table DP-1, "Profile of General Population and Housing Characteristics: 2010, 2010 Demographic Profile Data" for Louisa and Orange Counties. "2015–2019 American Community Survey 5 Year Estimates," Table DP05 – "ACS Demographic and Housing Estimates" for Louisa and Orange Counties. "2015–2019 American Community Survey 5 Year Estimates," Table B25001 – "Housing Units" and Table B25004 – "Vacancy Status" for counties within 50-mile radius of North Anna." "2015–2019 American Community Survey 5 Year Estimates," Table DP04 – Selected Housing Characteristics" for Louisa and Orange Counties. Available at <https://data.census.gov/cedsci/> (accessed March 2021).

[USDA] U.S. Department of Agriculture. 2020. "Web Soil Survey: Custom Soil Reports for Louisa County and Spotsylvania County, Virginia." Natural Resources Conservation Service. Available at <https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx> (accessed December 17, 2020).

[USGCRP] U.S. Global Change Research Program. 2009. *Global Climate Change Impacts in the United States*. New York, NY: NOAA National Climatic Data Center. June 2009. 196 p. Available at <https://www.globalchange.gov/browse/reports/global-climate-change-impacts-united-states> (accessed December 28, 2020).

[USGCRP] U.S. Global Change Research Program. 2014. *Climate Change Impacts in the United States: The Third National Climate Assessment*. Washington, DC: Federal National Climate Assessment and Development Advisory Committee. May 2014. Revised October 2014. 841 p. doi:10.7930/J0Z31WJ2.

[USGCRP] U.S. Global Change Research Program. 2017. *Climate Science Special Report: Fourth National Climate Assessment, Volume 1*. Washington, DC: USGCRP. 2017. 470 p. doi:10.7930/J0J964J6. Or available at <https://science2017.globalchange.gov/> (accessed December 28, 2020).

[USGCRP] U.S. Global Change Research Program. 2018. *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II*. Washington, DC: USGCRP. 2018. 1,515 p. doi:10.7930/NCA4.2018. Or available at <https://nca2018.globalchange.gov/> (accessed December 28, 2020).

[USGS] U.S. Geological Survey. 1986. *National water summary 1986; Hydrologic events and ground-water quality*. Water Supply Paper 2325, "Natural radioactivity in ground water - A review" by O. S. Zapecza and Zoltan Szabo. Compiled by: David W. Moody, Jerry E. Carr, Edith B. Chase, and Richard W. Paulson. ADAMS Accession No. ML093160829.

[USGS] U.S. Geological Survey. 2008. *Assessment of Moderate- and High-Temperature Geothermal Resources of the United States.* Menlo Park, CA: USGS. Fact Sheet 2008–3082. 2008. 4 p. Available at <https://pubs.usgs.gov/fs/2008/3082/pdf/fs2008-3082.pdf> (accessed March 20, 2021).

[USGS] U.S. Geological Survey. 2015. "Bat Fatalities at Wind Turbines—Investigating the Causes and Consequences." Fort Collins Science Center. March 18, 2015. Available at <https://www.usgs.gov/centers/fort/science/bat-fatalities-wind-turbines-investigating-causes-and-consequences?qt-science_center_objects=0#qt-science_center_objects> (accessed January 20, 2021).

[USGS] U.S. Geological Survey. 2020. "Nonindigenous Aquatic Species [NAS] Mapper [online database and mapping application]." [Search Reports for *Dreissena polymorpha*, zebra mussel, and *Channa argus*, northern snakehead]. April 29, 2021. Available at <https://nas.er.usgs.gov/viewer/omap.aspx> (accessed December 9, 2020).

[USGS] U.S. Geological Survey. 2021a. "Search Earthquake Catalog." [Search parameters: latitude 38.061571 N; longitude --77.790566 W; radius 80 km]. Earthquake Hazards Program. Available at <https://earthquake.usgs.gov/earthquakes/search/> (accessed January 13, 2021).

[USGS] U.S. Geological Survey. 2021b. "M 5.8 - 14km SSE of Louisa, Virginia" (M5.8 Central Virginia Earthquake of 23 August 2011). Available at <https://earthquake.usgs.gov/earthquakes/eventpage/se609212/executive#dyfi> (accessed January 13, 2021).

Van Gelder R.G. 1956. Echo-location failure in migratory bats. *Transactions of the Kansas Academy of Science* 59:220–222.

[VCEA] Virginia Clean Economy Act. 2020. Available at <https://lis.virginia.gov/cgi-bin/legp604.exe?201+sum+HB1526> (accessed November 6, 2020).

[VDCR] Virginia Department of Conservation and Recreation. 2017a. *Attendance Summary from 01/01/2015 to 12/30/2016.* [Virginia State Parks Web page]. Available at <https://www.dcr.virginia.gov/state-parks/document/16parkattend.pdf> (accessed March 9, 2021).

[VDCR] Virginia Department of Conservation and Recreation. 2020. "Virginia Natural Heritage Data Explorer." Search Report for Louisa and Spotsylvania Counties. Available at <https://vanhde.org/species-search> (accessed December 7, 2020).

[VDCR] Virginia Department of Conservation and Recreation. 2021. "Lake Anna State Park. Available at <https://www.dcr.virginia.gov/state-parks/lake-anna#general_information> (accessed March 9, 2021).

[VDEQ] Virginia Department of Environmental Quality. 2002. Letter from C. Forbes, Regional Permit Manager, to D. Heacock, Site Vice President, North Anna Power Station. No subject line (re: permit to Operate Auxiliary Boilers and Emergency Generators). July 1, 2002, ADAMS Accession Package No. ML21033A301.

[VDEQ] Virginia Department of Environmental Quality. 2014. *Virginia Pollutant Discharge Elimination System Permit No. VA0052451, Virginia Electric and Power Company, Dominion—North Anna Power Station, Louisa County.* May 8, 2014. *In:* Dominion 2020b, Attachment B: VPDES Permit. ADAMS Accession Nos. ML20246G698 and ML16035A498.

[VDEQ] Virginia Department of Environmental Quality. 2014b. *VA0052451: VPDES Permit Fact Sheet, North Anna Power Station, 2014 Reissuance*. 127 p. ADAMS Accession No. ML16035A498.

[VDEQ] Virginia Department of Environmental Quality. 2017. Email from B. Thomas, Regional Water Permits & Planning Manager, to K. Roller, Dominion. Subject: Dominion – North Anna Power Station 316(b). April 5, 2017. ADAMS Package Accession No. ML21033A301.

[VDEQ] Virginia Department of Environmental Quality. 2019a. Letter from J. Wilkinson, Regional Air Permit Manager, to J. Jenkins, Director, Nuclear Safety and Licensing, Dominion. No subject line. [re: Amendment to State Operating Permit.] June 13, 2019, ADAMS Accession Package No. ML21033A301.

[VDEQ] Virginia Department of Environmental Quality. 2020a. *2020 305(b)/303(d) Water Quality Assessment Integrated Report* June 2020. Available at <https://www.deq.virginia.gov/water/water-quality/assessments/integrated-report> (accessed November 11, 2020).

[VDEQ] Virginia Department of Environmental Quality. 2020b. "Environmental Data Mapper." [Search: Water Quality Assessment (WQA) Layers, 2020 Reservoirs]." Available at < https://apps.deq.virginia.gov/EDM/ tGISApplications.aspx> (accessed May 7, 2021).

[VDEQ] Virginia Department of Environmental Quality. 2020c. Letter from J. Schneider, Director, Water Planning Division, to K. Roller, Manager, Environmental, Dominion Energy Environmental Services. Subject: North Anna Power Station, Operating License Renewal Response to Request Regarding Section 401 Certification. September 16, 2020. ADAMS Package Accession No. ML21033A301.

[VDEQ] Virginia Department of Environmental Quality. 2020d. Status of Virginia's Water Resources: A Report on Virginia's Water Resources Management Activities. October 2020. Available at <https://www.deq.virginia.gov/home/showpublisheddocument?id=2119> (accessed January 11, 2020).

[VDEQ] Virginia Department of Environmental Quality. 2021. "Coastal Zone Management." Available at <https://www.deq.virginia.gov/get-involved/coastal-zone-management> (accessed March 12, 2021).

[VDGIF] Virginia Department of Game and Inland Fisheries. 2008. North and South Anna Rivers Investigation, Federal Aid Project – F111-R15. March 2008. 19 p. ADAMS Accession No. ML110601114.

[VDGIF] Virginia Department of Game and Inland Fisheries. 2015. *Virginia's 2015 Wildlife Action Plan.* Henrico, VA: VDGIF. September 1, 2015. 1,135 p. Available at <http://bewildvirginia.org/wildlife-action-plan/pdf/2015-Virginia-Wildlife-Action-Plan.pdf> (accessed December 3, 2020).

[VDGIF] Virginia Department of Game and Inland Fisheries. 2016. *Lake Anna Fisheries Management Report, Popular Format, Federal Aid Project - F111R*. Fredericksburg, VA: VDGIF. March 2016. 22 p Available at <https://www.dgif.virginia.gov/wp-content/uploads/Lake-Anna-Popular-Report-2016.pdf> (accessed November 24, 2020).

[VDGIF] Virginia Department of Game and Inland Fisheries. 2020a. "Lake Anna." Available at <https://dwr.virginia.gov/waterbody/lake-anna/> (accessed November 24, 2020).

[VDGIF] Virginia Department of Game and Inland Fisheries. 2020b. "Virginia Fish and Wildlife Information Service (VaFWIS) [online database]." [Search Report for Louisa County]. Available at <https://vafwis.dgif.virginia.gov/fwis/?Menu=Home.Geographic+Search> (accessed December 7, 2020).

[VDGIF] Virginia Department of Game and Inland Fisheries. 2020c. "Virginia Fish and Wildlife Information Service (VaFWIS) [online database]." [Search Report for Spotsylvania County]. Available at <https://vafwis.dgif.virginia.gov/fwis/?Menu=Home.Geographic+Search> (accessed December 7, 2020).

[VDGIF] Virginia Department of Game and Inland Fisheries. 2021. "Northern Long-eared Bat Winter Habitat and Roost Trees [online mapping application]." Available at <http://dgif-virginia.maps.arcgis.com/apps/webappviewer/index.html?id=32ea4ee49359 42c092e41ddcd19e5ec5> (accessed January 20, 2021).

[VDH] Virginia Department of Health. 2018. "2018 News Releases." Available at <https://www.vdh.virginia.gov/news/public-relations-contacts/archived-news-releases/2018-news-releases/> (accessed January 6, 2021).

[VDH] Virginia Department of Health. 2019. "2019 News Releases." Available at <https://www.vdh.virginia.gov/news/public-relations-contacts/archived-news-releases/2019-news-releases/> (accessed January 6, 2021).

[VDH] Virginia Department of Health. 2020a. Email from A. Warren, GIS Program Support Technician, to K. Roller, Environmental Manager, Dominion. Subject: Thermophilic Microorganisms in Lake Anna. February 21, 2020. *In* Appendix F of Dominion 2020b.

[VDH] Virginia Department of Health. 2020b. "2020 News Releases." Available at <https://www.vdh.virginia.gov/news/public-relations-contacts/archived-news-releases/2020-news-releases/> (accessed January 6, 2021).

[VDHR] Virginia Department of Historic Resources. 2021. Letter from J. Bellville-Marrion, Project Review Archaeologist, Review and Compliance Division, to O. Shehab-Dandan, Dominion Energy Services, Inc. Re: North Anna Power Station—Units 1 and 2 License Renewal, Louisa County Virginia, DHR Project No. 2000-1210. March 5, 2021. ADAMS Accession No. ML21076B027.

[VDWR] Virginia Department of Wildlife Resources. 2020. "Northern Snakehead." Available at <https://dwr.virginia.gov/fishing/snakehead/> (accessed December 9, 2020).

[VDMME] Virginia Department of Mines, Minerals, and Energy. 2021a. "Earthquakes." Division of Geology and Mineral Resources. Undated. Available at <https://www.dmme.virginia.gov/dgmr/earthquakes.shtml> (accessed January 13, 2021).

[VDMME] Virginia Department of Mines, Minerals, and Energy. 2021b. "MAJOR EARTHQUAKE 2011: AUGUST 23, 2011 1:51PM; 5.8 MAGNITUDE EARTHQUAKE, LOUISA COUNTY, VIRGINIA." Division of Geology and Mineral Resources. Undated. Available at <https://www.dmme.virginia.gov/dgmr/earthquake2011.shtml> (accessed January 13, 2021).

[VEPCO] Virginia Electric Power Company. 1985. *Impingement and Entrainment Studies for North Anna Power Station, 1978-1983.* Section 316(b) Demonstration. May 1985. 146 p. ADAMS Accession No. ML051150244.

[VEPCO] Virginia Electric and Power Company. 1986. *Section 316(a) Demonstration for North Anna Power Station: Environmental Studies of Lake Anna and the Lower North Anna River.* Virginia Power Corporate Technical Assessment. Water Quality Department. Richmond, VA. June 1986. 189 p. ADAMS Accession No. ML020230087.

[VEPCO] Virginia Electric and Power Company (Dominion). 2016. *Annual Radioactive Effluent Release Report, North Anna Power Station (January 01, 2015 to December 31, 2015).* April 26, 2016. 47 p. ADAMS Accession No. ML16125A506.

[VEPCO] Virginia Electric and Power Company (Dominion). 2017. *Annual Radioactive Effluent Release Report, North Anna Power Station (January 01, 2016 to December 31, 2016).* April 27, 2017. 43 p. ADAMS Accession No. ML17145A304.

[VEPCO] Virginia Electric and Power Company (Dominion). 2018. *Annual Radioactive Effluent Release Report, North Anna Power Station (January 01, 2017 to December 31, 2017).* April 16, 2018. 44 p. ADAMS Accession No. ML18116A455.

[VEPCO] Virginia Electric and Power Company (Dominion). 2019. *Annual Radioactive Effluent Release Report, North Anna Power Station (January 01, 2018 to December 31, 2018).* April 26, 2019. 131 p. ADAMS Accession No. ML19126A094.

[VEPCO] Virginia Electric and Power Company (Dominion). 2020. *Annual Radioactive Effluent Release Report, North Anna Power Station (January 01, 2019 to December 31, 2019).* April 20, 2020. 131 p. ADAMS Accession No. ML20122A157.

[VEPCO] Virginia Electric and Power Company (Dominion). 2019b. *Annual Radiological Environmental Operating Report, North Anna Power Station, (January 1, 2018 to December 31, 2018).* April 26, 2019. ADAMS Accession No. ML19126A093.

[VIMS] Virginia Institute of Marine Science. 2021. "Center for Coastal Resources Management." Page updated 2021. Available at <https://www.vims.edu/ccrm/wetlands_mgmt/handbook/permits/index.php> (accessed February 8, 2020).

Virginia Business. 2020. Dominion files construction, operations plan for $7.8B offshore wind farm. *Virginia Business Magazine* December 18, 2020. Available at <https://www.virginiabusiness.com/article/dominion-files-construction-operations-plan-for-7-8b-offshore-wind-farm/>(accessed January 25, 2021).

[VISAC] Virginia Invasive Species Advisory Committee. 2018. *Virginia Invasive Species Management Plan.* 56 p. Available at <http://vainvasivespecies.org/document/virginia-invasive-species-mananagement-plan-2018-final.pdf> (accessed December 9, 2020).

[WCCPS] Weldon Cooper Center for Public Service, Demographics Research Group, University of Virginia. 2019. "Total Population Projections for Virginia and its Localities, 2020–2040." June 2019. Available at <https://demographics.coopercenter.org/virginia-population-projections> (accessed March 2021).

Wu S., Mickley L.J., Leibensperger E.M., Jacob D.J., Rind D., Streets D.G. 2008. Effects of 2000–2050 global change on ozone air quality in the United States. *Journal of Geophysical Research.* 113:D06302. doi:10.1029/2007JD008917.

Zinn T.L., Baker W.W. 1979. Seasonal migration of the Hoary Bat, Lasiurus cinereus, through Florida. *Journal of Mammalogy* 60:634–635.

6.0 LIST OF PREPARERS

Members of the U.S. Nuclear Regulatory Commission's (NRC's) Office of Nuclear Material Safety and Safeguards (NMSS) prepared this draft supplemental environmental impact statement with assistance from other NRC organizations. Table 6-1 identifies each contributor's name, education and experience, and function or expertise.

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Name	Education and Experience	Function or Expertise
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Name	Education and Experience	Function or Expertise
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Caroline Hsu	B.S. in Molecular Biology; B.A. in English Literature; 12 years of government experience; 3 years of management experience	Terrestrial Ecology, Land Use, and Visual Resources
Nancy Martinez	B.S. Earth and Environmental Science; A.M. Earth and Planetary Science; 7 years of experience in environmental impact analysis	Air Quality, Meteorology and Climatology, Noise, Greenhouse Gases, Climate Change, Surface Water
Donald Palmrose	B.S. Nuclear Engineering; M.S. Nuclear Engineering; Ph.D. Nuclear Engineering; 34 years of experience including operations on U.S. Navy nuclear powered surface ships, technical and NEPA analyses, nuclear authorization basis support for DOE, and NRC project management.	Human Health, Uranium Fuel Cycle
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Name	Education and Experience	Function or Expertise
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7.0 LIST OF AGENCIES, ORGANIZATIONS, AND PERSONS TO WHOM THE NRC SENDS COPIES OF THIS SEIS

Table 7-1. List of Agencies, Organizations, and Persons to Whom the NRC Sends Copies of this SEIS

Name	Affiliation
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Diana Johnson	NA
Virginia McCormack	NA
Kimberly Cleland	NA
Edward Bogdan	Loudoun Climate Project
Steve Duggan	NA
Elena Day	NA
Paula Chow	NA
Edward Sandtner	NA
Natalie Pien	Sierra Club, Great Falls Group
Alane Callander	NA
James Lynch	NA
Erica Gray	NA
Andy Wade	County of Louisa
Don Safer	Tennessee Environmental Council and Nuclear Free Team of the Sierra Club
Fred Mladen	Dominion Energy
Robert Babyok	Louisa County Board of Supervisors
Thomas Saporito	Nuclear Energy Oversight Project
Bettina Rayfield, Manager	Commonwealth of Virginia Virginia Department of Environmental Quality Environmental Impact Review
Stepan Nevshehirlian	U.S. Environmental Protection Agency Region 3
Stephen Tryon, Director	U.S. Department of Interior Office of Environmental Policy and Compliance Attention: Lisa Treichel
Diane Curran, Esq.	Harmon, Curran, Spielberg, & Eisenberg, L.L.P.
Curtis Brown, State Coordinator	Commonwealth of Virginia
Lea Perlas, Interim Director	Virginia Office of Radiological Health
Judy Lamana, Founder	Fauquier Climate Change Group

Name	Affiliation
NA denotes no affiliation identified. Many scoping commenters did not provide their contact or affiliation information. The NRC staff has listed the names of these commenters in the scoping summary report (Agencywide Documents Access and Management System (ADAMS) Accession No. ML21181A127). The commenters were offered an opportunity to receive this SEIS. However, the staff could not send a copy of this SEIS to the commenters who did not provide contact information and those persons are not listed here. Appendix C, “Consultation Correspondence,” lists correspondence with agencies and Tribes, including distribution of the SEIS.	

8.0 INDEX

A

B

C

D

E

APPENDIX A

COMMENTS RECEIVED ON THE NORTH ANNA POWER STATION, UNITS 1 AND 2 ENVIRONMENTAL REVIEW

A. COMMENTS RECEIVED ON THE NORTH ANNA POWER STATION, UNITS 1 AND 2 ENVIRONMENTAL REVIEW

A.1 Comments Received During the Scoping Period

The U.S. Nuclear Regulatory Commission (NRC) staff began the scoping process for the environmental review of the North Anna Power Station, Units 1 and 2 (North Anna) subsequent license renewal application in October 2020, in accordance with the National Environmental Policy Act of 1969 (42 U.S.C. 4321 et seq.) (NEPA). On October 19, 2020, the NRC issued a notice of intent to conduct an environmental scoping process for subsequent license renewal of North Anna that was published in the *Federal Register* on October 23, 2020 (85 FR 67572). *Federal Register* notices are searchable using the notice number (xx FR xxxx) at Regulations.gov. In its notice of intent, the NRC requested that members of the public and stakeholders submit comments on the environmental review of North Anna to the Federal Rulemaking Website at Regulations.gov.

The North Anna scoping process also included a public meeting that was held on November 4, 2020. Because of the COVID-19 public health emergency, the public meeting took the form of an online webinar that was accessible by phone and computer. To advertise this public meeting, the NRC issued press releases and purchased newspaper advertisements. In addition to NRC staff, Dominion staff, local officials, and several members of the public attended the public meeting. After the NRC staff presented the prepared statements on the license renewal process, the staff opened the meeting for public comments. Attendees made oral statements that were recorded and transcribed by a certified court reporter. A summary and a transcript of the public scoping meeting are available in the NRC's Agencywide Documents Access and Management System (ADAMS) under ADAMS Accession No. ML20324A259. The ADAMS Public Electronic Reading Room is accessible at http://www.nrc.gov/reading-rm/adams.html.

At the conclusion of the scoping period process, the staff issued the North Anna Scoping Summary Report (ADAMS Accession No. ML21181A127). The report (a) contains comments received during the public meeting and through Regulations.gov, (b) groups these comments by subject area, and (c) contains NRC staff responses to these comments.

APPENDIX B

APPLICABLE LAWS, REGULATIONS, AND OTHER REQUIREMENTS

B. APPLICABLE LAWS, REGULATIONS, AND OTHER REQUIREMENTS

There are several Federal laws and regulations that affect environmental protection, health, safety, compliance, and consultation at every NRC-licensed nuclear power plant. Some of these laws and regulations require permits by or consultations with other Federal agencies or State, Tribal, or local governments. Certain Federal environmental requirements have been delegated to State authorities for enforcement and implementation. Furthermore, States have also enacted laws to protect public health and safety and the environment. It is the NRC's policy to make sure nuclear power plants are operated in a manner that provides adequate protection of public health and safety and protection of the environment through compliance with applicable Federal and State laws, regulations, and other requirements, as appropriate.

The Atomic Energy Act of 1954, as amended (AEA) (42 U.S.C. 2011 et seq.), authorizes the NRC to enter into an agreement with any State that allows the State to assume regulatory authority for certain activities (see 42 U.S.C. 2021). A State that enters into such an agreement with the NRC is called an Agreement State. Virginia is one such NRC Agreement State. In the Commonwealth of Virginia, the Virginia Department of Health's (VDH) Division of Radiological Health has regulatory responsibility over certain byproduct, source, and quantities of special nuclear materials not sufficient to form a nuclear critical mass. The Virginia Department of Emergency Management (VDEM) maintains a Radiological Emergency Planning and Response Program to provide response capabilities to radiological accidents or emergencies at the commercial nuclear power plants in and near the Commonwealth of Virginia.

In addition to carrying out some Federal programs, State legislatures develop their own laws. State statutes can supplement, as well as implement, Federal laws for protection of air, surface water, and groundwater. State legislation may address solid waste management programs, locally rare or endangered species, and historic and cultural resources.

The U.S. Environmental Protection Agency (EPA) has the primary responsibility to administer the Clean Water Act or CWA (33 U.S.C. 1251 et seq). The National Pollutant Discharge Elimination System (NPDES) program addresses water pollution by regulating the discharge of potential pollutants to waters of the United States. The Clean Water Act, as administered by EPA, allows for primary enforcement and administration through State agencies, as long as the State program is at least as stringent as the Federal program.

EPA has delegated the authority to issue NPDES permits to the Commonwealth of Virginia, which uses the terminology Virginia Pollutant Discharge Elimination System (VPDES) permits. The Virginia Department of Environmental Quality provides oversight for public water supplies, provides permits to regulate the discharge of industrial and municipal wastewaters—including discharges to groundwater—and monitors State water resources for water quality.

B.1 Federal and State Requirements

North Anna Power Station, Units 1 and 2 (North Anna), is subject to various Federal and State requirements. Table B-1 lists the principal Federal and State regulations and laws that are used or mentioned in this supplemental environmental impact statement for North Anna.

Table B-1. Federal and State Requirements

Law or Regulation	Requirements
	Current Operating License and License Renewal
Atomic Energy Act, 42 U.S.C. 2011 et seq.	The Atomic Energy Act (AEA) of 1954, as amended, and the Energy Reorganization Act of 1974 (42 U.S.C. 5801 et seq.) give the NRC the licensing and regulatory authority for commercial nuclear energy use. They allow the NRC to establish dose and concentration limits for protection of workers and the public for activities under NRC jurisdiction. The NRC implements its responsibilities under the AEA through regulations set forth in Title 10, “Energy,” of the *Code of Federal Regulations* (CFR).
National Environmental Policy Act of 1969, 42 U.S.C. 4321 et seq.	The National Environmental Policy Act (NEPA), as amended, requires Federal agencies to integrate environmental values into their decisionmaking process by considering the environmental impacts of proposed Federal actions and reasonable alternatives to those actions. NEPA establishes policy, sets goals (in Section 101), and provides means (in Section 102) for carrying out the policy. NEPA Section 102(2) contains action-forcing provisions to ensure that Federal agencies follow the letter and spirit of the Act. For major Federal actions significantly affecting the quality of the human environment, Section 102(2)(C) of NEPA requires Federal agencies to prepare a detailed statement that includes the environmental impacts of the proposed action and other specified information.
10 CFR Part 20	Regulations in 10 CFR Part 20, “Standards for Protection Against Radiation,” establish standards for protection against ionizing radiation resulting from activities conducted under licenses issued by the NRC. These regulations are issued under the Atomic Energy Act of 1954, as amended, and the Energy Reorganization Act of 1974, as amended. The purpose of these regulations is to control the receipt, possession, use, transfer, and disposal of licensed material by any licensee in such a manner that the total dose to an individual (including doses resulting from licensed and unlicensed radioactive material and from radiation sources other than background radiation) does not exceed the standards for protection against radiation prescribed in the regulations in this part.
10 CFR Part 50	Regulations in 10 CFR Part 50, “Domestic Licensing of Production and Utilization Facilities,” are NRC regulations issued under the Atomic Energy Act, as amended, and Title II of the Energy Reorganization Act of 1974, to provide for the licensing of production and utilization facilities, including power reactors.
10 CFR Part 51	Regulations in 10 CFR Part 51, “Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions,” contain the NRC’s regulations that implement NEPA.
10 CFR Part 54	NRC regulations in 10 CFR Part 54, “Requirements for Renewal of Operating Licenses for Nuclear Power Plants,” govern the issuance of renewed operating licenses and renewed combined licenses for nuclear power plants licensed under Sections 103 or 104b of the AEA, as amended, and Title II of the Energy Reorganization Act of 1974. The regulations focus on managing adverse effects of aging. The rule is intended to ensure that important systems, structures, and components will continue to perform their intended functions during the period of extended operation.

Law or Regulation	Requirements
	Air Quality Protection
Clean Air Act, 42 U.S.C. 7401 et seq.	The Clean Air Act (CAA) is intended to "protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare and the productive capacity of its population." The CAA establishes regulations to ensure maintenance of air quality standards and authorizes individual States to manage permits. Section 118 of the CAA requires each Federal agency, with jurisdiction over properties or facilities engaged in any activity that might result in the discharge of air pollutants, to comply with all Federal, State, inter-State, and local requirements with regard to the control and abatement of air pollution. Section 109 of the CAA directs the U.S. Environmental Protection Agency (EPA) to set National Ambient Air Quality Standards (NAAQS) for criteria pollutants. The EPA has identified and set NAAQS for the following criteria pollutants: particulate matter, sulfur dioxide, carbon monoxide, ozone, nitrogen dioxide, and lead. Section 111 of the CAA requires the establishment of national performance standards for new or modified stationary sources of atmospheric pollutants. Section 160 of the CAA requires that specific emission increases must be evaluated before permit approval to prevent significant deterioration of air quality. Section 112 requires specific standards for release of hazardous air pollutants (including radionuclides). These standards are implemented through plans developed by each State and approved by the EPA. The CAA requires sources to meet standards and obtain permits to satisfy those standards. Nuclear power plants may be required to comply with the CAA Title V, Sections 501–507, for sources subject to new source performance standards or sources subject to National Emission Standards for Hazardous Air Pollutants. EPA regulates the emissions of air pollutants using 40 CFR Parts 50 to 99.
	Water Resources Protection
Clean Water Act, 33 U.S.C. 1251 et seq., and the NPDES (40 CFR 122)	The Clean Water Act (CWA) was enacted to "restore and maintain the chemical, physical, and biological integrity of the Nation's water." The Act requires all branches of the Federal Government with jurisdiction over properties or facilities engaged in any activity that might result in a discharge or runoff of pollutants to surface waters, to comply with Federal, State, inter-State, and local requirements. As authorized by the CWA, the National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. The NPDES program requires all facilities that discharge pollutants from any point source into waters of the United States to obtain an NPDES permit. A nuclear power plant may also participate in the NPDES General Permit for Industrial Stormwater due to stormwater runoff from industrial or commercial facilities to waters of the United States. EPA is authorized under the CWA to directly implement the NPDES program; however, EPA has authorized many States to implement all or parts of the national program. Section 401 of the CWA requires States to certify that the permitted discharge would comply with all limitations necessary to meet established State water quality standards, treatment standards, or schedules of compliance. The U.S. Army Corps of Engineers (USACE) is the lead agency for enforcement of CWA wetland requirements (33 CFR Part 320, "General Regulatory Policies"). Under Section 401 of the CWA, EPA or a delegated State agency has the authority to review and approve, condition, or deny all permits or licenses that might result in a discharge to waters of the State, including wetlands.

Law or Regulation	Requirements
Coastal Zone Management Act of 1972, as amended (16 U.S.C. 1451 et seq.)	Congress enacted the Coastal Zone Management Act (CZMA) in 1972 to address the increasing pressures of over-development upon the Nation's coastal resources. The National Oceanic and Atmospheric Administration administers the Act. The CZMA encourages States to preserve, protect, develop, and, where possible, restore or enhance valuable natural coastal resources such as wetlands, floodplains, estuaries, beaches, dunes, barrier islands, and coral reefs, as well as the fish and wildlife using those habitats. Participation by States is voluntary. To encourage States to participate, the CZMA makes Federal financial assistance available to any coastal State or territory, including those on the Great Lakes, as long as the State or territory is willing to develop and implement a comprehensive coastal management program.
Wild and Scenic Rivers Act, 16 U.S.C. 1271 et seq.	The Wild and Scenic Rivers Act created the National Wild and Scenic Rivers System, which was established to protect the environmental values of free-flowing streams from degradation by impacting activities, including water resources projects.
Virginia Administrative Code (VAC), Title 9, "Environment": Agency 15, "Department of Environmental Quality" and Agency 25, "State Water Control Board"	Establishes the Commonwealth of Virginia's rules and regulations related to water quality and supply (Code of Virginia, Title 62.1, "Waters of the State, Ports and Harbors," Chapter 3.1, "State Water Control Law").
Waste Management and Pollution Prevention	
Resource Conservation and Recovery Act, 42 U.S.C. 6901 et seq.	The Resource Conservation and Recovery Act (RCRA) requires EPA to define and identify hazardous waste; establish standards for its transportation, treatment, storage, and disposal; and require permits for persons engaged in hazardous waste activities. Section 3006, "Authorized State Hazardous Waste Programs" (42 U.S.C. 6926), allows States to establish and administer these permit programs with EPA approval. EPA regulations implementing RCRA are found in 40 CFR Parts 260 through 283. Regulations imposed on a generator or on a treatment, storage, and/or disposal facility vary according to the type and quantity of material or waste generated, treated, stored, and/or disposed. The method of treatment, storage, and/or disposal also impacts the extent and complexity of the requirements.
Pollution Prevention Act, 42 U.S.C. 13101 et seq.	The Pollution Prevention Act establishes a national policy for waste management and pollution control that focuses first on source reduction, then on environmental issues, safe recycling, treatment, and disposal.
VAC 33: Title 9, Agency 15, Chapter 3.1. State Water Control Law	Virginia Department of Environmental Quality (DEQ) is authorized to implement a variety of laws and regulations pertaining to water quality and supply.
Protected Species	
Endangered Species Act, 16 U.S.C. 1531 et seq.	The Endangered Species Act (ESA) was enacted to prevent the further decline of endangered and threatened species and to restore those species and their critical habitats. Section 7, "Interagency Cooperation," of the Act requires Federal agencies to consult with the U.S. Fish and Wildlife Service (FWS) or the National Marine Fisheries Service (NMFS) on Federal actions that may affect listed species or designated critical habitats.

Law or Regulation	Requirements
Magnuson–Stevens Fishery Conservation and Management Act, 16 U.S.C. 1801 et seq.	The Magnuson–Stevens Fishery Conservation and Management Act, as amended, governs marine fisheries management in U.S. Federal waters. The Act created eight regional fishery management councils and includes measures to rebuild overfished fisheries, protect essential fish habitat, and reduce bycatch. Under Section 305 of the Act, Federal agencies are required to consult with the National Marine Fisheries Service for any Federal actions that may adversely affect essential fish habitat.
Historic Preservation and Cultural Resources	
National Historic Preservation Act, 54 U.S.C. 100101 et seq. (formerly 16 U.S.C. 470 et seq.)	The National Historic Preservation Act was enacted to create a national historic preservation program, including the National Register of Historic Places and the Advisory Council on Historic Preservation (ACHP). Section 106 of the Act requires Federal agencies to take into account the effects of their undertakings on historic properties. The Advisory Council on Historic Preservation regulations implementing Section 106 of the Act are found in 36 CFR Part 800, "Protection of Historic Properties." The regulations call for public involvement in the Section 106 consultation process, including involvement from Indian Tribes and other interested members of the public, as applicable.

B.2 Operating Permits and Other Requirements

Table B-2 lists the permits and licenses issued by Federal, State, and local authorities for operational activities at North Anna Units 1 and 2, as identified in Chapter 9 of Dominion's environmental report.

Table B-2. Operating Permits and Other Requirements

Permit	Responsible Agency	Number	Expiration Date	Authorized Activity
Authorization to export low-level waste	Southeast Compact Commission for Low Level Radioactive Waste Management (SECC)	None	Updated annually	Export of low-level radioactive waste outside the region
Virginia Pollutant Discharge Elimination System permit (VPDES)	Virginia Department of Environmental Quality (VDEQ)	VA0052451	Administratively continued	Discharge of wastewaters to waters of the State
Air permit	VDEQ	Registration number: 40726	Operating under a permit shield	Operation of air emission sources (emergency diesel generators)
Hazardous waste transportation/ shipment registration	U.S. Department of Transportation (USDOT)	4929 (issued to Virginia Electric and Power)	None	Hazardous materials shipments
Authorization to operate a wastewater treatment plant	VDEQ	VA0052451-01	N/A	Wastewater treatment plant operating permit

Permit	Responsible Agency	Number	Expiration Date	Authorized Activity
Waterworks operation permit	Virginia Department of Health (VDH)	2109610	N/A	Authorization to operate a non-transient non-community (potable) waterworks
Operating license	NRC	NPF-4 and NPF-7	04/01/2038 and 08/21/2040	Operation of North Anna
Long-term maintenance agreement of storm water management	VDEQ	N/A	N/A	Maintenance of detention basins and ISFSI retention basin
ISFSI Authorization	NRC	SNM-2507	06/30/2058	Operation of a dry storage ISFSI
Registration	U.S. EPA	VAD065376279	N/A	Hazardous waste generator registration
Registration	VDEQ	Registration PNA-7, 8, 9, 10, 11	Various	Operation of underground storage tanks
Registration	VDEQ	MB705136-0	03/31/2020	Selective taking of migratory birds
Federal Coastal Zone Management Act Consistency Concurrence	VDEQ	DEQ 19-124F (12/23/2019)	N/A	Needed verification that renewal of operating licenses would be consistent with the Coastal Zone Management program

Sources: Dominion 2020 (ADAMS Accession Nos. ML20246G698 and ML21042B904)

APPENDIX C

CONSULTATION CORRESPONDENCE

C.1 CONSULTATION CORRESPONDENCE

C.1.1 Endangered Species Act Section 7 Consultation

As a Federal agency, the U.S. Nuclear Regulatory Commission (NRC) must comply with the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.) (ESA), as part of any action authorized, funded, or carried out by the agency. In this case, the proposed agency action is whether to issue subsequent renewed licenses for the continued operation of North Anna Power Station, Units 1 and 2 (North Anna). The proposed action would authorize Dominion Energy Virginia (Dominion) to operate North Anna for an additional 20 years beyond the current renewed license term. 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) ("the Services" (collectively) or "Service" (individually)), as appropriate, to ensure that the proposed 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.

C.1.2 Federal Agency Obligations under Section 7 of the Endangered Species Act

The ESA and the regulations that implement ESA Section 7 at Title 50 of the *Code of Federal Regulations* (50 CFR) Part 402 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 (1) provide a list of any listed or proposed species or designated or proposed critical habitats that may be present in the action area or (2) 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 any such species or critical habitats may be present, the Federal agency prepares a biological assessment to evaluate the potential effects of the action and determine whether the species or critical habitats are likely to be adversely affected by the action (50 CFR 402.12(a); 16 U.S.C. 1536(c)).

Biological assessments are required for any agency action that is a "major construction activity" (50 CFR 402.12(b)). A major construction activity is a construction project or other undertaking having construction-type impacts that is a major Federal action 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.) (NEPA) (51 FR 19926). Federal agencies may fulfill their obligations to consult with the Services under ESA Section 7 and to prepare a biological assessment, if required, 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 ESA Section 7 consultation(s) in the NEPA document (50 CFR 402.06(b)).

C.1.3 Biological Evaluation

Subsequent license renewal does not require the preparation of a biological assessment because it is not a major construction activity. Nonetheless, the NRC staff must consider the impacts of its actions on federally listed species and designated critical habitats. In cases where the staff finds that license renewal "may affect" ESA-protected species or habitats, ESA Section 7 requires the NRC to consult with the relevant Service(s).

To support such consultations, the NRC staff has incorporated its analysis of the potential impacts of the proposed license renewal into Section 3.8 of this supplemental environmental impact statement (SEIS). The NRC staff refers to its ESA analysis as a "biological evaluation."

The NRC staff structured its evaluation in accordance with the Services' suggested biological assessment contents described at 50 CFR 402.12(f). Section 3.8.1 of this report describes the action area as well as the ESA-protected species and habitats potentially present in the action area. Section 3.8.2 assesses the potential effects of the proposed North Anna license renewal on the ESA-protected species and habitats present in the action area and contains the NRC's effect determinations for each of those species and habitat. This section also addresses cumulative effects. Finally, Sections 3.8.3 through 3.8.6 address the potential effects of the no-action alternative power replacement alternatives.

C.1.4 Chronology of Endangered Species Act Section 7 Consultation

Endangered Species Act Section 7 Consultation with the U.S. Fish and Wildlife Service

As part of its environmental review, the NRC staff considered whether any federally listed, proposed, or candidate species or proposed or designated critical habitats may be present in the action area (as defined at 50 CFR 402.02 and described in Section 3.8.1.1) for the proposed action of North Anna license renewal. With respect to species under the FWS's jurisdiction, the NRC staff submitted project information to the FWS's Environmental Conservation Online System (ECOS) Information for Planning and Conservation (IPaC) system. The FWS provided the NRC with a list of threatened and endangered species that may occur in the action area. The list included two species: the northern long-eared bat (*Myotis septentrionalis*) and the dwarf wedgemussel (*Alasmidonta heterodon*). The list also stated that no critical habitats are within the project area under review. During its review, the NRC staff identified no other listed species, proposed or candidate species, or proposed or designated critical habitats that may occur in the action area and that would be relevant to the staff's review.

The NRC staff evaluated the potential impacts of the proposed action on the two listed species in Section 3.8 of the SEIS. In its preliminary analysis, the staff determined that the dwarf wedgemussel is not present in the action area. Therefore, the staff did not evaluate this species any further. The staff concluded that the proposed license renewal may affect, but is not likely to adversely affect, the northern long-eared bat. In a letter dated October 26, 2020, the FWS concurred with this determination, based on the premise that activities associated with the proposed license renewal with the potential to affect the northern long-eared bat are consistent with the activities analyzed in a 2016 programmatic biological opinion. The FWS's October 26, 2020, letter documents that the NRC staff has fulfilled its ESA Section 7(a)(2) obligations with respect to the proposed North Anna license renewal. The ESA regulations at 50 CFR 402.16 prescribe certain circumstances that require Federal agencies to reinitiate consultation. As of the date of issuance of this draft SEIS, the NRC staff has identified no information that would warrant reinitiation of consultation.

Table C-1 lists the correspondence relevant to the NRC's ESA Section 7 consultation with the FWS.

Table C-1. Endangered Species Act Section 7 Consultation Correspondence with the U.S. Fish and Wildlife Service

Date	Description	ADAMS Accession No.[a]
Oct 26, 2020	Virginia Ecological Services Field Office (FWS) to B. Grange (NRC), Verification letter for the proposed North Anna subsequent license renewal under the January 5, 2016, programmatic biological opinion on final 4(d) rule for northern long-eared bat and activities excepted from take prohibition	ML20300A512
Jan 20, 2021	Virginia Ecological Services Field Office (FWS) to B. Grange (NRC), Updated list of threatened and endangered species for the proposed North Anna subsequent license renewal	ML21021A198

[a] Access these documents through the NRC's Agencywide Documents Access and Management System (ADAMS) at http://adams.nrc.gov/wba/.

Endangered Species Act Section 7 Consultation with the National Marine Fisheries Service

As discussed in Section 3.8.1.3 and 3.8.2.3, no federally listed species or critical habitats under NMFS's jurisdiction occur within the action area. Therefore, the NRC staff did not engage the NMFS pursuant to ESA Section 7 for the proposed North Anna license renewal.

C.2 Magnuson-Stevens Act Essential Fish Habitat Consultation

The NRC must comply with the Magnuson–Stevens Fishery Conservation and Management Act of 1996, as amended (16 U.S.C. 1801 et seq.), for any actions authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken that may adversely affect any essential fish habitat (EFH) identified under the Magnuson–Stevens Act.

In Sections 3.8.1.4 and 3.8.2.4 of this SEIS, the NRC staff concludes that the NMFS has not designated any EFH under the MSA in Lake Anna and that the proposed North Anna license renewal would have no effect on EFH. Thus, the MSA does not require the NRC to consult with the NMFS for the proposed action.

C.3 National Historic Preservation Act Section 106 Consultation

The National Historic Preservation Act of 1966, as amended (NHPA), requires Federal agencies to consider the effects of their undertakings on historic properties and consult with applicable State and Federal agencies, Tribal groups, 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 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 36 CFR 800.8(c), "Use of the NEPA Process for Section 106 Purposes," the NRC has elected to use the NEPA process to comply with its obligations under Section 106 of the National Historic Preservation Act.

Table C-2 lists the chronology of consultation and consultation documents related to the NRC's National Historic Preservation Act Section 106 review of the North Anna license renewal. The NRC staff is required to consult with the noted agencies and organizations in accordance with the statutes listed above.

1 **Table C-2. National Historic Preservation Act Correspondence**

Date	Sender and Recipient	Description	ADAMS Accession No.[(a)]
10/30/2020	R. Elliott (NRC) to R. Nelson, Director, Office of Federal Agency Programs, Advisory Council on Historic Preservation	Request for Scoping Comments Concerning the Environmental Review of North Anna Power Station, Units 1 and 2 Subsequent License Renewal Application	ML20294A420
10/30/2020	R. Elliott (NRC) to J. Langan, State Historic Preservation Officer, Virginia Department of Historic Resources	Request for Scoping Comments Concerning the Environmental Review of North Anna Power Station, Units 1 and 2 Subsequent License Renewal Application	ML20303A153
10/30/2020	R. Elliott (NRC) to J.R. Johnson, Governor Absentee-Shawnee Tribe	Request for Scoping Comments Concerning the Environmental Review of North Anna Power Station, Units 1 and 2 Subsequent License Renewal Application	ML20294A491
10/30/2020	R. Elliott (NRC) to W. Harris, Chief Catawba Indian Nation	Request for Scoping Comments Concerning the Environmental Review of North Anna Power Station, Units 1 and 2 Subsequent License Renewal Application	ML20294A491
10/30/2020	R. Elliott (NRC) to C. Hoskin, Jr, Principal Chief Cherokee Nation	Request for Scoping Comments Concerning the Environmental Review of North Anna Power Station, Units 1 and 2 Subsequent License Renewal Application	ML20294A491
10/30/2020	R. Elliott (NRC) to S. Adkins, Chief Chickahominy Indian Tribe	Request for Scoping Comments Concerning the Environmental Review of North Anna Power Station, Units 1 and 2 Subsequent License Renewal Application	ML20294A491
10/30/2020	R. Elliott (NRC) to G. Steward, Chief Chickahominy Indians – Eastern Division	Request for Scoping Comments Concerning the Environmental Review of North Anna Power Station, Units 1 and 2 Subsequent License Renewal Application	ML20294A491

Date	Sender and Recipient	Description	ADAMS Accession No.[(a)]
10/30/2020	R. Elliott (NRC) to D. Dotson, President Delaware Nation	Request for Scoping Comments Concerning the Environmental Review of North Anna Power Station, Units 1 and 2 Subsequent License Renewal Application	ML20294A491
10/30/2020	R. Elliott (NRC) to C. Brooks, Chief Delaware Tribe of Indians	Request for Scoping Comments Concerning the Environmental Review of North Anna Power Station, Units 1 and 2 Subsequent License Renewal Application	ML20294A491
10/30/2020	R. Elliott (NRC) to R. Sneed, Principal Chief Eastern Band of Cherokee Indians	Request for Scoping Comments Concerning the Environmental Review of North Anna Power Station, Units 1 and 2 Subsequent License Renewal Application	ML20294A491
10/30/2020	R. Elliott (NRC) to G.J. Wallace, Chief Eastern Shawnee Tribe of Oklahoma	Request for Scoping Comments Concerning the Environmental Review of North Anna Power Station, Units 1 and 2 Subsequent License Renewal Application	ML20294A491
10/30/2020	R. Elliott (NRC) to K. Branham, Tribal Chief Monacan Indian Nation	Request for Scoping Comments Concerning the Environmental Review of North Anna Power Station, Units 1 and 2 Subsequent License Renewal Application	ML20294A491
10/30/2020	R. Elliott (NRC) to S. Bass, Chief Nansemond Indian Nation	Request for Scoping Comments Concerning the Environmental Review of North Anna Power Station, Units 1 and 2 Subsequent License Renewal Application	ML20294A491
10/30/2020	R. Elliott (NRC) to R. Gray, Chief Pamunkey Indian Tribe	Request for Scoping Comments Concerning the Environmental Review of North Anna Power Station, Units 1 and 2 Subsequent License Renewal Application	ML20294A491

Date	Sender and Recipient	Description	ADAMS Accession No.[a]
10/30/2020	R. Elliott (NRC) to G. A. Richardson, Chief Rappahannock Tribe	Request for Scoping Comments Concerning the Environmental Review of North Anna Power Station, Units 1 and 2 Subsequent License Renewal Application	ML20294A491
10/30/2020	R. Elliott (NRC) to B. Barnes Chief Shawnee Tribe	Request for Scoping Comments Concerning the Environmental Review of North Anna Power Station, Units 1 and 2 Subsequent License Renewal Application	ML20294A491
10/30/2020	R. Elliott (NRC) to L. Henry, Chief Tuscarora Nation of New York	Request for Scoping Comments Concerning the Environmental Review of North Anna Power Station, Units 1 and 2 Subsequent License Renewal Application	ML20294A491
10/30/2020	R. Elliott (NRC) to J. Bunch, Chief United Keetoowah Band of Cherokee Indians in Oklahoma	Request for Scoping Comments Concerning the Environmental Review of North Anna Power Station, Units 1 and 2 Subsequent License Renewal Application	ML20294A491
10/30/2020	R. Elliott (NRC) to W.F. Adams, Chief Upper Mattaponi Indian Tribe	Request for Scoping Comments Concerning the Environmental Review of North Anna Power Station, Units 1 and 2 Subsequent License Renewal Application	ML20294A491
10/30/2020	R. Elliott (NRC) to W. Brown, Chief Cheroenhaka (Nottoway) Tribe	Request for Scoping Comments Concerning the Environmental Review of North Anna Power Station, Units 1 and 2 Subsequent License Renewal Application	ML20294A483
10/30/2020	R. Elliott (NRC) to M. Custalow, Chief Mattaponi Tribe	Request for Scoping Comments Concerning the Environmental Review of North Anna Power Station, Units 1 and 2 Subsequent License Renewal Application	ML20294A483

Date	Sender and Recipient	Description	ADAMS Accession No.[a]
10/30/2020	R. Elliott (NRC) to J. Caudill, Acting Chief Meherrin Nation	Request for Scoping Comments Concerning the Environmental Review of North Anna Power Station, Units 1 and 2 Subsequent License Renewal Application	ML20294A483
10/30/2020	R. Elliott (NRC) to L. Allston, Chief Nottoway Tribe	Request for Scoping Comments Concerning the Environmental Review of North Anna Power Station, Units 1 and 2 Subsequent License Renewal Application	ML20294A483
10/30/2020	R. Elliott (NRC) to C. Bullock, Chief Patawomeck Tribe	Request for Scoping Comments Concerning the Environmental Review of North Anna Power Station, Units 1 and 2 Subsequent License Renewal Application	ML20294A483
11/02/2020	B. Obermeyer, Delaware Tribe Historic Preservation Office, to R. Hoffman (NRC)	Response to NRC Request for Scoping Comments Concerning the Environmental Review of North Anna Power Station, Units 1 and 2 Subsequent License Renewal Application	ML21132A308
11/17/2020	T. Clouthier, Cultural Resource Director, Pamunkey Indian Tribe, to R. Elliott (NRC)	Response to NRC Request for Scoping Comments Concerning the Environmental Review of North Anna Power Station, Units 1 and 2 Subsequent License Renewal Application	ML20329A439
11/20/2020	R. Hoffman (NRC) to T. Clouthier, Cultural Resource Director, Pamunkey Indian Tribe	Email Response and Notification of Site Environmental Audit Session	ML20329A401
11/30/2020	E. Toombs, Tribal Historic Preservation Officer, Cherokee Nation, to R. Hoffman (NRC)	Response to NRC Request for Scoping Comments Concerning the Environmental Review of North Anna Power Station, Units 1 and 2 Subsequent License Renewal Application	ML21132A306

[a] Access these documents through the NRC's Agencywide Documents Access and Management System (ADAMS) at https://adams.nrc.gov/wba/

APPENDIX D

CHRONOLOGY OF ENVIRONMENTAL REVIEW CORRESPONDENCE

D. 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 the agency's environmental review of the North Anna Power Station, Units 1 and 2 (North Anna) subsequent license renewal application (SLRA). This appendix does not include consultation correspondence or comments received during the scoping process. For a list and discussion of consultation correspondence, see Appendix C of this supplemental environmental impact statement (SEIS). For scoping comments, see Appendix A of this SEIS and the "Scoping Summary Report" (Agencywide Documents Access and Management System (ADAMS) Accession No. ML21181A127). All documents are available electronically from the NRC's Public Electronic Reading Room found at: http://www.nrc.gov/reading-rm.html. From this site, the public can gain access to ADAMS, which provides text and image files of the NRC's public documents. 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 Dominion Energy Virginia (Dominion) to renew the operating license for North Anna.

Table D-1. Environmental Review Correspondence

Date	Correspondence Description	ADAMS Accession Number
08/24/2020	North Anna Power Station, Units 1 and 2 - Application for Subsequent License Renewal	ML20246G696
08/24/2020	North Anna Power Station, Units 1 and 2 - Application for Subsequent Renewed Operating Licenses [transmittal letter]	ML20246G697
08/24/2020	Appendix E: Applicant's Environmental Report Subsequent Operating License Renewal Stage North Anna Power Station Units 1 and 2.	ML20246G698
08/24/2020	Enclosure 3: North Anna Power Station Subsequent License Renewal Application (CD-ROM Titled: "NAPS_SLRA")	ML20246G700
09/17/2020	North Anna SLRA - Receipt and Availability Letter	ML20224A105
09/30/2020	Acceptance of SLR Application	ML20281A622
10/06/2020	North Anna SLRA - Portal Letter	ML20269A465
10/13/2020	North Anna Power Station, Units 1 and 2 – Determination of Acceptability and Sufficiency for Docketing, Proposed Review Schedule, and Opportunity for a Hearing Regarding the Virginia Electric and Power Company's Application for Subsequent License Renewal (EPID Nos. L-2020-SLR-0000 and L-2020-SLE-0000)	ML20258A284
10/15/2020	Press Release-20-049: NRC Accepts Application for Subsequent License Renewal of North Anna Reactors	ML20351A174

Date	Correspondence Description	ADAMS Accession Number
10/19/2020	North Anna Power Station, Unit Nos. 1 and 2: Notice of Intent to Prepare an Environmental Impact Statement and Conduct Scoping Process (EPID No. L-2020-SLE-0000) - letter to applicant	ML20274A111
10/19/2020	North Anna Power Station, Unit Nos. 1 and 2: Notice of Intent to Prepare an Environmental Impact Statement and Conduct Scoping Process (EPID No. L-2020-SLE-0000) - *Federal Register* Notice	ML20274A198
10/23/2020	Press Release-20-052: NRC Seeks Public Comment on Environmental Review Topics for North Anna Subsequent License Renewal	ML20351A177
10/26/2020	FWS to NRC, Verification letter for North Anna SLR under Programmatic Biological Opinion for Northern Long-eared Bat	ML20300A512
10/26/2020	FWS to NRC, North Anna Subsequent License Renewal Updated List of Threatened and Endangered Species That May Occur in Your Proposed Project Location and/or May Be Affected by Your Proposed Project	ML20300A513
10/28/2020	11/04/2020 Environmental Scoping Meeting Related to the North Anna Power Station, Units 1 and 2, Subsequent License Renewal Application	ML20302A036
11/12/2020	Environmental Scoping Meeting Related to the North Anna Power Station, Units 1 and 2, Subsequent License Renewal Application [transcript]	ML20317A206
11/19/2020	License Renewal Environmental Site Audit Plan Regarding the North Anna Power Station, Units 1 and 2, Subsequent License Renewal Application (EPID L-2020-SLE-0000)	ML20322A052
11/20/2020	Email Response to Pamunkey Request re North Anna Scoping	ML20329A401
12/03/2020	11/04/2020 North Anna Scoping Meeting Summary	ML20324A259
12/04/2020	License Renewal Severe Accident Mitigation Alternatives Audit Plan Regarding the North Anna Power Station, Units 1 and 2, Subsequent License Renewal Application (EPID No.: L-2020-SLE-0000) (Docket No.: 50-338 and 50-339)	ML20337A022
12/17/2020	Summary of the Historic and Cultural Resources Environmental Audit Meeting Related to the Review of the Subsequent License Renewal Application for the North Anna Power Station, Units 1 And 2.	ML20350B456
12/17/2020	NAPS SLRA SAMA Audit Summary	ML20351A388
01/22/2021	Letter to Mr. D. Stoddard - Re., North Anna Power Station, Units 1 and 2, Summary of the Subsequent License Renewal Environmental Audit	ML21025A340
01/29/2021	Request for Additional Information - North Anna Subsequent License Renewal Application Environmental Review (EPID number: L-2020-SLE-0000) (Docket No.: 50-338 and 50-339)	ML21028A390
02/04/2021	North Anna Power Station (NAPS), Units 1 and 2 - Update to Subsequent License Renewal Application (SLRA) Supplement 1	ML21035A303

Date	Correspondence Description	ADAMS Accession Number
02/10/2021	North Anna Power Station (NAPS) Units 1 and 2 - Subsequent License Renewal Application (SLRA) Requested Documents in Response to Environmental Audit	ML21033A301
02/11/2021	North Anna Power Station Units 1 And 2 - Subsequent License Renewal Application, Response to NRC Requests for Confirmation of Information for the Environmental Review	ML21042B904
02/22/2021	North Anna Power Station (NAPS), Units 1 and 2 - Subsequent License Renewal Application (SLRA) Environmental Review - Response to NRC Request for Additional Information	ML21053A433
03/17/2021	North Anna Power Station (NAPS), Units 1 and 2 - Subsequent License Renewal Application (SLRA) Additional Document in Response to Environmental Audit Re: Architectural Survey	ML21076B027
06/30/2021	Issuance of Environmental Scoping Summary Report Associated with The NRC Staff's Review of The North Anna Power Station, Unit Nos. 1 And 2, Subsequent License Renewal Application	ML21181A127

APPENDIX E

PROJECTS AND ACTIONS CONSIDERED IN THE CUMULATIVE IMPACTS ANALYSIS

E. Projects and Actions Considered in the Cumulative Impacts Analysis

E.1 Overview

Table E-1 identifies other past, present, and reasonably foreseeable projects and actions the U.S. Nuclear Regulatory Commission (NRC) staff considered when analyzing potential cumulative environmental impacts related to the continued operation of North Anna Power Station, Units 1 and 2 (North Anna) for an additional 20 years. The staff generally considered projects and actions within a 30-mile (48-km) radius of the North Anna site. The staff's analysis of potential cumulative impacts associated with the proposed action (subsequent license renewal) is presented in Section 3.16 of this SEIS. However, because of the uniqueness of each environmental resource area evaluated and its associated geographic area of analysis, Section 3.16 does not consider or explicitly evaluate every project and action listed in Table E-1.

Table E-1. Projects and Actions NRC Staff Considered in the North Anna Cumulative Impacts Analysis

Project Name	Summary of Project	Location (Relative to North Anna)	Status
Onsite Facilities/Projects			
North Anna Wastewater Treatment Plant Replacement	Installation of new permanent wastewater treatment facility	Onsite, within the existing wastewater treatment plant footprint	Project is partially funded. Plans are conceptual. Construction targeted for completion in 2022 (Dominion 2021)
North Anna Osprey Nest Platform Installation	Installation of alternative nesting platforms to deter osprey nesting inside the switchyard	Onsite, several locations	One nest platform installed in February 2020. Five additional platforms installed in February 2021 (Dominion 2021)
North Anna Cyber Security Testing Facility	Construction of new facility for storing and testing critical digital assets	Onsite, west of existing steam generator storage facility	Construction scheduled for completion in 2023 (Dominion 2021)
North Anna Main Generator Storage Building	Construction of new facility for storing Unit 1 and Unit 2 main generators	Onsite, north of Warehouse 5	Construction scheduled for completion in 2023 (Dominion 2021)
North Anna Unit 3	Proposed 1,600 MW advanced light-water reactor unit on 120 ac (48 ha) area	Onsite, west of the existing North Anna Units 1 and 2	NRC issued combined operating license in 2017. Licensee has not made decision whether to proceed with construction (Dominion 2020b)

Project Name	Summary of Project	Location (Relative to North Anna)	Status
Fossil Fuel Energy Facilities			
Ladysmith Power Station	Natural gas-fueled plant with 783 MW generating capacity from five units	Caroline County, approximately 15 mi (24 km) east	Operational (EIA 2021a; Dominion 2020c; EPA 2021)
Louisa Generation Facility	Natural gas and petroleum-fueled peaking plant with 466 MW generating capacity from five units	Gordonsville, VA, approximately 23 mi (37 km) west-northwest	Operational (EIA 2021a; EPA 2021; ODEC 2021)
Gordonsville Energy	Natural gas-fueled plant with 218 MW generating capacity from two units	Gordonsville, VA, approximately 23 mi (37 km) west-northwest	Operational (Dominion 2020c; EIA 2021a; EPA 2021)
Doswell Energy Center	Natural gas-fueled plant with 1,165 MW generating capacity from five units	Ashland, VA, approximately 25 mi (40 km) southeast	Operational (EIA 2021a; EPA 2021)
Rockville 1 & 2	Petroleum-fueled peaking units with combined 11 MW generating capacity	Rockville, VA, approximately 26 mi (41 km) south-southeast	Operational (EIA 2021a; EPA 2021)
Birchwood Power Station	Coal-fueled plant with 238 MW generating capacity	King George County, approximately 29 mi (47 km) northeast	Scheduled for shut down in 2021 (EIA 2021a; Free Lance-Star 2020
Electric Avenue Plant	Petroleum-fueled peaking unit with 6.9 MW generating capacity	Culpeper, VA, approximately 30 mi (48 km) north-northwest	Operational (EIA 2021a; EPA 2021)
Renewable Energy Facilities			
North Anna Hydro Power Station	1 MW hydroelectric facility located at the base of Lake Anna Dam	Louisa County, VA, approximately 5 mi (8 km) southeast	(Dominion 2020b, Dominion 2020c)
Whitehouse Solar Farm	Solar photovoltaic facility with 20 MW (8 MW net) generating capacity on 250 ac (100 ha)	Louisa County, VA, approximately 10 mi (16 km) west-southwest	Operational (EIA 2021a; Dominion 2020c)
Spotsylvania Solar Energy Center	Solar photovoltaic facility with 500 MW generating capacity on 6,350 ac (2,570 ha)	Spotsylvania County, approximately 10 mi (16 km) north	Under Construction. Scheduled to be in service by 2023 (AES 2021; Virginia Mercury 2019)
Belcher Solar	Solar photovoltaic facility with 88 MW generating capacity on 1,000 ac (400 ha)	Louisa County, VA, approximately 14 mi (22 km) west-southwest	Scheduled to be in service December 2020 (Dominion 2020c)

Project Name	Summary of Project	Location (Relative to North Anna)	Status
Madison Solar Generating Facility	Solar photovoltaic facility with 63 MW generating capacity on 660 ac (267 ha)	Orange County, VA, approximately 16 mi (26 km) north-northwest	Scheduled to be in service in 2022 (Dominion 2020c; Solar Power World 2020)
Martin Solar Center	Solar photovoltaic facility with 5 MW generating capacity on 35 ac (14 ha)	Goochland County, VA, approximately 19 mi (30 km) southwest	Operational (EIA 2021a; Coronal Energy 2021)
Palmer Solar Center	Solar photovoltaic facility with 5 MW generating capacity on 41 ac (16 ha)	Fluvanna County, VA, approximately 25 mi (40 km) west-southwest	Operational (EIA 2021a; Coronal Energy 2021)
Waste Management King George Landfill Gas to Energy Plant	Landfill-gas (biomass) fueled plant (at King George County Landfill) with 11.3 MW generating capacity	King George County, approximately 29 mi (47 km) northeast	Operational (EIA 2021a; EPA 2021)
Mining and Manufacturing Facilities			
Martin-Marietta Aggregates Doswell	Quarrying/Mining Operation	Doswell, VA, approximately 19 mi (31 km) southeast	Operational (EPA 2021; Martin Marietta 2021)
U.S. Silica	Quarrying/Mining Operation (Aplite)	Montpelier, VA, approximately 20 mi (32 km) south-southeast	Operational (EPA 2021; US Silica 2021)
Klockner Pentaplast	Plastics manufacturing facility	Gordonsville, VA, approximately 23 mi (37 km) west-northwest	Operational (EPA 2021; Klöckner Pentaplast 2020)
Bear Island Paper Company	Pulp/Paper mill producing newsprint stock	Ashland, VA, approximately 25 mi (41 km) southeast	Plant currently being converted to produce containerboard, with restart scheduled in 2022 (EPA 2021; Recycling Today 2020)
Martin-Marietta Aggregates Anderson Creek	Quarrying/Mining Operation	Rockville, VA, approximately 26 mi (42 km) south-southeast	Operational (EPA 2021; Martin Marietta 2021)
Vulcan Materials Company	Quarrying/Mining Operation	Rockville, VA, approximately 26 mi (42 km) south-southeast	Operational (EPA 2021; Vulcan undated)
Military and Other Facilities			

Project Name	Summary of Project	Location (Relative to North Anna)	Status
U.S. Army Garrison Fort A.P. Hill	76,000 ac (31,000 ha) Joint Forces training base under the U.S. Army Installation Management Command. Includes 27,000 ac (11,000 ha) live fire range	Caroline County, VA, approximately 25 mi (41 km) east	Operational (EPA 2021; Army 2021)
Landfills			
Livingston Landfill & Convenience Center	Municipal (non-hazardous) solid waste landfill	Spotsylvania, VA, approximately 6 mi (10 km) northeast	Operational (EPA 2021; Spotsylvania County 2021a)
Louisa County Sanitary Landfill	Municipal (non-hazardous) solid waste landfill	Mineral, VA, approximately 7 mi (11 km) southwest	Operational (EPA 2021; Louisa County 2021a)
Orange County Sanitary Landfill	Municipal (non-hazardous) solid waste landfill	Orange, VA, approximately 18 mi (29 km) northwest	Operational (Orange County 2021; EPA 2021)
Water Supply and Treatment Facilities			
Northeast Creek Water Treatment Plant	Municipal water supply with surface water reservoir source	Louisa, VA, approximately 10 mi (16 km) southwest	Operational (Dominion 2020b; EPA 2021; Louisa County 2021b)
Louisa Regional Wastewater Treatment Plant	Wastewater treatment plant	Louisa, VA, approximately 12 mi (19 km) west-southwest	Operational (Dominion 2020b; EPA 2021; Louisa County 2021b)
Zion Crossroads Water Treatment Plant	Municipal water supply with groundwater source (wellfield) and surface water reservoir	Zion Crossroads, VA, approximately 23 mi (37 km) west-southwest	Operational (EPA 2021; Louisa County 2021b)
Zion Crossroads Wastewater Treatment Facility	Wastewater treatment plant	Zion Crossroads, VA, approximately 23 mi (37 km) west-southwest	Operational (EPA 2021; Louisa County 2021b)
Massaponax Wastewater Treatment Plant	Wastewater treatment plant	Massaponax, VA, approximately 24 mi (39 km) northeast	Operational (EPA 2021; Spotsylvania County 2021b)
Motts Run Water Treatment Plant	Municipal water supply sourced from Rappahannock River and surface water reservoir	Fredericksburg, VA, approximately 22 mi (35 km) north-northeast	Operational (EPA 2021; Spotsylvania County 2021b)
Ni River Water Treatment Plant	Municipal water supply with surface water reservoir	Spotsylvania Courthouse, VA, approximately 16 mi (26 km) northeast	Operational (EPA 2021; Spotsylvania County 2021b)

Project Name	Summary of Project	Location (Relative to North Anna)	Status
FMC Wastewater Treatment Plant	Wastewater treatment plant	Fredericksburg, VA, approximately 24 mi (39 km) northeast	Operational (EPA 2021; Spotsylvania County 2021b)
Thornburg Wastewater Treatment Plant	Wastewater treatment plant	Thornburg, VA, approximately 16 mi (25 km) east-northeast	Operational. Facility is currently being upgraded to handle future growth (EPA 2021; Spotsylvania County 2021b)
Parks and Recreation Sites			
Lake Anna State Park	3,127-ac (1,265-ha) park with 10 mi (16 km) of lake frontage on North Anna Reservoir offering tours, hiking, camping, picnicking, and water activities	Approximately 3 mi (5 km) north-northwest	Operational; Managed by Virginia Department of Conservation and Recreation (Dominion 2020b; VDCR 2021a)
Fredericksburg and Spotsylvania National Military Park	Military park encompassing multiple detached units associated with four Civil War battlefields and featuring hiking and driving tours	Approximately 15 mi (24 km) northeast	Operational; Managed by National Park Service (Dominion 2020b; NPS 2021a)
North Anna Battlefield Park	172-ac (69-ha) historic battlefield park offering hiking and picnicking	Approximately 20 mi (32 km) southeast	Operational; Managed by Virginia Department of Wildlife Resources (Dominion 2020b; VDWR 2021a)
Green Springs National Historic Landmark District	14,000-ac (5,700-ha) district of 19th century farmsteads featuring rural architecture and landscapes	Approximately 21 mi (34 km) west	Operational; Managed by National Park Service (NPS 2021b)
Mattaponi Wildlife Management Area	2,542-ac (1,028-ha) Wildlife management area with 6.5 mi (10.4 km) of waterfront along the Mattaponi and South Rivers offering hunting, fishing, camping, and hiking	Approximately 22 mi (35 km) east	Operational; Managed by Virginia Department of Wildlife Resources (Dominion 2020b; VDWR 2021b)
Kings Dominion	400-ac (160-ha) amusement park with rides and attractions	Approximately 24 mi (39 km) southeast	Operational; Privately owned and managed by Cedar Fair Entertainment Company (Kings Dominion 2021; EPA 2021)
C.F. Phelps Wildlife Management Area	4,539-ac (1,836-ha) wildlife management area offering	Approximately 25 mi (40 km) north	Operational;

Project Name	Summary of Project	Location (Relative to North Anna)	Status
	hunting, fishing, canoeing, and hiking		Managed by Virginia Department of Wildlife Resources (Dominion 2020b; VDWR 2021c)
Powhatan State Park	1,565-ac (633-ha) park on James River offering hiking, camping, picnicking, and water activities	Approximately 27 mi (43 km) south-southeast	Operational; Managed by Virginia Department of Conservation and Recreation (Dominion 2020b; VDCR 2021b)
Other Recreational Areas	Six marinas on North Anna reservoir within 3 mi (5 km) of the plant site. Also, several public landings, campgrounds, and other recreational attractions	Within 10 mi (16 km)	Operational (Dominion 2020a, 2020b)
Transportation Facilities			
Aviation Facilities	Three private airfields, two public general aviation airports, and one private-use helipad	Helipad located onsite. Others located within 10 mi (16 km) of North Anna site	Operational (AirNav 2021; Dominion 2020b)
Other Facilities/Project/Trends			
Various minor air pollutant emissions, National Pollutant Discharge Elimination System permitted wastewater discharges, and hazardous waste small quantity generators	Various businesses with smaller effluent discharges and waste streams	Within 10 mi (16 km)	Operational (EPA 2021)
Future Development	Construction of housing units and associated commercial buildings; roads, bridges, and rail; water and/or wastewater treatment and distribution facilities; and associated pipelines as described in local land use planning documents.	Throughout region	Construction would occur in the future, as described in State and local land use planning documents

E.2 References

[AES] The AES Corporation. 2021. "Virginia." Available at <https://www.aes.com/virginia> (accessed February 20, 2021).

[AirNav] AirNav.com. 2021. "Airport Information." Available at <https://www.airnav.com/airports/> (accessed February 27, 2021).

[Army] U.S. Department of the Army. 2021. "U.S. Army Garrison Fort A.P. Hill." Available at <https://home.army.mil/aphill/index.php> (accessed February 27, 2021).

Coronal Energy. 2021. "Coronal Energy Utilities." Available at <https://coronalenergy.com/utilities> (accessed February 27, 2021).

[Dominion] Dominion Virginia Power. 2020a. *North Anna Power Station, Units 1 and 2 Application for Subsequent License Renewal*. August 2020. ADAMS Package Accession No. ML20246G703.

[Dominion] Dominion Virginia Power. 2020b. Appendix E, *Applicant's Environmental Report, Subsequent Operating License Renewal Stage, North Anna Power Station, Units 1 and 2*. August 2020. ADAMS Accession No. ML20246G698.

[Dominion] Dominion Energy. 2020c. "Projects and Facilities." Available at <https://www.dominionenergy.com/projects-and-facilities> (accessed February 20, 2021).

[Dominion] Dominion Virginia Power. 2021. Letter from M. D. Sartain, Vice President – Nuclear Engineering and Fleet Support, to NRC. Subject: Virginia Electric and Power Company, North Anna Power Station Units 1 and 2, Subsequent License Renewal Application, Environmental Review, Response to Request for Additional Information. February 22, 2021. 21 p. ADAMS Accession No. ML21053A433.

[EIA] U.S. Energy Information Administration. 2021a. "Virginia State Profile and Energy Estimates—Analysis." Washington, DC: EIA. Last updated: October 15, 2020. Available at <https://www.eia.gov/state/?sid=VA> (accessed February 11, 2021).

[EPA] U.S. Environmental Protection Agency. 2021. "Facility Search – Enforcement and Compliance Data." [Search for facilities within 50 miles of 38.033800/ -77.472200.] Available at <https://echo.epa.gov/facilities/facility-search> (accessed February 25, 2021).

Free Lance-Star. 2020. "Birchwood Power Plant in King George will close next year." *The Free Lance-Star*. February 21, 2020. Available at <https://fredericksburg.com/news/local/birchwood-power-plant-in-king-george-will-close-next-year/article_87d135f4-c3af-57d2-bd90-66daef5aedbc.html> (accessed February 28, 2021).

Kings Dominion. 2021. "Park Description." Available at <https://www.kingsdominion.com/media-center> (accessed February 17, 2021).

Klöckner Pentaplast. 2020. Available at <https://www.kpfilms.com/en/> (accessed February 26, 2021).

Louisa County. 2021a. "Louisa County Sanitary Landfill." Available at <https://www.louisacounty.com/224/Louisa-County-Sanitary-Landfill> (accessed February 25, 2021).

Louisa County. 2021b. "Utilities." Available at <https://www.louisacounty.com/> (accessed February 25, 2021).

Martin Marietta. 2021. "Facility Locator – Aggregates: Virginia, USA." Available at < https://www.martinmarietta.com/facility-locator/> (accessed May 12, 2021).

[NPS] National Park Service. 2021a. "Frederick & Spotsylvania National Military Park." Available at <https://www.nps.gov/frsp/index.htm> (accessed February 28, 2021).

[NPS] National Park Service. 2021b. "Green Springs." Available at <https://www.nps.gov/grsp/index.htm> (accessed February 19, 2021).

[ODEC] Old Dominion Electric Cooperative. 2021. “Generation Facilities.” Available at <https://www.odec.com/generation-transmission-overview/generation-facilities/> (accessed February 27, 2021).

Orange County. 2021. “Orange County Landfill/Solid Waste.” Available at <http://orangecountyva.gov/724/Landfill-Solid-Waste> (accessed February 25, 2021).

Recycling Today. 2020. “Update: Cascades to convert Bear Island mill to containerboard.” October 8, 2020. Available at <https://www.recyclingtoday.com/article/cascades-convert-bear-island-paper-mill-newsprint-containerboard/> (accessed February 26, 2021).

Spotsylvania County. 2021a. “Livingston Landfill and Convenience Center.” Available at <https://www.spotsylvania.va.us/BusinessDirectoryII.aspx?lngBusinessCategoryID=44> (accessed February 25, 2021).

Spotsylvania County. 2021b. “Spotsylvania Utilities Department: What We Do.” Available at <https://www.spotsylvania.va.us/808/What-We-Do> (accessed February 26, 2021).

Solar Power World. 2020. “Dominion Energy acquires 62.5-MW Cypress Creek Renewables solar project.” Available at <https://www.solarpowerworldonline.com/2020/08/dominion-energy-acquires-62-5-mw-cypress-creek-renewables-solar-project/> (accessed February 19, 2021).

[VDCR] Virginia Department of Conservation and Recreation. 2021a. “Lake Anna State Park.” Available at <https://www.dcr.virginia.gov/state-parks/lake-anna> (accessed February 25, 2021).

[VDCR] Virginia Department of Conservation and Recreation. 2021b. “Powhatan State Park.” Available at <https://www.dcr.virginia.gov/state-parks/powhatan> (accessed February 25, 2021).

[VDWR] Virginia Department of Wildlife Resources. 2021a. “North Anna Battlefield Park.” Available at <https://dwr.virginia.gov/vbwt/sites/north-anna-battlefield-park/> (accessed February 26, 2021).

[VDWR] Virginia Department of Wildlife Resources. 2021b. “Mattaponi WMA.” Available at <https://dwr.virginia.gov/wma/mattaponi/> (accessed February 26, 2021).

[VDWR] Virginia Department of Wildlife Resources. 2021c. “C.F. Phelps WMA.” Available at <https://dwr.virginia.gov/wma/cf-phelps/> (accessed February 26, 2021).

US Silica. 2021. “Locations.” Available at <https://www.ussilica.com/locations> (accessed February 25, 2021).

Virginia Mercury. 2019. “Biggest piece of Spotsylvania solar farm approved.” *The Virginia Mercury*. April 10, 2019. Available at <https://www.virginiamercury.com/2019/04/10/biggest-piece-of-spotsylvania-solar-farm-approved/> (accessed February 19, 2021).

[Vulcan] Vulcan Materials Company. Undated. “Construction Materials: Facilities Map.” Available at <https://www.vulcanmaterials.com/construction-materials/facilities-map/FindByState> (accessed February 25, 2021).

APPENDIX F

ENVIRONMENTAL IMPACTS OF POSTULATED ACCIDENTS

F. ENVIRONMENTAL IMPACTS OF POSTULATED ACCIDENTS

This appendix describes the environmental impacts from postulated accidents that may occur at North Anna Power Station, Units 1 and 2 (North Anna) during the subsequent license renewal period. The term "accident" refers to any unintentional event outside the normal plant operational envelope that could result in either: (a) an unplanned release of radioactive materials into the environment; or (b) the potential for an unplanned release of radioactive materials into the environment.

NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS) (NRC 1996, 2013a), evaluates in detail the following two classes of postulated accidents as they relate to license renewal. The GEIS conclusions are codified in 10 CFR Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions":

- Design-Basis Accidents: Postulated accidents that a nuclear facility must be designed and built to withstand without loss to the systems, structures, and components necessary to ensure public health and safety.
- Severe Accidents: Postulated accidents that are more severe than design-basis accidents because they could result in substantial damage to the reactor core, with or without serious offsite consequences.

This appendix first describes the NRC staff's evaluation of new and significant information related to design-basis accidents at North Anna, followed by an evaluation of new and significant information for postulated severe accidents at North Anna.

F.1 Background

Although this supplemental environmental impact statement (SEIS) documents the NRC staff's review of a subsequent license renewal application, it is helpful to keep in mind that long before any license renewal actions, an operating reactor has already completed the NRC licensing process for the original 40-year operating license. To receive a license to operate a nuclear power reactor, an applicant must submit to the NRC an operating license application that includes, among many other requirements, a safety analysis report. The applicant's safety analysis report presents the design criteria and design information for the proposed reactor and includes comprehensive data on the proposed site. The applicant's safety analysis report also describes various design-basis accidents and the safety features designed to prevent or mitigate their impacts. The NRC staff reviews the operating license application to determine if the plant's design—including designs for preventing or mitigating accidents—meets the NRC's regulations and requirements. At the conclusion of that review, an operating license would be issued only if the NRC finds, in part, that there is reasonable assurance that the activities authorized by the license can be conducted without endangering the health and safety of the public and that the activities will be conducted in accordance with the NRC's regulations.

F.1.1 Design-Basis Accidents

Design-basis accidents are postulated accidents that a nuclear facility must be designed and built to withstand without loss to the systems, structures, and components necessary to ensure public health and safety. Planning for design-basis accidents ensures that the proposed plant can withstand normal transients (e.g., rapid changes in the reactor coolant system temperature or pressure, or rapid changes in reactor power), as well as a broad spectrum of postulated accidents without undue hazard to the health and safety of the public. Many of these design-basis accidents may occur, but are unlikely to occur, even once during the life of the plant; nevertheless, carefully evaluating each design-basis accident is crucial to establishing the design basis for the preventive and mitigative safety systems of the proposed nuclear power plant. Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," and 10 CFR Part 100, "Reactor Site Criteria," describe the NRC's acceptance criteria for design-basis accidents.

Before the NRC will issue an operating license for a new nuclear power plant, the applicant must demonstrate the ability of its proposed reactor to withstand all design-basis accidents. The applicant and the NRC staff evaluate the environmental impacts of design-basis accidents for the hypothetical individual exposed to the maximum postulated amount of radiation (maximum exposed individual member of the public). The results of these evaluations of design-basis accidents are found in the reactor's original licensing documents, such as the applicant's final safety analysis report, the NRC staff's safety evaluation report, and the final environmental statement. Once the NRC issues the operating license for the new reactor, the licensee is required to maintain the acceptable design and performance criteria (which includes withstanding design-basis accidents) throughout the operating life of the nuclear power plant, including any license-renewal periods of extended operation. The consequences of design-basis accidents are evaluated for the hypothetical maximum exposed individual; as such, changes in the plant environment over time will not affect these evaluations.

The NRC regulation at 10 CFR 54.29(a), "Standards for Issuance of a Renewed License," requires license renewal applicants to demonstrate that identified actions have been or will be taken to manage the effects of aging and perform any required time-limited aging analyses (as further described in the regulation), such that there is reasonable assurance that the activities authorized by the renewed license will continue to be conducted in accordance with the plant's current licensing basis (CLB) (10 CFR 54.3(a), "Definitions"). Furthermore, the applicant must show that any changes made to the plant's CLB comply with paragraph (a) of 10 CFR 54.29 and are in accordance with the Atomic Energy Act of 1954, as amended, and the NRC's regulations. Because of the requirements that the plant's existing design-basis and aging management programs be in effect for license renewal, the environmental impacts of design-basis accidents as calculated for the original operating license application should not differ significantly from the environmental impacts of design-basis accidents at any other time during plant operations, including during the initial license renewal and subsequent renewal periods. Accordingly, the design of the nuclear power plant, relative to design-basis accidents during the period of extended operation, is considered to remain acceptable.

F.1.2 Design-Basis Accidents and License Renewal

Consistent with Regulatory Issue Summary RIS-2014-006, "Consideration of Current Operating Issues and Licensing Actions in License Renewal" (NRC 2014a), the early and adequate identification of design-basis accidents (prior to subsequent license renewal) makes these design-basis accidents and associated structures, systems, and components a part of the CLB of the plant as defined at 10 CFR 54.3(a). The NRC requires licensees to maintain the CLB of the plant under the current operating license, as well as during any license renewal period. Therefore, under the provisions of 10 CFR 54.30, "Matters not Subject to a Renewal Review," design-basis accidents are not subject to review under license renewal.

As stated in Section 5.3.2 of the 1996 GEIS, the NRC staff assessed the environmental impacts from design-basis accidents in individual plant-specific environmental impact statements (EISs) at the time of the initial license application review. Consistent with the NRC Reactor Oversight Program/Process, a licensee is required to maintain the plant within acceptable design and performance criteria, including during any license renewal term. As such, the NRC staff would not expect environmental impacts of continued plant operation to change significantly, and accordingly, an additional assessment of the environmental impacts from design-basis accidents is not necessary (10 CFR Part 51, Appendix B to Subpart A, “Environmental Effect of Renewing the Operating License of a Nuclear Power Plant”). The 1996 GEIS concluded that the environmental impacts of design-basis accidents are of SMALL significance for all nuclear power plants, because the plants were designed to withstand these accidents. For the purposes of initial or subsequent license renewal, the NRC designates design-basis accidents as a Category 1 generic issue—applicable to all nuclear power plants (see 10 CFR Part 51, Appendix B to Subpart A). During the license renewal review process, the NRC staff adopts the applicable Category 1 issue conclusions from the GEIS (unless new and significant information about the issue has been identified). Hence, the NRC staff need not address Category 1 issues (like design-basis accidents) in the site-specific SEIS for license renewal, unless new and significant information has been identified for those issues.

In its environmental report for the North Anna subsequent license renewal application, Dominion did not identify any new and significant information related to design-basis accidents at North Anna (Dominion 2020). The NRC staff also did not identify any new and significant information related to design-basis accidents during its independent review of Dominion’s environmental report, through the scoping process, or in its evaluation of other available information. Therefore, the NRC staff concludes that there are no environmental impacts related to design-basis accidents at North Anna during the subsequent license renewal period beyond those already discussed generically for all nuclear power plants in the GEIS.

F.1.3 Severe Accidents

Severe accidents are postulated accidents that are more severe than design-basis accidents because severe accidents can result in substantial damage to the reactor core, with or without serious offsite consequences. Severe accidents can entail multiple failures of equipment or functions.

F.1.4 Severe Accidents and License Renewal

Chapter 5 of the 1996 GEIS (NRC 1996) conservatively predicts the environmental impacts of postulated severe accidents that may occur during the period of extended operations at nuclear power plants. In the 2013 GEIS, the staff updated the NRC’s 1996 plant-by-plant severe accident environmental impact assessments (NRC 2013a, Appendix E). In the GEIS, the NRC considered impacts of severe accidents including:

- dose and health effects of accidents
- economic impacts of accidents
- effect of uncertainties on the results

The NRC staff calculated these estimated impacts by studying the risk analysis of severe accidents as reported in the EISs and/or final environmental statements that the NRC staff had prepared in support of each plant’s original reactor operating license review. When the NRC staff prepared the 1996 GEIS, 28 nuclear power plant sites (44 units) had EISs or final environmental statements that contained a severe accident analysis. Not all original operating reactor licenses contained a severe accident analysis because the NRC had not always required such analyses. The 1996 GEIS assessed the environmental impacts of severe accidents during the license renewal period for all plants by using the results of existing analyses and site-specific information to make conservative predictions. With few exceptions, the severe accident analyses evaluated in the 1996 GEIS were limited to consideration of reactor accidents caused by internal events. The 1996 GEIS addressed the impacts from external events (e.g., earthquakes and flooding) qualitatively.

For its severe accident environmental impact analysis for each plant, the 1996 GEIS used very conservative 95th-percentile upper-confidence bound estimates for environmental impact whenever available. This approach provides conservatism to cover uncertainties, as described in Section 5.3.3.2.2 of the 1996 GEIS. The 1996 GEIS concluded that the probability-weighted consequences of severe accidents as related to license renewal are SMALL compared to other risks to which the populations surrounding nuclear power plants are routinely exposed. Since issuing the 1996 GEIS, the NRC's understanding of severe accident risk has continued to evolve. The updated 2013 GEIS assesses more recent information and developments in severe accident analyses and how they might affect the conclusions in Chapter 5 of the 1996 GEIS. The 2013 GEIS also provides comparative data where appropriate. Based on information in the 2013 GEIS, the NRC staff determined that for all nuclear power plants, the probability-weighted consequences of severe accidents are SMALL. However, the GEIS determined that alternatives to mitigate severe accidents must be considered for all plants that have not considered such alternatives, as a Category 2 issue. See Table B-1, "Summary of Findings on NEPA [National Environmental Policy Act] Issues for License Renewal of Nuclear Power Plants," of Appendix B to Subpart A of 10 CFR Part 51, which states:

> 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.

An analysis of severe accident mitigation alternatives (SAMAs) was performed for North Anna at the time of initial license renewal (Dominion 2001). The staff documented its SAMA review in NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 7, Regarding North Anna, Units 1 and 2* (NRC 2002a). For the North Anna subsequent license renewal SAMA analysis, the NRC staff considered any new and significant information that might alter the conclusions of that analysis, as discussed below.

The NRC's regulations in 10 CFR Part 51, which implement Section 102(2) of NEPA, require that all applicants for license renewal must submit an ER to the NRC, in which they identify any ''new and significant information regarding the environmental impacts of license renewal of which the applicant is aware'' (10 CFR 51.53(c)(3)(iv)). This includes new and significant information that could affect the environmental impacts related to postulated severe accidents or that could affect the results of a previous SAMA analysis. Accordingly, in its subsequent license renewal application ER, Dominion evaluates areas of new and significant information that could affect the environmental impact of postulated severe accidents during the subsequent license renewal period of extended operation and possible new and significant information as it relates to SAMAs.

F.2 Severe Accident Mitigation Alternatives (SAMAs)

In a SAMA analysis, the NRC requires license renewal applicants to consider the environmental impacts of severe accidents, their probability of occurrence, and potential means to mitigate those accidents. As quoted above, 10 CFR Part 51, Table B-1 states, "Alternatives to mitigate severe accidents must be considered for all plants that have not considered such alternatives." This NRC requirement to consider alternatives to mitigate severe accidents can be fulfilled by a SAMA analysis. The purpose of the SAMA analysis is to identify design alternatives, procedural modifications, or training activities that may further reduce the risks of severe accidents at nuclear power plants and that are also potentially cost-beneficial to implement. The SAMA analysis includes the identification and evaluation of SAMAs that may reduce the radiological risk from a severe accident by preventing substantial core damage (i.e., preventing a severe accident) or by limiting releases from containment if substantial core damage occurs (i.e., mitigating the impacts of a severe accident) (NRC 2013a). The regulation at 10 CFR 51.53(c)(3)(ii)(L), states that each license renewal applicant must submit an environmental report that considers alternatives to mitigate severe accidents “[i]f the staff has not previously considered severe accident mitigation alternatives for the applicant's plant in an environmental impact statement or related supplement or in an environmental assessment.”

F.2.1 North Anna Initial License Renewal Application and SAMA Analysis in 2001

As part of its initial license renewal application submitted in 2001, Dominion’s environmental report included an analysis of SAMAs for North Anna (Dominion 2001). Dominion based this SAMA analysis on: (1) the North Anna probabilistic risk assessment (PRA) for total accident frequency, core damage frequency (CDF), and containment large early release frequency (LERF); and (2) a supplemental analysis of offsite consequences and economic impacts for risk determination. The North Anna PRA included a Level 1 analysis to determine the CDF from internally initiated events and a Level 2 analysis to determine containment performance during severe accidents. The offsite consequences and economic impacts analyses (Level 3 PRA) used the MELCOR Accident Consequence Code System 2 (MACCS2) code, Version 1.12, to determine the offsite risk impacts on the surrounding environment and the public. Inputs for the latter analysis included plant- and site-specific values for core radionuclide inventory, source term and release fractions, meteorological data, projected population distribution (based on 1990 census data, projected out to 2030),[1] emergency response evacuation modeling, and economic data. To help identify and evaluate potential SAMAs, Dominion considered insights and recommendations from SAMA analyses for other plants, potential plant improvements discussed in NRC and industry documents, and documented insights that the North Anna staff provided.

In its 2001 environmental report, Dominion considered 158 SAMA candidates. Dominion then performed a qualitative screening of those SAMAs, eliminating SAMAs that were not applicable to North Anna or had already been implemented at North Anna. Based on this qualitative screening, 107 SAMAs were eliminated, leaving 51 SAMAs subject to the final screening and evaluation process. The 51 remaining SAMAs are listed in Table G.2-2 of Appendix G of the 2001 environmental report (ER) (Dominion 2001). The final screening process involved identifying and eliminating those SAMAs whose cost exceeded twice their benefit. Ultimately, Dominion concluded that there were no potentially cost-beneficial SAMAs associated with the initial North Anna license renewal (Dominion 2001).

As part of its review of the initial North Anna license renewal application, the NRC staff reviewed Dominion’s 2001 analysis of SAMAs for North Anna, as documented in Supplement 7 to NUREG-1437 (NRC 2002b). Chapter 5 of Supplement 7 to NUREG-1437 contains the NRC staff’s evaluation of the potential environmental impacts of plant accidents and examines each SAMA (individually and, in some cases, in combination) to determine the SAMA’s individual risk reduction potential. The NRC staff then compared this potential risk reduction against the cost of implementing the SAMA to quantify the SAMA’s cost-benefit value.

In Section 5.2 of NUREG-1437, Supplement 7, the NRC staff found that Dominion used a systematic and comprehensive process for identifying potential plant improvements for North

[1] In contrast, as discussed in Section F.3.9 below, Dominion’s ER for subsequent license renewal utilized projected population values for the year 2060 (Dominion 2020).

Anna, and that its bases for calculating the risk reductions afforded by these plant improvements were reasonable and generally conservative. Further, the NRC staff found that Dominion's estimates of the costs of implementing each SAMA were reasonable and consistent with estimates developed for other operating reactors. In addition, the NRC staff concluded that Dominion's cost-benefit comparisons were performed appropriately. The NRC staff concluded that Dominion's SAMA methods and implementation of those methods were sound. The NRC staff agreed with Dominion's conclusion that none of the candidate SAMAs were potentially cost-beneficial based on conservative treatment of costs and benefits. The staff found that Dominion's conclusion was: (a) consistent with the low residual level of risk indicated in the North Anna PRA and (b) consistent with the fact that North Anna had already implemented many plant improvements identified during two risk analysis processes. These two risk analysis process were (1) the individual plant examination (IPE), a risk analysis that considers the unique aspects of a particular nuclear power plant, identifying the specific vulnerabilities to severe accidents of that plant and, (2) the individual plant examination of external events (IPEEE), a risk analysis that considers external events such as earthquakes and high winds (NRC 2002b).

F.2.2 Subsequent License Renewal Application and New and Significant Information as It Relates to the Probability-Weighted Consequences of Severe Accidents

As mentioned above, a license renewal application must include an ER that describes SAMAs if the NRC staff has not previously evaluated SAMAs for that plant in an EIS, in a related supplement to an EIS, or in an environmental assessment. As also discussed above, the NRC staff performed a site-specific analysis of North Anna SAMAs in NUREG-1437, Supplement 7 (NRC 2002b). Therefore, in accordance with 10 CFR 51.53(c)(3)(ii)(L) and Table B-1 of Appendix B to Subpart A of 10 CFR Part 51, Dominion is not required to provide another SAMA analysis in its ER for the North Anna subsequent license renewal application.

In Dominion's assessment of new and significant information related to SAMAs in its subsequent license renewal application, Dominion used the Nuclear Energy Institute (NEI) guidance document, NEI 17-04, Revision 1, "Model SLR [Subsequent License Renewal] New and Significant Assessment Approach for SAMA" (NEI 2019), which the NRC staff has endorsed (NRC 2019a). As discussed in Section F.5 below, NEI developed a model approach for license renewal applicants to use in assessing the significance of new information, of which the applicant is aware, that relates to a prior SAMA analysis that was performed in support of the issuance of an initial license, renewed license, or combined license.

NEI 17-04 provides a tiered approach that entails a three-stage screening process for the evaluation of new information. In this screening process, new information is deemed to be "potentially significant" to the extent that it results in the identification in Stage 1 (involving the use of PRA risk insights and/or risk model quantifications) of an unimplemented SAMA that reduces the maximum benefit (MB) by 50 percent or more. Maximum benefit is defined in Section 4.5 of NEI 05-01, Revision A, "Severe Accident Mitigation Alternatives (SAMA) Analysis Guidance Document" (NEI 2005b), as the benefit a SAMA could achieve if it eliminated all risk. The total offsite dose and total economic impact are the baseline risk measures from which the maximum benefit is calculated.

If a SAMA is found to result in a 50-percent reduction in maximum benefit in Stage 1, a Stage 2 assessment would then be performed (involving an updated averted cost-risk estimate for implementing that SAMA). A Stage 3 assessment (involving a cost-benefit analysis) would be required only for "potentially significant" SAMAs (i.e., those that are shown by the Stage 2 assessment to reduce the maximum benefit by 50 percent or more). Finally, if the Stage 3 assessment shows that a "potentially significant" SAMA is "potentially cost-beneficial," thus indicating the existence of "new and significant" information, then the applicant must supplement the previous SAMA analysis. The NRC staff endorsed NEI 17-04, Revision 1, for use by license renewal applicants on December 11, 2019 (NRC 2019a). Dominion's assessment of new and significant information related to its SAMA cost-benefit analysis is discussed in Section F.5 of this appendix.

Below, the NRC staff summarizes possible areas of new and significant information and assesses Dominion's conclusions.

F.3 Evaluation of New Information Concerning Severe Accident Consequences for North Anna as It Relates to the GEIS

The 2013 GEIS considers developments in plant operation and accident analysis that could have changed the assumptions made in the 1996 GEIS concerning severe accident consequences. The 2013 GEIS confirmed the determination in the 1996 GEIS that the probability-weighted consequences of severe accidents are SMALL for all plants. In the 2013 GEIS, Appendix E provides the NRC staff's evaluation of the environmental impacts of postulated accidents. Table E-19, "Summary of Conclusions," of the 2013 GEIS shows the developments that the NRC staff considered, as well as the staff's conclusions. Consideration of the items listed in Table E-19 was the basis for the NRC staff's overall determination in the 2013 GEIS that the probability-weighted consequences of severe accidents remain SMALL for all plants.

For subsequent license renewal for North Anna, the staff confirmed that there is no new and significant information that would change the 2013 GEIS conclusions on the probability-weighted consequences of severe accidents. The NRC staff evaluated Dominion's information related to the 2013 GEIS, Table E-19, "Summary of Conclusions," during the North Anna audit (NRC 2020a), during the scoping process, and through the evaluation of other available information. The results of that review follow.

F.3.1 New Internal Events Information (Section E.3.1 of the 2013 GEIS)

After Dominion submitted the North Anna initial license renewal application ER in 2001 and the NRC staff issued its corresponding SAMA review in its 2002 SEIS, there have been many improvements to North Anna's risk profile. The North Anna internal events CDF in the initial license renewal SAMA was approximately 3.50×10^{-5}/year (Dominion 2001). The current North Anna internal events PRA model of record has a CDF of approximately 1.36×10^{-6}/year (Dominion 2020). This change represents a 96-percent reduction or a factor of 25 reduction in CDF for each unit. This substantial improvement in CDF makes any proposed new SAMA or previously evaluated SAMA less likely to be cost-beneficial.

In addition, in the 2013 GEIS, the NRC staff reviewed the updated boiling-water reactor (BWR) and pressurized-water reactor (PWR) internal event CDFs. The CDF is an expression of the likelihood that, given the way a reactor is designed and operated, an accident could cause the fuel in the reactor to be damaged. The 2013 GEIS addresses new information on the risk and environmental impacts of severe accidents caused by internal events that had emerged following issuance of the 1996 GEIS and includes consideration of North Anna's plant-specific PRA analysis. The new information addressed in the 2013 GEIS indicates that PWR and BWR CDFs evaluated for the 2013 GEIS are generally comparable to or less than the CDFs that formed the basis for the 1996 GEIS (NRC 2013a).

Therefore, considering the CDF reduction in North Anna's risk profile and the new information evaluated in the 2013 GEIS, the NRC staff concludes that the offsite consequences of severe accidents initiated by internal events during the subsequent license renewal term at North Anna would not exceed the impacts predicted in the 2013 GEIS. For these issues, the GEIS predicted that the probability-weighted consequences of severe accidents would be SMALL for all nuclear plants. The NRC staff identified no new and significant information regarding internal events during its review of Dominion's ER, during the SAMA audit, through the scoping process, or through the evaluation of other available information. Thus, the NRC staff finds Dominion's conclusion acceptable that no new and significant information exists for North Anna concerning offsite consequences of severe accidents initiated by internal events that would alter the conclusions reached in the 2013 GEIS.

F.3.2 External Events (Section E.3.2 of the 2013 GEIS)

The 1996 GEIS concluded that severe accidents initiated by external events (such as earthquakes) could have potentially high consequences, but also found that the risks from these external events are adequately addressed through a consideration of severe accidents initiated by internal events (such as a loss of cooling water). Therefore, the 1996 GEIS concluded that an applicant for license renewal need only analyze the environmental impacts from an internal event to characterize the environmental impacts from either internal or external events.

The 2013 GEIS expanded the scope of the evaluation in the 1996 GEIS and used more recent technical information that included both internally and externally initiated event core-damage frequencies. Section E.3.2.3 of the 2013 GEIS concludes that the CDFs from severe accidents initiated by external events, as quantified in NUREG-1150, *Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants* (NRC 1990b), and other sources documented in the GEIS, are comparable to CDFs from accidents initiated by internal events, but lower than the CDFs that formed the basis for the 1996 GEIS.

The fire and seismic CDFs (3.9×10^{-5} per reactor-year and $6x10^{-6}$ per reactor-year, respectively) for North Anna as well as the sum of the two, were less than 5.9×10^{-5} per reactor-year. This value (5.9×10^{-5}) was the internal events mean value CDF for PWRs that the 2013 GEIS used to estimate probability-weighted, offsite consequences from airborne, surface water, and groundwater pathways, as well as the resulting economic impacts from such pathways.

Dominion indicated that the "NAPS-R07i" model was used to determine the level of significance of new information. This model includes internal events (including internal floods) and a Seismic PRA, which takes into account the 2011 Mineral, Virginia, earthquake (Dominion 2020). Dominion indicated this PRA model reflected the most up-to-date understanding of plant risk at the time of analysis. The staff determined that this approach is sufficient to evaluate new and significant information related to SAMAs because use of the model was consistent with the NEI 17-04 methodology.

On March 12, 2012, the NRC issued a request under 10 CFR 50.54(f), as part of implementing lessons learned from the accident at Fukushima, that, among other things, requested licensees to reevaluate the seismic hazards at their sites using present-day methodologies and guidance to develop a ground motion response spectrum (GMRS) (NRC 2012). Since the reevaluated seismic hazard for North Anna, as characterized by the GMRS, was not bounded by the current plant design-basis SSE 9safe-shutdown earthquake), the NRC requested that Dominion complete a seismic probabilistic risk assessment (Seismic PRA) to determine if plant enhancements were warranted. Dominion submitted its Seismic PRA on March 28, 2018 (Dominion 2018). The NRC staff reviewed Dominion's Seismic PRA and concluded that the results and risk insights provided by the Seismic PRA support the NRC's determination that no further response or regulatory action is required at North Anna (NRC 2019b). The staff indicated that a backfit was not warranted because the staff did not identify any potential modifications that (1) would result in substantial reductions in the seismic core damage frequency and mean-seismic large-early-release frequency, (2) would be a substantial safety improvement, or (3) would be necessary for adequate protection or compliance. The staff also noted that the actions taken by Dominion and experience gained after the 2011 Mineral earthquake "provide additional assurance regarding North Anna's ability to handle a beyond-design-basis seismic event" (NRC 2019b). In its June 9, 2020, letter completing its post-Fukushima assessment for North Anna, the staff noted that North Anna had implemented the safety enhancements mandated by the NRC based on the lessons learned from the Fukushima accident, and stated that the NRC will continue to provide oversight of North Anna's seismic safety enhancements through the Reactor Oversight Process (NRC 2020a, 2020b).

In conclusion, there was a greater than a factor of 25 decrease in the North Anna internal events CDF. North Anna also performed a Seismic PRA (external events) to determine if plant enhancements were warranted, and the staff determined that North Anna had implemented the safety enhancements mandated by the NRC based on the lessons learned from the Fukushima accident. As predicted in the 2013 GEIS, the sum of the North Anna external events CDFs was lower than the CDFs that formed the basis for the 1996 GEIS. Therefore, the NRC staff concludes that the probability-weighted offsite consequences of severe accidents initiated by external events during the subsequent license renewal term would not exceed the consequences predicted in the 2013 GEIS. For these issues, the GEIS predicts that the probability-weighted consequences would be SMALL for all nuclear plants. The NRC staff identified no new and significant information regarding external events during its review of Dominion's ER, through the SAMA audit, during the scoping process, or through the evaluation of other available information. Thus, the NRC staff concludes that no new and significant information exists for North Anna concerning offsite consequences of severe accidents initiated by external events that would alter the conclusions reached in the 2013 GEIS.

F.3.3 New Source Term Information (Section E.3.3 of the 2013 GEIS)

The source term refers to the magnitude and mix of the radionuclides released from the fuel (expressed as fractions of the fission product inventory in the fuel), as well as their physical and chemical form, and the timing of their release following an accident. The 2013 GEIS concludes that, in most cases, more recent estimates give significantly lower release frequencies and release fractions than was assumed in the 1996 GEIS. Thus, the environmental impacts of radioactive materials released during severe accidents, used as the basis for the 1996 GEIS (i.e., the frequency-weighted release consequences), are higher than the environmental impacts that would be estimated today using more recent source term information. The NRC staff also notes that results from the NRC's State-of-the-Art Reactor Consequence Analysis (SOARCA) project (which represents a significant ongoing effort to re-quantify realistic severe accident source terms) confirm that source term timing and magnitude values calculated in the SOARCA reports are significantly lower than those quantified in previous studies. The NRC staff expects to incorporate the information gleaned from the SOARCA project in future revisions of the GEIS (NRC 2013a).

For the reasons described above, current source term (timing and magnitude) at North Anna are likely to have significantly smaller effects than had been quantified in previous studies and the initial license renewal North Anna SAMA analysis in 2001. Therefore, the offsite consequences of severe accidents initiated by the new source term during the subsequent license renewal term would not exceed the impacts predicted in the GEIS. For these issues, the GEIS predicts that the probability-weighted consequences of severe accidents would be SMALL for all nuclear plants. The NRC staff identified no new and significant information regarding the source term during its review of Dominion's ER, through the SAMA audit, during the scoping process, or through the evaluation of other available information. Thus, the NRC staff concludes that no new and significant information exists for North Anna concerning the source term that would alter the conclusions reached in the 2013 GEIS.

F.3.4 Power Uprate Information (Section E.3.4 of the 2013 GEIS)

Operating at a higher reactor power level results in a larger fission product radionuclide inventory in the core than if the reactor were operating at a lower power level. In the event of an accident, the larger radionuclide inventory in the core would result in a larger source term. If the accident is severe, the release of radioactive materials from this larger source term could result in higher doses to offsite populations.

Large early release frequency (LERF) represents the frequency of event sequences that could result in early fatalities. The impact of a power uprate on early fatalities can be measured by considering the impact of the uprate on the LERF calculated value. To this end, Table E-14 of the 2013 GEIS presents the change in LERF calculated by each licensee that has been granted a power uprate of greater than 10 percent. Table E-14 shows that the increase in LERF ranges from a minimal impact to an increase of about 30 percent (with a mean of 10.5 percent). The 2013 GEIS, Section E.3.4.3, “Conclusion,” determines that a power uprate will result in a small-to- (in some cases) moderate increase in the environmental impacts from a postulated accident. However, taken in combination with the other information presented in the GEIS, the increases would be bounded by the 95-percent upper-confidence bound values in Table 5.10 and Table 5.11 of the 1996 GEIS.

In 2009, the NRC approved a 1.6-percent measurement uncertainty recapture (MUR) at North Anna, from 2,893 megawatts thermal (MWt) to 2,940 MWt (NRC 2009a). The MUR uprate is included in the current North Anna CDF and LERF. In the staff’s safety evaluation for the MUR uprate, the change in plant risk due to the uprate was determined to be insignificant since the power level increase is only 1.6-percent. The NRC staff's safety evaluation for the MUR power uprate concluded that the CLB (10 CFR 54.3, “Definitions”) dose-consequence analyses for design-basis accidents will remain bounding at the proposed MUR uprated power level (NRC 2009a).

Therefore, the NRC staff finds that the offsite consequences from the power uprate would not exceed the consequences predicted in the 2013 GEIS. The NRC staff has identified no new and significant information regarding power uprates during its review of Dominion’s ER, through the SAMA audit, during the scoping process, or through the evaluation of other available information. Thus, the NRC staff concludes that no new and significant information exists for North Anna concerning offsite consequences due to power uprates that would alter the conclusions reached in the 2013 GEIS.

F.3.5 Higher Fuel Burnup Information (Section E.3.5 of the 2013 GEIS)

According to the 2013 GEIS, increased peak fuel burnup from 42 to 75 gigawatt days per metric ton uranium (GWd/MTU) for PWRs, and 60 to 75 GWd/MTU for BWRs, results in small to moderate increases (up to 38 percent) in population dose in the event of a severe accident. However, taken in combination with the other information presented in the 2013 GEIS, the increases would be bounded by the 95-percent upper-confidence bound values in Table 5.10 and Table 5.11 of the 1996 GEIS.

In ER Section 4.13.4.4 of the ER, Dominion indicated that the average burnup level of the peak rod is not planned to exceed 60,000 MWd/MTU during the proposed SLR operating term. Therefore, the offsite consequences from higher fuel burnup would not exceed the consequences predicted in the 2013 GEIS. For these issues, the GEIS predicted that the probability-weighted consequences would be small for all nuclear plants. The NRC staff identified no new and significant information regarding higher fuel burnup during its review of

Dominion's ER, through the SAMA audit, during the scoping process, or through the evaluation of other available information. Thus, the staff concludes that no new and significant information exists for North Anna concerning offsite consequences due to higher fuel burnup that would alter the conclusions reached in the 2013 GEIS.

F.3.6 Low Power and Reactor Shutdown Event Information (Section E.3.6 of the 2013 GEIS)

The 2013 GEIS concludes that the environmental impacts from accidents at low power and shutdown conditions are generally comparable to those from accidents at full power, based on a comparison of the values in NUREG/CR-6143, *Evaluation of Potential Severe Accidents During Low Power and Shutdown Operations at Grand Gulf, Unit 1* (NRC 1995a), and NUREG/CR-6144, *Evaluation of Potential Severe Accidents During Low Power and Shutdown Operations at Surry, Unit 1* (NRC 1995b), with the values in NUREG-1150, *Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants* (NRC 1990b). The 1996 GEIS estimates of the environmental impact of severe accidents bound the potential impacts from accidents at low power and shut down, with margin. Surry was evaluated in NUREG-1150 and NUREG/CR-6144, and North Anna is a similarly designed plant (i.e., they are Westinghouse PWRs with large containments); thus, the NRC staff concludes that there are no plant configurations in low power and shutdown conditions likely to distinguish North Anna from the evaluated plants such that the assumptions in the 2013 and 1996 GEISs would not apply.

Finally, as discussed in SECY-97-168, "Issuance for Public Comment of Proposed Rulemaking Package for Shutdown and Fuel Storage Pool Operation" (NRC 1997), industry initiatives taken during the early 1990s have also contributed to the improved safety of low power and shutdown operations for all plants. Therefore, the offsite consequences of severe accidents, considering low power and reactor shutdown events, would not exceed the impacts predicted in either the 1996 or 2013 GEIS. For these issues, the GEIS predicts that the probability-weighted consequences of severe accidents would be small for all nuclear plants. The NRC staff identified no new and significant information regarding low power and reactor shutdown events during its review of Dominion's ER, through the NRC staff's SAMA audit, during the scoping process, or through the evaluation of other available information. Thus, the staff concludes that no new and significant information exists for North Anna concerning low power and reactor shutdown events that would alter the conclusions reached in the 2013 GEIS.

F.3.7 Spent Fuel Pool Accident Information (Section E.3.7 of the 2013 GEIS)

The 2013 GEIS concludes that the environmental impacts from accidents involving spent fuel pools (as quantified in NUREG-1738, *Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants* (NRC 2001)), can be comparable to those from reactor accidents at full power (as estimated in NUREG-1150 (NRC 1990b)). The 2013 GEIS further indicates that subsequent analyses performed, and mitigative measures employed since 2001, have further lowered the risk of accidents involving spent fuel pools. In addition, the GEIS notes that even the conservative estimates from NUREG-1738 (published in 2001) are much lower than the impacts from full power reactor accidents estimated in the 1996 GEIS. Therefore, the GEIS concludes, the environmental impacts stated in the 1996 GEIS bound the impact from spent fuel pool accidents for all plants. For these issues, the GEIS predicts that the impacts would be SMALL for all nuclear plants. There are no spent fuel configurations that would distinguish North Anna from the evaluated plants such that the assumptions in the 2013 and 1996 GEISs would not apply. The NRC staff identified no new and significant information regarding spent fuel pool accidents during its review of Dominion's ER, through the SAMA audit, during the scoping process, or through the evaluation of other available information. Thus, the NRC staff concludes that no new and significant information exists for

North Anna concerning spent fuel pool accidents that would alter the conclusions reached in the 2013 GEIS.

F.3.8 Use of Biological Effects of Ionizing Radiation (BEIR) VII Risk Coefficients (Section E.3.8 of the 2013 GEIS)

In 2005, the NRC staff completed a review of the National Academy of Sciences report, "Health Risks from Exposure to Low Levels of Ionizing Radiation: Biological Effects of Ionizing Radiation (BEIR) VII, Phase 2." The staff documented its findings in SECY-05-0202, "Staff Review of the National Academies Study of the Health Risks from Exposure to Low Levels of Ionizing Radiation (BEIR VII)" (NRC 2005). The SECY paper states that the NRC staff agrees with the BEIR VII report's major conclusion—namely, the current scientific evidence is consistent with the hypothesis that there is a linear, no-threshold, dose-response relationship between exposure to ionizing radiation and the development of cancer in humans. The BEIR VII conclusion is consistent with the hypothesis on radiation exposure and human cancer that the NRC uses to develop its standards of radiological protection. Therefore, the NRC staff has determined that the conclusions of the BEIR VII report do not warrant any change in the NRC's radiation protection standards and regulations because the NRC's standards are adequately protective of public health and safety and will continue to apply during North Anna's subsequent license renewal term. This general topic is discussed further in the NRC's 2007 denial of Petition for Rulemaking (PRM)-51-11 (72 FR 71083), in which the NRC stated that it finds no need to modify the 1996 GEIS considering the BEIR VII report. For these issues, the GEIS predicts that the impacts of using the BEIR VII risk coefficients would be SMALL for all nuclear plants.

The NRC staff identified no new and significant information regarding the risk coefficient used in the BEIR VII report during its review of Dominion's ER, through the SAMA audit, during the scoping process, or through the evaluation of other available information. Thus, the staff concludes that no new and significant information exists for North Anna concerning the biological effects of ionizing radiation that would alter the conclusions reached in the 2013 GEIS.

F.3.9 Uncertainties (Section E.3.9 of the 2013 GEIS)

Section 5.3.3 in the 1996 GEIS provides a discussion of the uncertainties associated with the analysis in the GEIS and in the individual plant EISs used to estimate the environmental impacts of severe accidents. The 1996 GEIS used 95th percentile upper confidence bound estimates whenever available for its estimates of the environmental impacts of severe accidents. This approach provides conservatism to cover uncertainties, as described in Section 5.3.3.2.2 of the 1996 GEIS. Many of these same uncertainties also apply to the analysis used in the 2013 GEIS update. As discussed in Sections E.3.1 through E.3.8 of the 2013 GEIS, the GEIS update used more recent information to supplement the estimate of environmental impacts contained in the 1996 GEIS. In effect, the assessments contained in Sections E.3.1 through E.3.8 of the 2013 GEIS provided additional information and insights into certain areas of uncertainty associated with the 1996 GEIS. However, as provided in the 2013 GEIS, the impact and magnitude of uncertainties, as estimated in the 1996 GEIS, bound the uncertainties introduced by the new information and considerations addressed in the 2013 GEIS. Accordingly, in the 2013 GEIS, the NRC staff concluded that the reduction in environmental impacts resulting from the use of new information (since the 1996 GEIS analysis) outweighs any increases in impact resulting from the new information. As a result, the findings in the 1996 GEIS remain valid. The NRC staff identified no new and significant information regarding uncertainties during its review of Dominion's ER, the SAMA audit, the scoping process, or the evaluation of other available information. Accordingly, the NRC staff concludes that no new and significant information exists for North Anna concerning uncertainties that would alter the conclusions reached in the 2013 GEIS.

Section E.3.9.2 of Appendix E to the 2013 GEIS discusses the impact of population increases on offsite dose and economic consequences. The 2013 GEIS, in Section E.3.9.2, states the following:

> The 1996 GEIS estimated impacts at the mid-year of each plant's license renewal period (i.e., 2030 to 2050). To adjust the impacts estimated in the NUREGs and NUREG/CRs to the mid-year of the assessed plant's license renewal period, the information (i.e., exposure indexes [EIs]) in the 1996 GEIS can be used. The EIs adjust a plant's airborne and economic impacts from the year 2001 to its mid-year license renewal period based on population increases. These adjustments result in anywhere from a 5 to a 30 percent increase in impacts, depending upon the plant being assessed. Given the range of uncertainty in these types of analyses, a 5 to 30 percent change is not considered significant. Therefore, the effect of increased population around the plant does not generally result in significant increases in impacts.

The population used in the North Anna initial license renewal ER (Dominion 2001, Section 4.20) was extrapolated to the year 2030 and found to be 2,468,629. In the SLR ER, Dominion extrapolated the population to the year 2060. Dominion projected the total population for the year 2060 to be 5,069,774. As can be seen from the data in Tables 5.10 and 5.11 of the 1996 GEIS, the estimated risk of early and latent fatalities from individual postulated nuclear power plant accidents is SMALL using very conservative 95th-percentile, upper-confidence bound estimates for environmental impact. The early and latent fatalities represent only a small fraction of the risk to which the public is exposed from other sources. As provided in Regulatory Guide (RG) 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," the CDF risk metric is used as a surrogate for the individual latent cancer fatality risk, and the LERF risk metric is used as a surrogate for the individual early fatality risk. Given the substantial reduction in the North Anna CDF by a factor of 25, as explained in the PRA internal events section above, and the currently small North Anna LERF value of 2.49×10^{-6}/year demonstrates that the risk of early and latent fatalities from individual postulated nuclear power plant accidents has decreased since the issuance of the 1996 GEIS (NRC 2015). Furthermore, as discussed in Section E.3.3 of the 2013 GEIS and in this SEIS, more recent estimates give significantly lower release frequencies and release fractions for the source term than was assumed in the 1996 GEIS. Specifically, the 2013 GEIS states that "a comparison of population dose from newer assessments illustrates a reduction in impact by a factor of 5 to 100 when compared to older assessments, and an additional factor of 2 to 4 due to the conservatism built into the 1996 GEIS values." The effect of this reduction in total dose impact far exceeds the effect of a population increase. The staff concludes that the overall effect of increased population around the plant during the SLR period of extended operation does not result in significant increases in impacts. Thus, the staff concludes that no new and significant information exists for North Anna concerning population increases that would alter the conclusions reached in the 2013 GEIS.

F.3.10 Summary and Conclusion (Section E.5 of the 2013 GEIS)

The 2013 GEIS categorizes "sources of new information" by their potential effect on the best-estimate environmental impacts associated with postulated severe accidents. These effects can: (1) decrease the environmental impact associated with severe accidents; (2) not affect the environmental impact associated with severe accidents; or (3) increase the environmental impact associated with severe accidents.

Areas of new and significant information that can result in the first effect (decrease the environmental impacts associated with severe accidents) at North Anna include:

- new internal events information (significant decrease)
- new source term information (significant decrease)
- population (population dose decreases when using more recent studies)

Areas of new and significant information that can result in the second effect (no effect on the environmental impact associated with severe accidents) or the third effect (increase the environmental impact associated with severe accidents) include:

- use of BEIR VII risk coefficients
- consideration of external events (comparable to internal event impacts)
- spent fuel pool accidents (could be comparable to full-power event impacts)
- higher fuel burnup (small-to-moderate increases)
- low power and reactor shutdown events (could be comparable to full-power event impacts)

The 2013 GEIS states, "[g]iven the difficulty in conducting a rigorous aggregation of these results with the differences in the information sources utilized, a fairly simple approach is taken." The GEIS estimated the net increase from the five areas listed above would be (in a simplistic sense) approximately an increase by a factor of 4.7. At the same time, however, for North Anna, the reduction in risk due to newer internal event information alone is a decrease in risk by a factor of 25. The net effect of an increase by a factor of 4.7 and a decrease by a factor of 25 would be an overall lower estimated impact (as compared to the 1996 GEIS assessment) by a factor of 20.3 (25 minus 4.7). Thus, the NRC staff finds that there is no new and significant information related to severe accidents at North Anna that would alter the conclusions reached in the 2013 GEIS that the probability-weighted consequences of severe accidents are SMALL for all plants.

Other areas of new information relating to the North Anna severe accident risk, severe accident environmental impact assessment, and cost-beneficial SAMAs are described below. These areas of new information demonstrate additional conservatism in the evaluations in the GEIS and Dominion's ER, because they result in further reductions in the impact of a severe accident.

F.4 Other New Information Related to NRC Efforts to Reduce Severe Accident Risk Following Publication of the 1996 GEIS

The Commission considers ways to mitigate severe accidents at a given site more than just in the one-time SAMA analysis associated with a license renewal application. The Commission has considered and adopted various regulatory requirements for mitigating severe accident risks at reactor sites through a variety of NRC programs. For example, in 1996, when it promulgated Table B-1, "Summary of Findings on NEPA Issues for License Renewal of Nuclear Power Plants," in Appendix B to Subpart A of 10 CFR Part 51, "Environmental Effect of Renewing the Operating License of a Nuclear Power Plant," the Commission explained in a *Federal Register* notice:

> The Commission has considered containment improvements for all plants pursuant to its Containment Performance Improvement program…and the Commission has additional ongoing regulatory programs whereby licensees search for individual plant vulnerabilities to severe accidents and consider cost-

> beneficial improvements (Final rule, "Environmental Review for Renewal of Nuclear Power Plant Operating Licenses," 61 FR 28467 (June 5, 1996)).

These "additional ongoing regulatory programs" that the Commission mentioned include the IPE and the IPEEE program, which consider "potential improvements to reduce the frequency or consequences of severe accidents on a plant-specific basis and essentially constitute a broad search for severe accident mitigation alternatives." Further, in the same rule, the Commission observed that the IPEs "resulted in a number of plant procedural or programmatic improvements and some plant modifications that will further reduce the risk of severe accidents" (61 FR 28481) [*Federal Register* notices are accessible and searchable at https://www.federalregister.gov]. Based on these and other considerations, the Commission stated its belief that it is "unlikely that any site-specific consideration of SAMAs for license renewal will identify major plant design changes or modifications that will prove to be cost-beneficial for reducing severe accident frequency or consequences." The Commission noted that it may review and possibly reclassify the issue of severe accident mitigation as a Category 1 issue upon the conclusion of its IPE/IPEEE program, but deemed it appropriate to consider SAMAs for plants for which it had not done so previously, pending further rulemaking on this issue.

The Commission reaffirmed its SAMA-related conclusions in Table B-1 of Appendix B to Subpart A of 10 CFR Part 51 and 10 CFR 51.53(c)(3)(ii)(L), "Postconstruction environmental reports," in *Exelon Generation Co., LLC* (Limerick Generating Station, Units 1 and 2), CLI-13-07, (October 31, 2013). In addition, the Commission observed that it had promulgated those regulations because it had "determined that one SAMA analysis would uncover most cost-beneficial measures to mitigate both the risk and the effects of severe accidents, thus satisfying our obligations under NEPA" (NRC 2013b).

The NRC has continued to address severe accident-related issues since the agency published the GEIS in 1996. Combined NRC and licensee efforts have reduced risks from accidents beyond those accidents that were considered in the 1996 GEIS. The 2013 GEIS describes many of those efforts (NRC 2013a). In the remainder of Section F.4 of this SEIS, the NRC staff describes several efforts to reduce severe accident risk (i.e., CDF and LERF) following publication of the 1996 GEIS. Each of these initiatives applies to all reactors, including North Anna. Section F.4.1 describes requirements adopted following the terrorist attacks of September 11, 2001 to address the loss of large areas of a plant caused by fire or explosions. Section F.4.2 describes the SOARCA project, which indicates that source-term timing and magnitude values may be significantly lower than source-term values quantified in previous studies using other analysis methods. Section F.4.3 describes measures adopted following the Fukushima earthquake and tsunami events of 2013. Section F.4.4 discusses efforts that have been made to use plant operating experience to improve plant performance and design features. These are areas of new information that reinforce the conclusion that the probability-weighted consequences of severe accidents are SMALL for all plants, as stated in the 2013 GEIS, and further reduce the likelihood of finding a cost-beneficial SAMA that would substantially reduce the severe accident risk at North Anna.

F.4.1 10 CFR 50.54(hh)(2) Requirements Regarding Loss of Large Areas of the Plant Caused by Fire or Explosions

As discussed on page E-7 of the 2013 GEIS, following the terrorist attacks of September 11, 2001, the NRC conducted a comprehensive review of the agency's security program and made further enhancements to security at a wide range of NRC-regulated facilities. These enhancements included significant reinforcement of the defense capabilities for nuclear facilities, better control of sensitive information, enhancements in emergency preparedness, and implementation of mitigating strategies to deal with postulated events potentially causing loss of large areas of the plant due to explosions or fires, including those that an aircraft impact might create. For example, the Commission issued Order EA-02-026, "Order for interim safeguards and security compensatory measures" (NRC 2002c) to provide interim safeguards and security compensatory measures, which ultimately led to the promulgation of a new regulation in 10 CFR 50.54(hh). This regulation requires commercial power reactor licensees to prepare for a loss of large areas of the facility due to large fires and explosions from any cause, including beyond-design-basis aircraft impacts. In accordance with 10 CFR 50.54(hh)(2), licensees must adopt guidance and strategies to maintain or restore core cooling, containment, and spent-fuel pool cooling capabilities under circumstances associated with the loss of large areas of the plant due to explosion or fire (NRC 2013a).

NRC requirements pertaining to plant security are subject to NRC oversight on an ongoing basis under a plant's current operating license and are beyond the scope of license renewal. As discussed in Section 5.3.3.1 of the 1996 GEIS, the NRC addresses security-related events using deterministic criteria in 10 CFR Part 73, "Physical Protection of Plants and Materials," rather than by risk assessments or SAMAs. However, the implementation of measures that reduce the risk of severe accidents, including measures adopted to comply with 10 CFR 50.54(hh), "Conditions of licenses," also have a beneficial impact on the level of risk evaluated in a SAMA analysis, the purpose of which is to identify potentially cost-beneficial design alternatives, procedural modifications, or training activities that may further reduce the risks of severe accidents. Dominion has updated North Anna's guidelines, strategies, and procedures to meet the requirements of 10 CFR 50.54(hh); therefore, those efforts have contributed to mitigation of the risk of a beyond-design-basis event. Accordingly, actions taken by Dominion to comply with those regulatory requirements have further contributed to the reduction of risk at North Anna.

In sum, the new information regarding actions that Dominion has taken to prepare for potential loss of large areas of the plant due to fire or explosions has further contributed to the reduction of severe accident risk at North Anna. Thus, this information does not alter the conclusions reached in the 2013 GEIS regarding the probability-weighted consequences of severe accidents.

F.4.2 State-of-the-Art Reactor Consequence Analysis

The 2013 GEIS notes that a significant NRC effort is ongoing to re-quantify realistic, severe-accident source terms under the State-of-the-Art Reactor Consequence Analysis (SOARCA) project. Results indicate that source-term timing and magnitude values quantified using SOARCA are significantly lower than source-term values quantified in previous studies using other analysis methods (NRC 2008). The NRC staff plans to incorporate this new information regarding source term timing and magnitude using SOARCA in future revisions of the GEIS (NRC 2013a).

The NRC has completed a SOARCA study for Surry; like North Anna, Surry is a Westinghouse PWR with a large containment, in close proximity to North Anna (NRC 2013c). The Surry SOARCA analyses indicate that successful implementation of existing mitigation measures can prevent reactor core damage or delay or reduce offsite releases of radioactive material. All SOARCA scenarios, even when unmitigated, progress more slowly and release much less radioactive material than the potential releases cited in the 1982 Siting Study, NUREG/CR-2239, *Technical Guidance for Siting Criteria Development* (NRC 2012b). As a result, the calculated risks of public health consequences of severe accidents modeled in SOARCA are very small.

This new information regarding the SOARCA project's findings has further contributed to the likelihood of a reduction of the calculated severe accident risk at North Anna, as compared to the 1996 GEIS and the North Anna SAMA evaluation for the initial license renewal application in 2001. Thus, the NRC staff finds there is no new and significant information related to the SOARCA project that would alter the conclusions reached in the 2013 GEIS or North Anna’s previous SAMA analysis.

F.4.3 Fukushima-Related Activities

As discussed in Section E.2.1 of the 2013 GEIS, on March 11, 2011, a massive earthquake off the east coast of the main island of Honshu, Japan, produced a tsunami that struck the coastal town of Okuma in Fukushima Prefecture. The resulting flooding damaged the six-unit Fukushima Dai-ichi nuclear power plant, causing the failure of safety systems needed to maintain cooling water flow to the reactors. Due to the loss of cooling, the fuel overheated, and there was a partial meltdown of fuel in three of the reactors. Damage to the systems and structures containing reactor fuel resulted in the release of radioactive material to the surrounding environment (NRC 2013a).

As further discussed in Section E.2.1 of the 2013 GEIS, in response to the earthquake, tsunami, and resulting reactor accidents at Fukushima Dai-ichi (hereafter referred to as the Fukushima events), the Commission directed the NRC staff to convene an agency task force of senior leaders and experts to conduct a methodical and systematic review of NRC regulatory requirements, programs, and processes (and their implementation) relevant to the Fukushima events. After thorough evaluation, the NRC required significant enhancements to U.S. commercial nuclear power plants. The enhancements included: adding capabilities to maintain key plant safety functions following a large-scale natural disaster; updating evaluations on the potential impact from seismic and flooding events; adding new equipment to better handle potential reactor core damage events; and strengthening emergency coping capabilities. Additional discussion specific to the North Anna response to earthquakes, including Dominion’s performance of a Seismic PRA, is available above in Section F.3.2 and Section 3.4.4 of this SEIS.

In summary, the Commission has imposed additional safety requirements on operating reactors, including North Anna, following the Fukushima accident (as described in the preceding paragraphs). The new regulatory requirements have further contributed to the reduction of severe accident risk at North Anna. Therefore, the NRC staff concludes that there is no new and significant information related to the Fukushima events that would alter the conclusions reached in the 2013 GEIS or North Anna’s previous SAMA analysis.

F.4.4 Operating Experience

Section E.2 of the 2013 GEIS mentions the considerable operating experience that supports the safety of U.S. nuclear power plants. As with the use of any technology, greater user experience generally leads to improved performance and improved safety. Additional operating experience at nuclear power plants has contributed to improved plant performance (e.g., as measured by trends in plant-specific performance indicators), a reduction in adverse operating events, and new lessons learned that improve the safety of all operating nuclear power plants (NRC 2013a).

F.4.5 Conclusion

In sum, the new information related to NRC efforts to reduce severe accident risk described above contribute to improved safety, as do safety improvements not related to license renewal, including the NRC and industry response to generic safety issues (NRC 2011). Thus, the performance and safety record of nuclear power plants operating in the United States, including North Anna, continue to improve. This improvement is also confirmed by analysis, which indicates that, in many cases, improved plant performance and design features have resulted in reductions in initiating event frequency, CDF, and containment failure frequency (NRC 2013a).

As discussed above, the NRC and the nuclear industry have addressed and continue to address numerous severe accident-related issues since the publication of the 1996 GEIS and the 2001 North Anna SAMA analysis. These actions reinforce the conclusion that the probability-weighted consequences of severe accidents are SMALL for all plants, as stated in the 2013 GEIS, and further reduce the likelihood of finding a cost-beneficial SAMA that would substantially reduce the severe accident risk at North Anna.

F.5 Evaluation of New and Significant Information Pertaining to SAMAs Using NEI 17-04, "Model SLR New and Significant Assessment Approach for SAMA"

In its evaluation of the significance of new information, the NRC staff considers that new information is significant if it provides a seriously different picture of the impacts of the Federal action under consideration. Thus, for mitigation alternatives such as SAMAs, new information is significant if it indicates that a mitigation alternative would substantially reduce an impact of the Federal action on the environment. Consequently, with respect to SAMAs, new information may be significant if it indicates a given potentially cost-beneficial SAMA would substantially reduce the impacts of a severe accident or the probability or risk of a severe accident occurring (NRC 2013a).

As discussed earlier in Section F.2.2, Dominion stated in its ER (submitted as part of its subsequent license renewal application), that it used the methodology in NEI 17-04 Revision 1, "Model SLR New and Significant Assessment Approach for SAMA" (NEI 2019) to evaluate new and significant information as it relates to the North Anna subsequent license renewal SAMAs. By letter dated December 11, 2019, the staff reviewed NEI 17-04 and found it acceptable for interim use, pending formal NRC endorsement of NEI 17-04 by incorporation in RG 4.2, Supplement 1, "Preparation of Environmental Reports for Nuclear Power Plant License Renewal Applications" (NRC 2019). In general, as discussed earlier, the NEI 17-04 methodology (NEI 2017) does not consider a potential SAMA to be significant unless it reduces by at least 50 percent the maximum benefit as defined in Section 4.5, "Total Cost of Severe Accident Risk/Maximum Benefit," of NEI 05-01, Revision A, "Severe Accident Mitigation Alternatives (SAMA) Analysis Guidance Document." NEI 05-01 is endorsed in NRC RG 4.2, Supplement 1 (NRC 2013a).

NEI 17-04, "Model SLR New and Significant Assessment Approach for SAMA," describes a three-stage process for determining whether there is any new and significant information relevant to a previous SAMA analysis.

- **Stage 1**: The subsequent license renewal applicant uses PRA risk insights and/or risk model quantifications to estimate the percent reduction in the maximum benefit associated with: (1) all unimplemented "Phase 2" SAMAs for the analyzed plant; and (2) those SAMAs identified as potentially cost-beneficial for other U.S. nuclear power plants and which are applicable to the analyzed plant. If one or more of those SAMAs are shown to reduce the maximum benefit by 50 percent or more, then the applicant must complete Stage 2. (Applicants that demonstrate through the Stage 1 screening process that there is no potentially significant new information are not required to perform the Stage 2 or Stage 3 assessments.)
- **Stage 2**: The subsequent license renewal applicant develops updated averted cost-risk estimates for implementing those SAMAs. If the Stage 2 assessment confirms that one or more SAMAs reduce the maximum benefit by 50 percent or more, then the applicant must complete Stage 3.

- **Stage 3**: The subsequent license renewal applicant performs a cost-benefit analysis for the "potentially significant" SAMAs identified in Stage 2.

Upon completion of the Stage 1 screening process, Dominion determined that there is no potentially significant new information affecting its North Anna SAMA analysis; thus, Dominion did not perform the Stage 2 or Stage 3 assessments. The following sections summarize Dominion's application of the NEI 17-04 methodology to North Anna SAMAs.

F.5.1 Data Collection

NEI 17-04 Section 3.1, "Data Collection," explains that the initial step of the assessment process is to identify the "new information" relevant to the SAMA analysis and to collect and develop those elements of information that will be used to support the assessment. The guidance document states that each applicant should collect, develop, and document the information elements corresponding to the stage or stages of the SAMA analysis performed for the site. For North Anna subsequent license renewal, the NRC staff reviewed the onsite information during an audit at NRC headquarters and determined that Dominion had considered the appropriate information (NRC 2020a).

F.5.2 Stage 1 Assessment

Section E4.15.3, "Methodology for Evaluation of New and Significant SAMAs," of Dominion's ER describes the process it used to identify any potentially new and significant SAMAs from the 2001 SAMA analysis (Dominion 2020). In Stage 1 of the process, Dominion used PRA risk insights and/or risk model quantifications to estimate the percent reduction in the maximum benefit associated with the following two types of SAMAs:

(1) all unimplemented "Phase 2" SAMAs for North Anna.

(2) those SAMAs identified as potentially cost-beneficial for other U.S. nuclear power plants and that are applicable to North Anna (Dominion 2020).

F.5.3 Dominion's Evaluation of Unimplemented North Anna "Phase 2" SAMAs

In 2001, Dominion submitted an application for initial operating license renewal (Dominion 2001), which the NRC approved in 2002 as described above in Section F.2.1. As part of the subsequent license renewal application, Dominion examined its initial license renewal SAMA analysis and the North Anna PRA again, for insights. The purpose was to determine if there was any new and significant information regarding the SAMA analyses that were performed to support issuance of the initial renewed operating licenses for North Anna. Dominion reevaluated the 51 SAMAs that were considered "Phase 2" in connection with initial license renewal, using the NEI 17-04 process.

The list of SAMAs collected was evaluated qualitatively to screen any that are not applicable to North Anna or already exist at North Anna. The remaining SAMAs were then grouped (if similar) based on similarities in mitigation equipment or risk reduction benefits, and all were evaluated for the impact they have on the North Anna CDF and source term category frequencies if implemented. In addition, two other screening criteria were applied to eliminate SAMAs that have excessive cost. First, SAMAs were screened if they were found to reduce the North Anna maximum benefit by greater than 50 percent in the initial North Anna license renewal, but also if they were found not to be cost-effective due to high cost in the first license renewal. Second, SAMAs related to creating a containment vent were screened because this plant modification has been evaluated industrywide and explicitly found to not be cost-effective in Westinghouse large/dry containments. If any of the SAMAs were found to reduce the total CDF or at least one consequential source term category frequency by at least 50 percent, then the SAMA was retained for a Stage 2 assessment (Level 3 PRA evaluation of the reduction in maximum benefit). As discussed below, all SAMAs were screened as not significant without the need to go to the Stage 2 assessment or PRA Level 3 evaluation.

F.5.4 Dominion's Evaluation of SAMAs Identified as Potentially Cost-Beneficial at Other U.S. Nuclear Power Plants and Which Are Applicable to North Anna

The 2013 GEIS (NRC 2013a) considered the plant-specific supplemental EISs that document potential environmental impacts and mitigation measures for severe accidents relevant to license renewal for each plant. Some of these plant-specific supplements had identified potentially cost-beneficial SAMAs. Dominion reviewed the SEISs of plants with a similar design to North Anna (PWR Large/Dry Containments), to identify 283 potentially cost-beneficial SAMAs from other plants. This large list of industry SAMAs was qualitatively screened using the criteria that a potential SAMA is either not applicable to the North Anna design or the SAMA has already been implemented at North Anna. Dominion grouped the remaining SAMAs based on similarities in mitigation equipment or risk reduction benefits. Thus, Dominion evaluated 51 North Anna-specific SAMAs and 283 potentially cost-beneficial SAMAs identified at similarly designed nuclear power plants (industry SAMAs) for a total of 334 SAMAs.

Section E4.15.4 of Dominion's subsequent license renewal ER provides the North Anna evaluation using the methodology in NEI 17-04, "Model SLR New and Significant Assessment Approach for SAMA." The industry SAMAs that were not qualitatively screened were then merged with the North Anna-specific SAMAs collected from initial license renewal, with similar SAMAs grouped together for further analysis. The combined SAMA list was then quantitatively screened to determine if the CDF or any source term category frequency would be reduced at least 50 percent if the SAMA was implemented. Table E4.15-1 of the ER presents the 39 industry SAMAs that were not qualitatively screened out, combined with the 51 North Anna-specific SAMAs selected for further evaluation. Table E4.15-2 presents the quantitative screening results from the bounding SAMA evaluations. As seen in Table E4.15-2, none of the bounding quantitative screening evaluations resulted in a reduction of total CDF, total LERF, or total large release frequency (LRF) greater than 50 percent. Of the results presented in Table E4.15-2, one case (case name labeled as "EDG") yielded an internal events LERF reduction of 57 percent. However, Dominion explained that the total change in the Maximum Benefit for the EDG case is well below 50 percent. Since Dominion's Stage 1 analysis demonstrated that none of the SAMAs considered for quantitative evaluation would reduce the North Anna maximum benefit by 50 percent or greater, Dominion concluded that no new and significant information relevant to the original SAMA analysis for North Anna exists, and no further analysis is needed.

The NRC staff reviewed North Anna's onsite information and its SAMA Stage 1 process during an in-office audit at NRC headquarters (NRC 2020c). The staff found that Dominion had used a methodical and reasonable approach to identify any SAMAs that might reduce the maximum benefit by at least 50 percent and therefore could be considered potentially significant. Therefore, the NRC staff finds that Dominion properly concluded, in accordance with the NEI 17-04 guidance, that it did not need to conduct a Stage 2 assessment.

F.5.5 Other New Information

As discussed in Dominion's subsequent license renewal application ER and in NEI 17-04, there are some inputs to the SAMA analysis that are expected to change or to potentially change for all plants. Examples of these inputs include the following:

- Updated Level 3 PRA model consequence results, which may be impacted by multiple inputs, including, but not limited to, the following:
  - population, as projected within a 50-mile (80-km) radius of the plant

  - value of farm and nonfarm wealth
  - core inventory (e.g., due to power uprate)
  - evacuation timing and speed
  - Level 3 PRA methodology updates
  - cost-benefit methodology updates

In addition, other changes that could be considered new information may be dependent on plant activities or site-specific changes. These types of changes (listed in NEI 17-04) include the following:

- Identification of a new hazard (e.g., a fault that was not previously analyzed in the seismic analysis).
  - Updated plant risk model (e.g., a fire PRA that replaces the IPEEE analysis).
- Impacts of plant changes that are included in the plant risk models will be reflected in the model results and do not need to be assessed separately.
- Nonmodeled modifications to the plant.
  - Modifications determined to have no risk impact need not be included (e.g., replacement of the condenser vacuum pumps), unless they impact a specific input to SAMA (e.g., new low-pressure turbine in the power conversion system that results in a greater net electrical output).

The NEI methodology described in NEI 17-04 uses "maximum benefit" to determine if SAMA-related information is new and significant. Maximum benefit is defined in Section 4.5 of NEI 05-01, Revision A, "Severe Accident Mitigation Alternatives (SAMA) Analysis Guidance Document" (NEI 2005b), as the benefit a SAMA could achieve if it eliminated all risk. The total offsite dose and total economic impact are the baseline risk measures from which the maximum benefit is calculated. The methodology in NEI 17-04 considers a cost-beneficial SAMA to be potentially significant if it reduces the maximum benefit by at least 50 percent. The NRC staff finds the criterion of exceeding a 50-percent reduction in the maximum benefit a reasonable significance value because it correlates with significance determinations in the American Society of Mechanical Engineers and American Nuclear Society PRA standard (cited in Regulatory Guide (RG) 1.200) (ASME/ANS 2009; NRC 2009b), NUMARC 93-01, "Industry Guideline for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants" (NRC endorsed in RG 1.160) (NEI 2018; NRC 2018) and NEI 00-04, "10 CFR 50.69 SSC Categorization Guideline" (endorsed in RG 1.201) (NEI 2005a; NRC 2006), which the NRC has cited or endorsed. It is also a reasonable quantification of the qualitative criteria that new information is significant if it presents a seriously different picture of the impacts of the Federal action under consideration, requiring a supplement (NUREG-0386, *United States Nuclear Regulatory Commission Staff Practice and Procedure Digest: Commission, Appeal Board, and Licensing Board Decisions* (NRC 2009c)). Furthermore, it is consistent with the criteria that the NRC staff accepted in the Limerick Generating Station license renewal final SEIS (NRC 2014). The NRC staff finds the approach in NEI 17-04 to be reasonable because, with respect to SAMAs, new information may be significant if it indicates a potentially cost-beneficial SAMA could substantially reduce the probability or consequences (risk) of a severe accident occurring. The implication of this statement is that "significance" is not solely related to whether a SAMA is cost-beneficial (which may be affected by economic factors, increases in population, etc.), but it also depends on a SAMA's potential to significantly reduce risk to the public.

F.5.6 Conclusion

The NRC staff reviewed Dominion's new and significant information analysis for severe accidents and SAMAs at North Anna during the subsequent license renewal period and finds Dominion's analysis and methods to be reasonable. As described above, Dominion evaluated a total of 334 SAMAs for North Anna subsequent license renewal and did not find any SAMAs that would reduce the maximum benefit by 50 percent or more. The NRC staff reviewed Dominion's evaluation and concludes that Dominion's methods and results were reasonable. Based on North Anna's Stage 1 qualitative and quantitative screening results, Dominion demonstrated that none of the plant-specific and industry SAMAs that it considered constitute new and significant information in that none changed the conclusion of North Anna's previous SAMA analysis. Further, the NRC staff did not otherwise identify any new and significant information that would alter the conclusions reached in the previous SAMA analysis for North Anna. Therefore, the NRC staff concludes that there is no new and significant information that would alter the conclusions of the SAMA analysis performed for North Anna's initial license renewal.

In addition, given the low residual risk at North Anna, the substantial decrease in internal event CDF at North Anna from the previous SAMA analysis, and the fact that no potentially cost-beneficial SAMAs were identified during North Anna's initial license renewal review, the staff considers it unlikely that Dominion would have found any potentially cost-beneficial SAMAs for subsequent license renewal. Further, Dominion's implementation of actions to satisfy the NRC's orders and regulatory requirements regarding beyond-design-basis events after the September 2001 terrorist attacks and the March 2011 Fukushima events, including Dominion's performance of a seismic PRA, as well as the conservative assumptions used in earlier severe accident studies and SAMA analyses, also make it unlikely that Dominion would have found any potentially significant cost-beneficial SAMAs during its subsequent license renewal review. For all the reasons stated above, the NRC staff concludes that Dominion reached reasonable SAMA conclusions in its subsequent license renewal ER and that there is no new and significant information regarding any potentially cost-beneficial SAMA that would substantially reduce the risks of a severe accident at North Anna.

F.6 References

All NRC NUREG reports listed in Appendix F are available electronically from the NRC's public Web site found at: https://www.nrc.gov/reading-rm/doc-collections/nuregs/index.html. From this site, the public can gain access to NRC's collection of technical reports by using the technical report numbers (e.g., NUREG-xxxx or NUREG/CR-xxxx).

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

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

10 CFR Part 54. C*ode of Federal Regulations*. Title 10, *Energy*, Part 54, "Requirements for Renewal of Operating Licenses for Nuclear Power Plants."

10 CFR Part 100. C*ode of Federal Regulations*. Title 10, *Energy*, Part 100, "Reactor Site Criteria."

72 FR 71083. U.S. Nuclear Regulatory Commission. "Denial of petition for rulemaking PRM-51-11." *Federal Register* 72(240):71083–71086. December 14, 2007.

[ASME/ANS] American Society of Mechanical Engineers/American Nuclear Society. 2009. *Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications.* ASME/ANS RA-Sa-2009, Addendum A to RA-S-2008. February 2009.

[Dominion] Dominion Energy Virginia. 2001. *North Anna Power Station, Units 1 and 2, License Renewal Application, Appendix E, Applicant's Environmental Report.* May 2001. 238 p. ADAMS Accession No. ML011500475.

[Dominion] Dominion Virginia Power. 2018. *North Anna Power Station, Units 1 and 2 Response to March 12, 2012 Information Request Seismic Probabilistic Risk Assessment for Recommendation 2.1.* March 28, 2018. ADAMS Accession No. ML18093A445.

[Dominion] Dominion Virginia Power. 2020. *Appendix E, Applicant's Environmental Report, Subsequent Operating License Renewal Stage, North Anna Power Station, Units 1 and 2.* August 2020. ADAMS Accession No. ML20246G698.

[NEI] Nuclear Energy Institute. 2005a. *10 CFR 50.69 SSC Categorization Guideline.* NEI 00-04. Washington, DC: NEI. July 2005. ADAMS Accession No. ML052910035.

[NEI] Nuclear Energy Institute. 2005b. *Severe Accident Mitigation Alternatives (SAMA) Analysis Guidance Document.* NEI 05-01, Rev A. Washington, DC: NEI. November 2005. 79 p. ADAMS Accession No. ML060530203.

[NEI] Nuclear Energy Institute. 2017. Model SLR New and Significant Assessment Approach for SAMA. NEI 17-04, Rev 0. Washington, DC: NEI. June 2017. 24 p. ADAMS Accession No. ML17181A470.

[NEI] Nuclear Energy Institute. 2018. *Industry Guideline for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants.* Nuclear Management and Resources Council (NUMARC) 93-01, Revision 4F. Washington, DC: NEI. April 2018. ADAMS Accession No. ML18120A069.

[NEI] Nuclear Energy Institute. 2019. *Model SLR New and Significant Assessment Approach for SAMA*. NEI 17-04, Rev 1. Washington, DC: NEI. August 2019. 24 p. ADAMS Accession No. ML19316C718.

[NRC] U.S. Nuclear Regulatory Commission. 1990b. *Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants.* Washington, DC: NRC. NUREG-1150, Volumes 1 and 2. December 31, 1990. ADAMS Accession No. ML040140729.

[NRC] U.S. Nuclear Regulatory Commission. 1995a. *Evaluation of Potential Severe Accidents During Low Power and Shutdown Operations at Grand Gulf, Unit 1.* Washington, DC: NRC. NUREG/CR-6143. July 1995. ADAMS Accession No. ML20058E812.

[NRC] U.S. Nuclear Regulatory Commission. 1995b. *Evaluation of Potential Severe Accidents During Low Power and Shutdown Operations at Surry, Unit 1.* Washington, DC: NRC. NUREG/CR-6144. October 1995. ADAMS Accession No. ML18151A227.

[NRC] U.S. Nuclear Regulatory Commission. 1996. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Final Report*. Washington, DC: NRC. NUREG-1437, Volumes 1 and 2. May 9, 1996. 1,204 p. ADAMS Accession Nos. ML040690705 and ML040690738.

[NRC] U.S. Nuclear Regulatory Commission. 1997. *Issuance for Public Comment of Proposed Rulemaking for Shutdown and Fuel Storage Pool Operation.* Washington, DC: NRC. SECY-97-168. 125 p. July 30, 1997. Available at <https://www.nrc.gov/reading-rm/doc-collections/commission/secys/1997/secy1997-168/1997-168scy.pdf> (accessed December 28, 2018).

[NRC] U.S. Nuclear Regulatory Commission. 2001. *Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants.* Washington, DC: NRC. NUREG-1738. February 2001. ADAMS Accession No. ML010430066.

[NRC] U.S. Nuclear Regulatory Commission. 2002a. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants Regarding North Anna, Units 1 and 2*. Washington, DC: NRC. NUREG-1437, Supplement 7. Final Report. November 2002. 411 p. ADAMS Accession Nos. ML023380542 and ML023380567.

[NRC] U.S. Nuclear Regulatory Commission. 2002b. *NRC Regulatory Issue Summary 2002--03: Guidance on the content of Measurement Uncertainty Recapture Power Uprate Applications*. Washington, DC: NRC. RIS 2002-03. January 31, 2002. 27 p. ADAMS Accession No. ML013530183.

[NRC] U.S. Nuclear Regulatory Commission. 2002c. *Order for Interim Safeguards and Security Compensatory Measures*. Washington, DC: NRC. Order EA-02-026. February 2002. ADAMS Accession No. ML020490027.

[NRC] U.S. Nuclear Regulatory Commission. 2005. *Staff Review of the National Academies Study of the Health Risks from Exposure to Low Levels of Ionizing Radiation (BEIR VII).* Washington, DC: NRC. SECY-05-0202. October 29, 2005. ADAMS Accession No. ML052640532.

[NRC] U.S. Nuclear Regulatory Commission. 2006. *Guidelines for Categorizing Structures, Systems, and Components in Nuclear Power Plants According to their Safety Significance*. Regulatory Guide 1.201, Revision 1. Washington, DC: NRC. May 2006. ADAMS Accession No. ML061090627.

[NRC] U.S. Nuclear Regulatory Commission. 2008. *State-of-the-Art Reactor Consequence Analyses (SOARCA) Project Accident Analysis*. Randall Gauntt and Charles Tinkler presented at the 2008 Regulatory Information Conference (RIC), Rockville, Maryland. March 11, 2008. Available at <https://www.nrc.gov/public-involve/conference-symposia/ric/slides/gauntt-soarca.pdf> and <https://www.nrc.gov/about-nrc/regulatory/research/soar.html> (accessed July 18, 2019).

[NRC] U.S. Nuclear Regulatory Commission. 2009a. Letter from V. Sreenivas, Project Manager, to D. Heacock, Virginia Electric and Power Company. Subject: North Anna Power Station, Unit Nos. 1 and 2, Issuance of Amendments 257 & 238 regarding Measurement Uncertainty Recapture Power Uprate (TAC Nos. ME0965 and ME0966). October 22, 2009. ADAMS Accession No. ML092250616.

[NRC] U.S. Nuclear Regulatory Commission. 2009b. *An Approach for Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities*. Regulatory Guide 1.200, Revision 2. Washington, DC: NRC. March 2009. ADAMS Accession No. ML090410014.

[NRC] U.S. Nuclear Regulatory Commission. 2009c. *United States Nuclear Regulatory Commission Staff Practice and Procedure Digest: Commission, Appeal Board, and Licensing Board Decisions.* NUREG-0386. March 2009. ADAMS Accession No. ML091310514.

[NRC] U.S. Nuclear Regulatory Commission. 2011. *Resolution of Generic Safety Issues. NUREG-0933, Main Report and Supplements 1–34*. December 2011. <https://www.nrc.gov/sr0933/index.html> (accessed July 08, 2021)

[NRC] U.S. Nuclear Regulatory Commission. 2012. *Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-Ichi Accident.* March 12, 2012. ADAMS Accession No. ML12053A340.

[NRC] U.S. Nuclear Regulatory Commission. 2012b. *Technical Guidance for Siting Criteria Development*. NUREG/CR-2239. March 2012. ADAMS Accession No. ML072320420.

[NRC] U.S. Nuclear Regulatory Commission. 2013a. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*, Revision 1. NUREG-1437, Volumes 1, 2, and 3. June 2013. 1,535 p. ADAMS Package Accession No. ML13107A023.

[NRC] U.S. Nuclear Regulatory Commission. 2013b. *Memorandum and Order in the Matter of Exelon Generation Company, LLC (Limerick Generating Station, Units 1 and 2).* CLI-13-07. October 31, 2013. ADAMS Accession No. ML13304B417.

[NRC] U.S. Nuclear Regulatory Commission. 2013c. *State-of-the-Art Reactor Consequence Analyses Project, Volume 2: Surry Integrated Analysis*. NUREG/CR-7110, Volume 2, Revision 1. Washington, DC; NRC. August 2013.

[NRC] U.S. Nuclear Regulatory Commission. 2014. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants Regarding Limerick Generating Station Units 1 and 2.* Final Report. Washington, DC: NRC. NUREG-1437, Supplement 49. August 2014. ADAMS Accession Nos. ML14238A284 and ML14238A559.

[NRC] U.S. Nuclear Regulatory Commission. 2014a. *NRC Regulatory Issue Summary 2002-03: Guidance on the Consideration of Current Operating Issues and Licensing Actions in License Renewal.* Washington, DC: NRC. RIS 2014-06. May 5, 2014. 7 p. ADAMS Accession No. ML13177A325.

[NRC] U.S. Nuclear Regulatory Commission. 2015. *North Anna Power Station, Unit Nos. 1 And 2, Issuance of Amendments to Extend Type A Test Frequency To 15 Years (Tac Nos. Mf4332 And Mf4333)* June 16, 2015. ADAMS Accession No. ML15133A381.

[NRC] U.S. Nuclear Regulatory Commission. 2018. “Monitoring the Effectiveness of Maintenance at Nuclear Power Plants.” Regulatory Guide 1.160, Revision 4. August 2018. ADAMS Accession No. ML18220B281.

[NRC] U.S. Nuclear Regulatory Commission. 2019a. Letter from A. Bradford, NRC, to C. Earls, NEI. Subject: Interim endorsement of NEI 17-04, Model SLR [subsequent or second license renewal] new and significant assessment approach for SAMA, Revision 1. December 11, 2019. ADAMS Accession No. ML19323E740.

[NRC] U.S. Nuclear Regulatory Commission. 2019b. North Anna Power Station, Units 1 and 2—“Staff Review of Seismic Probabilistic Risk Assessment Associated with Reevaluated Seismic Hazard Implementation of the Near-Term Task Force Recommendation 2.1: Seismic.” April 25, 2019. ADAMS Accession No. ML19052A522.

[NRC] U.S. Nuclear Regulatory Commission. 2020a. Letter from R. Elliott, NRC, to D. Stoddard, Dominion. Subject: “North Anna Power Station, Units 1 and 2 – Summary of the subsequent license renewal severe accident mitigation alternatives audit (EPID Number: L-2020-SLE-0000)(Docket: 50-338 and 50-339).” December 17, 2020. ADAMS Accession No. ML20351A388.

[NRC] U.S. Nuclear Regulatory Commission. 2020b. Letter from R. Bernardo, NRC, to D. Stoddard, Senior Vice President and Chief Nuclear Officer. Subject: "North Anna Power Station, Units 1 And 2—Documentation of the completion of required actions taken in response to the lessons learned from the Fukushima Dai-Ichi accident." June 9, 2020. ADAMS Accession No. ML20139A077.

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10. SUPPLEMENTARY NOTES

11. ABSTRACT (200 words or less)

The U.S. Nuclear Regulatory Commission staff prepared this supplemental environmental impact statement (SEIS) as part of its environmental review of Dominion Energy Virginia's application to renew the operating licenses for North Anna Power Station, Units 1 and 2 (North Anna) for an additional 20 years. This SEIS includes the NRC staff's evaluation of the environmental impacts of the license renewal and alternatives to license renewal. Alternatives considered include:

(1) new nuclear (small modular reactors) and
(2) combination alternative (solar, offshore wind, small modular reactors, and demand-side management)

The NRC staff's recommendation is that the adverse environmental impacts of license renewal for North Anna are not so great that preserving the option of license renewal for energy planning decisionmakers would be unreasonable.

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