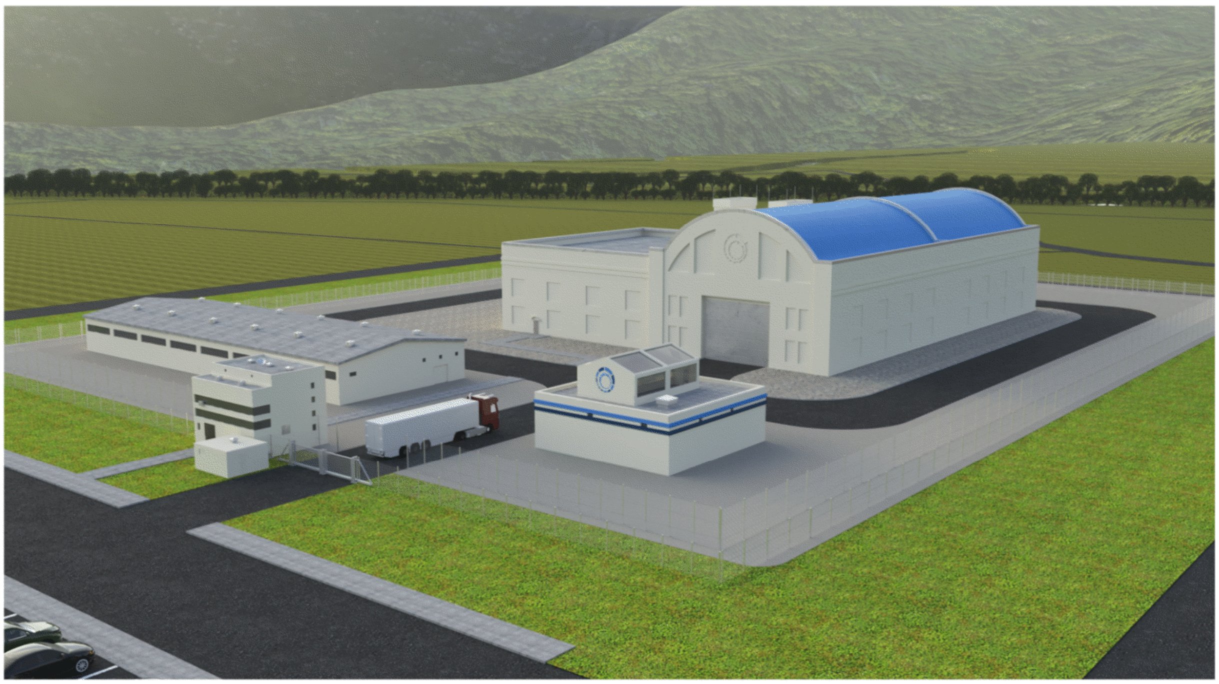
Enclosure 1

Environmental Report (Non-Proprietary)

Kairos Power



Hermes Non-Power Reactor

Environmental Report

HER-ER-001

Revision 0

October 2021

Master Table of Contents

CHAPTER 3
DESCRIPTION OF THE AFFECTED ENVIRONMENT

CHAPTER 4
IMPACTS OF PROPOSED CONSTRUCTION, OPERATIONS, AND DECOMMISSIONING

CHAPTER 5
ALTERNATIVES

CHAPTER 6
CONCLUSIONS

List of Acronyms

AADT	annual average daily traffic
AEC	Atomic Energy Commission
ALARA	as low as reasonably achievable
APE	area of potential effect
ARDP	Advanced Reactor Demonstration Program
ASCE	American Society of Civil Engineers
ASER	Annual Site Environmental Report
BCC	birds of conservation concern
BGEPA	Bald and Golden Eagle Protection Act
BLM	Bureau of Land Management
BLS	Bureau of Labor Statistics
BMAP	Biological Monitoring and Abatement Program
BMP	best management practice
BORCE	Black Oak Ridge Conservation Easement
C&D	construction and demolition
CAPARS	Computer-assisted Protective Action Recommendation System
CE	commercially exploited
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CO	carbon monoxide
CP	construction permit
CPA	construction permit application
CRM	Clinch River mile
CRN	Clinch River Nuclear
CRNS	Clinch River Nuclear Site
CROET	Community Reuse Organization of East Tennessee
CSA	combined statistical area
DAW	dry active waste
DHRS	decay heat removal system
DOE	Department of Energy
DOT	Department of Transportation
DVS	Dynamic Verification Strategy
EAB	exclusion area boundary
EIS	Environmental Impact Statement
EJ	Environmental Justice
EM	Environmental Management
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
ER	Environmental Report
ERB	effluent release boundary
ESP	Early Site Permit
ESPA	Eastern Snake Plain Aquifer

ESRP	Eastern Snake River Plain
ETHRA	East Tennessee Human Resource Agency
ETTP	East Tennessee Technology Park
FEMA	Federal Emergency Management Agency
GHG	greenhouse gases
GIS	geographical information system
GUI	graphical user interface
HALEU	high-assay low-enriched uranium
HAP	hazardous air pollutant
HEPA	high-efficiency particulate air
HRR	Heat rejection radiator
HVAC	Heating, ventilation, and air conditioning
IGS	inert gas system
IMS	inventory management system
INL	Idaho National Laboratory
IP	industrial package
ISG	Interim Staff Guidance
JFD	joint frequency distribution
KOP	key observation point
KUB	Knoxville Utilities Board
LCD	local climatological data
LCF	latent cancer fatality
LLRW	low-level radioactive waste
LOS	levels of service
LPZ	low population zone
LTP	license termination plan
LWR	light water reactor
MBTA	Migratory Bird Treaty Act
MCL	maximum contaminant level
MEI	maximally exposed individual
MGD	million gallons per day
MHA	maximum hypothetical accident
MIK	Mitchell Branch
MOA	memorandum of agreement
MW	megawatts
NAAQS	National Ambient Air Quality Standards
NASS	National Agricultural Statistics Service
NAVD	North American Vertical Datum
NCDC	National Climatic Data Center
NEPA	National Environmental Policy Act
NNL	National Natural Landmark
NOx	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRC	Nuclear Regulatory Commission
NRCS	Natural Resources Conservation Service

NRHP	National Register of Historic Places
NWS	National Weather Service
OL	operating license
ORGDP	Oak Ridge Gaseous Diffusion Plant
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
OSHA	Occupational Safety and Health Administration
PCB	polychlorinated biphenyl
PHRS	primary heat rejection system
PHSS	pebble handling and storage system
PHTS	primary heat transport system
PHX	primary heat exchanger
PMWP	probable maximum winter precipitation
PSAR	Preliminary Safety Analysis Report
PSD	Prevention of Significant Deterioration
PWS	public water system
R&D	research and development
RAMP	Radiation Protection Computer Code Analysis and Maintenance Program
RBI	reservoir benthic index
REMP	radiological environmental monitoring program
RFAI	reservoir fish assemblage index
RG	Regulatory Guide
RMP	Rocky Mountain Power
ROI	region of influence
ROW	right of way
RQD	rock quality designation
SHPO	State Historic Preservation Officer
SPCC	spill prevention, control and countermeasure
STP	sewage treatment plant
SVOC	semivolatile organic compound
SWPPP	stormwater pollution prevention plan
TDEC	Tennessee Department of Environment and Conservation
TDOT	Tennessee Department of Transportation
TEDE	total effective dose equivalent
TLD	thermoluminescent dosimeter
TMS	tritium management system
TRISO	TRI-structural ISOtropic
TRM	Tennessee River mile
TRU	transuranic waste
TVA	Tennessee Valley Authority
TWRA	Tennessee Wildlife Resources Agency
UCO	uranium oxycarbide
USACE	U.S. Army Corps of Engineers
USCB	U.S. Census Bureau
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service

USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOC	volatile organic compounds
WIFIA	Water Infrastructure Finance and Innovation Act
WMA	wildlife management area
WSA	wilderness study area

Kairos Power

Chapter 1

Introduction

Hermes Non-Power Reactor

Environmental Report

Revision 0

October 2021

TABLE OF CONTENTS

List of Tables

List of Figures

CHAPTER 1 INTRODUCTION

1.1 INTRODUCTION OF THE ENVIRONMENTAL REPORT

In accordance with the provisions of Title 10 of the Code of Federal Regulations (CFR) Part 50 "Domestic Licensing of Production and Utilization Facilities," and supporting guidance, Kairos Power is providing this Environmental Report (ER) in support of an application to construct and operate a non-power test reactor (Hermes) facility within the Heritage Center Industrial Park (Heritage Center) in Oak Ridge, Tennessee.

This ER is provided with the construction permit application as required by 10 CFR 51.50(a). The ER provides information to the U.S. Nuclear Regulatory Commission (NRC) to facilitate preparation of an Environmental Impact Statement (EIS) in accordance with the provisions of 10 CFR 51 Subpart A - National Environmental Policy Act – Regulations Implementing Section 102(2). This chapter provides an introduction to the assessment of the environmental effects of construction, operation, and decommissioning of this facility on the site and surrounding areas.

This ER follows and is organized consistent with the NRC guidance provided in Final Interim Staff Guidance (ISG) Augmenting NUREG-1537, Part 1, Chapter 19, and supports the regulatory review that is performed by the NRC under 10 CFR 51. Although this ISG is specific to medical isotope facilities, it reflects more recent NRC staff guidance for environmental reports and is useful for other non-power reactor facilities. This ER describes the project, potential alternatives, and the methods and sources used in the environmental impact analysis.

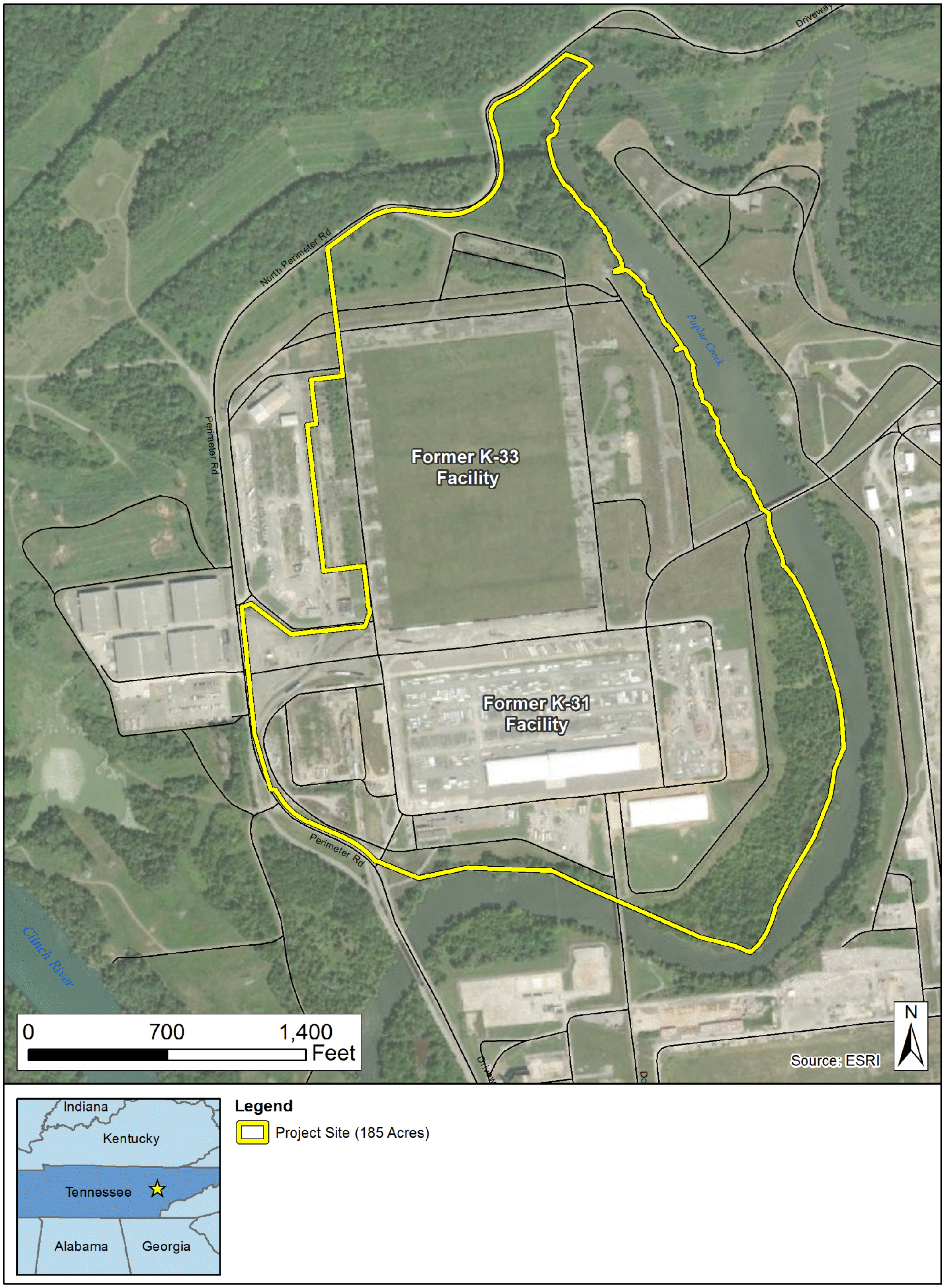
This ER also describes the existing environment at the site and vicinity, and summarizes the environmental impacts of construction, operation, and decommissioning. The purpose and need for the proposed action is provided in Subsection 1.3. A more detailed description of the proposed action is provided in Chapter 2 of this ER.

1.2 SITE HISTORY

The Heritage Center was once part of the U.S. Department of Energy (DOE) East Tennessee Technology Park (ETTP). The site area, originally named K-25, was established as part of the World War II Manhattan Project where the nation's first gaseous diffusion uranium enrichment plant (K-25) was built and operated. Additional uranium enrichment facilities (K-27, K-29, K-31, and K-33) were built adjacent to the original K-25 buildings during the Cold War, and these facilities formed a complex officially known as the Oak Ridge Gaseous Diffusion Plant (ORGDP). Uranium enrichment operations at the site ceased in 1986, and restoration, decontamination, and decommissioning activities began soon after. Reindustrialization of the ETTP began in 1996 by the DOE in cooperation with the Community Reuse Organization of East Tennessee (CROET) in preparation for conversion of the site to a private sector industrial park, to be called the Heritage Center.

The proposed site for the Hermes test reactor facility (facility) is the former location of Building K-33, which was constructed in 1954 as the final section of the five-stage uranium enrichment cascade at the ORGDP. The two original buildings (K-25 and K-27) were used to produce weapons grade highly enriched uranium. Buildings K-29, K-31, and K-33 were added to produce low enriched uranium for nuclear power plant fuel. Building K-33 was a two-story, 82-foot tall structure with approximately 64 acres of floor space. In 1987, Building K-33 was placed in permanent shutdown. Between 1997 and 2005, equipment removal and decontamination of Buildings K-29, K-31, and K-33 were conducted, and in 2009, the DOE targeted Building K-33 for demolition. Demolition activities for Building K-33 were completed in 2011 (Figure 1.1-1).

Figure 1.1-1: Site Location



1.3 PURPOSE AND NEED FOR THE PROPOSED ACTION

The proposed federal action is the issuance of a construction permit and an operating license under the provisions of 10 CFR 50, which would allow the construction and operation of a non-power test reactor facility to demonstrate the key technologies of the Kairos Power Fluoride Salt-Cooled, High Temperature Reactor (KP-FHR) for future commercial deployment. The reactor design is an advanced nuclear reactor technology that leverages TRI-structural ISOtropic (TRISO) particle fuel in pebble form combined with a low-pressure fluoride salt coolant.

Kairos Power's reactor development program, which the Hermes test reactor would support, relies on learning and risk reduction by narrowing the design space through progressive test cycles. Through these accelerated test cycles and applied engineering, teams are empowered to collaborate and learn, building on ongoing achievements. Experimental facilities and capabilities (both nuclear and non-nuclear) support Kairos Power's rapid technology demonstration. Construction and operation of the test reactor also provides validation and qualification data to support future commercial KP-FHR reactors. In consideration of this approach, the Hermes reactor siting is based on the following:

- Facilitating rapid deployment of a non-power reactor in support of Kairos Power’s iterative development approach
- Selecting a site that is, or can readily be, supported by sufficient existing high-quality site data for licensing and design
- Supporting both near-term and future testing capabilities; this objective results in a very strong preference for close proximity to a DOE national laboratory site capable of and willing to support testing requirements
- Supporting opportunities for future development; this objective equates to identifying a nexus to either a future Kairos Power commercial reactor market or potential for future expansion for Kairos Power production, fabrication, or commercial reactor deployment

This project was selected for an award under the DOE’S Office of Nuclear Energy’s new Advanced Reactor Demonstration Program (ARDP) associated with Risk Reduction for Future Demonstration projects. Therefore, the need for the project is also tied directly to the DOE’s objective under ARDP to assist private industries in the United States to demonstrate advanced nuclear reactors, with a goal of designing and developing safe and affordable reactor technologies that can be licensed and deployed over the next 10 to 14 years.

1.4 REGULATORY PROVISIONS, PERMITS, AND REQUIRED CONSULTATIONS

A number of federal, state, local, and other permits and consultations are required for the construction and operation of the facility. Table 1.4-1 lists the permits and other approvals required for construction and operation along with the current status of each. Table 1.4-2 lists the required consultations for construction and operation along with the current status of each.

In addition to the formal consultations listed in Table 1.4-2, Kairos Power has made informal contacts with the National Nuclear Security Administration, the Bureau of Indian Affairs, the Tennessee Department of Environment and Conservation (TDEC), the Tennessee Department of Transportation (TDOT), and the City of Oak Ridge. The purpose of these informal consultations was to inform the agencies about the project and to coordinate project planning.

An onsite field delineation of a wetland and other “waters of the United States” within the Project’s Study Area was conducted, and no wetlands were observed on the former K-33 Facility. Therefore, no permitting or consultation with the U.S. Army Corps of Engineers (USACE) is expected to be required.

The Hermes reactor is designed and planned to comply with all applicable environmental quality standards and regulatory requirements. No potential administrative delays or other problems have been identified that would prevent any required agency consultations or approvals.

Table 1.4-1: Permits and Approvals Required for Construction and Operation (Page 1 of 3)

Agency	Regulatory Authority	Permit or Approval	Activity Covered	Status
U.S. Nuclear Regulatory Commission	Atomic Energy Act 10 CFR 50.50	Construction Permit	Construction of the facility	Addressed in the construction permit application
	10 CFR 50.57	Operating License	Operation of the facility	To be addressed in the operating license application
	10 CFR 40	Source Material License	Possession, use, and transfer of radioactive source material	To be addressed in the operating license application
	10 CFR 30	By-Product Material License	Production, possession, and transfer of radioactive by-product material	To be addressed in the operating license application
	10 CFR 70	Special Nuclear Material License	Receipt, possession, use, and transfer of special nuclear material	To be addressed in the operating license application
	National Environmental Policy Act (NEPA) 10 CFR 51	Environmental Assessment or Environmental Impact Statement in accordance with NEPA	Site approval for construction and operation of a radiation facility	Addressed in this ER
Federal Aviation Administration	Federal Aviation Act 14 CFR 77	Construction Notice	Construction of structures that potentially may impact air navigation (greater than 200 feet) Construction of structures above a 1 to 100 slope from the nearest runway	Highest stack height is below the 200-foot requirement, not required. Notification could be required.
U.S. Environmental Protection Agency	Resource Conservation and Recovery Act 40 CFR 261 and 262	Acknowledgement of Notification of Hazardous Waste Activity	Generation of hazardous waste	Notification not yet submitted
	Clean Water Act 40 CFR 112, Appendix F	Spill Prevention, Control and Countermeasure (SPCC) Plans for Construction and Operation	Storage of oil during construction and operation	SPCC Plans not yet prepared
U.S. Department of Transportation	Hazardous Material Transportation Act	Certificate of Registration	Transportation of hazardous materials	Registration application not yet submitted

Table 1.4-1: Permits and Approvals Required for Construction and Operation (Page 2 of 3)

Agency	Regulatory Authority	Permit or Approval	Activity Covered	Status
Tennessee Department of Environment & Conservation (TDEC)	Federal Clean Air Act	Air Pollution Control Construction Permit	Construction of an air pollution emission source that is not specifically exempted	Permit application not yet submitted
	Federal Clean Air Act	Air Pollution Control Operation Permit	Operation of an air pollution emission source that is not specifically exempted	Permit application not yet submitted
	Federal Clean Water Act	Construction Storm Water Discharge Permit	Discharge of storm water runoff from the construction site	Notice of Intent to be covered by general permit not yet submitted
	Federal Clean Water Act	Industrial Storm Water Discharge Permit	Discharge of storm water runoff from the site during facility operation	Notice of Intent to be covered by general permit not yet submitted
Tennessee Department of Safety and Professional Services		Building Plan Review	Compliance with state building codes; required before a local building permit can be issued for a commercial building	Plans not yet submitted
Tennessee Department of Transportation (TDOT)		Permit for Connection to State Trunk Highway	Construction of driveway connection to Hwy 58	Driveway will not be connected to a state highway, permit not required.
		Right-of-Entry Permit	Construction by the City of Oak Ridge of utility extensions across Hwy 58	Utilities will not cross a state highway, permit not required

Table 1.4-1: Permits and Approvals Required for Construction and Operation (Page 3 of 3)

Agency	Regulatory Authority	Permit or Approval	Activity Covered	Status
City of Oak Ridge		Site Plan Approval	Administrative approval of the site layout and plans for parking, lighting, landscaping, etc.	Plans not yet submitted for review
		Storm Water Plan Approval (may be included in Site Plan Approval)	Administrative approval of grading and drainage plans	Plans not yet submitted for review
		Erosion Control Permit (may be included in Site Plan Approval)	Administrative approval of erosion control plans	Plans not yet submitted for review
		Building Permit	Construction of buildings	Permit application not yet submitted
		Plumbing Plan Approval	Installation of plumbing systems	Permit application not yet submitted
		Heating, ventilation, and air conditioning (HVAC) Plan Approval	Installation of HVAC systems	Permit application not yet submitted
		Fire Sprinkler and Alarm Permit	Installation of sprinkler and alarm systems	Permit application not yet submitted
		Occupancy Permit	Occupancy of completed buildings	Permit application not yet submitted
		Sanitary Sewer and Water Supply Facility Approvals	Administrative approval of construction, installation, and operation of connections to the municipal sewer and water supply systems	Permit application not yet submitted
		Conditional Use Permit	Construction of multiple buildings on the same site	Permit application not yet submitted

Note:
No jurisdictional wetlands or waters of the United States are anticipated to be impacted by project activities; therefore, authorization under Section 404 of the Clean Water Act is not expected to be required for construction or operation.

Table 1.4-2: Consultations Required for Construction and Operation

Agency	Regulatory Authority	Required Consultation	Surveys Required	Status
U.S. Fish and Wildlife Service	Endangered Species Act, 16 United States Code (U.S.C.) 1536, Section 7	Consultation regarding potential to adversely affect Federal listed species and designated critical habitat. Initial informal consultation may continue to formal consultation if action determined likely to adversely affect listed species or critical habitat	None	Developed biological assessment of potential for adverse effects from the project as part of the EA. Conclusions to be used in informal consultation to request USFWS concurrence with *no effect* or *may affect but not likely to adversely affect* determinations for each species. Letter requesting concurrence not yet submitted.
	Bald and Golden Eagle Protection Act, 16 U.S.C. 668-668c	If nest present, follow National Bald Eagle Management Guidelines and contact local USFWS Field Office for additional guidance as needed to avoid disturbance.	Field survey for the presence of nests in the vicinity of the project.	Field survey identified no nests in the project vicinity.
Tennessee Historical Commission	National Historic Preservation Act, Section 106	Consultation with Tennessee SHPO regarding potential to adversely impact historic resources; concurrence with no adverse impact	None	Original DOE consultation was completed. No consultation regarding the Proposed Action has been conducted.
TDEC – Division of Natural Heritage and Tennessee Wildlife Resources Agency	Rare Species Protection and Conservation Act, TN Code §70-8-101-112	Assessment of potential for project to affect rare species with a state protected status.	None	EA assessed potential occurrence of and effects on species with state protected status.
Native American Nations:	National Environmental Policy Act National Historic Preservation Act Native American Graves Protection and Repatriation Act	Consultation regarding protection of traditional Native American religious and cultural resources	None	No consultation regarding the Proposed Action has been conducted.

Kairos Power

Chapter 2

Proposed Action

Hermes Non-Power Reactor

Environmental Report

Revision 0

October 2021

TABLE OF CONTENTS

List of Tables

List of Figures

CHAPTER 2 PROPOSED ACTION

2.1 PROPOSED ACTION

The Proposed Federal Action is issuance of a Construction Permit (CP) and subsequent Operating License (OL) for a non-power reactor facility (Hermes) to test and demonstrate the key technologies, design features, and safety functions of the Kairos Power Fluoride Salt-Cooled High Temperature Reactor (KP-FHR) technology. The facility would also provide data that may be used for the validation of safety analysis tools and computational methodologies used for the designing and licensing future KP-FHR reactors.

The applicant for this CP and the OL and owner of the facility is Kairos Power LLC, (Kairos Power). Information about Kairos Power is provided with the Preliminary Safety Analysis Report (PSAR). As the owner and licensee, Kairos Power has the necessary authority and control related to the construction and operation of the facility once the CP and the OL are approved.

Kairos Power is requesting NRC review and approval of the CP application to support construction of safety-related structures, systems, and components anticipated to begin as early as mid-2023. Kairos Power is a recipient of a U.S. Department of Energy (DOE) Advanced Reactor Demonstration Program (ARDP) award for Risk Reduction funding for the KP-FHR technology with initial operations proposed to begin by mid-2026. To support this objective, the earliest start date for construction is expected to be April 2023 and the earliest projected date for completion of construction is mid-2025. The latest projected date for completion of construction is anticipated to be December 2026. The facility is expected to have a 10-year operational license. Therefore, decommissioning activities would be expected to be initiated after the operational phase ends and is anticipated to begin in 2036.

The construction phase of this project is estimated to require an estimated average of 212 onsite workers (425 at peak times) and a monthly average of 213 truck deliveries and four offsite shipments of construction debris. Table 2.1-1 shows estimates for materials that would be consumed. Additionally, approximately 31,800 gallons of diesel fuel (as a bounding assumption, fuel is assumed to be diesel) is assumed to be consumed on an average monthly basis. Table 2.1-2 shows the different types of construction equipment that would be used during the construction phase. These construction activities are estimated to affect an estimated 138 acres of land, of which an estimated 30 acres would be permanently disturbed for operation of the facility.

A low-pressure, molten salt coolant, i.e., Li2BeF4 (Flibe) and the intermediate coolant (nitrate salt) would be shipped to the site prior to startup. Flibe is estimated to be delivered in 20 shipments of 1 ton each. Nitrate salt is estimated to be delivered in 28 shipments of approximately 7 tons each.

During operations, an estimated average of 38 workers per weekday (68 full-time positions) are required for staffing. An estimated monthly average of 15 truck deliveries and four offsite waste shipments. An additional 20 shipments of Flibe (approximately one ton each) is estimated to be delivered to the facility before the end of the first two years of operation and 28 shipments per year of nitrate salt (7 tons each) for the duration of operations. Hazardous materials that would be stored onsite in small quantities include new Flibe and nitrate salt lubricating oil for rotating equipment and cleaning materials and consumables used for cleaning and maintenance. A bounding value of approximately 21,555 gallons of diesel fuel for the standby diesel generator would be contained in an onsite storage tank.

Once the facility reaches the end of its licensed life, the Operating License would be amended by the NRC and decommissioning activities would be commenced. Radioactive equipment and materials will be disposed according to local and federal laws and regulations. It is estimated that post-operational

decommissioning activities would require an average of 170 workers (340 at peak times) and a monthly average of 4 truck deliveries and 170 offsite waste shipments. Materials consumed during decommissioning are estimated to include approximately 25,000 gallons of diesel fuel (as a bounding assumption, fuel is assumed to be diesel) on a monthly basis. Table 2.1-2 shows the different types of construction equipment that is expected to be used during the decommissioning phase.

Table 2.1-1: Estimated Materials Consumed During Construction Phase Material

Material	Amount
Concrete	29,000 cubic yards
Structural Steel	490 tons
Steel Sheet Pilings	520 tons
Precast Piles	9,300 tons
Precast Panels (12” thick)	4,400 tons
Asphalt	4,500 cubic yards
Stone	13,000 cubic yards
Roofing/Siding	125,000 square feet
Temporary Structure (Tent)	153,000 square feet

Table 2.1-2: Proposed Equipment Used in the Construction and Decommissioning Phases

Equipment	Present During Construction (Y or N)	Present During Decommissioning (Y or N)
Air Compressor, 370 cfm	Y	Y
Air Compressor, 600 cfm	Y	Y
Asphalt Paving Machine, 130 HP	Y	N
Backhoe Cat 426, 1.3 CY 85 HP	Y	Y
Backhoe Cat 428, 1.3 CY 85 HP	Y	Y
Compactor Cat 433B, Smooth Drum roller	Y	N
Compactor Cat CP433C, Sheepsfoot Soil, 28,000#	Y	N
Compactor Plate	Y	N
Concrete Pump, 100 yph	Y	N
Concrete saw, hand	Y	Y
Crane Crawler 100 ton	Y	Y
Crane Crawler 150 ton	Y	Y
Crane Hydraulic 18 ton	Y	Y
Crane Hydraulic 40 ton	Y	Y
Crane Hydraulic 60 ton	Y	Y
Crane Truck, 85 ton	Y	Y
Dozer - Cat D5, 90 HP	Y	Y
Dozer - Cat D8, 305 HP	Y	Y
Demo Hammer, 7,500#	Y	Y
Excavator Cat 320, 24'-10" dig depth	Y	Y
Excavator Cat 330, 26'-6" dig depth	Y	Y
Farm Tractor	Y	N
Finisher – Concrete	Y	N
Hydromulcher	Y	N
Lift, boom JLG800, 80' articulating	Y	Y
Lift, boom JLG40, 40' telescoping	Y	Y
Lift, boom JLG60, 60' telescoping	Y	Y
Lift, Fork 8000 lb	Y	Y
Lift, Scissor 24'	Y	Y
Wheel Loader, Cat 950 4 CY	Y	Y
Pile Driver Vibratory Hammer	Y	N
Power Tools	Y	Y
Trencher, < 5' deep	Y	Y
Truck, Dump 14 CY	Y	Y
Truck, Dump 16 CY	Y	Y
Truck, Dump 18 CY	Y	Y
Truck, flatbed 16'	Y	Y
Welding Machine 300 amp	Y	Y
Welding Machine 400 amp	Y	Y
Welding torch- oxygen/acetylene	Y	Y
Well Drilling, Air Track Drill up to 4" diameter	Y	N

Notes:
cfm – cubic feet per minute; HP – horsepower; yph – yards per hour; lb – pound; CY – cubic yards; amp – ampere

2.2 SITE LOCATION AND LAYOUT

2.2.1 Project Site Location

The overall site (Figure 2.2-1) encompasses approximately 185 acres and is located within the East Tennessee Technology Park (ETTP) on the sites of the Former K-33 Facility and Former K-31 Facility. The ETTP, located in the northwest quadrant of the Oak Ridge Reservation (ORR), is adjacent to the Clinch River arm of Watts Bar Reservoir in Roane County and is approximately 13 miles west of downtown Oak Ridge, Tennessee (see Figure 2.2-2). The reactor would be located at approximately 35° 56' 15.9" latitude, and -84° 24' 11.2" longitude.

Table 2.2-1 lists nearby federal facilities, industrial facilities, transportation, and residential facilities. Table 2.2-2 lists the sensitive populations (e.g., schools, daycare facilities, hospitals), nearest resident, and landmarks (including highways, transportation facilities, rivers, and other bodies of water) within 5 miles of the site. No daycare centers or retirement homes are located within 5 miles of the site.

2.2.2 Site Layout

Figure 2.2-3 shows the planned layout of major structures for the facility. It is assumed that approximately 30 acres would be permanently disturbed for operations of the facility. The following structures in the facility are shown in Figure 2.2-3:

- Reactor Building
- Auxiliary Systems Building
- Maintenance and Storage Building
- Administration Building
- Security Building and Fence

2.2.3 Chemical, Diesel Fuel, and Hazardous and Radioactive Material Receipt, Holding, Storage Areas

The process chemicals to be used in the facility and support buildings on the site would be received in the loading area of the Reactor Building and stored within the Maintenance and Storage Building, the Reactor Building, and the Auxiliary Systems Building. Radioactive materials are expected to be stored in the Reactor Building. Hazardous materials would be stored in the Maintenance and Storage Building. Diesel fuel would be stored in an onsite diesel fuel tank.

2.2.4 Utilities

Process (demineralized) water for the facility is expected to be shipped to the site via truck. Potable water is expected to be obtained from the City of Oak Ridge Public Works. Wastewater is expected to be treated by the Rarity Ridge Wastewater Treatment Plant. Facility water and sewer pipelines are expected to be connected to nearby utility pipelines via current utility rights-of-way.

Facility stormwater systems are expected to be designed to meet permit requirements in a facility National Pollutant Discharge Elimination System (NPDES) permit. In addition, a Stormwater Pollution Prevention Plan (SWPPP) for the facility would be prepared and implemented.

An electrical distribution line connected to nearby electric transformers is expected to provide electricity to the facility.

2.2.5 Monitoring Stations

The need for and general description of monitoring stations for various media are described below:

- Air Monitoring and Meteorological Monitoring

See Section 3.2.4 for a discussion of air quality and meteorological monitoring.

- Groundwater Monitoring
  Groundwater sampling stations (monitoring wells) would be located downgradient of the Reactor Building to monitor for groundwater radiological contamination.
- Surface Water Monitoring
  Surface water sampling stations would be installed to collect surface water samples as required by the facility NPDES permit.
- Ecological Monitoring
  See Section 4.5 for a discussion of ecological monitoring.
- Radiological Monitoring
  Radiation monitoring would primarily be accomplished using continuous air monitors and passive dosimeters such as thermoluminescent dosimeters. Radiation monitoring stations would be located:
  - At an offsite location with a sufficient distance to provide a control station which monitors background dose
  - At areas expected to have regular occupancy, such as the administration building, the auxiliary building, the receiving area, and the security station
  - At points along the site boundary; considerations in selecting these monitoring locations include the direction to the nearest permanent resident or livestock, the shortest distance between the Reactor Building and the site boundary, and data collected on local prevailing winds (See Section 3.2.4.1)
  - At areas of special interest such as the decay heat removal system (DHRS) exhaust vents

2.2.6 References

1. Tennessee Valley Authority, Clinch River Nuclear Site Early Site Permit Application, Part 2, Site Safety Analysis Report, Revision 2, Section 2.2, March 8, 2019.

2. Energy*Solutions*, Bear Creek Processing Facility, 2016. Retrieved from https://www.energysolutions.com/waste-processing/bear-creek-processing-facility/.

3. Oak Ridge National Laboratory, User Facilities, Website: https://www.ornl.gov/content/user-facilities, accessed June 27, 2021.

4. Munger, F., "What to do With White Oak Lake," Cleanup, EPA, Oak Ridge EM, ORNL, TDEC, July 09, 2015. Retrieved from http://knoxblogs.com/atomiccity/2015/07/09/what-to-do-with-white-oak-lake/.

5. Van Winkle, J.E., "Baseline Environmental Analysis Report for the K-1251 Barge Facility at the East Tennessee Technology Park," Oak Ridge, Tennessee, 2007. Retrieved from https://www.osti.gov/biblio/964674-EpJWXe/.

6. Krause, C., "Medical Isotope Firm CEO tells of plans for OR facility," The Oak Ridger, March 19, 2020. Retrieved from https://www.oakridger.com/story/news/technology/2020/03/19/medical-isotope-firm-ceo--tells-of-plans-for-or-facility/112376002/.

7. Roane Regional Business & Technology Park, Roane ECD, Website: https://www.roaneecd.com/sites/roane-regional-business-tech-park/, accessed June 27, 2021.

8. Pounds, B., "More Steps Taken Toward Creation of New Oak Ridge Airport," Oak Ridger, March 16, 2021. Retrieved from https://www.aviationpros.com/airports/news/21214654/more-steps-taken-toward-creation-of-new-oak-ridge-airport.

9. Pounds, B., “UT-Battelle Gives City $500K for Airport,” Oak Ridger, Aviation Pros, March 24, 2021. Retrieved from https://www.aviationpros.com/airports/news/21215666/utbattelle-gives-city-500k-for-airport.

10. Oak Ridge Municipal Planning Commission, Virtual Regular Business Meeting, March 18, 2021. Retrieved from http://oakridgetn.gov/images/uploads/Documents/Boards&Commissions/Planning%20Commission/Agenda/PC_Packet_03_18_2021.pdf.

Table 2.2-1: Nearby Facilities (Page 1 of 2)

Project Name	Summary of Project	Location (from Reactor Building)	Status	Potentially Affected Resource(s)	Notes
Federal Facilities					
Proposed Clinch River Nuclear Site (Reference 1)	Two or more small modular reactors to be built by the Tennessee Valley Authority (TVA)	3.5 miles south-southeast	Proposed NRC issued ESP-006 on December 19, 2019	Water resources, air quality, socioeconomics	Potential for overlapping construction timeline
Energy*Solutions*, LLC Bear Creek Facility (Reference 2)	Processing and packaging of radioactive material for permanent disposal	Approximately 2.1 miles southeast	Operational	Air quality, water resources, human health	
Oak Ridge National Laboratory (Reference 3)	DOE Nuclear and High-Tech Research Facility	Approximately 5 miles east	Operational since 1943	Water resources, air quality, socioeconomics	
White Oak Dam (Reference 4)	Manhattan Project impoundment on White Oak Creek with 25-acre settling pond. Formed to reduce radioactive waste runoff into Clinch River	Approximately 5 miles southeast	Operational since 1943	Water resources, human health	
Y-12 Shipping and Receiving (Onsite verification)	Non-hazardous shipping and receiving facility	West and adjacent <1000 feet	Operational	Water resources, air quality, socioeconomics human health	
K-1251 Barge Facility (Reference 5)	Barge docking facility approximately 1 acre in size	2 miles southeast	Operational	Water resources, human health	
TVA Kingston Fossil Plant	Coal-fired electrical generating facility	7 miles southwest	Operational	Air quality, water resources, socioeconomics	
TVA Bull Run Fossil Plant	Coal-fired electrical generating facility	15 miles east	Operational	Air quality, water resources, socioeconomics	
Industrial Facilities					
Coquí Pharma (Reference 6)	Planned Medical Isotope Production Facility	Duct Island; Approximately 0.75 miles south	Proposed	Land use, water resources, air quality, noise, socioeconomics	Close proximity and potential for overlapping construction timeline

Table 2.2-1: Nearby Facilities (Page 2 of 2)

Project Name	Summary of Project	Location (from Reactor Building)	Status	Potentially Affected Resource(s)	Notes
Roane Regional Business and Technology Park (Reference 7)	Business and industrial park with sites for development	Approximately 5 miles southeast	Operational since 2001	Land use, water resources, air quality, socioeconomics	Operational, contains the following businesses: • Advanced Plasma Products • C,R Barger & Sons • Dynamic Tooling Systems • H.T Hackney • Proton Power
Horizon Center Industrial Park (Reference 8)	Industrial park with sites for development; current residents include the Carbon Fiber Technology Facility and the ORNL pilot demonstration facility for reducing the cost of carbon fiber	Approximately 2.3 miles northeast	Operational/ under development	Land use, air quality, water resources, socioeconomics	Accidents due to the current materials and operations at this facility are not expected to affect the site.
Hallsdale Water Treatment Plant	Municipal wastewater treatment facility	Approximately 18 miles east	Operational		Due to its distance to the site, accidents due to the current materials and operations at this facility are not expected to affect the site.
City of Oak Ridge Water Plant	Municipal wastewater treatment facility	Approximately 10 miles northeast	Operational		Due to its distance to the site, accidents due to the current materials and operations at this facility are not expected to affect the site.
Transportation Facilities					
Proposed General Aviation Airport at the East Tennessee Technology Park Heritage Center (Reference 8, Reference 9)	Development of a general aviation airport	Approximately 1.1 miles east	Proposed	Land use, air quality, socioeconomics	Close proximity and potential for overlapping construction timeline
Residential Facilities					
The Preserve at Clinch River water treatment facility (Reference 10)	Residential water and wastewater treatment facility	Approximately 2 miles south	Operational since 2002	Land use, water resources, air quality, noise, socioeconomics	

Table 2.2-2: Sensitive Populations, Nearest Resident, and Landmarks within 5 Miles of the Site

Facility Type	Location of Interest	Distance to Site Boundary (miles)
Residential	Nearest Full-Time Resident	0.7
Park	Black Oak Ridge Conservation Easement	Adjacent
	Oak Ridge Country Club	4.9
Medical	Michael Dunn Center	4.6
Educational	None	-
Community Center	Bradbury	4.5
Animal Production	None	-
Rivers/Creeks	Clinch River arm of the Watts Bar Reservoir	0.4
	Poplar Creek	0.2
Barge Access	K-1251 Barge Facility	2
Railroads	Heritage Railroad Corporation	0.2
	Norfolk Southern Railway Company	3.3
Highways	Interstate 40	4.9
	TN State Route 58	1.2
	TN State Route 95	2.2
	TN State Route 327	1
	TN State Route 61	3.5

Figure 2.2-1: Hermes Reactor Site

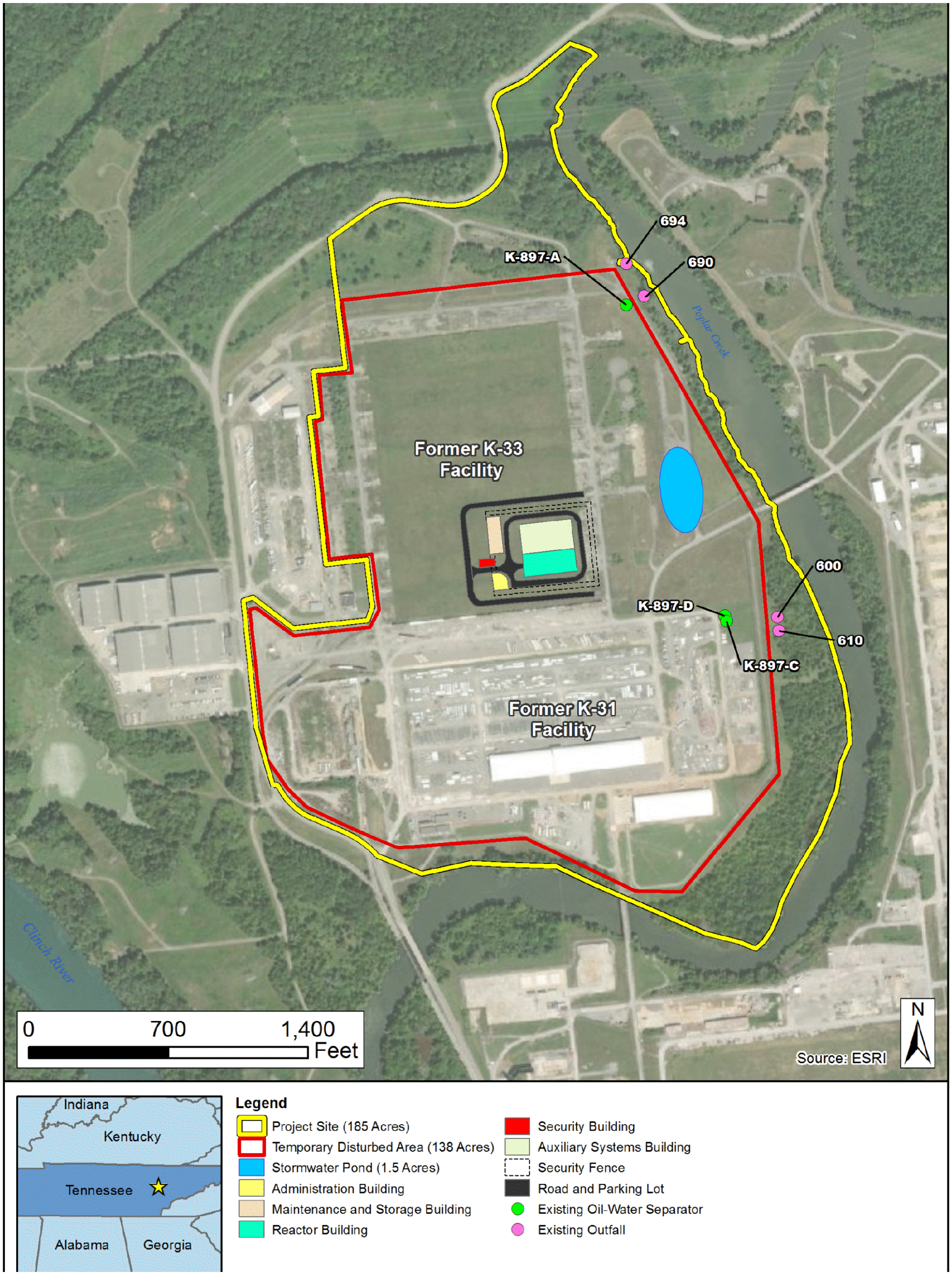


Figure 2.2-2: Site Location

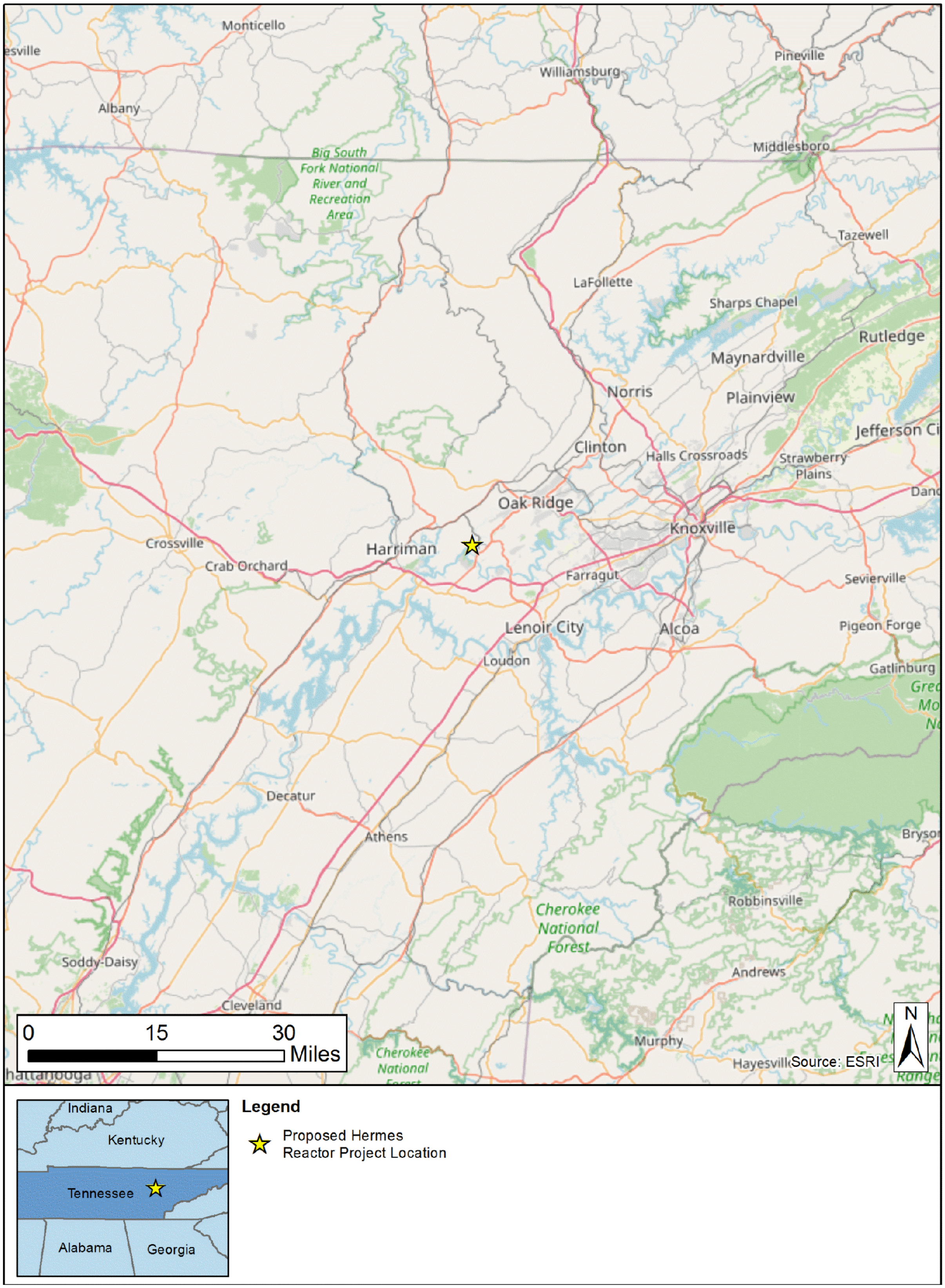
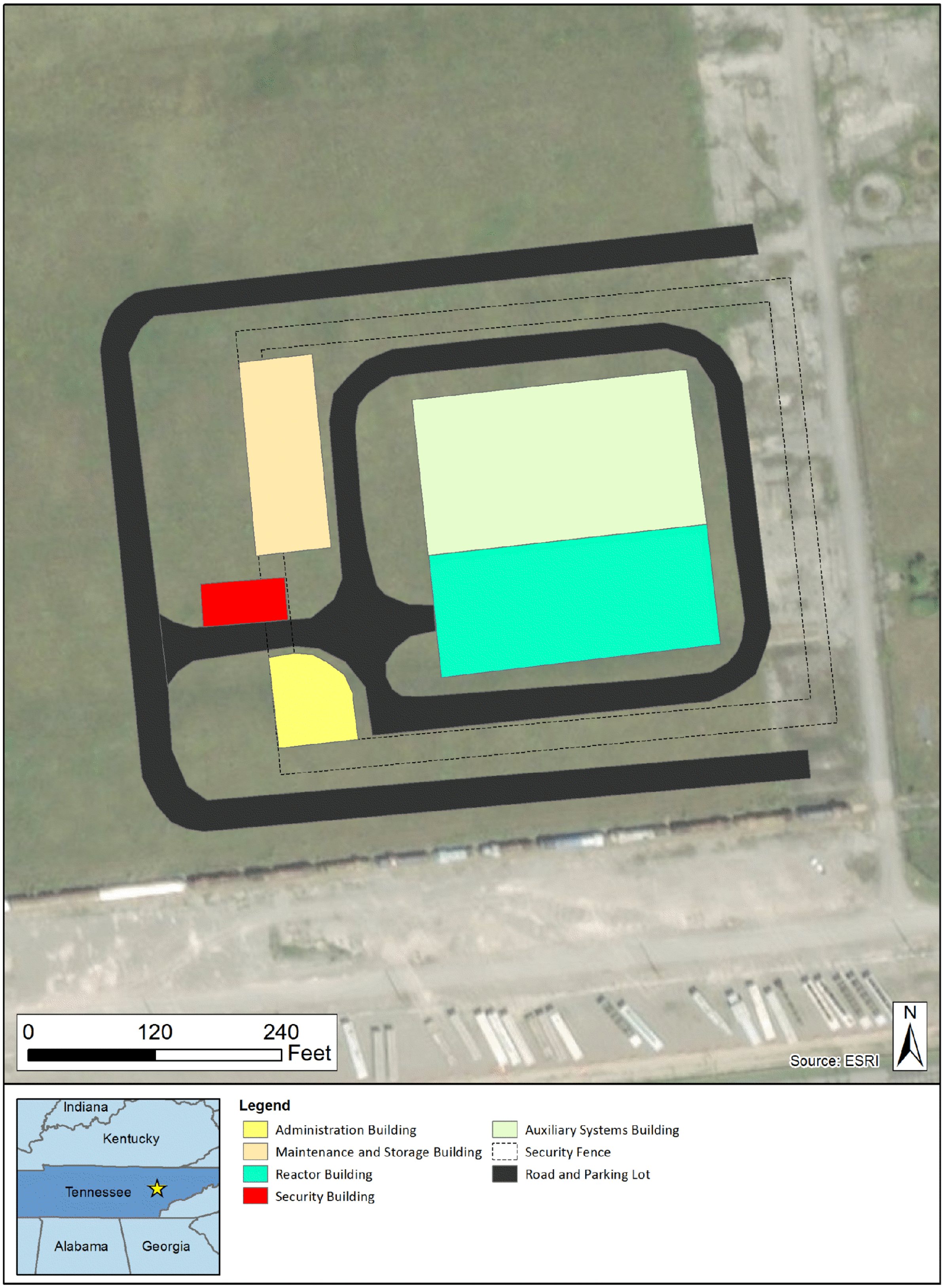


Figure 2.2-3: Expected Site Layout



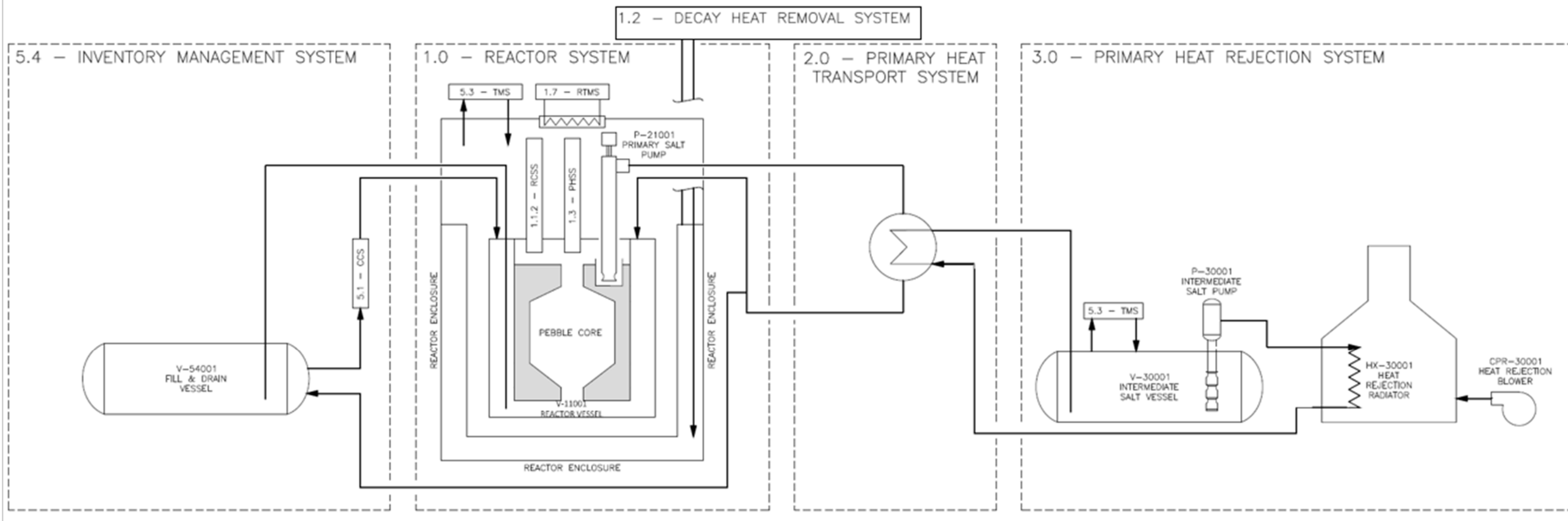
2.3 NON-POWER REACTOR

The facility would house one Hermes reactor. The Hermes reactor is a KP-FHR with the core configuration made up of a pebble bed core, graphite moderator/reflector, and Flibe molten salt coolant. This will be a non-power test reactor with approximate dimensions of the reactor vessel being 3.4 meters in diameter and 4.7 meters in height. The facility will contain only one unit with a maximum thermal power of 35 megawatts (MW) thermal (MWth). The purpose of the reactor will be to demonstrate and test the design features and safety functions of the technology. It will be a non-power test reactor, whereby the heat generated in the core will not be used for the production of electric power. Instead, heat will be transported out of the core via the primary heat transport system (PHTS) and then dissipated into the atmosphere via the primary heat rejection system (PHRS). Figure 2.3-1 shows the process flow diagram for the reactor and heat dissipation .

The reactor vessel and internal structures will be constructed of stainless steel that conforms to the 2019 composition specification requirements of American Society of Mechanical Engineers Section III, Division 5, with a targeted service life of 10 years. The moderator/reflector will be constructed of a nuclear grade graphite selected for its compatibility with the chemistry environment of the reactor core and would also have a targeted service life of 10 years.

The reactor core will use 4-centimeter (cm)-diameter graphite pebbles with embedded coated TRI-structural ISOtropic (TRISO) particle fuel. The particles will be comprised of a uranium fuel kernel and three layers of carbon and ceramic based materials that prevent the release of radioactive fission products. The maximum enrichment of the uranium fuel will be 19.55 weight percent, and the required start-up fissile inventory is estimated to be no greater than 25 kilograms (kg) ^{235}U. A fraction of the pebbles in the core are moderator (graphite-only) pebbles. Fuel pebbles are extracted from the reactor while online using the pebble extraction machine, the burnup is measured, and the fuel is either returned to the reactor or removed to storage. The estimated residence time for pebbles in Hermes is about 315 days.

Figure 2.3-1: Hermes Reactor Process Flow Diagram



2.4 WATER CONSUMPTION AND TREATMENT

2.4.1 Water Sources and Consumption

Structures, facilities, and improvements requiring a water supply would be connected to an approved water system. Groundwater underlying the property is not planned to be extracted.

Service water for the facility would be obtained from the City of Oak Ridge Public Works. Demineralized water would also be shipped to the site and stored onsite for use in the DHRS and the spent fuel cooling system (as needed). The size of the demineralized water tank is expected to be no larger than 75,000 gallons and the tank is expected to be located outside the reactor building.

Figure 2.4-1 shows a water balance diagram for the facility. Water uses for the facility would include the following:

- Chilled water system
- Potable water, bathrooms
- Fire protection system
- DHRS
- Spent fuel cooling system
- Component cooling water system

Service water required for the chilled water system is estimated to be approximately 34 gallons per minute (gpm) or 0.05 million gallons per day (MGD). This flow would be the makeup water required to offset the estimated evaporation rate from the chilled water system.

Service water required for the potable water and bathrooms is estimated to be approximately 16 gpm or 0.02 MGD. Sanitary wastewater would be discharged to the Rarity Ridge Wastewater Treatment Plant at an estimated rate of approximately 16 gpm (0.02 MGD).

Service water required for refilling the fire protection system, e.g., following actuation. The refill rate is estimated at 800 gpm but this event would be rare and only until the system is refilled. Treated (demineralized) water required for the DHRS is estimated to be approximately 1 gpm (less than 0.01 MGD). This flow would offset the estimated evaporation rate from the DHRS. Treated water would also be used to provide makeup water to the spent fuel cooling system, component cooling water system, and chilled water system, each at a flow rate of less than 1 gpd.

Stormwater runoff would flow to a stormwater pond and then be discharged to Poplar Creek in accordance with the facility NPDES permit requirements. The discharge location and monitoring requirements will be discussed in more detail in the Operating License Application. For the purposes of this Environmental Report, it is assumed that stormwater collected in the stormwater pond would be discharged to an existing outfall. (see Figure 2.2-1).

2.4.2 Water Treatment System

Demineralized water would be trucked to the facility and stored in a holding tank for use as needed in the DHRS and the spent fuel cooling system.

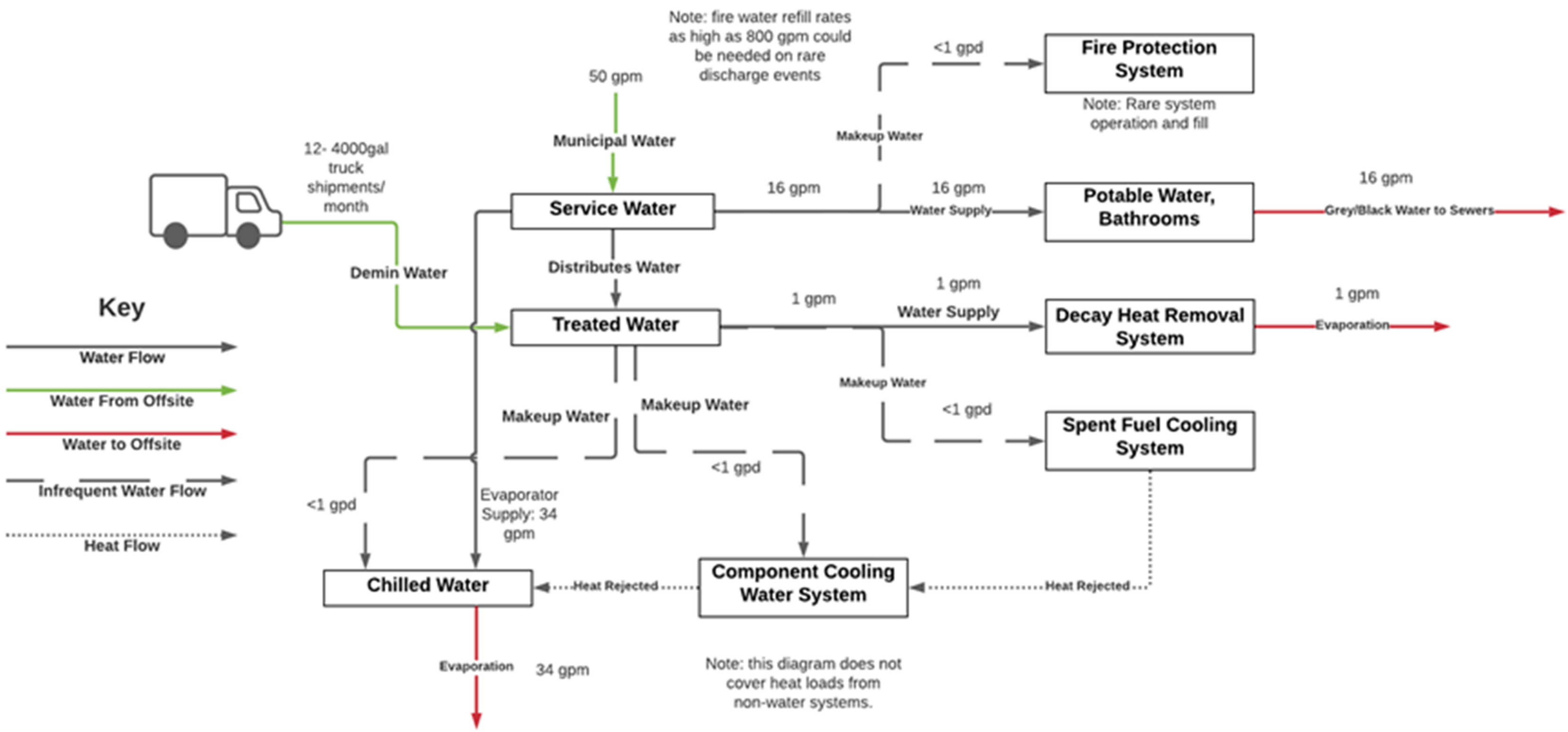
Municipal water obtained from the City of Oak Ridge Public Works Department would be used for the chilled water system, which is typically treated prior to addition to the chilled water system, and then dosed periodically. The dosing would be determined by testing. The types of chemicals added to the water would be:

- Biocides – added to inhibit microbial growth in the water to avoid fouling

- Corrosion inhibitors – added to inhibit corrosion of piping and components through which the cooling water flows. Often corrosion is inhibited by halogen-based biocides
- Scale inhibitors – added to reduce scale formation, particularly within heat exchangers. The specific inhibitor(s) is selected based on the chemistry of the makeup water for the Chilled Water System or Component Cooling Water System.

Potable water used at the facility would also be obtained from the City of Oak Ridge Public Works Department.

Figure 2.4-1: Water Balance Diagram



2.5 COOLING AND HEAT REMOVAL SYSTEMS

2.5.1 Raw Cooling Water System

No raw water usage is planned for the facility. Water is not planned to be pumped directly from the Clinch River, Poplar Creek, or groundwater.

2.5.2 Decay Heat Removal System

Decay heat would be removed from the fuel by the in-vessel natural circulation of Flibe. The natural circulation would transfer the heat to the reactor vessel shell. The DHRS would remove decay heat from the reactor vessel shell using a passive water-based, ex-vessel system via thermal-radiation and convection (Figure 2.5-1). The DHRS is a safety-related system that will be capable of heat removal via passive operation and will be always active above a threshold power. The DHRS will maintain adequate decay heat removal during postulated events above the threshold power, even if the PHRS is unavailable.

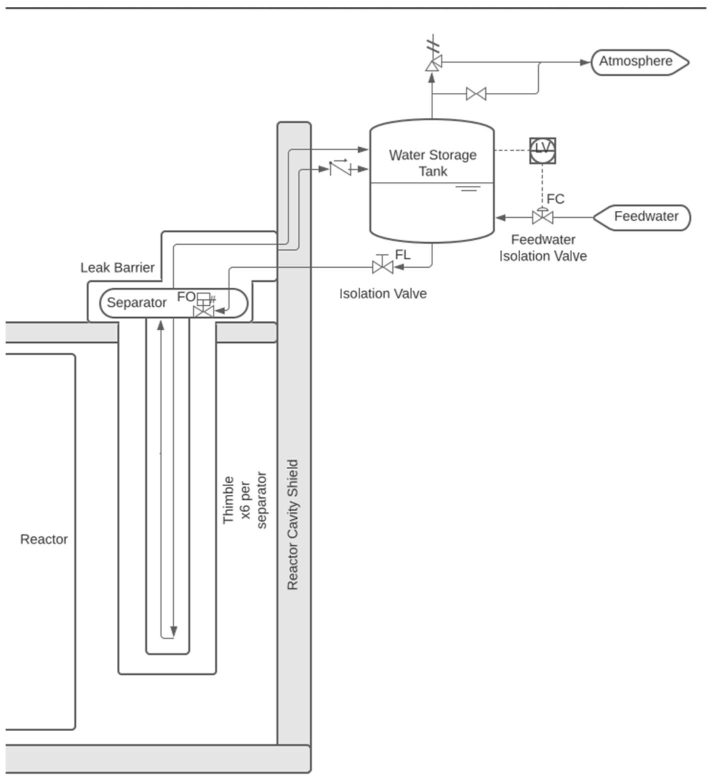
The DHRS will consist of four parallel, independent cooling trains, each designed to remove heat from the reactor vessel shell. Water would be supplied to the DHRS as described in Section 2.4. During normal operations, supply cooling water would be supplied to the four DHRS water storage tanks. If the supply water is unavailable, the DHRS water storage tanks will have sufficient inventory for the DHRS to perform its heat removal function for at least 72 hours. Each water storage tank would provide water to a set of thimbles that act as thermosyphons located circumferentially around the outside of the reactor vessel shell. The thimbles would remove heat from the reactor vessel through continuous boil off of the feedwater supply. Steam separators would provide an interface between the water storage tanks and the individual thimbles that the tanks supply. The steam separator would achieve this function by controlling the water level inside its volume through the use of a passive float valve located on the feedwater line. Fluid would be fed from the steam separator to the guide tube and back up the evaporator tube through buoyancy-driven flow. The density differential associated with this flow would be developed in the evaporator region, where heat would be absorbed in the fluid via convective heat transfer, causing nucleation and flow boiling. The two-phase mixture would be ejected into the steam separator, which would return liquid to the static level and allow steam to flow freely out the steam return line. The DHRS would operate with a continuous direct boil-off for reactor power greater than 10 MWth.

During normal operation, filtered and treated water would be used to continuously replenish the inventory of the DHRS. The DHRS water storage tanks would hold approximately 1,700 gallons each. This water inventory would be sufficient for the DHRS to perform its heat removal function for at least 72 hours of continuous cooling operation without operator action or electrical power. The DHRS will not directly interact with the primary coolant and heat is removed by passive means during any postulated event. The DHRS will also have a dual-walled design for leak prevention and detection.

2.5.3 Primary Heat Rejection System

The PHTS would be responsible for transferring the required, normal operating, heat load from the reactor through the primary heat exchanger (PHX) to the PHRS heat rejection radiator (HRR) and the surrounding atmosphere, which would be the ultimate heat sink. This heat load would include all normal steady operating loads (up to 35 MWth) along with any residual heat removal that may be required during normal reactor shutdown conditions. If the PHRS were to be unavailable when residual heat removal is required, the DHRS will be utilized instead. The PHRS heat rejection stack is expected to be located just north of the Reactor Building in the Auxiliary Systems Building.

Figure 2.5-1: Decay Heat Removal System Diagram



Note: not to scale and subject to change

2.6 WASTE SYSTEMS

Waste generated at the facility during the phases of construction, operation, and decommissioning would include radioactive, nonradioactive, and hazardous wastes. Waste management systems would provide mechanisms for the collection and disposition of the waste in accordance with applicable State, NRC, and other Federal environmental regulations. The disposal of the waste would occur in permitted nonradioactive, nonhazardous, and hazardous waste disposal facilities and licensed radioactive disposal facilities.

2.6.1 Radioactive Liquid, Solid, and Gaseous Waste Systems

Radioactive waste generation will occur during the operations phase and decommissioning phase. The following subsections describe the waste systems implemented during the operations phase of the facility. These systems would be designed to limit discharges of radioactive materials in accordance with 10 CFR 20. The methods employed for the controlled release of those contaminants would be dependent primarily upon the state of the radioactive material (i.e., liquid, solid, or gaseous). Estimated quantities of the radioactive waste described in the following section are provided in Table 2.6-1.

2.6.1.1 Liquid Radioactive Waste Systems

Liquid radioactive waste systems would collect, store, monitor, process, and dispose of potentially radioactive liquid waste produced from normal reactor operations and maintenance. Liquid radioactive waste sources handled during operations and maintenance include those from vent condensates, drains, and decontamination. A portion of liquid radioactive waste would be expected to be recycled or packaged and shipped offsite for treatment and disposal. Small amounts of waste may be released to the wastewater treatment plant; this waste would be monitored and disposed of within the limits of 10 CFR 20, Appendix B, Table 3 (limits for releases to sewers).

Liquid (i.e., molten) salt wastes would be managed by separate systems to remove and containerize the salt waste. After removal of the salt from its circulating system, they would be collected in storage containers and allowed to cool and solidify during storage. Both Flibe and nitrate salt would then be disposed in solid form. Approximately 200 tons of nitrate salt would be disposed annually during operation. Used solidified Flibe would be stored onsite until decommissioning and then disposed as solid radioactive waste.

2.6.1.2 Solid Radioactive Waste Systems

Solid radioactive waste systems would provide for the collection, processing, packaging, and storage of wet and dry solid radioactive waste produced from normal reactor operations and maintenance. Since there would be no solid waste disposal at the site, low-level radioactive waste (LLRW) would be shipped offsite periodically during operations while other solid wastes would be stored onsite until the decommissioning phase and then would be disposed of in accordance with state and federal regulations.

2.6.1.2.1 Dry Solid Wastes

Dry solid wastes would include used personal protective equipment, contaminated rags, paper towels, paper, plastic containers, laboratory apparatus, small parts and equipment, air filters, and tools. Items of dry solid waste would be collected in suitable containers and LLRW would be stored onsite in approved storage areas. After a period of storage, the containers would be removed from the designated storage areas and prepared for disposal. A solid waste compactor would be considered to reduce the volume size of some solid waste for ultimate disposal. Shielded containers would be utilized in the event offsite shipment of high-activity waste if required.

2.6.1.2.2 Wet Solid Wastes

Wet solid wastes would include filters and or sieves from the inert gas system (IGS), chemistry control system, and IGS oxygen and moisture absorbers. Like dry solid wastes, wet solid wastes would be packaged and prepared for onsite storage and then eventual shipment offsite.

2.6.1.2.3 Tritium Management System

The tritium management system (TMS) would provide capture of tritium (H-3) from gas streams in various plant locations to reduce environmental releases. Figure 2.6-1 identifies the tritium management system components and indicates the approximate distribution of tritium throughout the reactor system. H-3 is produced primarily by neutron irradiation of lithium in the salt coolant, such as from lithium-7 (Li-7), lithium-6 (Li-6) remaining after initial enrichment, and Li-6 produced from transmutation of beryllium-9 (Be-9). The primary system functions of the TMS include:

- H-3 separation from argon in the IGS
- H-3 separation from dry air in the PHRS cover gas
- H-3 separation from dry air in Reactor Building cells
- Final collection and disposition of H-3

The TMS would produce three solid radioactive waste streams:

- High specific activity H-3 stored as metal hydride
- High specific activity H-3 on molecular sieve
- Low specific activity tritium on molecular sieve

2.6.1.2.4 Fuel Pebble Handling and Storage System

Operation of the facility is estimated to be 10 years and would generate approximately 38,800 spent pebbles per year. Therefore, over this duration, it is estimated that 388,000 used pebbles would be produced. The Hermes reactor fuel and moderator pebbles are continually cycled through the pebble handling and storage system (PHSS) which removes pebbles from the reactor for inspection. A fuel pebble is removed permanently from circulation and placed in a storage canister if it meets pre-set standards for burnup and integrity. Fuel and moderator pebbles that are removed are replaced with new pebbles. This system requires a constant supply of new fuel pebbles. The storage canisters would be transferred to an onsite canister storage system with an estimated conservative storage capacity of 192 canisters. Section 2.7.1 provides a description of spent fuel storage.

2.6.1.3 Gaseous Radioactive Waste System

The facility is not expected to need a gaseous radioactive waste system. Gaseous radioactive wastes generated would be primarily discharged to the Reactor Building exhaust system, in which they pass through a high efficiency particulate air filter. Releases to the atmosphere would be controlled such that the total radiation exposure to persons outside the controlled area is as low as reasonably achievable and does not exceed applicable regulations.

2.6.2 Nonradioactive and Hazardous Waste Systems

The facility would generate general types and quantities of nonradioactive and nonhazardous solid waste. No specific systems are planned other than waste management plans and policies that would control nonradioactive and nonhazardous solid wastes. Solid waste management and control measures for the facility would include waste reduction, recycling, and waste minimization practices that would be employed during all project phases (construction, operation, decommissioning). Such wastes would be managed in accordance with applicable federal and state regulations.

The facility would generate a variety of wastes that would be classified as hazardous under the Resource Conservation and Recovery Act. These wastes could include, but would not be limited to, paint-related materials and spent solvents used for cleaning and degreasing. The facility may also generate universal waste such as spent batteries and fluorescent light bulbs. It is anticipated that the facility would be a Small Quantity Generator of hazardous waste, with generation amounts considered to be insignificant. Scrap metal, universal wastes, used oil, and antifreeze would be collected and stored, and recycled or recovered at an offsite permitted recycling or recovery facility, as appropriate.

2.6.3 Direct Radiation Sources Stored Onsite or Near the Facility

2.6.3.1 Direct Radiation Sources Stored Onsite

Areas that would contain direct sources would be inside the Reactor Building. Sources of radiation in these areas would include those associated with the primary reactor systems, the PHSS, spent fuel storage, waste Flibe storage, neutron startup sources, and other LLRW storage and shipping. The spent fuel dry storage cavity would be designed with thick concrete wall for radiation shielding and have the capacity for spent fuel generated over the life of the facility. Flibe is utilized in the inventory management system (IMS), located in the Reactor Building. Baseline radiation levels onsite are discussed in Section 3.8.

2.6.3.2 Direct Radiation Sources Stored Near the Facility

Radiation dose to the public from nuclear reactor facilities near the facility include contributions from facilities on the ORR and from normal operations at TVA’s Watts Bar Nuclear facility. TVA’s Watts Bar Nuclear facility is located on the Tennessee River at River Mile 528, about 50 miles north of Chattanooga and about 40 miles southwest of the facility. These facilities are discussed in more detail in Section 3.8.

2.6.4 Pollution Prevention and Waste Minimization

Pollution prevention and waste minimization planning provides the framework for promoting environmental stewardship and educating employees in the environmental aspects of activities occurring in the workplace, the community, and homes. The facility would have a program for pollution prevention and waste minimization that is expected to include the following:

- Waste minimization and recycling for the various phases of the facility construction and operation
- Employee training and education on general environmental activities and hazards regarding the facility, operations, and the pollution prevention program, as well as waste minimization requirements, goals, and accomplishments
- Employee training and education on specific environmental requirements and issues
- Responsibilities for pollution prevention and waste minimization
- Consideration of pollution prevention and waste minimization in day-to-day activities and engineering

2.6.5 References

1. Pacific Northwest National Laboratory. 2020. “Environmental Impacts from Transportation of Fuel and Wastes to and from Non-LWRs.” PNNL-29365. September 2020.

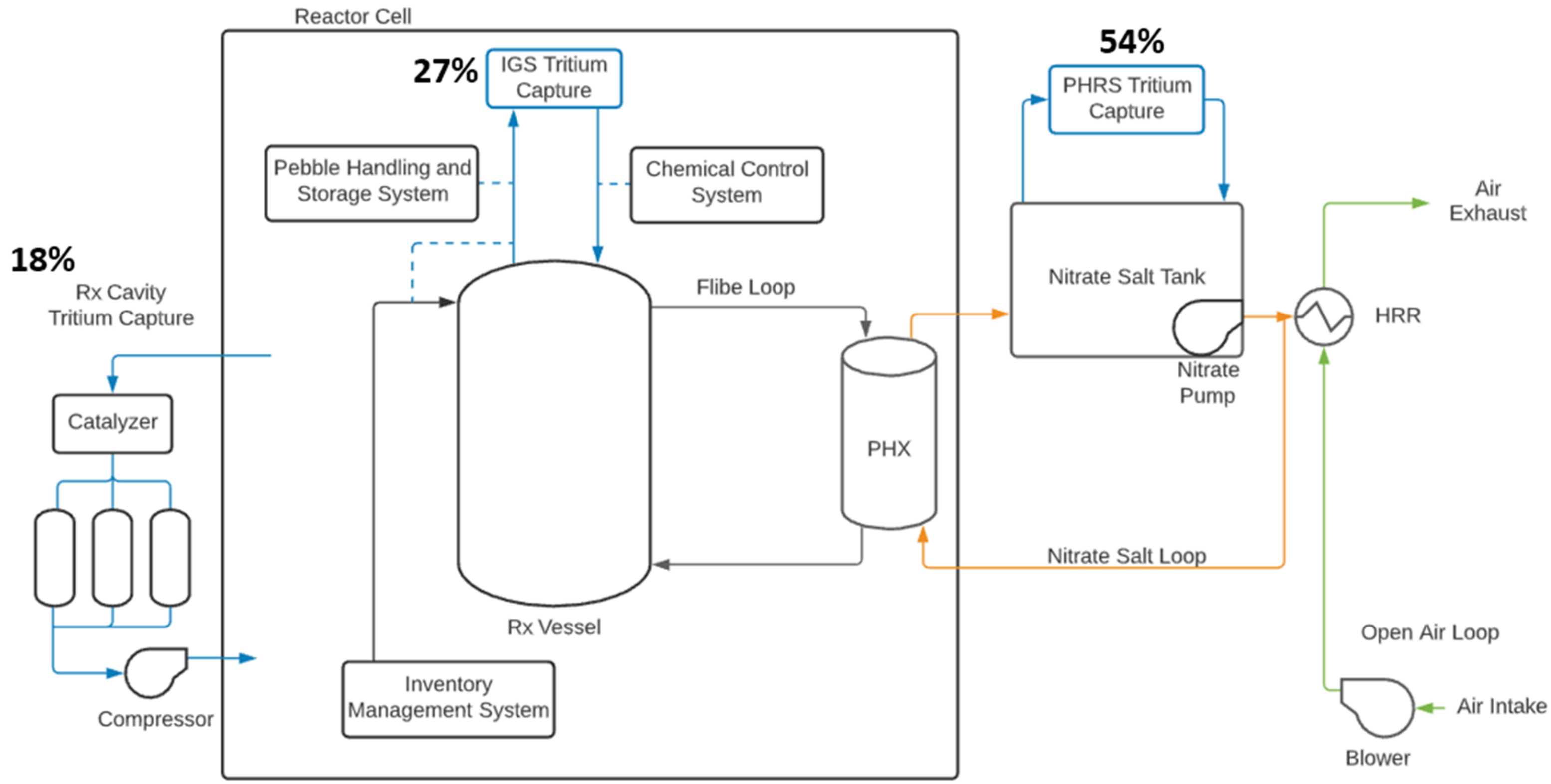
2. Atomic Energy Commission. 1972. “Environmental Survey of Transportation of Radioactive Material to and from Nuclear Power Reactors.” WASH-1238. December 1972.

Table 2.6-1: Estimated Type and Quantity of Radioactive Wastes

Description	Matrix	10 CFR 61.55 Waste Class	Contents	Volume/year	No. of Shipments/year	Destination
IGS Capture Materials	Solid	B	Zr-Based Getter Alloy, H-3	10 ft^3	1	Waste Control Specialists
PHRS Capture Materials	Solid	B	Molecular Sieve, H-3	10 ft^3	1	Waste Control Specialists
Reactor Cell Capture Materials	Solid	B	Molecular Sieve, H-3	660 ft^3	8	Waste Control Specialists
Flibe	Solid	B or C	Be, H-3, C-14, Activation, Fission, and Transmutation Products	-	Only shipped at decommissioning (3 shipments)	Waste Control Specialists
Nitrate Salt	Solid	A or B	H-3	200 tons 2,870 ft^3	10	Energy*Solutions* or Waste Control Specialists
Dry Active Waste (DAW)	Solid	A	PPE, filters etc.	< 8,800 ft^3 [a]	< 26 [b]	Energy*Solutions* or Waste Control Specialists
Liquid Waste	Liquid	A	Activated water or maintenance liquids (i.e., cleaners)	This value is not expected to be significant.	This value is not expected to be significant.	Energy*Solutions*
Spent Fuel	Solid	-	-	38,800 fuel pebbles in approximately 18 canisters	Shipped at decommissioning or for fuel qualification testing	Federal Facility

[a] Based on 46 55-gallon drums per shipment.
[b] The total LLRW waste shipments would be bounded by 46 annual shipments, the number of shipments from an 880 MWe reference reactor (Reference 1, Reference 2).

Figure 2.6-1: Approximate Tritium Distribution throughout the Reactor System



2.7 STORAGE, TREATMENT, AND TRANSPORTATION OF RADIOACTIVE AND NONRADIOACTIVE MATERIALS

2.7.1 New and Irradiated Fuel

The Hermes reactor will use spherical fuel pebbles containing embedded TRISO particles. The fuel design is described in PSAR Section 4.2. A manufacturer has not been decided for the Hermes reactor. New fuel is anticipated to either be shipped to the facility in U.S. Department of Transportation (DOT) certified shipping containers or manufactured at a nearby manufacturing facility using high-assay low-enriched uranium (HALEU) supplied from external sources. The fuel would also be stored onsite in the shipping containers until loaded into the PHSS.

During reactor operations, the facility would receive an initial shipment of fuel and periodic shipments of fuel to support continued operations over an estimated 10-year license period. When removed from the reactor, used TRISO fuel pebbles would be stored in canisters in a spent fuel storage area within the Reactor Building. Each canister would hold approximately 2,100 fuel pebbles. Once a canister is filled, the canister would be initially stored in a water-cooled storage pool. During this time the decay heat generation drops rapidly. The pool would also accommodate a full core off-load for temporary storage. After the initial cooling period in the pool, fuel canisters would be transferred to the larger air-cooled storage cavity. The air-cooled cavity would have an estimated conservative storage capacity of 192 canisters, which is sufficient for 10 years of licensed reactor operation.

If necessary, spent fuel canisters would be loaded into dry storage casks suitable for onsite storage on an exterior spent fuel storage pad. Such storage canisters have not been specifically designed for the Hermes fuel but the individual canisters are compatible with conventional dry cask overpacks. Spent fuel would ultimately be transferred from onsite storage casks to spent fuel shipping containers certified by the NRC and DOT. While a large number of transportation packages are certified by the NRC for shipping unirradiated light water reactor (LWR) fuel, irradiated LWR fuel, and radioactive waste, transportation packages would need to be certified for shipping non-LWR fuel. Without a certified design, the number of spent fuel shipments cannot be calculated, but would be bounded by the 60 annual shipments of spent fuel provided for an 880 MW-electric (MWe) reference reactor described in NRC guidance (Reference 1).

Spent fuel would eventually be transported by truck or rail to a final spent fuel repository or a regional spent fuel storage facility. Neither facility currently exists in the United States. However, the transportation distance is likely bounded by the approximate 2,100 miles from Oak Ridge, Tennessee to Beatty, Nevada. Beatty, Nevada is located just west of Yucca Mountain, the site in the United States most studied for suitability as a spent fuel repository.

2.7.2 Low-level Radioactive Waste

Operations and decommissioning would generate solid LLRW. Generally, LLRW would be stored in strong, tight industrial packages approved for transportation. Common waste containers include B-12 and B-25 steel boxes, and 55-gallon steel drums. LLRW would be transported by truck to disposal sites west of Andrews, Texas (Waste Control Specialists) or near Clive, Utah (Energy*Solutions)*. The Waste Control Specialists disposal site accepts Class A, B, and C waste and is approximately 1,300 miles from Oak Ridge. The Energy*Solutions* disposal site accepts only Class A waste and is approximately 2,000 miles from Oak Ridge. Some wastes could be managed through Energy*Solutions* Bear Creek LLRW processing facility located less than 4 miles south of the site. While the ultimate disposal route for waste processed through the Bear Creek facility is dependent on the waste type, it often ultimately gets shipped to Utah for final disposal.

Flibe is utilized in the IMS, the PHTS, and the reactor, all of which are located in the Reactor Building. Used radioactive Flibe that is removed from the IMS in liquid form during normal operations would be filled into containers where it would be allowed to cool and solidify. It is estimated that the Flibe's specific activity in curies per ton (Ci/ton) after a cooling period of 1 year would be 380 Ci/ton. No other treatment would be required. The solid Flibe is anticipated to be stored onsite until decommissioning when it would be shipped to Waste Control Specialists for Class B or C LLRW disposal. Storage areas for solidified Flibe waste would require additional radiation shielding to keep occupation radiation doses below regulatory limits an as low as reasonably achievable.

An estimated 120 drums of Flibe waste would be generated over the assumed 10 year licensed life of the facility. The waste would require a Type B shipping cask. The capacity of a Type B cask is dependent on the shielding necessary. Assuming a minimum of six drums per cask, 120 drums would require 20 cask shipments. Alternatively, Type B drums could be used likely resulting in more drums per shipment and fewer shipments.

During operations, nitrate salts used to transfer heat from the reactor to the heat dissipation system would be pumped through the PHRS. The nitrate salts would be approximately 60 percent sodium nitrate and 40 percent potassium nitrate by weight. Used radioactive nitrate salt would be pumped into storage containers and allowed to cool prior to being shipped to Waste Control Specialists for Class B LLRW disposal or to Energy*Solutions* for Class A LLRW disposal. No other treatment would be required. Based on an estimated 200 tons of nitrate salt shipped to the site annually, an average of 10 truck shipments per year would be required to ship an equivalent amount of salt waste. Waste containers would not require radiation shielding.

The IGS would transport radioactive materials (fission products, tritium, and other radionuclides) for downstream treatment. The TMS would capture tritium from gas streams in various plant location in order to reduce environmental releases. The TMS would separate tritium from argon in the IGS, from dry air in the PHRS cover gas, and from dry air in the Reactor Building cells and collect the tritium in solid materials for final disposition as a solid LLRW. These wastes are expected to be Class B LLRW that would be stored on site in approved shipping containers until transported to Waste Control Specialist for disposal.

Tritium would not ultimately be stored in a liquid or gaseous form in the TMS. A modest amount of water may be used for analytical purposes such as tritium trapping in water bubblers and liquid scintillation counting (estimated 1 ft^3/year with dissolved tritium activity of 10 Ci [10 Ci/year total liquid water waste]). There would be a small amount of tritium ingress into other water systems, but it is not expected that water from these systems would be released as effluent from the Reactor Building.

The total number of LLRW shipments has not been calculated. However, including the number of waste nitrate slat shipments, the total number of LLRW shipments would be expected to be bounded by the 46 annual shipments of LLRW provided for an 880 MWe reference reactor described in NRC guidance (Reference 1).

2.7.3 Nonradioactive Materials

Nonradioactive Flibe is anticipated to be shipped to the site in approximately 20 initial 1-ton shipments with an additional 20 tons estimated to be shipped before the end of the first two years of operation. The Flibe would be stored in the Reactor Building. Nitrate salt would be shipped to the facility at an estimated rate of 200 tons per year in approximately 28 shipments (7 tons per shipment) and stored in the intermediate salt vessel located in the Reactor Building. As discussed in Section 2.4, the facility would also receive twelve 4,000-gallon shipments of demineralized water each month.

2.7.4 References

1. Atomic Energy Commission, 1972. “Environmental Survey of Transportation of Radioactive Material to and from Nuclear Power Reactors.” WASH-1238. December 1972.

Kairos Power

Chapter 3

Description of the Affected Environment

Hermes Non-Power Reactor

Environmental Report

Revision 0

October 2021

TABLE OF CONTENTS

List of Tables

List of Figures

CHAPTER 3 DESCRIPTION OF THE AFFECTED ENVIRONMENT

3.1 LAND USE AND VISUAL RESOURCES

This section describes the characteristics of the land use of the site and the region. In addition, a description of the visual resources of the site is provided. The land use for the site and region is analyzed using the National Land Cover Database (2016). The visual resources are rated using the U.S. Department of the Interior Bureau of Land Management (BLM) Visual Resource Management Plan (Reference 1).

3.1.1 Land Use

3.1.1.1 Site

The site consists of an approximately 185-acre parcel located within the DOE ETTP in Oak Ridge, Tennessee. The site is located in Roane County, adjacent to the Clinch River arm of the Watts Bar Reservoir, approximately 13 miles west of downtown Oak Ridge. The site is classified as “public use” on the Tennessee Comptroller of the Treasury Existing Land Use map for Oak Ridge (Reference 2).

The site is located on a parcel that previously housed Buildings K-31 and K-33, which were part of the K-25 complex and operated as the Oak Ridge Gaseous Diffusion Plant (ORGDP) (Reference 3). Uranium enrichment operations at the K-25 site ceased in 1986, and restoration, decontamination, and decommissioning activities began soon after. Reindustrialization of the ETTP began in 1996 by DOE in cooperation with the Community Reuse Organization of East Tennessee in preparation for conversion of the site to a private sector industrial park. Currently the site is a Brownfield (Reference 5). The ETTP has been transformed into a multi-use industrial park and conservation area. It is also part of the Manhattan Project National Historic Park (Reference 4).

Existing structures and infrastructure on site include temporary storage buildings associated with another project including a construction lay down area, temporary construction buildings, job trailers, fencing, underground utilities (water, wastewater, storm water drains), electrical and telephone lines, and foundations of previously decommissioned buildings. Facilities proposed to be located on the developed site are described in Chapter 2 and illustrated in Figure 2.2-1. Land cover on the site is classified as either grassland/herbaceous at the site of the former K-33 facility or developed, high intensity for the area of the former K-31 facility as shown on Figure 3.1-1.

3.1.1.2 Region

The “region” of the site is defined as the area within a 5-mile radius of the site centerpoint (Figure 3.1-1). Major land use/land cover within the region is listed in Table 3.1-1 and depicted in Figure 3.1-2. The dominant land use in the region is herbaceous grassland (39.3 percent) (Reference 6).

The region in which the site is located is known as the Great Valley of East Tennessee, which is comprised of valleys at elevations of around 800 feet above mean sea level (amsl) and ridges around 1,000 feet amsl or higher. The area is situated between the Cumberland Mountains, approximately 23.5 miles to the northwest, and the Great Smoky Mountains approximately 31.6 miles to the southeast. The area is rich in natural resources, characterized by forest, streams and reservoirs fragmented by urban development and agriculture. Part of the Ridge and Valley Province of East Tennessee, the site is located to the west of Poplar Creek on a gently rolling valley between Black Oak Ridge and Pine Ridge (Reference 7).

The site is located in the City of Oak Ridge, Tennessee. The City of Oak Ridge has a plan for the ETTP site called the Oak Ridge Blueprint Plan that outlines the anticipated development of Oak Ridge and the

surrounding area. The Oak Ridge Blueprint Plan is the approved plan of the City of Oak Ridge (approved May 13, 2019) (Reference 8). The Plan presents a citizen-supported, visionary plan for future growth and development in Oak Ridge. Based upon community values and ideas as well as current challenges, the Blueprint Plan is intended to evolve over time to respond to changing issues and community input while providing ongoing guidance for plans and actions throughout the city (Reference 8). The Municipal Planning Commission can make advisory reports, studies, and recommendations that relate to the approved plan, including progress reports, and advise whether a public or private project or activity is in agreement with the plan (Tennessee Code Annotated, Section 13-4-103) (Reference 8).

Knoxville, Tennessee, is the nearest major metropolitan area, located approximately 25 miles east of the site (Reference 9). Major transportation corridors in the region are Interstate 40 (I-40, which is the major east-west interstate highway located south of the site) and Interstate 75 (I-75, which travels in a north-south direction). I-40 and I-75 intersect approximately 9.5 miles east-southeast of the site. The closest airport to Oak Ridge is McGhee-Tyson Airport in Knoxville, Tennessee (Reference 10).

Outside the City of Oak Ridge, which includes the Oak Ridge National Laboratory (ORNL) and the site, the surrounding land uses are generally residential and agricultural in nature, used primarily for single-family residences and small farms. Popular recreational activities in the area include fishing, hunting, boating, water skiing, and swimming (Reference 9). The Great Smoky Mountains National Park and Dollywood are both easily accessed from Oak Ridge (Reference 10).

An evaluation of the identified transportation routes and pipelines within the 5-mile vicinity of the site identified one navigable waterway, one major highway, four major roads, one major rail line, one minor rail line, two natural gas pipelines, and one proposed airport for assessment. These facilities are listed below:

- Clinch River arm of the Watts Bar Reservoir
- I-40
- Tennessee State Highways 58 (TN 58), 61 (TN 61), 95 (TN 95), and 327 (TN 327)
- Norfolk Southern rail line north of the site
- Heritage Railroad Corporation Railway
- Two active natural gas transmission pipelines: East Tennessee Natural Gas Pipeline 1 (East) and Pipeline 2 (North)
- Proposed general aviation airport at the ETTP Heritage Center

There are no chemical plants, refineries, mining/quarrying, or military facilities within 5 miles of the site.

High intensity developed lands (37.2 percent), medium intensity developed lands (10.1 percent), and deciduous forest (8.9 percent) make up the other major land uses. The remaining land uses within the region include mixed evergreen and woody wetlands (Reference 6). There is no crop production on the site and no significant crop production within the region. Corn, soybeans, and wheat are produced in small quantities throughout the region, but not at quantities sufficient for reporting in the U.S. Department of Agriculture's (USDA) National Agricultural Statistics Service (NASS) most of the years between 2010-2020. Various varieties of hay are produced in varying quantities within the region (Reference 11). Figure 3.1-3 shows the USDA NASS land cover and crop production in the region.

3.1.2 Visual Resources

The visual setting of the area affected by the construction, operation, and decommissioning of the facility is represented by predominantly an industrial viewshed to the south and east and by a forested viewshed to the north and west. The area immediately surrounding the proposed facility is a highly developed industrial setting with several paved lots and structures on the ETTP. The viewshed extending

east and south of the site is highly developed with roads, paved lots, and industrial buildings on the ETTP. This development extends for more than a mile from the site. Poplar Creek runs along the eastern and southern borders of the site through the industrialized area. To the north of the site, the land is forested with mountains visible in the distance. Several transmission lines and rights-of-ways (ROWs) are visible from the site. To the west, and approximately 0.5 miles past industrial buildings and paved lots adjacent to the site, the land is forested with mountains visible in the distance and transmission lines and ROWs visible through the mountains. The Clinch River arm of the Watts Bar Reservoir is in the southwest viewshed.

The aesthetic and scenic quality of the site was rated in accordance with the BLM Visual Resource Management System (Reference 12). Aesthetics “relates to the pleasurable characteristics of a physical environment as perceived through the five senses of sight, sound, smell, taste, and touch,” while scenic quality is “the relative worth of a landscape from a visual perception point of view” based on seven key factors (i.e., landform, vegetation, water, color, adjacent scenery, scarcity, and cultural modifications). Scenic quality is rated as “A,” “B,” or “C,” with “A” being the highest visual rating, and “C” being the lowest visual rating (Reference 13). Based on the site assessment conducted in June 2021, the overall site for the Proposed Action is rated as a “C” classification primarily because of the cultural modifications at the site and surrounding industrial areas. The scenic quality is improved by the adjacent scenery of the nearby Poplar Creek and Clinch River, and the surrounding hills and mountains with dense, natural vegetation.

The sensitivity level is the measure of public concern for the maintenance of scenic quality. A sensitivity level of high, medium, or low is primarily determined following evaluation of the types of users, amount of use, public interest, adjacent land users, and special area management objectives (Reference 12). The site has a low to moderate sensitivity rating for existing conditions. The North Boundary Greenway and Black Oak Ridge Conservation Easement (BORCE) areas north and northeast of the facility are areas for the public to enjoy the outdoors through walking and bike riding. The K-25 Overlook and Visitor Center along TN 58, just northeast of where Perimeter Road intersects TN 58, is another viewing area for stationary members of the public to enjoy the area.

3.1.3 References

1. Multi-Resolution Land Characteriscs Consortium, Data, Database: https://www.mrlc.gov/data?f%5B0%5D=category%3Aland%20cover, accessed September 17, 2021.

2. Tennessee Comptroller of the Treasury, Existing Land Use, Oak Ridge, Tennessee, 2021.

3. U.S. Department of Energy, Oak Ridge Environmental Management Program, ETTP Fact Sheet. 2019.

4. Flessner, D., "Oak Ridge, Tennessee, site cleans up 75-year waste legacy," Chattanooga Times Free Press, Retrieved from https://www.timesfreepress.com/news/local/story/2020/oct/13/oak-ridge-cleans-75-year-waste-legacy/534035/.

5. mygeodata.cloud, East Tennessee Technology Park, 2021.

6. U.S. Geological Survey, National Land Cover Database, Retrieved from: https://www.mrlc.gov/national-land-cover-database-nlcd-2016.

7. Parr, P.D. and J.F. Hughes, "2006 Oak Ridge Reservation Physical Characteristics and Natural Resources," ORNL/TM-2006/110, September 2006.

8. City of Oak Ridge, "City Blueprint," May 13, 2019.

9. U.S. Department of Energy, "Environmental Monitoring Plan for the Oak Ridge Reservation," DOE/ORO--2227/R5, October 2012.

10. Explore Oak Ridge, All roads lead to Oak Ridge, Website: https://exploreoakridge.com/where-to-stay/directions/, accessed September 1, 2021.

11. U.S. Department of Agriculture, County Estimates, Website: https://www.nass.usda.gov/Statistics_by_State/Tennessee/Publications/County_Estimates/index.php, accessed September 18, 2021.

12. U.S. Department of Interior - Bureau of Land Management, "Visual Resource Inventory Manual H-8410-1," 1986.

13. U.S. Department of Interior - Bureau of Land Management, "Manual 8400 – Visual Resource Management," April 1984.

Table 3.1-1 Summary of 2016 Land Use/Land Cover within the Site and Region

National Land Cover Database [2016] Land Cover Class	Site		Region	
	Acres	Percent	Acres	Percent
Open Water			1,832.7	3.6%
Developed, Open Space			2,813.9	5.6%
Developed, Low Intensity			2,301.9	4.6%
Developed, Medium Intensity	18.51	10.1%	976.3	1.9%
Developed, High Intensity	68.39	37.3%	573.9	1.1%
Barren			65.6	0.1%
Deciduous Forest	16.38	8.9%	26,241.3	52.2%
Evergreen Forest			1,215.6	2.4%
Mixed Evergreen	5.70	3.1%	3,688.1	7.3%
Shrub/Scrub			440.6	0.9%
Herbaceous Grassland	72.15	39.3%	705.3	1.4%
Pasture/Hay			8,175.3	16.3%
Cultivated Crops			5.2	0.01%
Woody Wetlands	2.28	1.2%	1,201.8	2.4%
Emergent Herbaceous Wetland			27.3	0.1%
Total	**183.40**	**100.0%**	**50,264.8**	**100.0%**

Note: Site is approximately 185 acres; this table is based on the specific GIS polygons within the site boundary.
Source: (Reference 1)

Figure 3.1-1: Site Land Cover

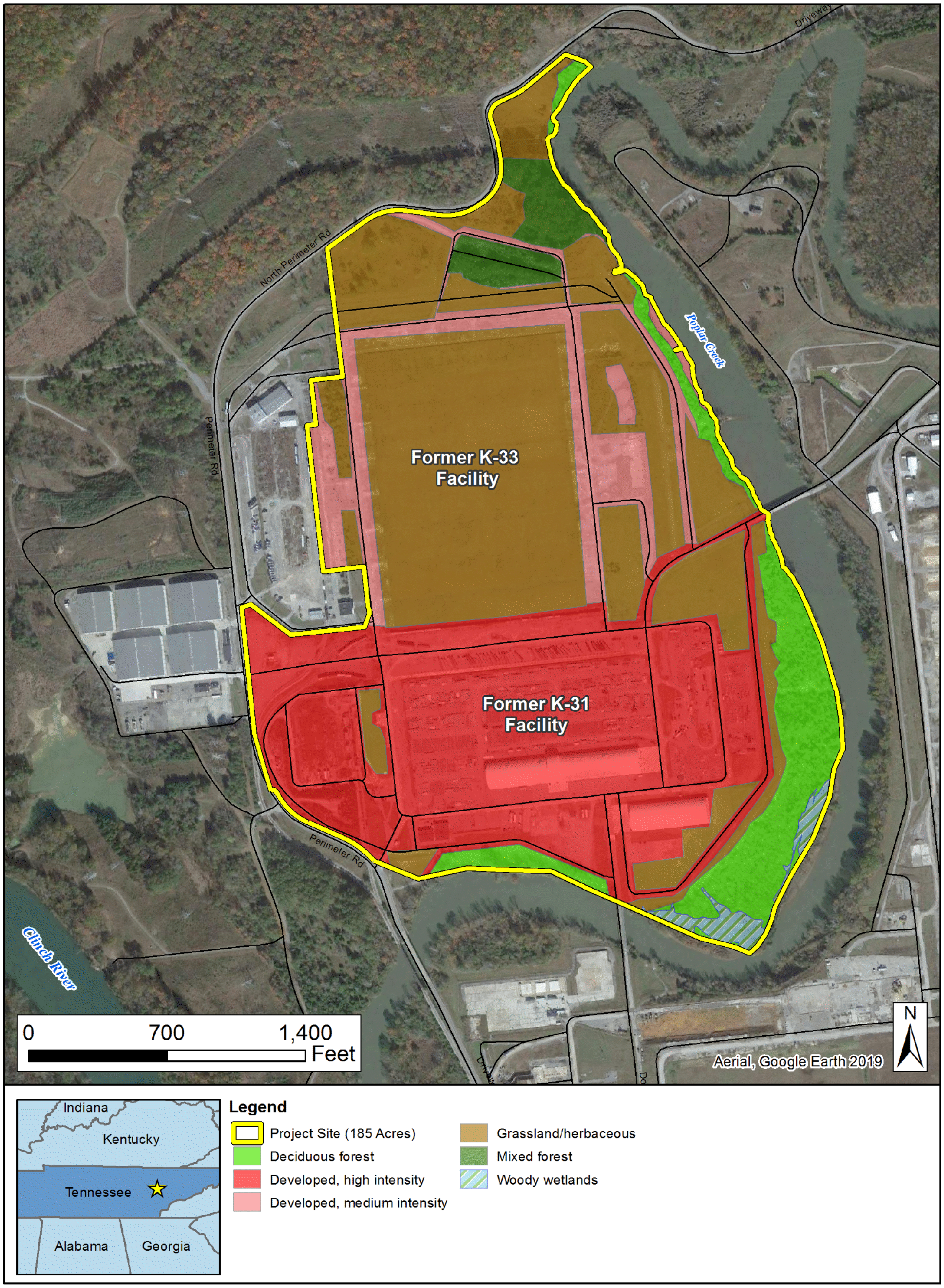


Figure 3.1-2: Major Land Uses in the Region

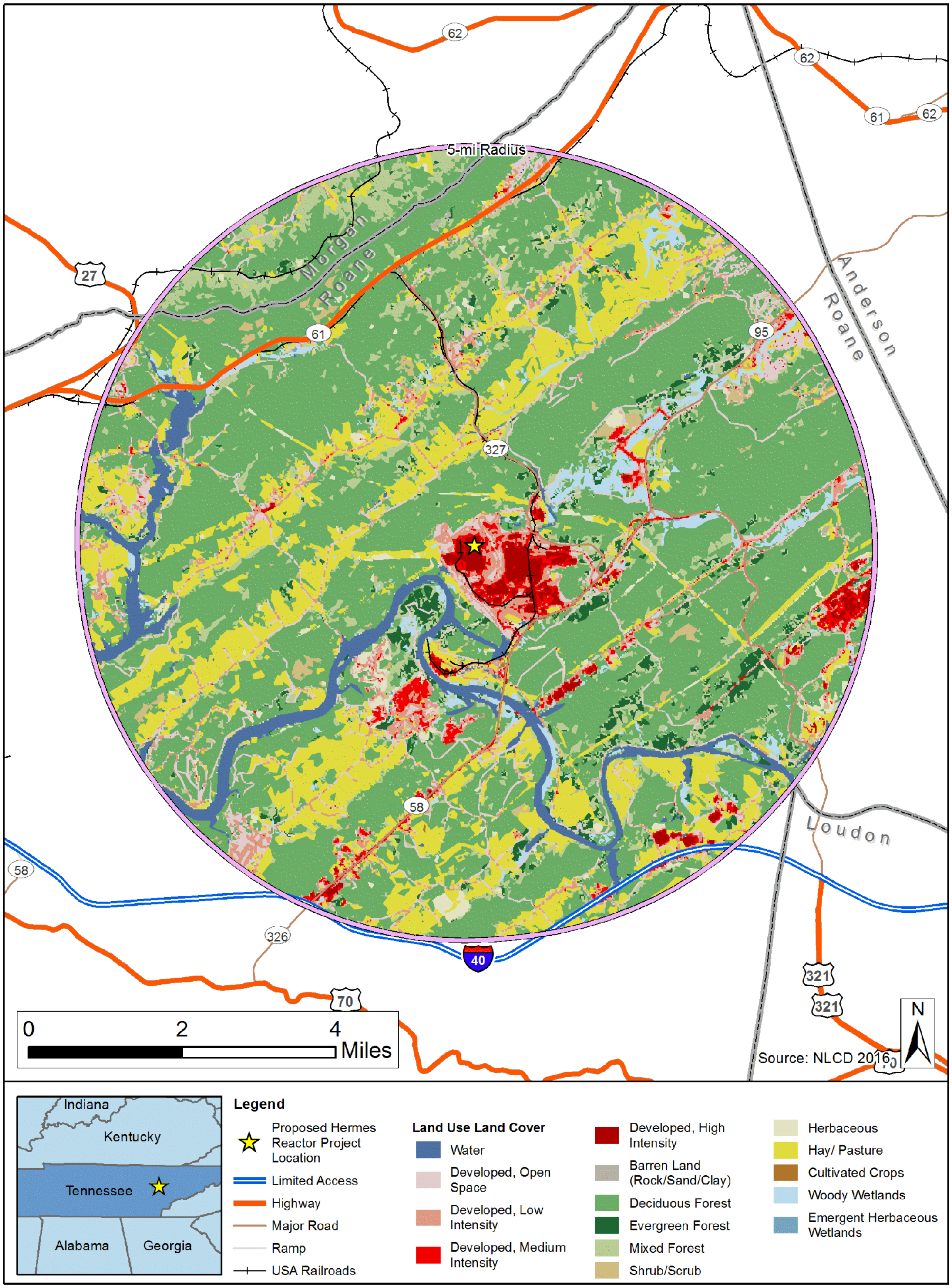
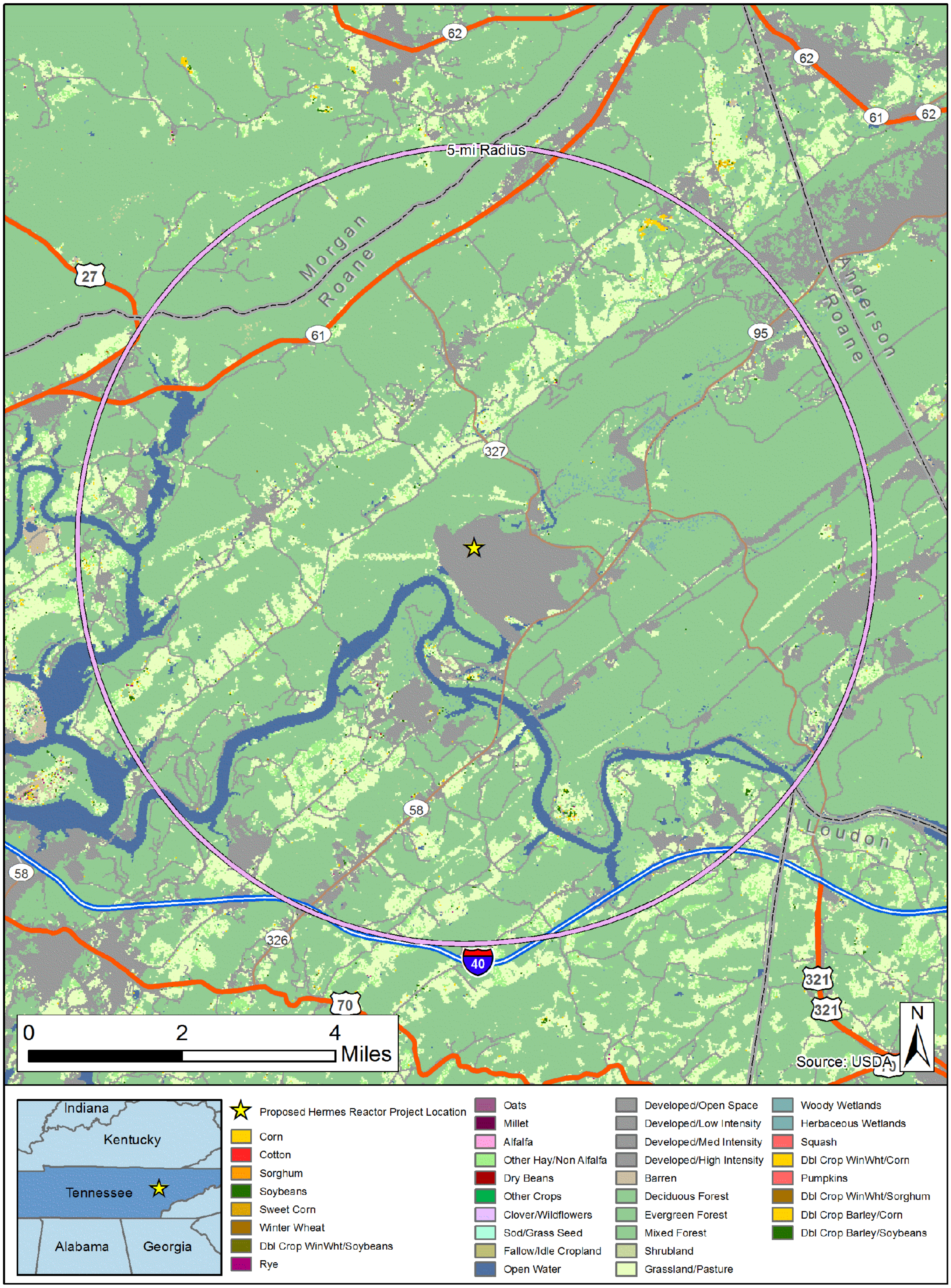


Figure 3.1-3: 2020 Cropland Within 5 Miles of the Site



3.2 METEOROLOGY, CLIMATOLOGY, AIR QUALITY, AND NOISE

3.2.1 Regional Climatology

Climate is a statistical description of the weather conditions that occur during a long period of time, usually several decades. Weather refers to short-term variations (minutes to months) in the atmosphere.

Sources of data typically used to analyze the climate at a site include weather maps (depictions of areal weather phenomena at one point in time), atlas maps summarizing long-term climate, records of weather at specific monitoring stations at specific times, and long-term climatic statistics at specific monitoring stations.

The purpose of an analysis of regional climate is to understand the local climate at the site in the context of the climate of the surrounding area. Climate phenomena are then analyzed at progressively smaller scales and within smaller areas. As the area being analyzed becomes more focused, some of the more distant monitoring stations that are considered initially in the broad analysis are excluded. The end result is a documented, systematic approach that defines local climate within a context that includes a broad surrounding region.

The site is located in Roane County in the eastern portion of Tennessee. The location is part of a region commonly referred to as “The Great Valley,” and the location in its regional setting is shown in Figure 3.2-1. The site is located approximately 8.7 miles southwest of the City of Oak Ridge, Tennessee business district.

This region of Tennessee is dominated much of the year by the Azores-Bermuda anti-cyclonic circulation. This dominance is most pronounced in late summer and early fall and is accompanied by extended periods of fair weather and widespread atmospheric stagnation. In winter and early spring, eastward moving migratory high- or low-pressure systems bring alternately cold and warm air masses into the area. The resultant changes in wind, atmospheric stability, precipitation, and other meteorological elements cause the normal circulation to become more diffuse over the region. In the summer and early fall, the migratory systems are less frequent and less intense. Frequent incursions of warm, moist air from the Gulf of Mexico and occasionally from the Atlantic Ocean are experienced in the summer. The site is primarily affected by cyclones from the southwest and Gulf Coast that move toward the northeast United States by passing along either the west side or the east side of the Appalachian chain and by cyclones from the Plains or Midwest that move up the Ohio River Valley.

Topography influences the weather and climate of the region around the site. The site is situated between two major mountain regions. To the northwest lie the Cumberland Mountains and to the southeast are the Great Smoky Mountains. These mountainous regions orient “The Great Valley” in a southwest-to-northeast alignment as shown in Figure 3.2-1. Prevailing winds in the region reflect the channeling of air flow caused by the orientation of the valleys and ridges. Average wind speeds are low, with a mean annual wind speed of 2.1 miles per hour (mph) at Oak Ridge (Reference 1). During winter when the jet stream moves southward, the Cumberland Mountains also serve to retard or moderate cold outbreaks by blocking dense, cold polar continental air masses. The Cumberland Mountains also reduce the intensity of thunderstorms in the summer that are produced by synoptic-scale systems crossing the region, due to the downward momentum of the air mass as it comes off the higher terrain and moves into the Great Valley. Thunderstorms are more frequently caused by the heating of the land during the day. The orographic lift produced by the local topography may enhance these “air mass” thunderstorms (Reference 2).

Area temperatures measured in Oak Ridge indicate warm summers and mild winters. In January, the normal daily maximum temperature is about 47 degrees Fahrenheit (°F) with a normal daily minimum temperature of about 29°F, based on 30 years of data. In July, the normal daily maximum temperature is about 88°F, while the normal daily minimum temperature is about 69°F based on 30 years of data (1981-2010) from the National Climatic Data Center (NCDC) (Reference 3). Relative humidity in the region averaged 73 percent based on a 30-year period of record from the Knoxville local climatological data (1981-2010) from the NCDC (Reference 4). The site is located in Tennessee Climate Division 1, also known as the East Tennessee Climate Division.

Precipitation averages about 51 inches annually (Reference 3). Late winter (January – March) is usually the wettest season, with more than 14 inches, while late summer–early autumn (August – October) is the driest season, with less than 10 inches. Droughts are uncommon in this region of the United States.

Snowfall in the Oak Ridge area, though normally light, usually occurs from November through March. Severe storms are relatively infrequent as the region is east of maximum tornado activity, south of the most significant snowstorms, and inland from hurricane and tropical storm tracks (Reference 5).

3.2.2 Regional Air Quality

The site is located in the City of Oak Ridge in Roane County, Tennessee. Oak Ridge spans both Roane and Anderson Counties, which are part of the Knoxville-Sevierville-LaFollette, Tennessee air quality area (Reference 6). The immediate areas of Roane and Anderson Counties are currently in attainment for all criteria pollutants (ozone, particulate matter, carbon monoxide, nitrogen oxides, sulfur dioxide, and lead) (Reference 6).

Maintenance areas are those geographic areas that have a history of non-attainment but are currently in compliance with the National Ambient Air Quality Standards. Parts of Roane County were in non-attainment for several years for particulate matter with an aerodynamic diameter of 2.5 microns or less ($PM_{2.5}$) and was redesignated to maintenance status in 2017. Similarly, Anderson County was in non-attainment for several years for 8-hour ozone and $PM_{2.5}$ but was redesignated to maintenance status in 2015 for 8-hour ozone and in 2017 for $PM_{2.5}$. Of the 10 counties that surround Roane and Anderson Counties (i.e., Campbell, Cumberland, Knox, Louden, McMinn, Meigs, Morgan, Rhea, Scott, and Union Counties), only Louden and Knox Counties, which border the entire eastern borders of Roane and Anderson Counties, respectively, have been previously in non-attainment for 8-hour ozone and $PM_{2.5}$. However, these two counties are currently in maintenance status.

Where visibility is an important value of the area, the Clean Air Act protects air quality and visibility of large national parks and wilderness areas managed by the National Park Service, the U.S. Fish and Wildlife Service (USFWS), or the U.S. Forest Service (USFS). These are considered Class I areas. Class I areas include national parks larger than 6,000 acres and national wilderness areas larger than 5,000 acres (Reference 7). All other (Class II) areas have less protection than Class I areas. For the benefit of these national parks and special areas, the Prevention of Significant Deterioration (PSD) program limits air pollution from new major sources (Reference 8 and Reference 9). The Environmental Protection Agency (EPA) guidance (Reference 10) states that a Class I visibility impact analysis is necessary for a major source locating within 160.9 miles of a Class I area. For the benefit of these national parks and special areas, the PSD program limits air pollution from new major sources (Reference 7 and Reference 8). EPA guidance (Reference 9) states that a Class I visibility impact analysis is necessary for a major source locating within 160.9 miles of a Class I area. Class I areas are national parks and wilderness areas that are potentially sensitive to visibility impairment. Table 3.2-1 lists all the federal Class I areas within a 310-mile radius of the site that are protected by the Regional Haze Program (40 CFR Part 81). The table shows that there are two federal Class I areas within 62 miles of the site: Joyce Kilmer-Slickrock

Wilderness Area and Great Smoky Mountains National Park. The remaining parks that are within 310 miles of the site are Cohotta Wilderness Area, Shining Rock Wilderness Area, Mammoth Cave National Park, Linville Gorge Wilderness Area, Sipsey Wilderness Area, and James River Face Wilderness Area (see Figure 3.2-2).

3.2.3 Severe Weather

Severe weather phenomena may require consideration in the design of safety-related structures, systems and components. Statistics on severe weather phenomena were obtained from historic data. Most data are taken from the NCDC storm events database (Reference 10) that covers the 71-year period of 1950–2020, but even longer data periods are used for some phenomena to try to better capture the occurrence of rare events.

3.2.3.1 Extreme Wind

Windstorms are relatively infrequent, but may occur several times a year, usually associated with thunderstorms. Moderate and occasionally strong winds sometimes accompany migrating cyclones and air mass fronts. The strong winds are usually associated with lines of thunderstorms along or ahead of cold fronts and are more probable in the late winter and spring than any other time of the year. Brief, strong gusts of wind due to downdrafts and outflow from individual thunderstorms can occur, but are generally limited to the large, intense thunderstorms that develop in the spring and summer.

Estimated extreme winds are based on climatological data from Oak Ridge and Knoxville, Tennessee (Reference 1 and Reference 4) and hourly observations from the Oak Ridge Reservation (ORR) meteorological Tower J and Tower L near the site (Reference 11).

Hourly averaged (scalar) wind speeds at the 20-meter level are available for this climate review from Tower J during 2018–2020, from the 10-meter or 15-meter level plus the 30-meter level during 2016-2020 from Tower L, from the 10-meter level at the Oak Ridge airport station during 1999-2020, and from the 10-meter level at the Knoxville airport during 1981-2020. The anemometer on Tower L was located at the 10-meter level from January 2016-October 2017 and was moved in November 2017 to the 15-meter level where it remained through May 2021. The wind data from all 5 years were analyzed together. The maximum hourly averaged wind speed for the 3 years of data analyzed (2018-2020) at Tower J is 24.8 mph. The maximum hourly averaged wind speed for the 5 years of data analyzed (2016-2020) at Tower L is 21.4 mph at the 10-meter or 15-meter level and 24.4 mph at the 30-meter level. In comparison, Oak Ridge has a maximum hourly averaged wind speed of 29.0 mph, and Knoxville has a maximum hourly averaged wind speed of 60.0 mph. Tower L recorded a peak wind speed (i.e., the maximum hourly wind gust) of 78.3 mph at the 15-meter level and 84.5 mph at the 30-meter level. Oak Ridge recorded a peak wind speed of 53 mph, and Knoxville recorded a peak wind speed of 76 mph.

The 100-year return period fastest mile of wind in the site area is approximately 90 mph (Reference 12).

Hurricane winds are mainly a concern for coastal locations as shown by the wind speed contours presented in Regulatory Guide (RG) 1.221 and NUREG/CR-7005. Due to the rapid dissipation of hurricane winds as they move inland away from their oceanic energy source, hurricane winds should not be a concern for the site. The wind speed contours in RG 1.221 and NUREG/CR-7005 stop well short of the site location with a wind speed contour of 130 mph.

Due to the significant inland distance from both the Atlantic Ocean and the Gulf of Mexico (more than 300 miles), tropical storm impacts are rare at the site, and are mostly from storm remnants. Impacts are generally restricted to flood effects from heavy rains (see Section 3.2.3.3). From 1905 to the present, there have been ten tropical storms within a 50-mile radius of the site. Although some of these were originally classified as hurricanes, all were classified as tropical storms when they reached the site area.

Review of the NCDC storm events database for the period of January 1, 1950, through December 31, 2020, shows that there was only one tropical storm on September 16, 2004, near Roane County, and it caused minimal damage. This storm was associated with Hurricane Ivan.

3.2.3.2 Tornadoes and Waterspouts

The probability of a tornado occurring at the site is low based on records from the National Weather Service (NWS) Morristown tornado database (Reference 13) and the NCDC storm events database (Reference 10). During the 71-year period of 1950–2020, 5 tornadoes were reported within 10 miles of the site (see Table 3.2-2). The intensities ranged from F0/EF0 to F3/EF3.

Based on the tornado strike probability presented in NUREG/CR-4461, the number of tornado events from 1950 through August 2003 within a 2-degree box surrounding the site is 226. This gives an annual average of four tornado events striking somewhere within the 2-degree box.

3.2.3.3 Water Equivalent Precipitation Extremes

Historical precipitation data for the site were obtained from several surrounding NWS and Tennessee Valley Authority (TVA) sites (Reference 4, Reference 14, Reference 15, Reference 16, and Reference 17), and are summarized in Table 3.2-3. Based on the similarity of the maximum recorded 24-hour and monthly totals among these stations and the areal distribution of these stations around the site, the data suggest that these statistics are reasonably representative of precipitation extremes that might be expected to be observed at the site. Droughts are uncommon in the vicinity of the site. Records indicate that sixteen episodes of severe drought have occurred in the past two hundred years. The worst was the decade of the 1980s, the driest overall period in the state's history. Several severe heat waves hit the continental United States throughout the 1980s, including Tennessee, causing severe to extreme drought conditions in eastern Tennessee as classified by the Palmer z-Index (Reference 14, Reference 18, Reference 19, and Reference 20).

The maximum estimated annual precipitation is in the range of 47–53 inches. The maximum 24-hour rainfall is less than 10 inches, and the maximum monthly rainfall is less than 20 inches (see Table 3.2-3).

The average annual snowfall in the vicinity of the site is less than 12 inches. Normal and extreme snowfall events are discussed in Section 3.2.3.6.

3.2.3.4 Hail, Snowstorms and Ice Storms

In Roane County, severe hail (3/4 inch in diameter or larger) has been reported only 36 times during 1950–2020 (Reference 10). This corresponds to less than one severe hail event per year. During the same period, surrounding counties reported severe hail between 50 (Loudon) and 93 (Knox) times.

The maximum reported snow depth at Knoxville (Reference 4) reported during the 61-year period of record was 15 inches in February 1960. Snowfall records for stations around the site (see Table 3.2-3) show a maximum 24-hour snowfall of 20 inches (March 1993) at Chattanooga (Reference 14).

Frost penetration depth is important for protection of water lines and other buried structural features that are subject to freeze damage. The extreme depth is slightly less than 19.6 inches based on Figure 13 in Reference 21.

Estimations of regional glaze probabilities have been made by Tattelman and Gringorten (Reference 22). For Region V, which contains Tennessee, storms with ice greater than or equal to 1 inch of ice occurred 5 times in 50 years and storms with ice greater than or equal to 2 inches of ice occurred 2 times in 50 years.

For ice storms with wind gusts greater than or equal to 44.7 mph, the estimated ice thickness is less than 1 inch for 25- and 50-year return periods, and 1.4 inches for a 100-year return period.

Based on the data provided in American Society of Civil Engineers (ASCE) Standard No. 7-16 (Reference 23), Figure 10.4-2, the 500-year mean recurrence interval of uniform ice thickness due to freezing rain for Roane County is 1.0 inch with a concurrent 3-second wind gust of 30 mph.

For glaze ice, the point probabilities for ice thicknesses are about 0.20 for greater than or equal to 0.5 inches and 0.36 for greater than or equal to 0.25 inches. These probabilities correspond to recurrence intervals of once in five years and once in three years, respectively. Glaze ice thicknesses less than or equal to 0.5 inches generally result in little structural damage. However, storms which produce these lesser ice thicknesses can present a hazard to travel in the affected areas, and when combined with strong winds, can damage above-ground utility wires.

3.2.3.5 Thunderstorms and Lightning

Thunderstorms are common in the Oak Ridge region with a normal range of 34-65 days with thunderstorms based on data collected from 2001-2020 at the ORR (Reference 24). The greatest frequency of thunderstorms is during the summer with a range of 18-40 days during May–August. This is characteristic of a diurnal afternoon thunderstorm pattern due to solar heating.

The site averages 4 to 8 cloud-to-ground lightning flashes per square kilometer annually based on a 26-year period from 1993-2018 (Reference 25).

A review of cloud-to-ground lightning strike data from a 10-year period from 2011-2019 at the site indicates that 3 of the 10 years had a lightning strike occurring within a few hundred feet of the site (Reference 24). One of these years, 2019, was a year with an exceptionally high number of cloud-to-ground lightning strikes. Two lightning strikes occurred at the future location of the site with several more strikes occurring within a few hundred feet of the site.

3.2.3.6 Snowpack and Probable Maximum Winter Precipitation

Snowpack, as used in this section, is defined as a layer of snow and/or ice on the ground surface, and is usually reported daily, in inches, by the NWS at first-order weather stations. Historical snowpack and snowfall were developed by reviewing data from first-order NWS stations and the cooperative network.

From Figure 7-1 of ASCE 7-16, the 50-year mean recurrence interval snowpack for the Oak Ridge area is determined to be 10 pounds per square foot (psf). Converting this to a 100-year return period snowpack, using the 0.82 adjustment factor presented in Table C7-3 of ASCE 7-16, results in the 100-year return period snowpack determined to be 8.2 psf.

The maximum reported snow depth at Chattanooga, Tennessee (Reference 26), the highest snow depth at a nearby NWS station, was used to estimate the weight of the maximum historic snowpack at the site. The greatest snow depth reported during the 77-year period of record (1938–2014) for Chattanooga, was 19 inches in March 1993. Interim Staff Guidance (ISG) on Assessment of Normal and Extreme Winter Precipitation Loads on the Roofs of Seismic Category I Structures (ISG-7) (Reference 27), provides an algorithm (see Equation 2.3.1-1) for converting historical maximum snowpack depth to a ground snow load.

$$L = 0.279D^{1.36} \qquad \text{Equation 2.3.1-1}$$

Where, D is the snowpack depth in inches and L is the resulting snow load in psf.

Using the 19-inch snow depth for Chattanooga gives a snow load of 15.3 psf for the maximum historical snowpack.

The 100-year return period snowfall event is given in data provided by the NCDC. Based on this data, the 48-hour 100-year return snowfall event for Oak Ridge is 15.7 inches during a March 1960 snowstorm (Reference 28 and Reference 29) and 18.8 inches for Knoxville during a February 13-14, 1960 snowstorm (Reference 29 and Reference 30). The historical maximum snowfall event for a 48-hour period was determined to be 28 inches recorded in Westbourne, Tennessee from February 19, 1960 to February 21, 1960 (Reference 30). The equation below from ISG-7 was used to determine the snow load due to the 48-hour 100-year return period snowfall event and the historical maximum snowfall event.

$$L = 0.15 \times S \times 5.2 \qquad \text{Equation 2.3.1-2}$$

where L is the snow load in psf and S is the snowfall depth in inches.

Using the maximum 100-year return snowfall event of 18.8 inches results in a snow load of 14.7 psf. Using a 28-inch historical maximum snowfall event for a 48-hour period results in a snow load of 21.9 psf.

The normal winter precipitation event, defined as the maximum ground-level weight (pounds per square feet) of the 1) 100-year snowpack (snow cover), 2) historical snowpack (snow cover), 3) 100-year return 2-day snowfall event, or 4) historical maximum 2-day snowfall event, is determined to be 21.9 psf. The extreme frozen winter precipitation event, defined as the maximum of the 1) 100-year return 2-day snowfall event or 2) historical maximum 2-day snowfall event, is also determined to be 21.9 psf.

From Hydro-Meteorological Report HMR-53, NUREG/CR-1486 (Reference 31), the 48-hour probable maximum winter precipitation (PMWP) (January through March) for a 10 square-mile (mi^2) area is estimated to be 23.5 inches by logarithmic interpolation. The March PMWP was utilized since the historically highest snowpack occurred in March 1993. The 48-hour PMWP is equivalent to the extreme liquid winter precipitation event.

3.2.3.7 Extreme Temperatures

Temperature data for Knoxville (Reference 15) and Oak Ridge (Reference 16) are presented in Table 2.3-4 and Table 2.3-5, respectively. Normal temperatures have ranged from the upper 30s (°F) in the winter to the upper 70s in the summer at both locations. Normal daily maximum temperatures ranged from about 47°F in mid-winter to about 88°F in mid-summer. The normal daily minimum temperatures ranged from about 29°F in mid-winter to about 69°F in mid-summer. The extreme daily maxima recorded were 105°F (June and July 2012) at Knoxville and 105°F (July 1952 and June 2012) at Oak Ridge, while the extreme daily minima (during January 1985) were -24°F and -17°F, respectively.

Temperatures measured by Tower L for 2018–2019 (Reference 11) are presented in Table 2.3-6. Tower L shows a similar pattern of daily average temperatures ranging from the mid 20s (°F) in winter to upper 70s (°F) in summer. Normal daily maximum temperatures ranged from about 59.0°F in mid-winter to about 79.1°F in mid-summer. The normal daily minimum temperatures ranged from about 25.3°F in mid-winter to about 71.5°F in mid-summer. A maximum temperature of 96.2°F and a minimum temperature of 0.5°F were recorded over the 2-year period.

3.2.3.8 Restrictive Dispersion Conditions

Dispersion conditions depend on the density of the plume, atmospheric stability, wind speed, the presence of buildings, and the distance to the observer/receptor. For this project, the releases will be either neutrally or positively buoyant. Buildings cause turbulence and eddies in the air flow that can lead to an increased plume width and entrainment of air into plumes, which in turn leads to increased dispersion. As a result, buildings generally tend to produce enhanced dispersion closer to the source, leading to lower ground-level concentrations farther from the source. However, buildings can bring

elevated plumes to the ground and can also inhibit dispersion depending on the release height of the plume and direction of the prevailing winds. For instance, a ground-level release between two buildings may result in little dispersion and an increased plume concentration (Reference 32).

The speed of the prevailing winds, in conjunction with atmospheric stability, plays a large role in the dispersion or lack of dispersion of a plume. Higher wind speeds tend to disperse the plume more effectively than lower wind speeds, and stable atmospheric conditions tend to reduce the lateral and vertical spreading of the plume, leading to less dispersion than in unstable atmospheric conditions. The most constraining case for ground-level releases involves low wind speeds and stable conditions. The most constraining case for elevated releases for the site would likely involve moderate wind speeds and neutral conditions.

Figure 3.2-3 shows calculations of atmospheric dispersion over distance produced by the Office of Nuclear Safety for several scenarios (Reference 33 and Reference 34). Two wind speed/atmospheric stability combinations were studied: (1) 1.0 meters per second wind speed combined with a moderately stable atmosphere and (2) 4.5 meters per second wind speed combined with a neutral atmosphere. The two meteorological cases were studied for a ground-level release as well as a buoyant plume release from a source 20 meters tall. The analysis assumed a person standing in an open field on the plume centerline downwind of the source. The analysis shows for both meteorological cases that restricted dispersion combined with limited plume height, whether a ground-level plume or a buoyant elevated plume, leads to peak ground-level concentrations. In the case of low winds and moderately stable conditions, concentrations remain relatively high over a large distance range 1,400 meters from the sources for both ground-level and elevated plume releases. In the case of moderate winds and a neutral atmosphere, ground-level concentrations of the plume drop off with distance become moderately reduced at a distance beyond 1,200 meters from the sources for both ground-level and elevated plume releases.

3.2.4 Local Meteorology

3.2.4.1 Topography

Topography around the site, shown in Figure 3.2-4 for areas near the site and in Figure 3.2-5 out to approximately 60 miles from the site, strongly influences the local climate. Mountain ranges located both northwest and southeast of the site are oriented generally northeast-southwest. The Appalachian Mountains to the east and southeast provide an orographic barrier that reduces the low-level atmospheric moisture from the Atlantic Ocean brought into the area by winds from the east.

Considerable low-level atmospheric moisture from the Gulf of Mexico is often brought into the area by prevailing winds from the south, southwest, or west.

The site is located at an elevation of approximately 765 feet (amsl). The site is situated between the Clinch River to the east and McKinney Ridge to the east-northeast. On the southeastern edge of the DOE Oak Ridge area, approximately 1.2 miles from the site is a small area of mountains just over 900 feet in elevation above sea level. Terrain to the south and north of the site is characterized as alternating ridges and valleys oriented along a southwest-to-northeast axis, as shown in Figures 3.2-4 and 3.2-5. McKinney Ridge, Black Oak Ridge, and the ridges to the south/southeast reach an elevation over 1,100 feet above sea-level (approximately 300 feet above plant grade). The closest ridge is the Black Oak Ridge acting as the northern boundary of the site. There is a significant gap in the southern ridges to the south of the site (Clinch River Gap). Figures 3.2-6 through 3.2-13 show the elevation profiles within 50 miles of the site in each of eight compass directions (at 45-degree intervals).

The geographic orientation of the ridges and valleys generally aligns with the prevailing regional winds from the southwest, but the gaps in the ridges permit wind flow from other directions as well. The combination of high pressure associated with the Azores-Bermuda anti-cyclonic circulation and the nearby ridges result in generally light wind speeds.

Three different towers are located near the project site: ORR Tower J, Tower L, and Tower D. Tower J is located approximately 1.08 km southeast of the site (see Figure 4.2-2) and has meteorological instruments at 20 meters. Tower L was located approximately 1.53 km south-southeast of the site, and had meteorological instruments located at various heights during the course of its operation, including 2 meters, 10 meters, 15 meters, and 30 meters. Tower D is located approximately 7.17 km southeast of the site, and has meteorological instruments at 15 meters, 35 meters, and 60 meters. Average surface wind speeds for the site are 4.4 mph at a height of 20 meters above ground level based on ORR Tower J. Tower L observed an average wind speed of 3.4 mph at 15 meters, and Tower D observed an average wind speed of 3.1 mph at 15 meters. These average wind speeds are based on years 2018-2019 wind data at the lowest wind levels for each tower.

Data from all three towers were used to evaluate the impact of topography on the site. Tower L is slightly closer to the ridge that is south of the site than Tower J, and therefore shows slightly more influence from terrain than Tower J. Tower D is within approximately 0.6 miles of Chestnut Ridge (immediately to the north and west of the tower) and Haw Ridge (to the south and east). The terrain channeling is from southwest to northeast for these towers. The principal impact of the terrain is on wind directions as shown in the wind roses (see Figures 3.2-14 through 3.2-19), which have a similar pattern of winds with the prevailing winds coming from the south-southwest to west-southwest directions and northeast to east-northeast directions.

3.2.4.2 Local Data Sources

Beginning in the 1940s, this site was under the jurisdiction of the Atomic Energy Commission (AEC) and later the DOE. In the late 1940s, at the request of the AEC, the U.S. Weather Bureau conducted, for the first time, a meteorological survey of the Oak Ridge, Tennessee area to provide detailed information regarding wind flow patterns and other factors to determine dispersion of radioactive contaminants (Reference 35). This study led to the establishment of an extensive network of meteorological towers and forecast capability that is still in existence today. A more recent study of the meteorological patterns in the ORNL area was completed in 2011 (Reference 36). The network of meteorological observations provides a strong basis for the onsite meteorological data needed for the site.

For the period of meteorological analysis using local meteorological towers (2018-2019), the ORR operated several meteorological towers that provided data on meteorological conditions and on the transport and dispersion aspects of the atmosphere. Data collected at the towers (available at https://metweb.ornl.gov/page1.htm) are used by the DOE in routine dispersion modeling to predict impacts from facility operations and as input to emergency response atmospheric models, which are used for simulated and actual accidental releases from a facility. Data from the towers are also used to support various research and engineering projects.

Environmental monitoring is performed within the ORR, including the ETTP, to measure radiological and nonradiological parameters directly in environmental media adjacent to the facilities. Data from the environmental monitoring program are analyzed to assess the environmental impact of DOE operations on the entire reservation and the surrounding area.

Meteorological data are collected at different levels above the ground, to 60 meters at some towers, to assess the vertical structure of the atmosphere, particularly with respect to wind shear and stability. Stable boundary layers and significant wind shear zones (associated with the local ridge-and-valley

terrain and the Great Valley of Eastern Tennessee) can significantly affect the movement of a plume after a facility release. Data are collected at the 10- or 15-meter level at most towers, but the wind measurement height is 20 meters for Tower J. Data are collected at some towers at 30, 33, 35, and 60 meter levels. Temperature, relative humidity, and precipitation are measured at some sites at 2 meters, but wind speed and wind direction typically are not. Atmospheric stability (a measure of the vertical mixing properties of the atmosphere) is generally calculated from temperature difference measured at most towers, although RG 1.23 allows for alternative stability class computation methods (e.g., using the standard deviation of the wind direction – sigma-theta, or use of the standard deviation of the vertical wind direction (sigma-phi). RG 1.23 is not directly applicable to non-power reactors but is considered informative with respect to atmospheric stability. When stability is calculated for most ORR sites using the sigma-phi method, the calculation relies on the measurement of the standard deviation of vertical wind speed using three-dimensional sonic wind monitors. Barometric pressure and solar radiation are measured at one or more of the towers. Instrument calibrations are managed by UT-Battelle and are performed every 6 months by an independent auditor.

3.2.4.3 Plans to Access Local Meteorological Data during License Period

Kairos Power is relying upon existing measurements taken within the ORR to address pre-operational site-specific meteorological monitoring. On May 6, 2021, Tower L was decommissioned because the land it occupies has been ceded by the DOE to another party. The tower will not be relocated; instead, it has been replaced with a wind lidar measurement program (using a Vaisala WindCube remote-sensing lidar instrument). This instrument has a vertical range of at least 200 meters, which is a significant upgrade from the 30-meter upper level for Tower L. The WindCube also measures sigma-phi data, which can be used for determination of stability class as an alternative to delta-T measurements. The location of the WindCube placement is at the PAM-35 site within the ETTP area.

The representativeness of wind measurements within all areas of the ETTP area to the actual site can be reviewed at any time by reviewing the “Current Meteorology” ORNL site at https://metweb.ornl.gov/page1.htm. This web page features output from the real-time wind assimilation and prediction system. Reviews of the wind field from the CAPARS system indicate that wind behavior within the ETTP area is relatively consistent. Therefore, placement of the new WindCube system at the PAM-35 site is expected to provide future onsite meteorological measurements for the facility during the operational phase, if necessary.

3.2.4.4 Comparison of Local and Regional Wind Roses

During the January 1, 2018 – December 31, 2019 period, 20-meter wind data were collected by the meteorological Tower J, and 15-meter and 30-meter wind data were collected by the meteorological tower L, both at the site. During the same time period, Tower D collected wind data at 15-meters, 35-meters, and 60-meters. The meteorological facility generally met criteria for obtaining data representative of the atmospheric conditions. Tower J is the closest to the site, but it only has one level of data. Therefore, Towers L and D were also used in the analysis. Tower L is located just south of Tower J. In November 2017, the lower anemometer height for Tower L was moved from 10 meters to 15 meters to increase siting fetch due to the close proximity of surrounding buildings. The 30-meter height is generally comparable to or higher than structures where hypothetical accidental releases might occur at the Hermes reactor. Tower D is the closest 60-meter tower in the vicinity of site, and its data has been used for a consistency check with data from Tower L due to the multiple levels of data.

The site area tower data are presented as wind roses in Figures 3.2-14 through 3.2-19. A wind rose for Chattanooga, based on ten years of data (2000–2009), is presented in Figure 3.2-20 and a wind rose for Oak Ridge, based on ten years of data (2000–2009), is presented in Figure 3.2-21.

Wind speeds at the ORR meteorological towers near the site during 2018–2019 (see Table 3.2-7) were generally light with an average 20-meter speed of 4.4 mph at Tower J, an average 15-meter wind speed of 3.4 mph at Tower L, and an average 15-meter wind speed of 3.1 mph at Tower D. The maximum hourly average (scalar) wind speed was 24.8 mph at Tower J, 21.4 mph at Tower L, and 16.8 mph at Tower D. At higher levels, Towers L and D also show similar wind behavior. The 30-meter level on Tower L has an average wind speed of 4.1 mph and a maximum hourly average wind speed of 24.4 mph. The 35-meter level on Tower D has an average wind speed of 3.9 mph and a maximum hourly average wind speed of 21.1 mph, while the 60-meter level on Tower D has an average wind speed of 5.0 mph and a maximum hourly average wind speed of 26.2 mph.

The geographic orientation of the ridges and valleys generally aligns with the prevailing regional winds from the southwest and northeast, but the gaps in the ridges permit wind flow from other directions as well as noted in the wind roses. The combination of high pressure associated with the Azores-Bermuda anticyclonic circulation and the nearby ridges results in generally light wind speeds with average surface wind speeds for the site being less than or equal to 5 mph. The site is surrounded by complex terrain, with alternating ridges and valleys oriented along a southwest to northeast axis. The local wind patterns are influenced by the complex terrain, with up-valley (south southwest to west southwest)/down-valley (northeast to east northeast) flow patterns common, and stable conditions with light winds frequently observed as seen at all levels of all three meteorological towers. These flow patterns influence the dispersion around the site.

3.2.4.5 Atmospheric Stability

A typical method for computing atmospheric stability is based on the temperature difference between two tower measurement levels, e.g., between the upper and lower measurement levels. However, alternative methods for determining atmospheric stability, e.g., based upon sigma-theta or sigma-phi, are allowed by RG 1.23. The frequency of occurrence of Pasquill (classes A-G) atmospheric stability classes based upon temperature difference for local ORR meteorological Tower L over a 2-year period (2018-2019) is presented in Table 2.3-8. While the atmosphere at the site for the two years analyzed appears to be almost equally stable, neutral, and unstable, the stable lapse conditions (classes E, F, and G - i.e., inversions) occur much of the time (42 percent). However, the majority of the stable lapse conditions are only slightly stable (class E), occurring 27 percent of the time. The most stable class (class G) occurs approximately 5.5 percent of the time. Neutral lapse conditions (class D) occur approximately 27 percent of the time. Unstable classes occur approximately 31 percent of the time.

3.2.5 Programs or Policies to Reduce Greenhouse Gas Emissions

Kairos Power is committed to minimizing its carbon footprint and promoting initiatives to reduce emissions of greenhouse gases (GHG). The purpose of the Hermes demonstration reactor is to better facilitate the broad deployment of non-GHG emitting electricity generation. Kairos Power will develop a program to avoid and control GHG emissions associated with the facility. It is expected that this program could include elements of the following, as appropriate for the facility:

- Participating in EPA initiatives such as the Climate Leaders Program, ENERGY STAR Commercial Buildings Program, Green Power Partnership, and SmartWay Transport Partnership.
- Developing a GHG emission inventory, including appropriate procedures for estimating or monitoring GHG emissions.
- Investigating and implementing methods for avoiding or controlling the GHG emissions identified in the inventory.
- Implementing energy efficiency and conservation programs at the facility.

- Encouraging carpooling or other measures to minimize GHG emissions due to vehicle traffic during construction and operation of the facility.
- Conducting periodic audits of GHG control procedures and implementing corrective actions when necessary.

3.2.6 Noise

Noise is unwanted or unwelcome sound usually caused by human activity that is added to the natural acoustic setting of a locale. It is further defined as sound that disrupts normal activities and diminishes the quality of the environment. Sound pressure levels are measured in units called decibels (dB). In order to establish a uniform noise measurement that simulates people's perception of loudness and annoyance, the decibel measurement is weighted to account for those frequencies most audible to the human ear. This is known as the A-weighted sound level, or dBA. The dBA scale is based on intensity and weighted for frequency because the human ear does not perceive all frequencies in the same way. As dBA increases, hearing is more likely to be damaged. Approximate noise levels measured in dBA of common activities/events are provided below (Reference 37, Reference 38, and Reference 39). For most people to perceive an increase in noise, the change or difference must be at least 3 dBA. At 5 dBA, the change will be readily noticeable.

- 0 dBA - the softest sound a person can hear with normal hearing
- 10 dBA - normal breathing
- 20 dBA – average whispering at 5 feet, rustling leaves
- 30 dBA – quiet rural area
- 50 dBA – quiet suburb, moderate rainfall,
- 60 dBA - normal conversation
- 80 dBA – garbage disposal, freight train at 15 meters
- 90 dBA – subway, passing motorcycle (25 feet)
- 110 dBA – auto horn at 1 meter,
- 120 dBA – thunder, chain saw
- 140 dBA – near jet engine

Because the sound pressure level unit of dBA describes a noise level at just one moment and very few noises are constant, other ways of describing noise over extended periods have been developed. One way of describing fluctuating sound is to describe the fluctuating noise heard over a specific time period as if it had been a steady, unchanging sound. For this condition, a descriptor called the "equivalent sound level," L_{eq}, can be computed. L_{eq} is the constant sound level that, in a given situation and time period (e.g., one hour, denoted by $L_{eq(1)}$, or 24 hours, denoted as $L_{eq(24)}$), conveys the same sound energy as the actual time-varying sound. The Day-Night Sound Level (i.e., L_{dn}) refers to a 24-hour average noise level with a 10 dB penalty applied to the noise levels during the hours between 10 PM and 7 AM due to increased sensitivity to noise levels during these hours.

In June 2021, noise receptor locations near the site were selected for monitoring in order to establish the baseline ambient noise conditions at the site, and as representative locations for the immediately adjacent neighborhood area(s) with potential to be affected under the Proposed Action. These locations are described in Table 3.2-9 and shown in Figure 3.2-22. Noise receptor locations were selected based on the following criteria to get an accurate picture of the ambient noise environment: (1) close to public accessible road/area, i.e., along the site boundary; and (2) to provide coverage on area that is away from public road/activities, i.e., inside the vacant site.

This baseline noise survey was conducted from June 15 to June 16, 2021. Noise monitoring was conducted over approximately 24 hours at each receptor location, which measured both daytime and nighttime

ambient noise conditions on the site. The 15-minute interval existing noise levels in terms of L_{eq} were used to calculate the range of $L_{eq(1)}$ and L_{dn} as summarized in Table 3.2-10. The measured noise levels represent an ambient noise environment common to a quiet rural area surrounding the site. The R1 location was measured at having higher ambient noise levels as compared to R2; this is attributed to its closer proximity to the industrial activities at ETTP, as well as a public accessible road.

The nearest noise receptors within a 5-mile radius of the site include two parks (BORCE) [adjacent] and the Oak Ridge Country Club [4.9 miles northeast]), one rehabilitation facility (Michael Dunn Center [4.6 miles southwest]), and several churches. The nearest resident is approximately 0.7 mile north of the proposed facility, but the residential area is separated from the site by forests.

There is also a railroad station/yard immediately to the west of the site and the proposed Oak Ridge airport would be approximately 1.1 mile southeast of the site. These would be contributors to noise in the area. The Preserve Marina approximately 2 miles southwest on the Clinch River near Brashear Island. Other industries or businesses within 5 miles of the site include the ORNL Carbon Fiber Technology Center (2.25 miles northeast of the site), the proposed Clinch River Nuclear (CRN) site (3.53 miles south of the site), ORNL (4.87 mile east of the site).

3.2.7 References

1. National Climatic Data Center, 1999-2020 Annual Local Climatological Data (LCD) for Oak Ridge, TN, 2021.
2. U.S. Department of Energy, "Oak Ridge Reservation Annual Site Environmental Report (ASER) – 2019 - Appendix B: Climate Overview of the Oak Ridge Area," DOE/CSC-2513, September 2020.
3. National Climatic Data Center, Data Tools: 1981-2010 Normals for Oak Ridge, TN, Website: https://www.ncdc.noaa.gov/cdo-web/datatools/normals, accessed July 2021.
4. National Climatic Data Center, 1981-2020 Annual Local Climatological Data (LCD) for Knoxville, TN, 2021.
5. Tennessee Department of Environment and Conservation Air Pollution Control Division, "2020 Tennessee Annual Monitoring Network Plan," July 1, 2020.
6. U.S. Environmental Protection Agency, Tennessee Nonattainment/Maintenance Status for Each County by Year for All Criteria Pollutants, Website: https://www3.epa.gov/airquality/greenbook/anayo_tn.html, accessed April 13, 2021.
7. U.S. Environmental Protection Agency, Prevention of Significant Deterioration Basic Information, Website: https://www.epa.gov/nsr/prevention-significant-deterioration-basic-information, accessed June 8, 2021.
8. National Park Service, National Parks and the Clean Air Act, Website: https://www.nps.gov/subjects/air/cleanairact.htm, accessed April 13, 2021.
9. U.S. Environmental Protection Agency, "New Source Review Workshop Manual - Prevention of Significant Deterioration and Nonattainment Permitting," October 1990.
10. National Climatic Data Center, Storm Events Database, Retrieved from: http://www.ncdc.noaa.gov/stormevents, accessed May 6, 2021.
11. Oak Ridge National Laboratory, Oak Ridge Reservation Meteorology – Climate Data, Normals, and Extremes – Annual, Hourly Climate Data – Oak Ridge Reservation (2001-2020). Retrieved from https://metweb.ornl.gov/page5.htm.

12. Thom, H.C.S., "New Distributions of Extreme Winds in the United States," Journal of the Structural Division, Proceedings of the American Society of Civil Engineers, Vol. 94, No. ST 7:1787-1801, 1968.

13. Mississippi State University, NWS Morristown Tornado Database, Retrieved from: http://www.midsouthtornadoes.msstate.edu/index.php?cw=mrx.

14. National Climatic Data Center, Chattanooga, TN daily average precipitation data for years 1938 through 2014.

15. National Climatic Data Center, 2013 Annual Local Climatological Data for Nashville, TN.

16. National Climatic Data Center, 1998 Annual Local Climatological Data for Oak Ridge, TN.

17. National Climatic Data Center, 2013 Annual Local Climatological Data for Oak Ridge, TN.

18. Tennessee Encyclopedia, The Tennessee Encyclopedia of History and Culture, Tennessee Historical Society, Disasters, Website: https://tennesseeencyclopedia.net/, accessed August 18, 2021.

19. Homeland Security Digital Library, 1980 US Heat Wave and 1988 U.S. Drought/Heatwave, Retrieved from: https://www.hsdl.org/c/tl/1980-us-heat-wave/ and https://www.hsdl.org/c/tl/1988-u-s-droughtheatwave/.

20. Karl, T.R. and P.J. Young, "The 1986 Southeast Drought in Historical Perspective," Bulletin of American Meteorological Society, Vol. 68:773-778.

21. National Oceanic and Atmospheric Administration, "NOAA Manual NOS NGS 1, Geodetic Bench Marks," September 1978.

22. Tattelman, P. and I.L. Gringorten, "Estimated Glaze Ice and Wind Loads at the Earth’s Surface for the Contiguous United States," AD-775 068, October 16, 1973.

23. American Society of Civil Engineers, "Minimum Design Loads for Buildings and Other Structures," ASCE/SEI 7-16, 2016.

24. Oak Ridge National Laboratory, Oak Ridge Reservation Meteorology – Climate Data, Normals, and Extremes – Severe Weather Statistics – Oak Ridge Area, Retrieved from: https://metweb.ornl.gov/page5.htm.

25. Koehler, T.L., "Cloud-to-Ground Lightning Flash Density and Thunderstorm Day Distributions Over the Contiguous United States Derived from NLDN Measurements: 1993-2018," Monthly Weather Review, Vol. 148:313-332.

26. National Weather Service, Chattanooga, TN Climate Page. Records from 1879-Present, Retrieved from: https://www.weather.gov/mrx/chaclimate.

27. U.S. Nuclear Regulatory Commission, "Interim Staff Guidance (ISG) on Assessment of Normal and Extreme Winter Precipitation Loads on the Roofs of Seismic Category I Structures (ISG-7)."

28. Snow Plow News, Official Snowfall Records for Oak Ridge and Knoxville, Tennessee, Website: https://blog.snowplownews.com/snowfall_records/oak-ridge-tennessee/, accessed August 19, 2021.

29. Huotari, J., "Snowfall again!," Oakridger, Retrieved from https://www.oakridger.com/article/20100216/NEWS/302169991

30. Tennessee Valley Authority, "Snow and Ice Storms of 1959-1960 in Tennessee River Basin," March 1960.

31. National Oceanic and Atmospheric Administration, "Hydrometeorological Report HMR-53, Seasonal Variation of 10-Square-Mile Probable Maximum Precipitation Estimates, United States East of the 105th Meridian," NUREG/CR-1486, April 1980.

32. Argonne National Laboratory-Environmental Assessment Division, "Model Review and Evaluation for Application in DOE Safety Basis Documentation of Chemical Accidents – Modeling Guidance for Atmospheric Dispersion and Consequence Assessment," September 1997.

33. Nuclear Safety Research and Development, "Technical Report for Calculations of Atmospheric Dispersion at Onsite Locations for Department of Energy Nuclear Facilities," April 2015.

34. NUREG-1140, "A Regulatory Analysis on Emergency Preparedness for Fuel Cycle and Other Radioactive Material Licensees," August 1991.

35. U.S. Weather Bureau of Oak Ridge Tennessee, "A Meteorological Survey of the Oak Ridge Area," ORO-99, 1953.

36. Birdwell, K.R., "Wind Regimes in Complex Terrain of the Great Valley of Eastern Tennessee," May 2011.

37. U.S. Department of Housing and Urban Development, Chapter 1 – Basic Overview of the Environmental Noise Problem, Noise Guidebook, 2009.

38. IAC Acoustics, Comparative Examples of Noise Levels, Website: https://www.iacacoustics.com/blog-full/comparative-examples-of-noise-levels.html, accessed May 10, 2021.

39. American Speech-Language-Hearing Association, Loud Noise Dangers, Website: https://www.asha.org/public/hearing/loud-noise-dangers/#dangerous, accessed May 10, 2021.

Table 3.2-1: Nearest Federal Class I Areas to the Site

Class I Area/Federal Land Manager	Distance from the Site (km)	Approximate distance from the Site (miles)	Direction from the Site
Joyce Kilmer-Slickrock Wilderness Area (USFS) – TN/NC	72.4	45	
Great Smoky Mountains NP (NPS) – TN/NC	80	50	
Cohotta Wilderness Area (USFS) GA	112.6	70	South, southwest
Shining Rock Wilderness Area (USFS) – NC	153	95	Southeast
Mammoth Cave NP (NPS) (KY)	200	125	Northwest
Linville Gorge Wilderness Area (USFS) – NC	225	140	East
Sipsey Wilderness Area (USFS) – AL	322	200	Southwest
James River Face Wilderness (USFS) VA	475	295	Northeast

Table 3.2-2: Tornados within 10 miles of the Site

Date	Counties Affected	Magnitude (WS range)	Length (miles)	Width (yards)	Closest Distance to the Site (miles)
2/21/1993	Anderson and Knox	F-3 (158-206 mph)	16	150	10
2/21/1993	Roane, Loudon, and Blout	F-3 (158-206 mph)	30	100	7.24
5/18/1995	Morgan	F-0 (40-72 mph)	0.5	23	5.95
11/10/2002	Morgan	F-3 (158-206 mph)	8.3	300	7.74
6/10/2014	Roane	EF-0 (65-68 mph)	0.5	100	7.05
Sources: (Reference 10 and Reference 14), Section 3.2.3.2					

Table 3.2-3: Regional Precipitation Extremes

Station	Period of Record (years)	Normal Annual Rainfall (inches)	Max 24-hour Rainfall (inches)	Max Monthly Rainfall (inches)	Normal Annual Snowfall (inches)	Max 24-hour Snowfall (inches)	Max Monthly Snowfall (inches)
Oak Ridge NWS Station	30[(a)]	50.91	–	–	11.1	–	–
	66[(b)]	–	7.48 (Aug 1960)	19.27 (Jul 1967)	–	–	–
	52[(b)]	–	–	–	–	12.0 (Mar 1960)	21.0 (Mar 1960)
Knoxville NWS Station[(b)]	30	47.86	–	–	6.5	–	–
	72	–	5.98 (Sep 2011)	12.67 (Jan 2013)	–	–	–
	69	–	–	–	–	18.2 (Nov 1952)	23.3 (Feb 1960)
Chattanooga NWS Station[(b)]	30	52.48	–	–	3.9	–	–
	74	–	9.50 (Sep 2011)	16.32 (Mar 1980)	–	–	–
	76	–	–	–	–	20.0 (Mar 1993)	20.0 (Mar 1993)
Nashville NWS Station[(b)]	30	47.25	–	–	6.3		
	74	–	9.09 (May 2010)	16.43 (May 2010)	–	–	–
	66	–	–	–	–	10.2 (Dec 1963)	18.9 (Feb 1979)

[(a)] (Reference 16)
[(b)] (Refence 4, Reference 14, Reference 15, and Reference 17)
Source: Section 3.2.3.3

Table 3.2-4: Air Temperatures for Knoxville, Tennessee

	Normal Daily Maximum	Normal Dry Bulb	Normal Daily Minimum	Extreme Daily Maximum	Extreme Daily Minimum
Period of Record (years)	**30[(a)]**	**30[(a)]**	**30[(a)]**	**72**	**72**
January	47.3	38.2	29.2	77	-24[(c)]
February	52.3	42.4	32.4	83	-8
March	61.4	50.3	39.2	86	1
April	70.3	58.8	47.3	92	22
May	78.1	67.2	56.2	96	32
June	85.4	75.0	64.7	105[(b)]	43
July	88.2	78.4	68.7	105[(b)]	49
August	87.8	77.8	67.8	102	49
September	81.8	71.1	60.4	103	36
October	71.2	59.9	48.5	91	25
November	60.4	49.7	39.0	84	5
December	49.8	40.8	31.7	80	-6
Annual	69.5	59.1	48.8	105[(b)]	-24[(c)]

[(a)] 1981-2010
[(b)] June 2012 and July 2012
[(c)] January 1985
Notes: Air Temperature (°F) from 2013 Annual Knoxville Local Climatological Data.

Table 3.2-5: Air Temperatures for Oak Ridge, Tennessee

	Normal Daily Maximum	Normal Dry Bulb	Normal Daily Minimum	Extreme Daily Maximum	Extreme Daily Minimum
Period of Record (years)	**30[(a)]**	**30[(a)]**	**30[(a)]**	**66**	**66**
January	46.6	37.7	28.9	76	-17[(c)]
February	51.9	41.8	31.7	79	-13
March	61.4	50.4	39.3	86	1
April	70.6	58.8	46.9	92	20
May	78.3	66.8	55.2	95	30
June	85.7	75.1	64.5	105[(b)]	39
July	88.4	78.5	68.6	105[(b)]	49
August	88.0	77.6	67.2	103	50
September	81.7	70.7	59.7	102	33
October	71.1	59.5	48.0	90	21
November	59.6	48.9	38.3	83	0
December	49.6	40.3	31.1	78	-7
Annual	69.4	58.8	48.3	105[(b)]	-17[(c)]

(a) 1981-2010
(b) July 1952 and June 2012
(c) January 1985
Notes: Air Temperature (°F) from 2013 Annual Oak Ridge Local Climatological Data.

Table 3.2-6: Air Temperatures for Tower L

Month	Maximum Daily Average	Minimum Daily Average
January	46.3	25.3
February	59.0	36.0
March	58.7	36.8
April	67.4	46.6
May	76.7	64.3
June	79.1	69.0
July	79.0	70.5
August	78.0	71.5
September	77.4	69.6
October	75.6	48.8
November	53.7	34.7
December	53.8	31.3

Table 3.2-7: Average (Scalar) Wind Speed for the Site (2018-2019)

	Tower J	Tower L	Tower D
	Average (scalar) 20-m Wind Speed (mph)	Average (scalar) 15-m Wind Speed (mph)	Average (scalar) 15-m Wind Speed (mph)
2018			
1st quarter	5.19	4.20	3.61
2nd quarter	4.59	3.74	3.38
3rd quarter	3.45	2.75	2.59
4th quarter	4.17	3.25	2.92
2019			
1st quarter	5.26	4.13	3.61
2nd quarter	4.64	3.73	3.41
3rd quarter	3.11	2.64	2.38
4th quarter	4.83	3.26	2.93
Overall	**4.34**	**3.46**	**3.10**

Table 3.2-8: Pasquill Atmospheric Stabilities for Tower L

Stability Class	Description	Percent Occurrence
A	Extremely Unstable	30.81
B	Moderately Unstable	0.00
C	Slightly Unstable	0.00
D	Neutral	27.04
E	Slightly Stable	26.83
F	Moderately Stable	9.79
G	Extremely stable	5.53
A,B,C	Unstable	30.81
D	Neutral	27.04
E,F,G	Stable	42.15
Notes: Atmospheric stability classes based on 15-30 m temperature difference data for 2018-2019 for Tower L.		

Table 3.2-9: Description of the Noise Monitoring Sites

Receptor	Location	Land-Use	Duration	Periods
R1	Site Boundary	Industrial	24 Hours	Normal Weekday
R2	Site Interior	Industrial	24 Hours	Normal Weekday

Table 3.2-10: Measured Ambient Noise Levels

Receptor	Location	$L_{eq(1)}$	L_{dn}
R1	Site Boundary	33-52 dBA	53 dBA
R2	Inside of Site	33-46 dBA	46 dBA

Figure 3.2-1: Regional Topography

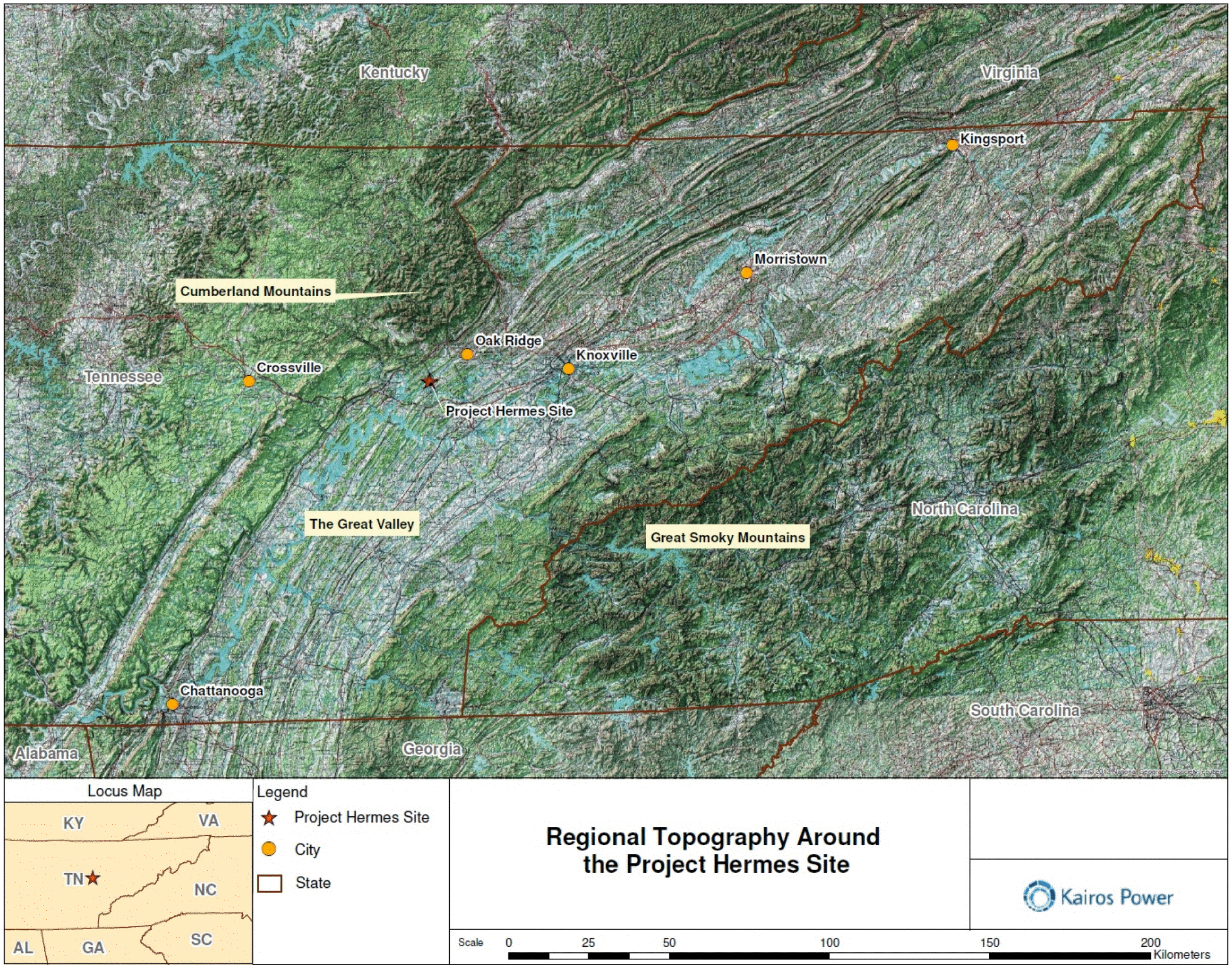
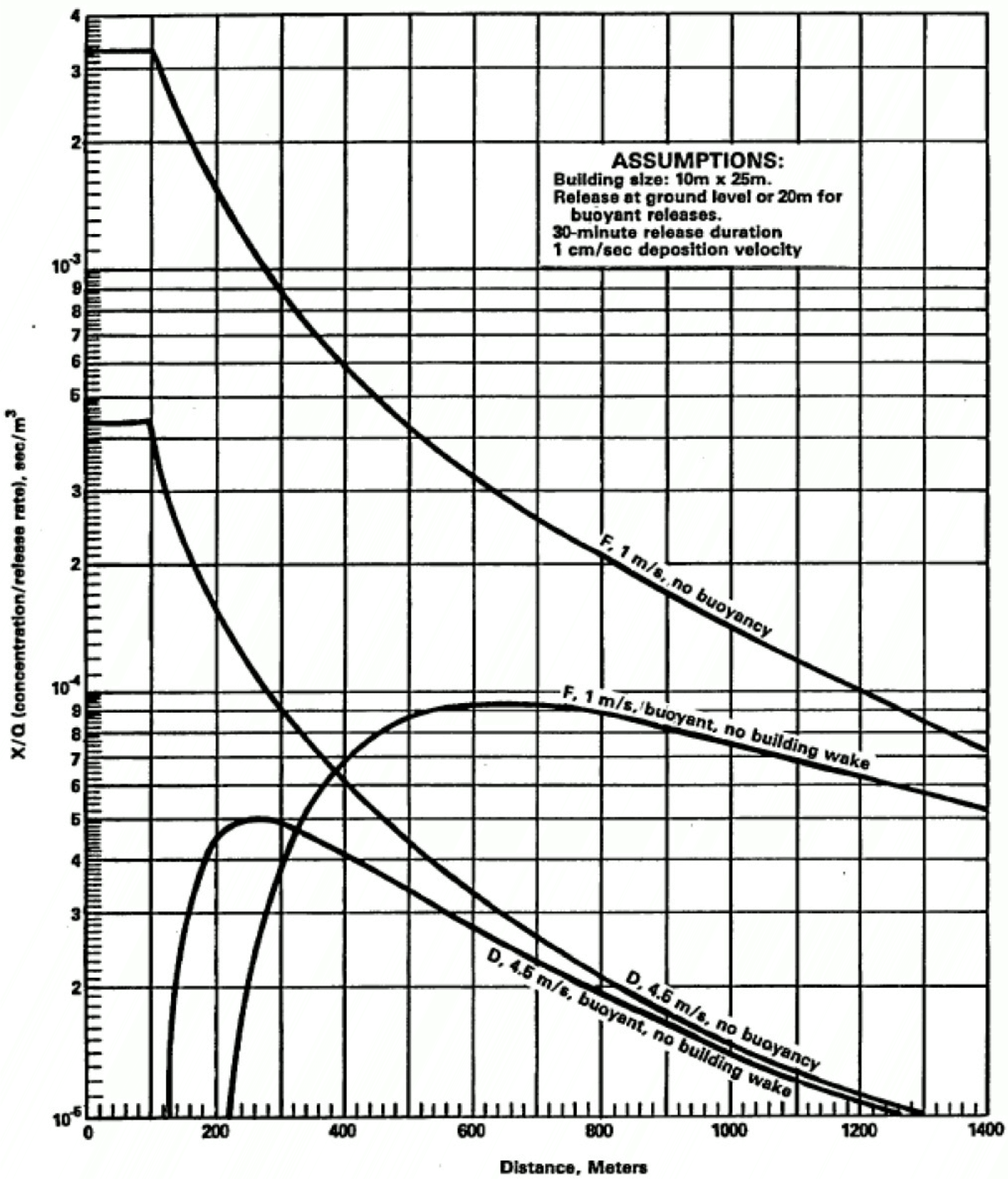


Figure 3.2-2: Class I Areas Within 500 km of Site

Figure 3.2-3: Atmospheric Dispersion Versus Distance



Note: (Reference 33 and Reference 34)

Figure 3.2-4: Local Topography and Locations of Meteorological Towers

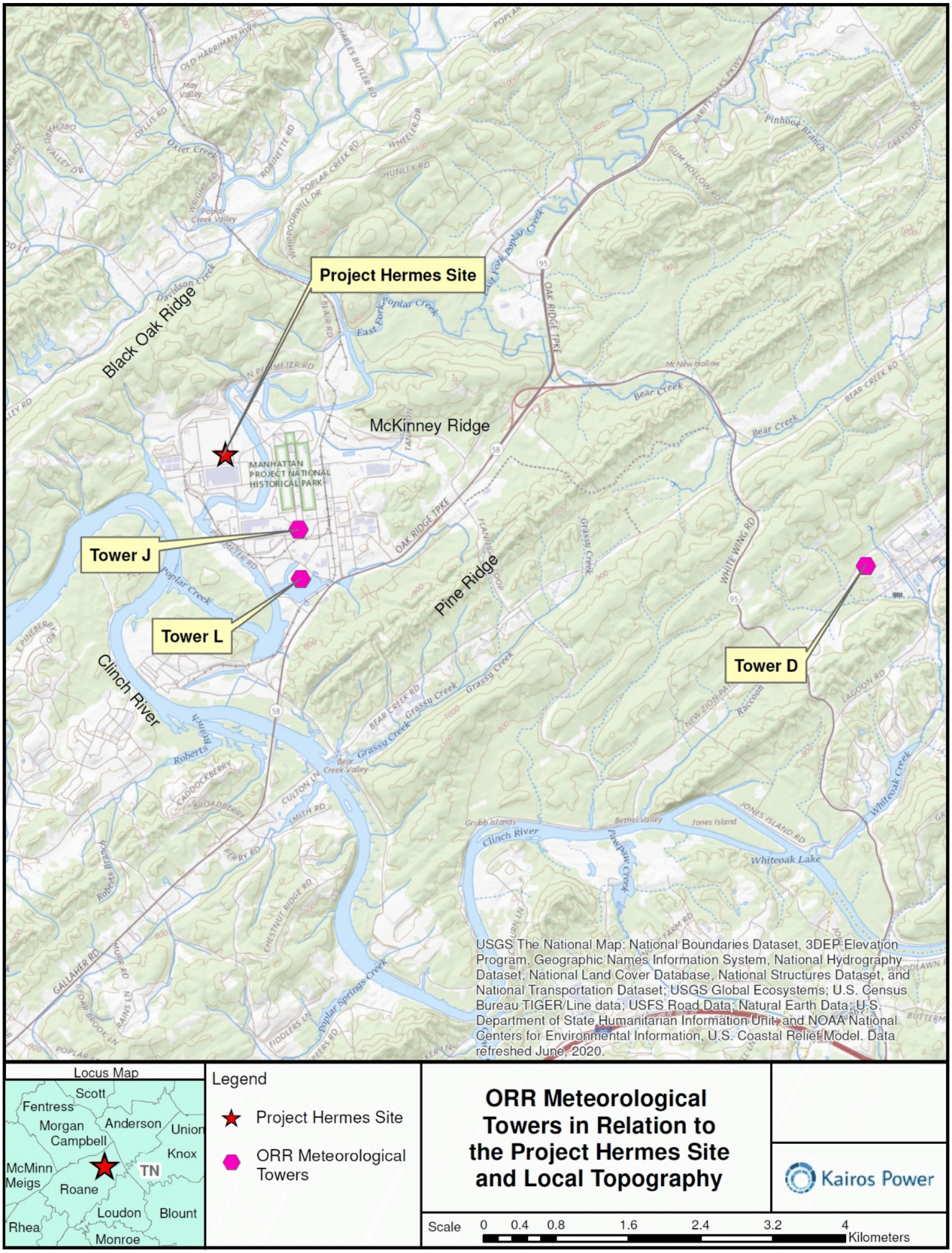


Figure 3.2-5: Topography and Locations of Meteorological Towers Within 100 km of the Site

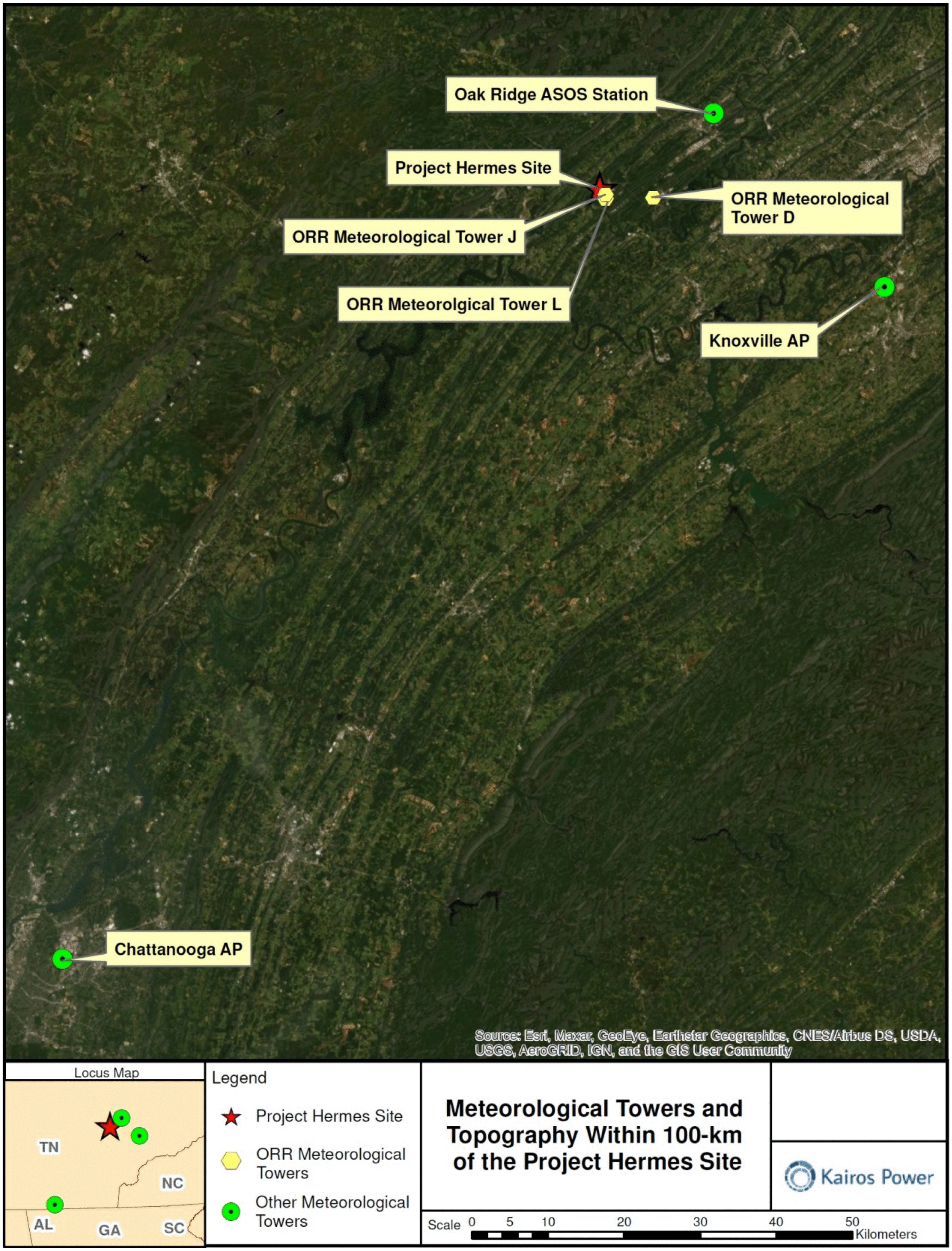
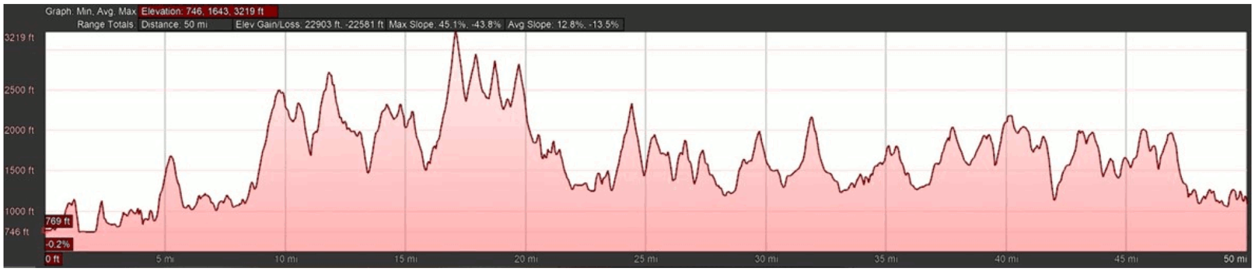
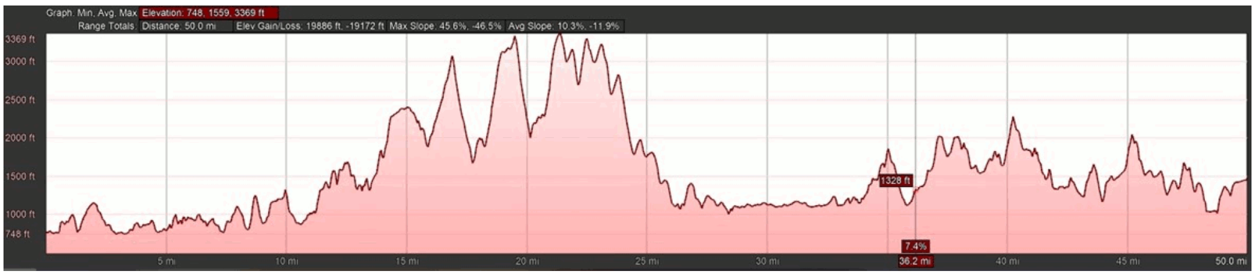


Figure 3.2-6: Terrain Elevations Within 50 miles North and North-Northeast of the Site



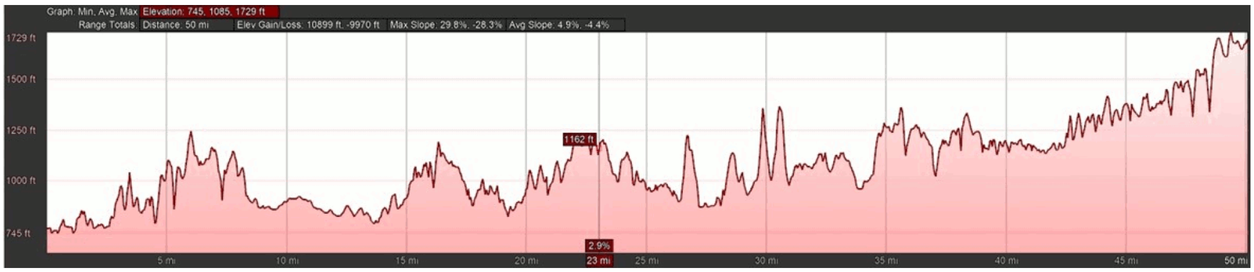
North



North-Northeast

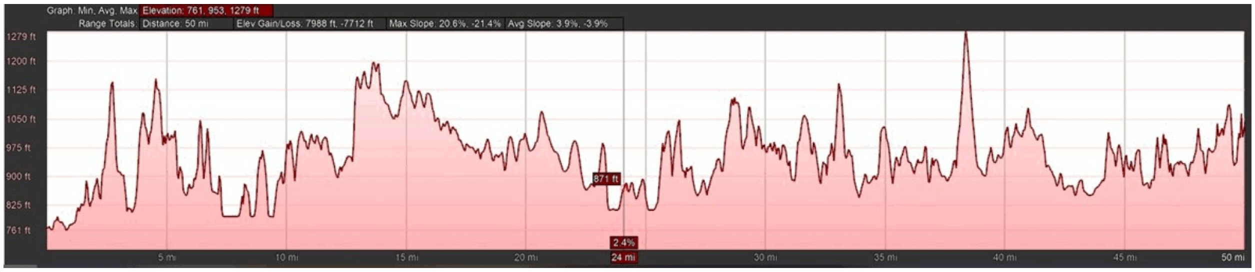
Figure 3.2-7: Terrain Elevations Within 50 miles Northeast and East-Northeast of the Site

Northeast



East-Northeast

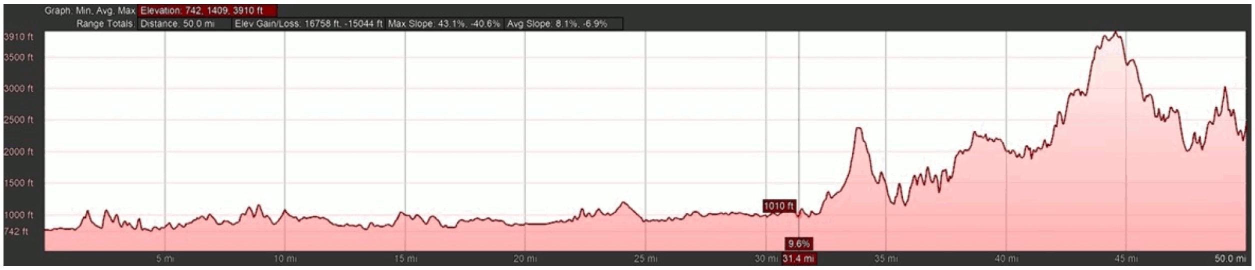
Figure 3.2-8: Terrain Elevations Within 50 miles East and East-Southeast of the Site



East

East-Southeast

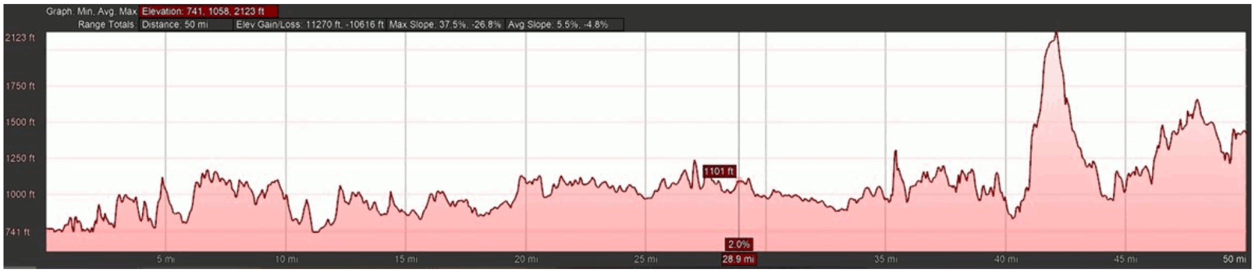
Figure 3.2-9: Terrain Elevations Within 50 miles Southeast and South-Southeast of the Site



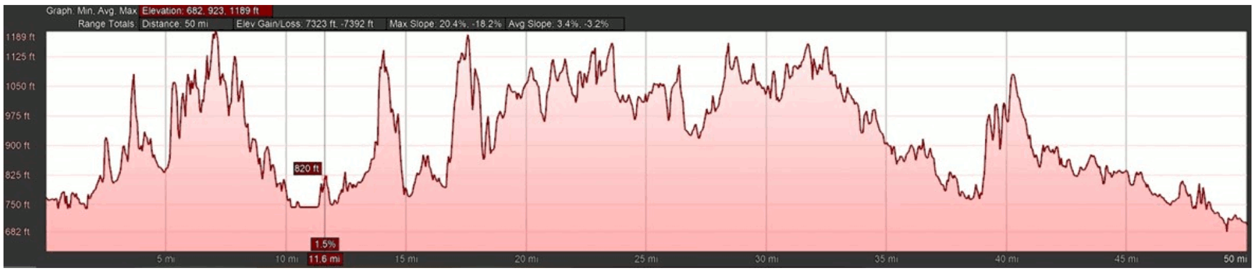
Southeast

South-Southeast

Figure 3.2-10: Terrain Elevations Within 50 miles South and South-Southwest of the Site



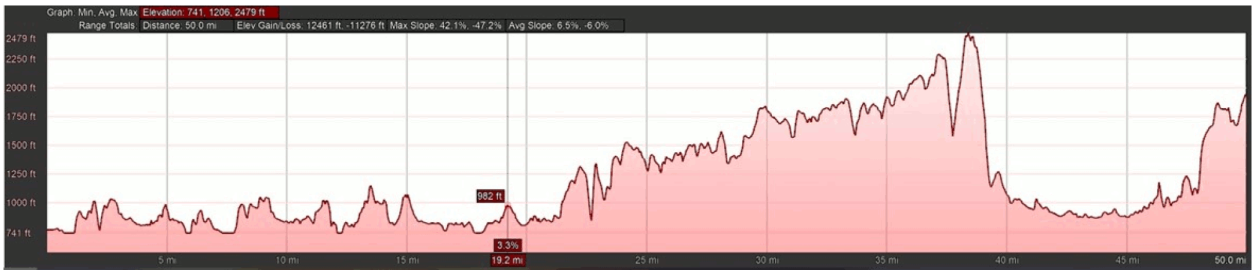
South



South-Southwest

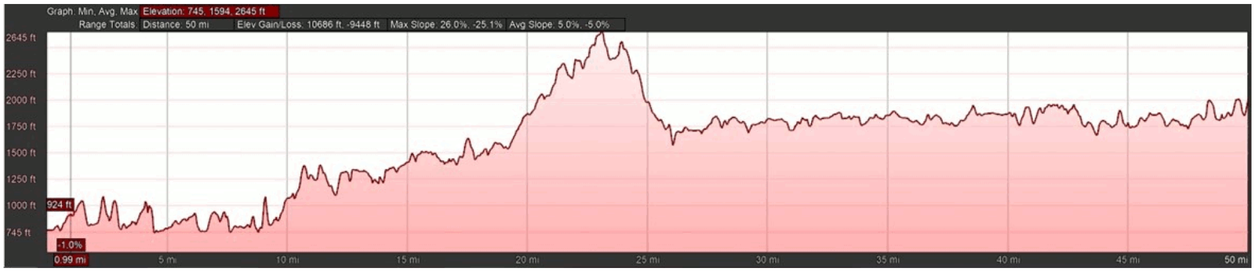
Figure 3.2-11: Terrain Elevations Within 50 miles Southwest and West-Southwest of the Site

Southwest

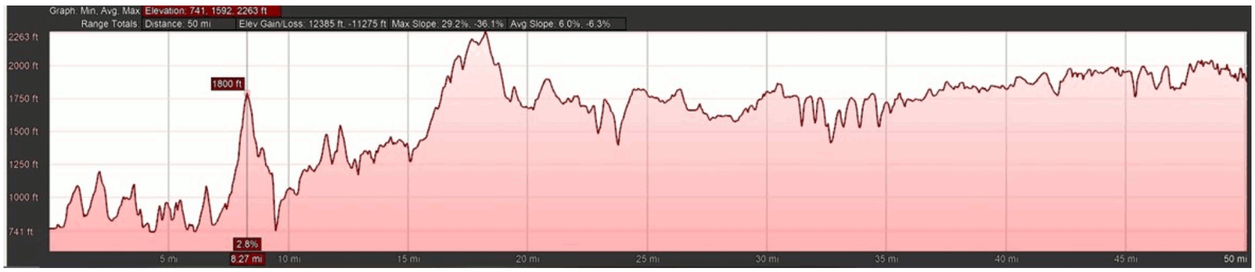


West-Southwest

Figure 3.2-12: Terrain Elevations Within 50 miles West and West-Northwest of the Site

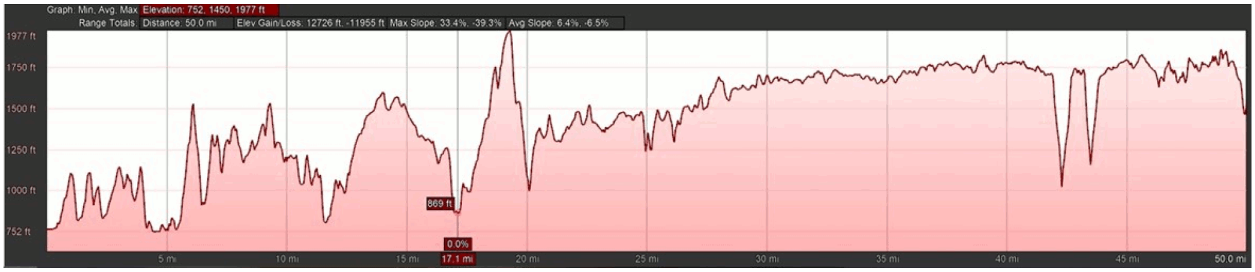


West

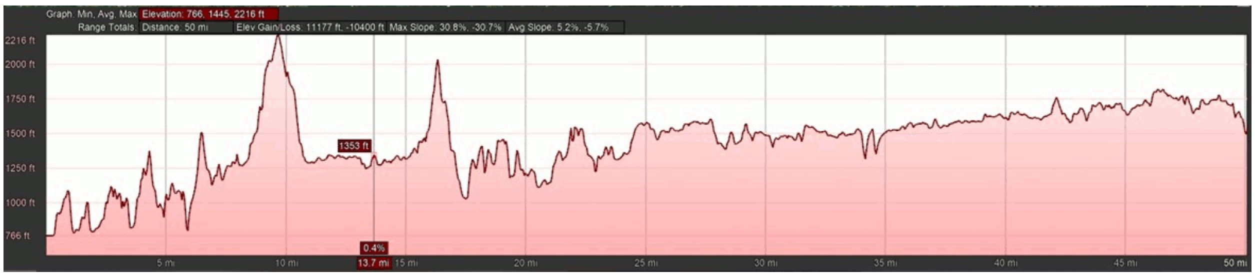


West-Northwest

Figure 3.2-13: Terrain Elevations Within 50 miles Northwest and North-Northwest of the Site



Northwest

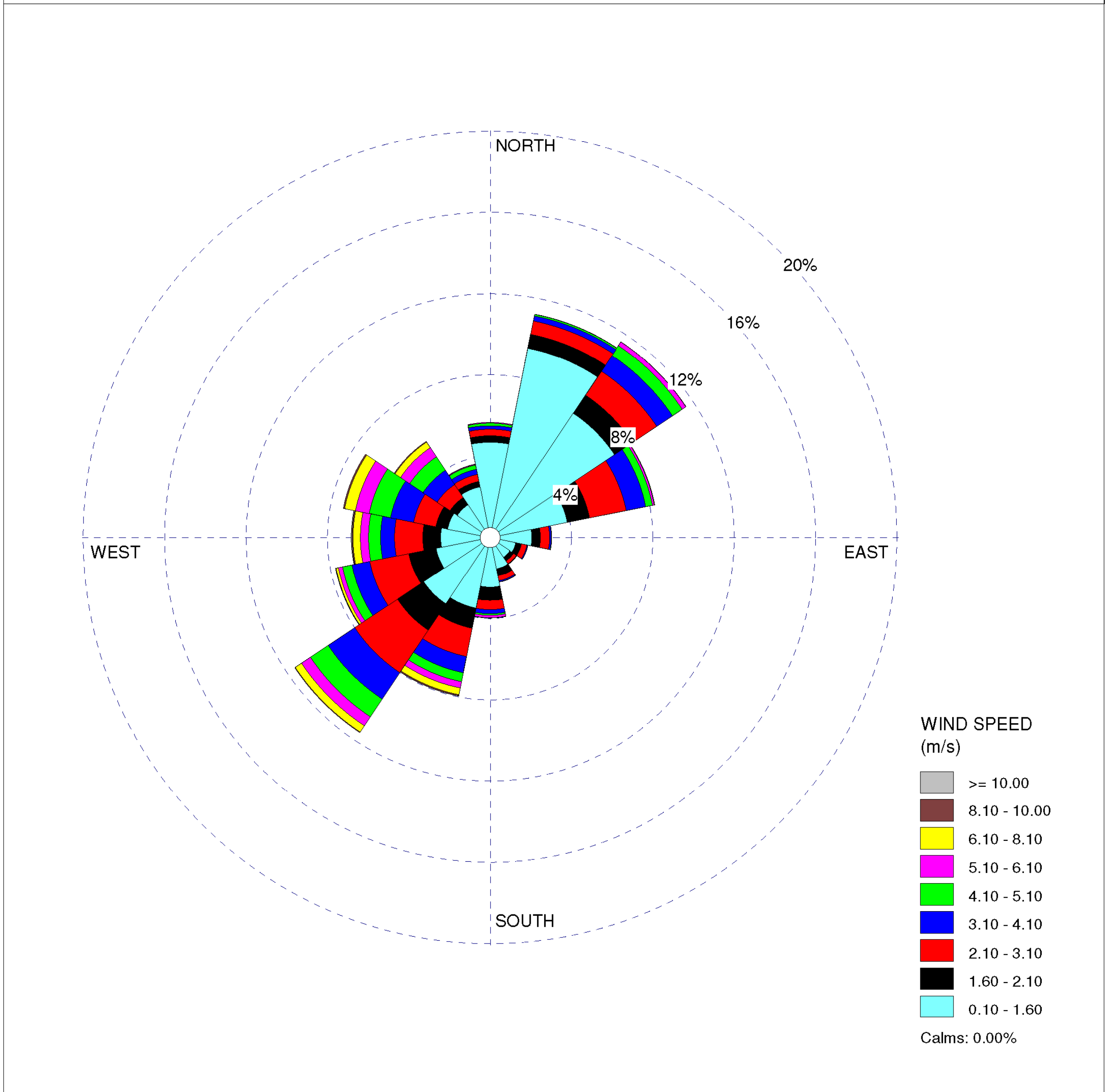


North-Northwest

Figure 3.2-14: Tower J 20 meter Wind Rose

WIND ROSE PLOT:
2018-2019 Wind Rose for Tower J 20 m Level

DISPLAY:
Wind Speed
Direction (blowing from)



COMMENTS:

DATA PERIOD:
Start Date: 1/1/2018 - 00:00
End Date: 12/31/2019 - 23:00

COMPANY NAME:

MODELER:

CALM WINDS:
0.00%

TOTAL COUNT:
17520 hrs.

AVG. WIND SPEED:
1.97 m/s

DATE:
6/23/2021

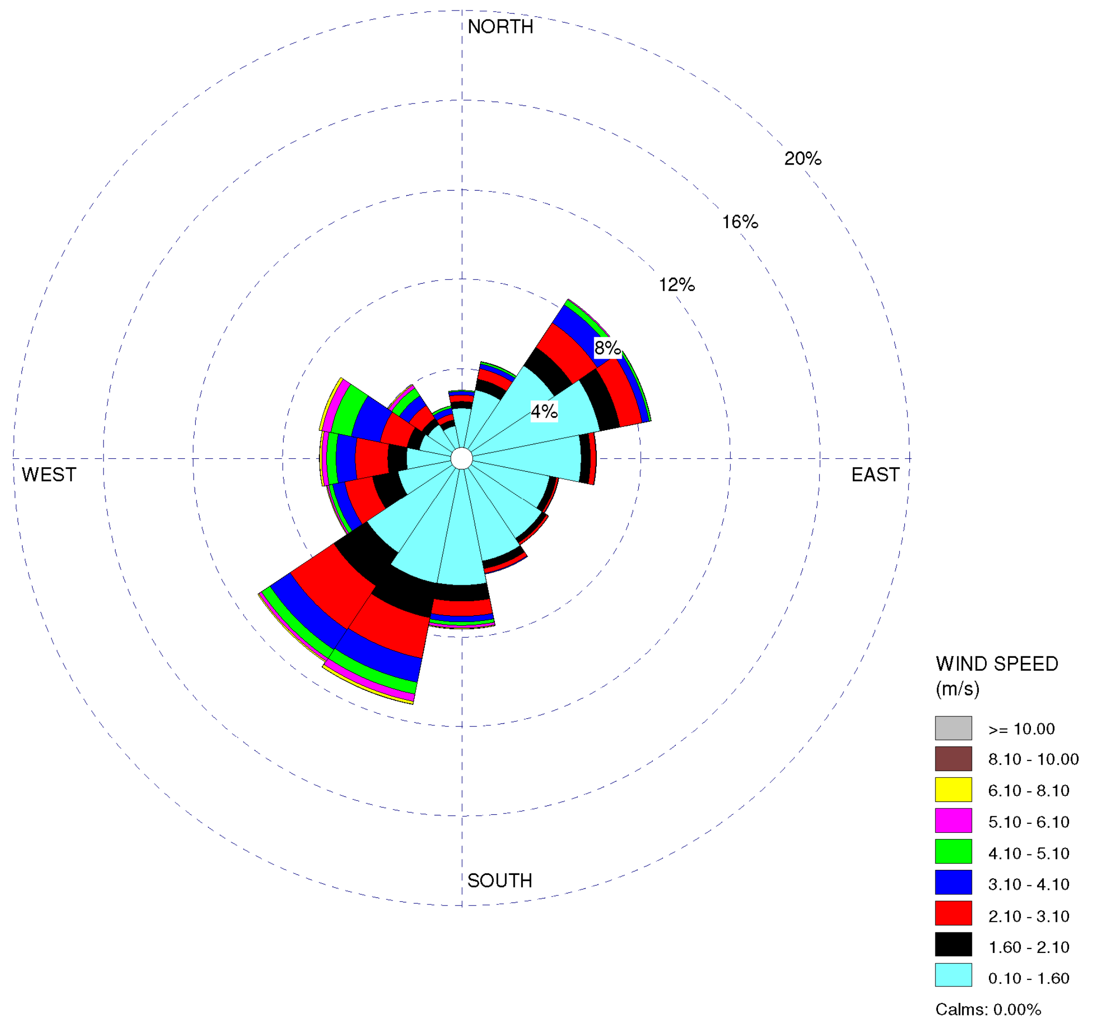
PROJECT NO.:

WRPLOT View - Lakes Environmental Software

Figure 3.2-15: Tower L 15 meter Wind Rose

WIND ROSE PLOT:
2018-2019 Wind Rose for Tower L 15 m Level

DISPLAY:
Wind Speed
Direction (blowing from)



COMMENTS:

DATA PERIOD:
Start Date: 1/1/2018 - 00:00
End Date: 12/31/2019 - 23:00

COMPANY NAME:

MODELER:

CALM WINDS:
0.00%

TOTAL COUNT:
17520 hrs.

AVG. WIND SPEED:
1.54 m/s

DATE:
6/23/2021

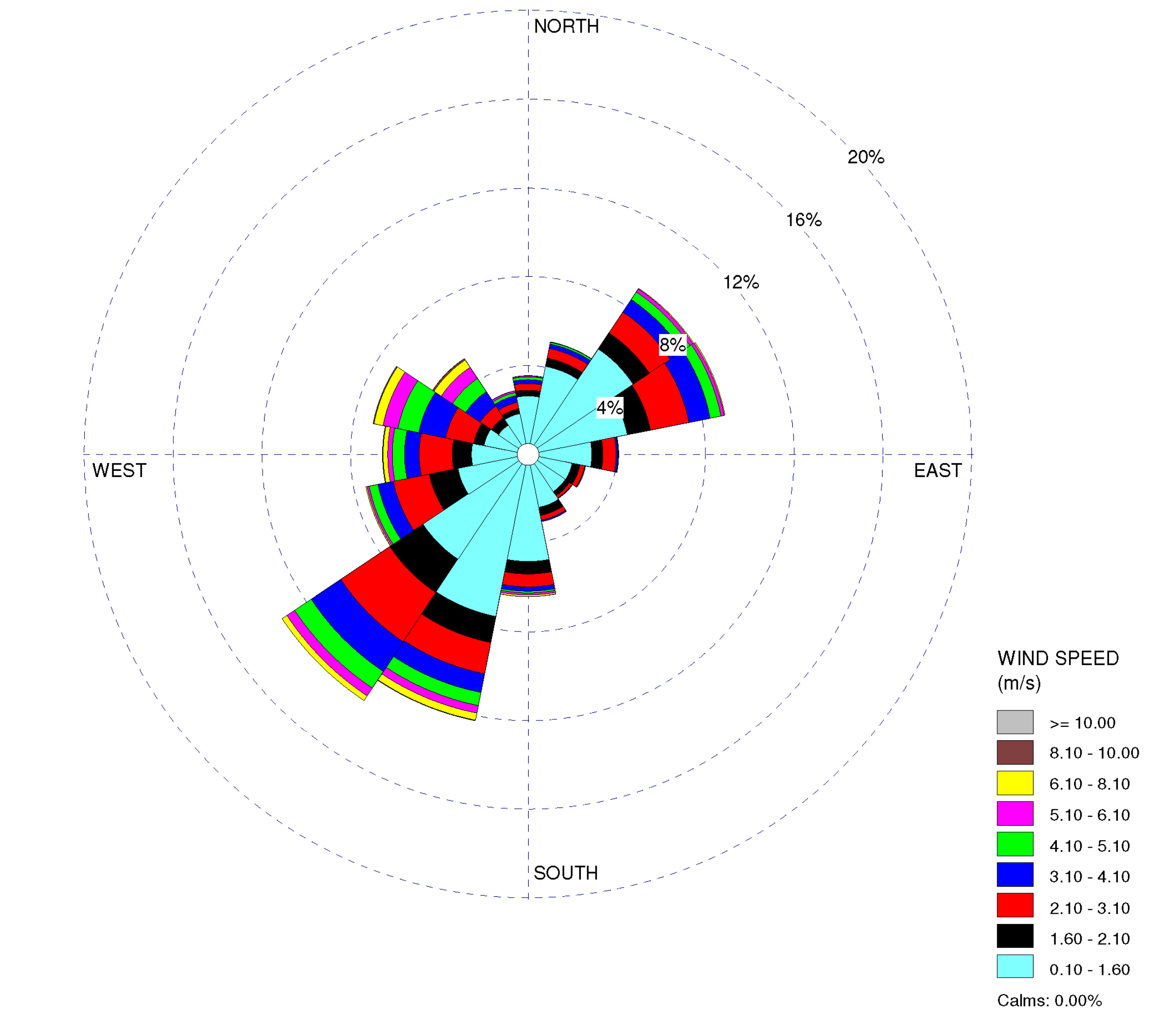
PROJECT NO.:

WRPLOT View - Lakes Environmental Software

Figure 3.2-16: Tower L 30 meter Wind Rose

WIND ROSE PLOT:
2018-2019 Wind Rose for Tower L 30 m Level

DISPLAY:
Wind Speed
Direction (blowing from)



COMMENTS:

DATA PERIOD:
Start Date: 1/1/2018 - 00:00
End Date: 12/31/2019 - 23:00

COMPANY NAME:

MODELER:

CALM WINDS:
0.00%

TOTAL COUNT:
17520 hrs.

AVG. WIND SPEED:
1.83 m/s

DATE:
6/23/2021

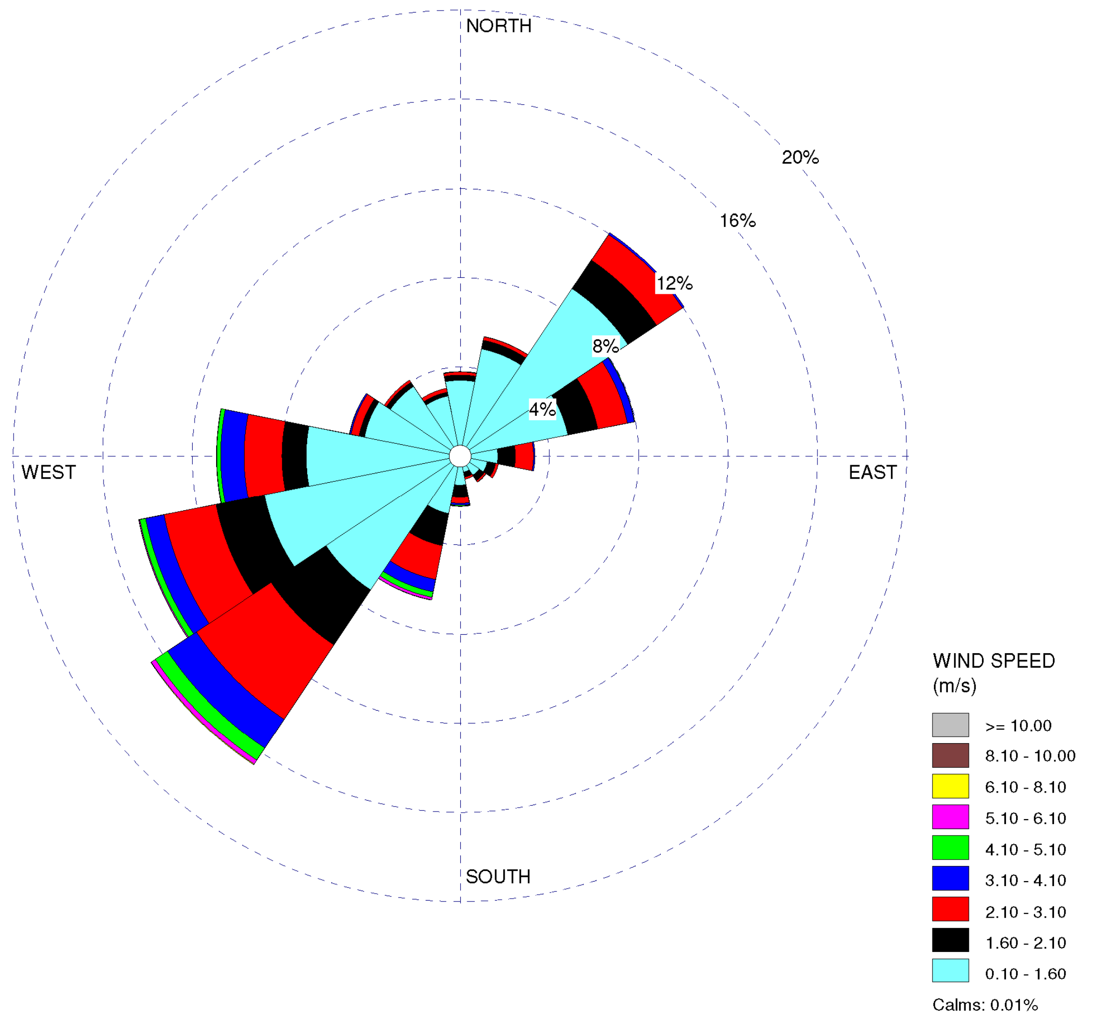
PROJECT NO.:

WRPLOT View - Lakes Environmental Software

Figure 3.2-17: Tower D 15 meter Wind Rose

WIND ROSE PLOT:
2018-2019 Wind Rose for Tower D 15 m Level

DISPLAY:
Wind Speed
Direction (blowing from)



COMMENTS:

DATA PERIOD:
Start Date: 1/1/2018 - 00:00
End Date: 12/31/2019 - 23:00

COMPANY NAME:

MODELER:

CALM WINDS:
0.01%

TOTAL COUNT:
17520 hrs.

AVG. WIND SPEED:
1.39 m/s

DATE:
6/23/2021

PROJECT NO.:

WRPLOT View - Lakes Environmental Software

Figure 3.2-18: Tower D 35 meter Wind Rose

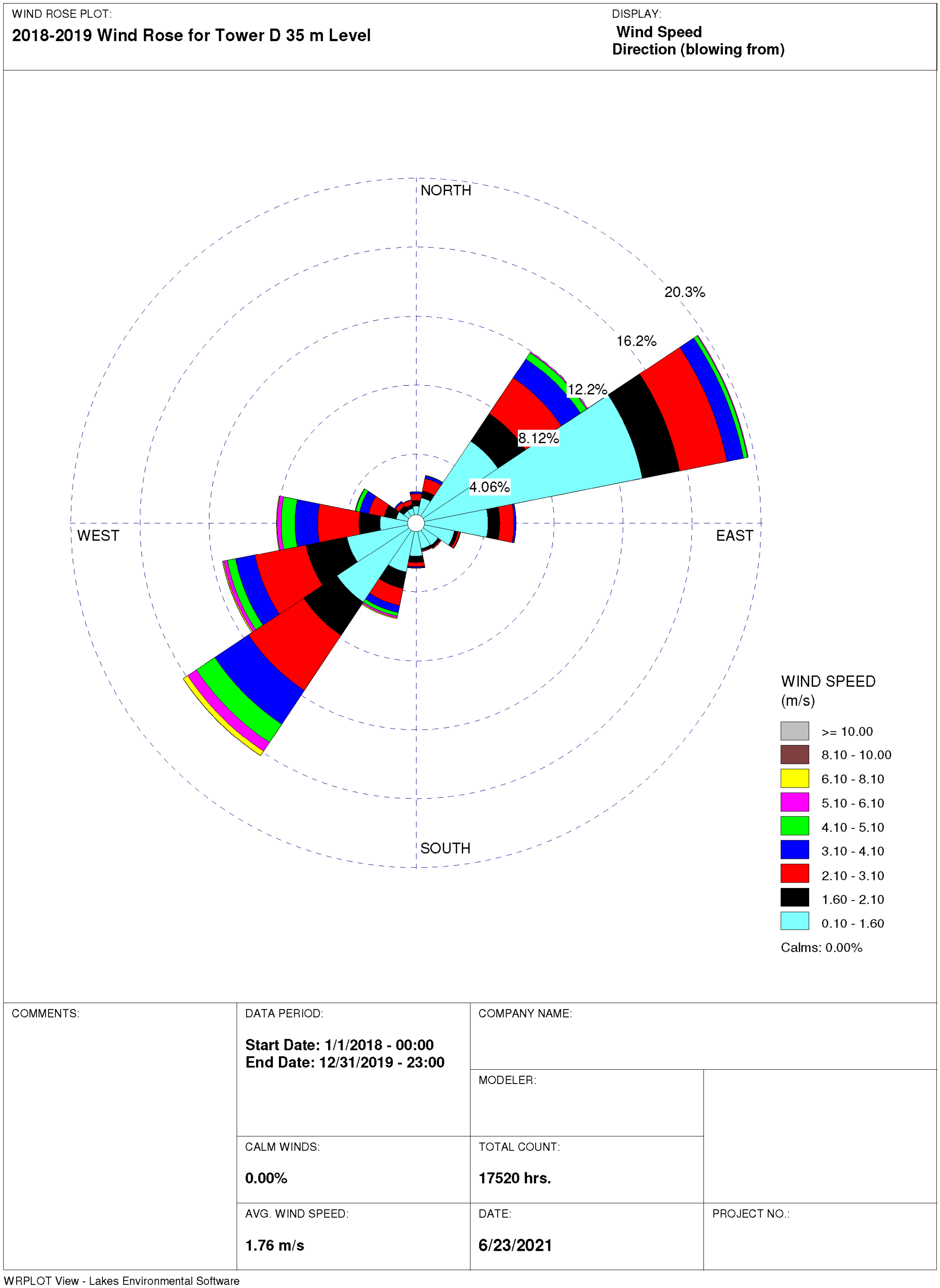
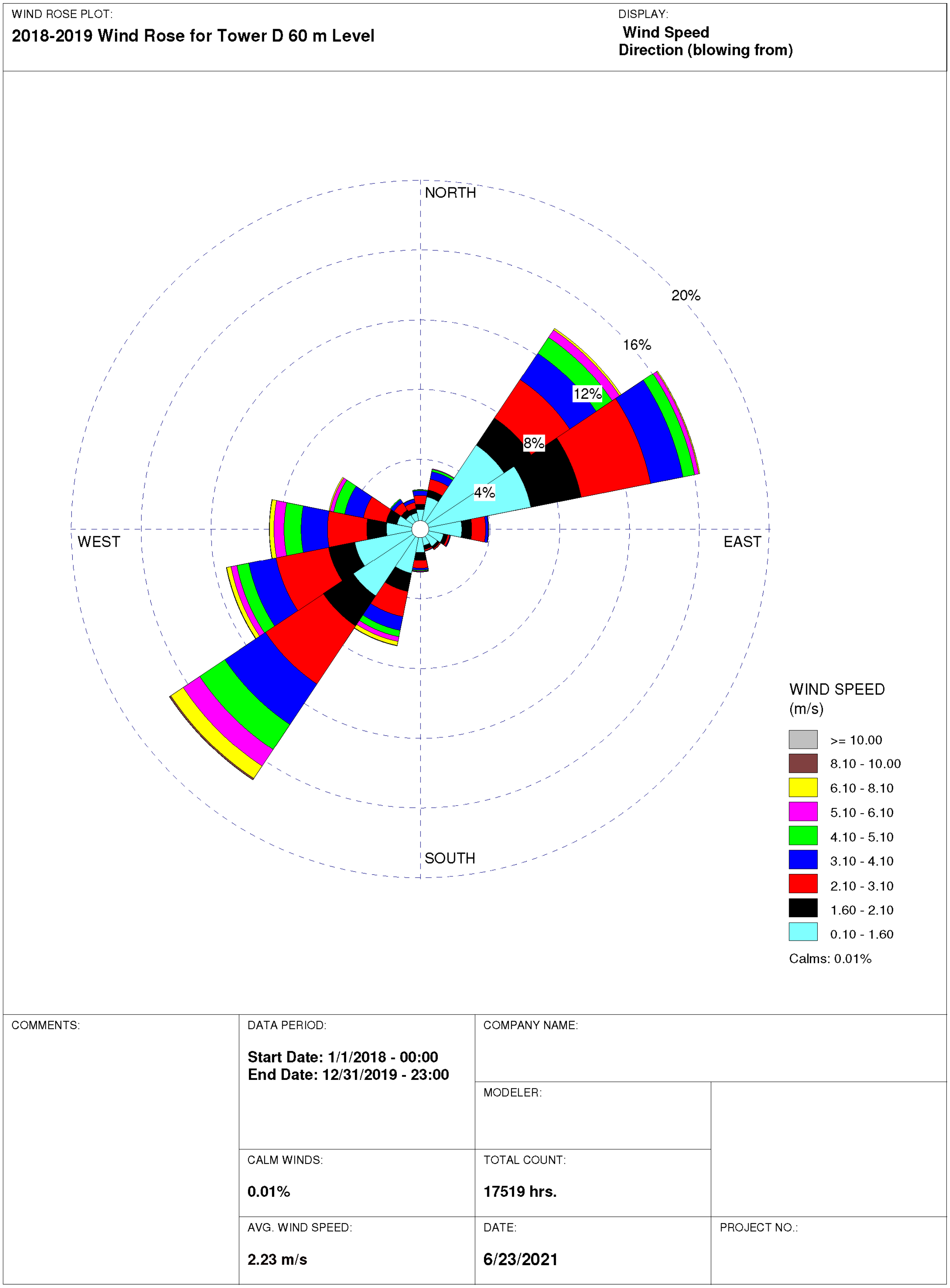


Figure 3.2-19: Tower D 60 meter Wind Rose



WRPLOT View - Lakes Environmental Software

Figure 3.2-20: Chattanooga, TN 10-Year (2000-2009) Wind Rose

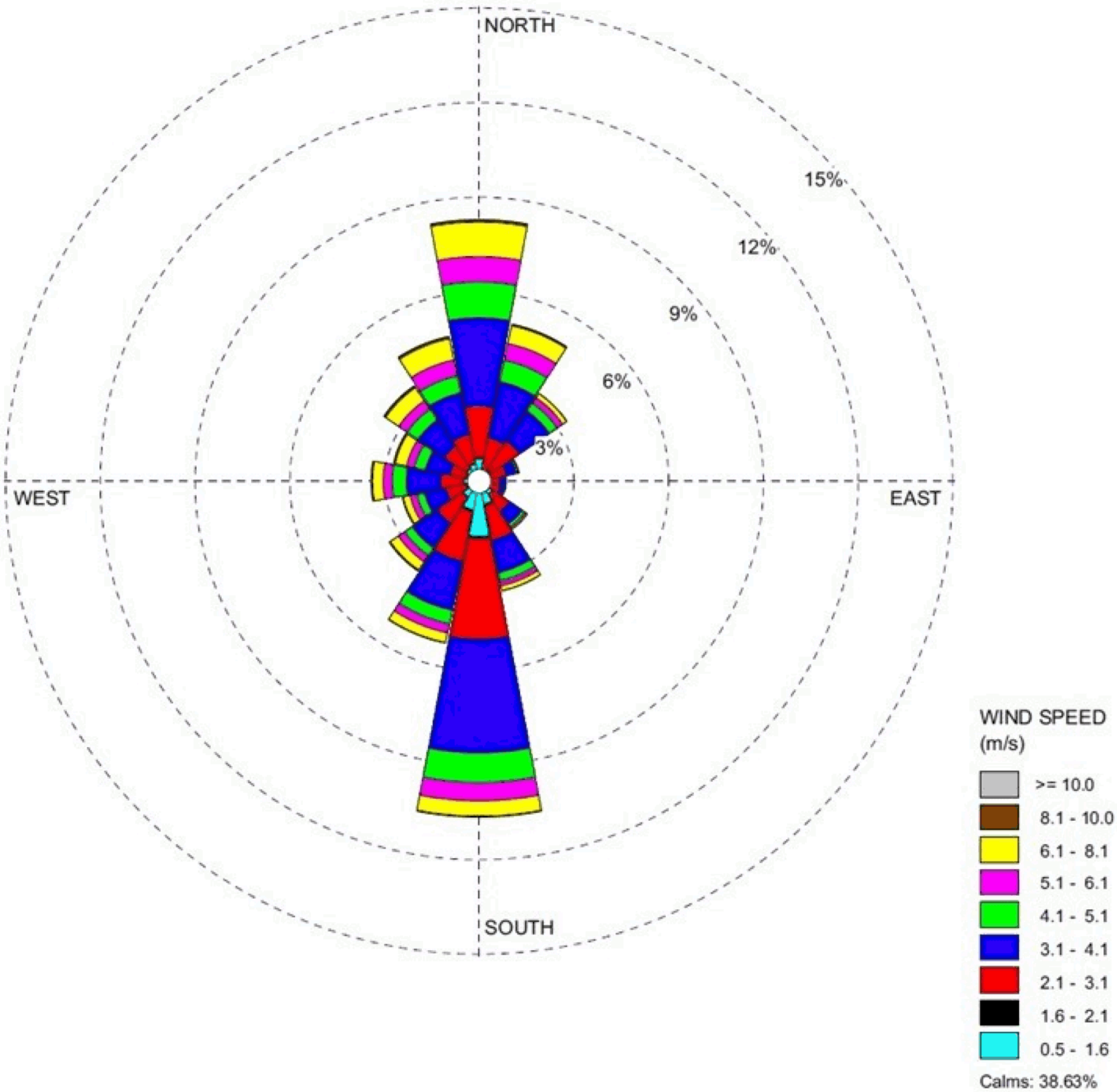


Figure 3.2-21: Oak Ridge, TN 10-Year (2000-2009) Wind Rose

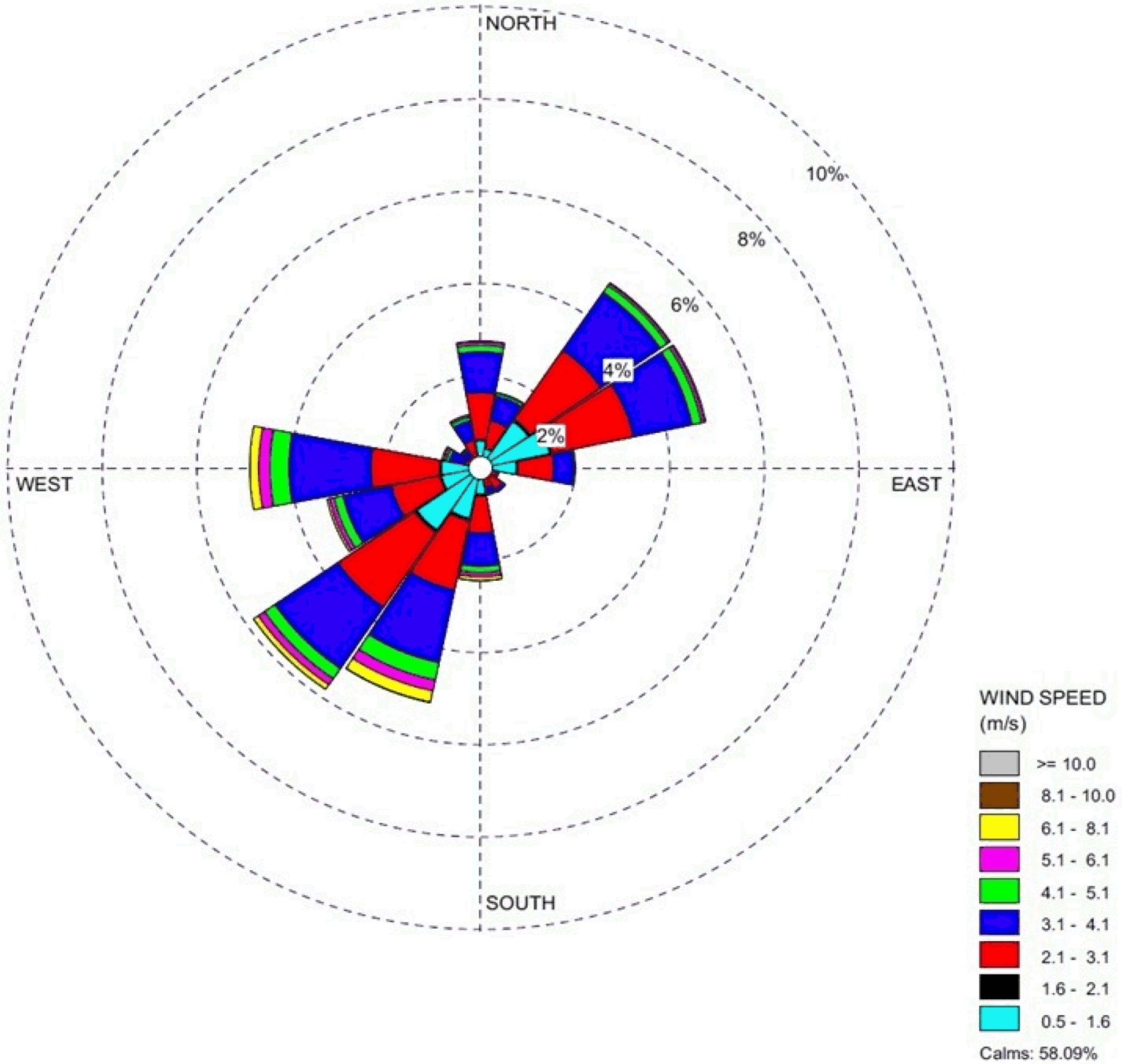
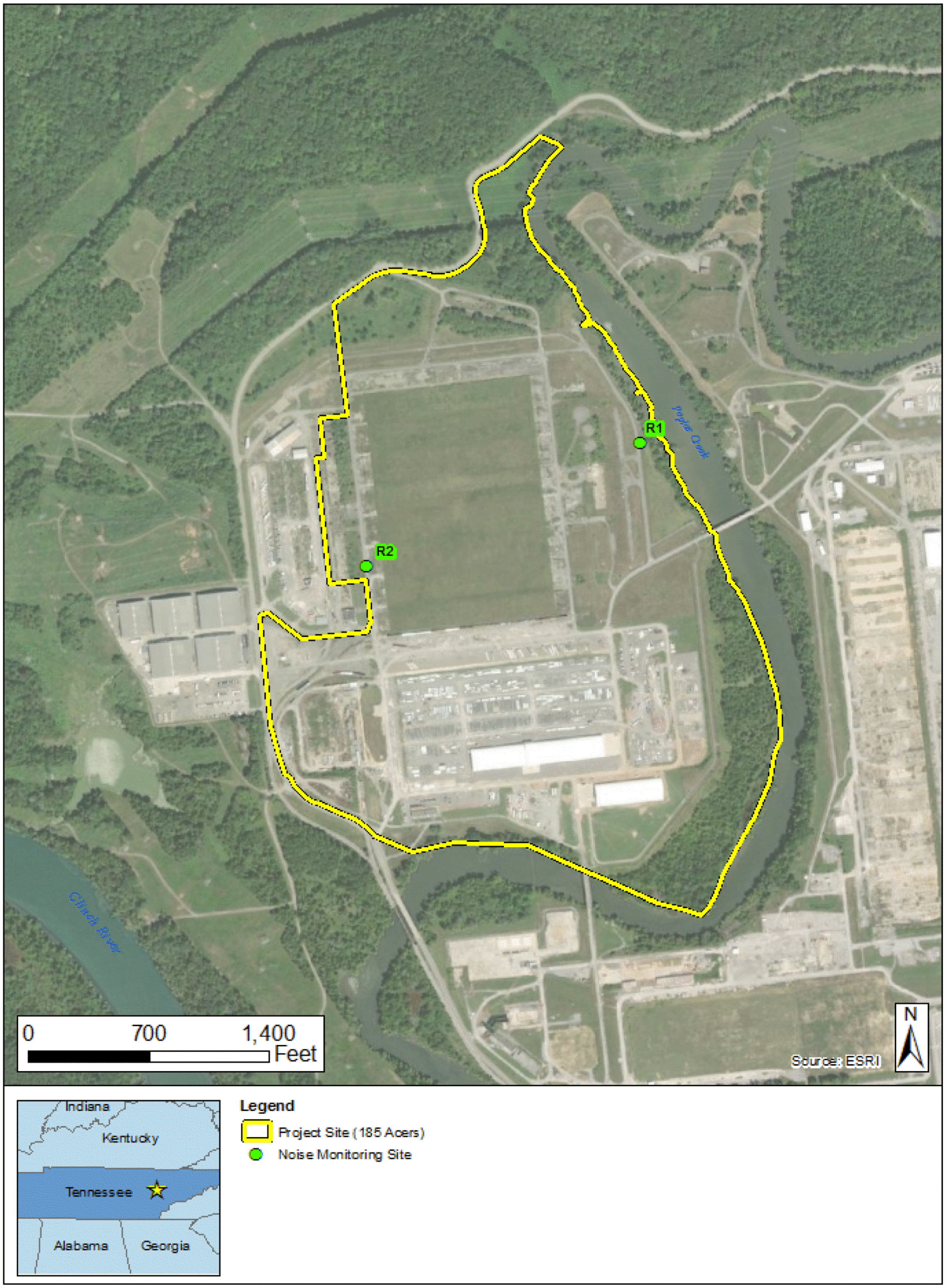


Figure 3.2-22: Noise Monitoring Locations



3.3 GEOLOGIC ENVIRONMENT

This section provides a description of the geology, soils, and seismology of the site and region.

3.3.1 Summary of Onsite Geotechnical Investigations

From its original development as gaseous diffusion plants during the Cold War to its reimagining as an industrial park, the former K-31/K-33 site (now the proposed site) has been studied, and the site-specific geology characterized, for decades. Recent geotechnical investigations of the site have included:

- Geologic Mapping of the Oak Ridge K-25 Site, Oak Ridge, Tennessee (Reference 1)
- Final Sitewide Remedial Investigation Feasibility Study for ETTP, November 2007 (Reference 2)
- Transfer of Land and Facilities within the ETTP and Surrounding Area Environmental Assessment, October 2011 (Reference 3)
- K-31/K-33 Area Groundwater Remedial Site Evaluation Report for ETTP, September 2018 (Reference 4)

The Geologic Mapping of the K-25 site (Reference 1) recorded stratigraphic and structural data and provided a bedrock map of the ETTP.

The Final Sitewide Remedial Investigation Feasibility Study for ETTP (Reference 2) provides soil and geologic information for the entire ETTP, along with a map of cut and fill areas that were used during the site preparation for the gaseous diffusion plants.

The Environmental Assessment for the Transfer of Land and Facilities within the ETTP (Reference 3) summarizes the geology of the site prior to transferring the DOE property to ETTP for economic development use.

The K-31/K-33 Area Groundwater Remedial Site Evaluation Report for ETTP (Reference 4) provides cross-sections of the subsurface of the K-31/K-33 area based upon borehole data from installation of groundwater monitoring wells. Bedrock identification and depth are recorded along with fill and soil depth across the area.

Results from these reports have been used to characterize the site geology.

3.3.2 Geology

As part of the Valley and Ridge physiographic province of East Tennessee, the site is characterized by a series of narrow, parallel valleys and ridges. The Late Paleozoic collision of Gondwana with what would become the eastern North American coast resulted in the formation of the Appalachian Mountains along with a fold-thrust belt of Cambrian through Pennsylvanian sedimentary strata. Erosion of this belt varied by orientation and placement as well as lithology, resulting in a series of parallel, northeast to southwest trending valleys and ridges stretching from Virginia to Georgia.

Narrow, parallel valley and ridge sedimentary features characterize the region within 5 miles of the site. Black Oak Ridge lies to the north of the site with Pine Ridge, Chestnut Ridge, Haw Ridge, and Copper Ridge progressively south. K-31 and K-33 are nestled in a valley adjacent to East Fork Ridge to the east and Clinch River to the west.

Bedrock lithology in the region includes strata from:

- Upper Ordovician to Lower Mississippian outcrops (post-Chickamauga rocks)
- Middle to Upper Ordovician (Chickamauga Group)
- Upper Cambrian to Lower Ordovician (Knox Group)
- Middle to Upper Cambrian (Conasauga Group)

- Lower Cambrian (Rome Formation)

Valleys in the area are typically underlain by Chickamauga limestones or by Conasauga Group shale and shaley limestones. Ridges are capped with the more resistant sandstones and siltstones of the Rome and the post-Chickamauga rocks or by Knox Group dolostones (Reference 1, Reference 5, and Reference 6).

The former K-31 site includes 25.6 relatively flat acres with the former K-33 site to the north and Poplar Creek to the south and east. Located immediately north of the former K-31 site, the former K-33 site includes 73 relatively flat acres bordered by Poplar Creek to the east and south and by the Clinch River to the west. This former industrial site exhibits a slope between 0 and 5 percent, with elevations ranging from almost 860 feet amsl in the northeast down to almost 740 feet amsl on the shore of Poplar Creek. Elevations of the former K-31 and K-33 building footprints range from 760 to 765 feet amsl, with overland and groundwater flow generally following a radial pattern toward Poplar Creek and the K-901 Holding Pond (Reference 5 and Reference 6).

As shown in Figure 3.3-1, the site is underlain primarily by members of the Chickamauga Group, with members of the Knox Group at Black Oak Ridge on the northern edge of the site. The stratigraphy of the ETTP area is shown in Figure 3.3-2. From youngest to oldest, bedrock underlying the site include:

- Hermitage Limestone
- Carters Limestone
- Lebanon Limestone
- Ridley Limestone
- Murfreesboro Limestone
- Pond Spring Formation
- Mascot Dolomite
- Kingsport Formation

Only the Mascot Dolomite and the Kingsport Formation are members of the Knox Group; the rest are part of the Chickamauga Group (Reference 1 and Reference 3). At the northernmost boundary of the site, the Mascot Dolomite and the Kingsport Formation outcrop at the base of Black Oak Ridge. Deformed by extensive folding and faulting, these massive, dolomite-rich carbonate beds are more resistant to erosion than the younger limestones (Reference 1). In general, the bedrock strata at the site strike east-west and dip towards the south, with the youngest strata cropping out in the southern part of the site, and the oldest strata in the north (Reference 1 and Reference 2).

At the southern edge of the site, the Hermitage Limestone is a 115 feet thick unit with light-gray to reddish-gray, thin to medium beds of limestone. Fossils are abundant and include crinoids, brachiopods, and bryozoans. A maroon, olive-tan calcareous shale often marks the base of this unit (Reference 1).

Beneath the Hermitage Formation lies the Carters Limestone; almost 500 feet of thick-bedded, fossil-poor limestone. This unit transitions from micritic, poorly bedded, mud-cracked limestone at the top, followed by apple-green, or even maroon, micaceous, 1 to 3 feet thick metabentonite beds; then gray-black, fossiliferous cherts in a medium and thick, blue-gray limestone; and finally mud-cracked, olive gray topped, interbedded limestone with gray-black pods and lenses of chert (Reference 1).

Approximately 130 feet of Lebanon Limestone underlie the Carters Limestone. Thin and cobbly-bedded, the Lebanon Limestone is chert-poor, but fossil-rich. Fossils in the Lebanon Limestone include brachiopods, bryozoans, gastropods, and cephalopods (Reference 1).

Beneath the Lebanon Limestone lies approximately 150 feet of Ridley Limestone. The upper portion of this unit contains minor amounts of gray-black chert along with abundant fossils in coarse-grained

limestone beds. Chert is largely absent from the older, thick-bedded to massively-bedded, dark-gray fucoidal limestone (Reference 1).

Marked by nodular, ropy, gray -black chert with silicious fossils, approximately 330 feet of micrite to fine-grained crystalline Murfreesboro Limestone underlie the Ridley. The Murfreesboro Limestone is marked by thin beds interbedded with thick to massive beds and with ropy, black chert. Fossils include bryozoans (Reference 1).

Approximately 440 feet of the Pond Spring Formation underlies the Murfreesboro Limestone. A distinctive mudstone-rich unit, the Pond Spring unit consists of maroon, green, and gray argillaceouss limestone interbedded with chert along with green and red shales. Fossils are rare (Reference 1).

Beneath the Pond Springs Formation lies the erosional surface of the Mascot Dolomite. Due to the remnant erosional surface, the thickness of this unit varies greatly, but averages 400 feet in thickness. The Mascot Dolomite is marked by thick to massive beds of light-gray, fine-grained dolomite with pink streaks. A medium-bedded to thick-bedded white porcelaneous chert is in the middle of this unit. Nearer the base, a jasperoidal and flinty chert layer with stromatolitic laminations occurs with basal contact of thick-bedded dolomites containing a jasperoidal, cherty matrix of sandstone (Reference 1).

Under the Mascot Dolomite lies the Kingsport Formation, approximately 575 feet thick layers of gray dolomite commonly interbedded with thick to massive limestones containing jasperoidal chert and gastropods. The top of the Kingsport Dolomite is marked with a milky-white, gastropod-rich chert (Reference 1).

3.3.3 Soils

3.3.3.1 Onsite Soil Types

Built in 1951 and 1954, K-31 and K-33 operated as part of the ORGDP. The original soils at the site were reworked to provide a stable, level foundation for the former K-31 and K-33 facilities, and were reworked again during the decontamination and decommissioning of these facilities (Reference 2 and Reference 7). The plant ceased operations in 1985 and was permanently shut down in 1987. Decontamination and decommissioning of the facilities followed. The 32-acre building for the K-33 facility was demolished in 2011 followed by the 32-acre building for K-31 in 2015. After decontamination, decommissioning, and demolition of these massive facilities, the slab was removed or grouted in place to provide a site available for industrial use. This effort included removal of soils down to 10 feet below ground surface.

The USDA does not publish a Natural Resources Conservation Service Soil Survey for the former K-31 and K-33 industrial facilities. Soil in these industrial footprints is classified as Urban Land, a mixture of impervious surfaces along with well-drained, moderately permeable soils. A mixture of silts, clays, and sands characterizes soil at the site (Reference 7 and Reference 8).

Although soils in the K-31 and K-33 footprint have not been extensively characterized, the Chickamauga Group underlies the majority of the K-31 and K-33 footprint with contributions from the Knox Group in the northern extent of the area. Typical weathering of the Chickamauga and Knox Groups occurs in place, producing clay and silty clay (Reference 2 and Reference 3). As shown in Figure 3.3-3, characterization of boring logs for groundwater monitoring wells in the region of the site show about four feet of undifferentiated fill covering about 20 feet of clay, with an isolated lens of sandy clay. Logs also record a depth to bedrock ranging between 20 to 40 feet below ground surface (Reference 4).

3.3.3.2 Prime Farmland

The USDA does not publish a soil survey for the former ETTP, however, given the site's classification as a Brownfield, no prime farmlands or farmland of statewide importance would be present onsite. Surveys have been published for soil in the surrounding area. As shown in Figure 3.3-4, soil within a 5-mile area of the site includes soil types designated as prime farmland. While approximately 1,415 acres are water and nearly 18,000 acres are not surveyed, soils in the area include more than 32,600 acres not classified as prime farmland and more than 2,600 acres classified as prime farmland. Prime farmland soils in the area include:

- Allegheny-Cotaco complex, occasionally flooded
- Capshaw silt loam 2 to 5 percent slopes
- Etowah loam, 2 to 5 percent slopes
- Pope-Philo complex, frequently flooded
- Waynesboro loam, 2 to 5 percent slopes
- Whitwell loam, 1 to 4 percent slopes, occasionally flooded

As shown in Figure 3.3-4, much of the prime farmland soils in the area are Capshaw silt loam (43 percent) with major contributions from Hamblen silt loam, Etowah loam, and Whitwell loam providing 22 percent, 14 percent, and 14 percent, respectively.

3.3.3.3 Soil Erodibility

As discussed with respect to onsite soil types above, the site soils are classified as Urban Land, a mixture of impervious surfaces along with well-drained, moderately permeable soils (Reference 7 and Reference 8). Also, the site is nearly flat, with a slope ranging between 0 and 5 percent. Stormwater runoff features from the prior K-33 facilities remain in place on the site. A review of the site in June 2021, found no evidence of erosion. A geologic and geotechnical investigation study explored site-specific subsurface conditions at the site between the 22nd of March 2021 and the 30th of March 2021. This site-specific investigation included a series of geotechnical borings, observation trenches, groundwater monitoring wells, and a laboratory testing program. Additional details of the geotechnical investigation are provided in the Kairos Power Preliminary Safety Analysis Report (PSAR), Section 2.5.2.2.

Six soil test borings (B-1 through B-6) and six observation trenches (OT-1 through OT-6) were excavated to determine subsurface conditions. Location of the borings, existing piezometers, and observation trenches were established with field Global Positioning System handheld devices, and are presented in detail in Chapter 2, Kairos Power PSAR.

Topsoil was encountered in the borings and trenches at a depth of 4 to 12 inches. Beneath this was fill, ranging in depths of 12 to 21 feet. The fill materials consisted of red to yellow fat clay with limestone and rock fragments. Alluvial soils were encountered below the fill. Concrete foundations were encountered at less than 12 feet deep. Soil analysis revealed the consistency to be medium firm to very hard. Residual soils (weathered from underlying bedrock) were found below the alluvial soils and were considered soft to very hard. Bedrock resulted in auger refusal between 14 to 54 feet in the borings and 13 to 20 feet in the trenches. At the north of the site, bedrock was encountered at approximately 55 feet, at the middle of the site it was encountered at 35 feet, and at the south end it was encountered at approximately 20 feet. Groundwater was encountered at approximately 6-8 feet below ground surface.

The north portion of the site is underlain by the Mascot Formation, a gray, medium to thickly bedded, fresh, hard rock. The bedrock is directly underneath the residuum and presented a Rock Quality Designation (RQD) of 70 percent to 100 percent. At the north end of the site, around Boring B-1, the Mascot bedrock was encountered at a depth of about 55 feet.

The midsection of the site, near the area of Boring B-2, is underlain by the Pond Springs Formation, which is a light gray, medium bedded, medium jointed limestone. There was an approximately 5 feet thick weathered layer that quickly transitioned to fresh hard rock with RQD of 70 percent. The Pond Springs bedrock was encountered at a depth of about 35 feet below the ground surface.

The south end of the site is underlain by the Murfreesboro dolomitic limestone. Encountered at depths of about 20 feet near Boring B-5, this formation is light gray, medium, close jointed, with an approximately 3 feet weathered layer. Below the weathered zone, RQD is greater than 80 percent.

3.3.4 Seismology

Potential geologic hazards within 5 miles of the site include faults and sinkholes. Forces exerted on the strata in this region in the Late Paleozoic resulted in folding and faulting, causing complex orientations and even repeated strata. Major faults trend northeast to southwest through east Tennessee from Virginia to Georgia (Reference 3 and Reference 9).

More than a dozen major northeast to southwest trending faults lie within 40 miles of the site (Reference 9). The Chattanooga and Kingston faults lie to the north of the site, and the Whiteoak Mountain and Copper Creek faults lie to the south. In addition, several faults branch off the Whiteoak fault including, to the east of the site, the K-25 fault that branches north before turning east.

East Tennessee is in a mid-tectonic plate region. Thrust faults in the region are inactive; significant movement occurred nearly 200 million years ago. The region is a relatively active seismic zone of low to moderate intensity with no anticipated catastrophic release of energy (Reference 3). Since 1913, almost seventy earthquakes of magnitude (Richter) greater than 3.0 have occurred within 124 miles of the site. The largest, magnitude 5.2, occurred in 1916 south of Asheville, North Carolina (Reference 10). As shown in Figure 3.3-5, over a 50-year period, there is only a 10 percent probability that peak ground acceleration will exceed 30 percent of the acceleration due to gravity.

3.3.5 Other Hazards

Characterization of boring logs for groundwater monitoring wells in the region of the site show that the surficial soils consist of about 4 feet of undifferentiated fill underlain by about 20 feet of clay, with an isolated lens of sandy clay. These clay soils have very little potential to become saturated and exhibit liquefaction. Drainage on these relatively flat former facilities occurs as radial overland flow toward Poplar Creek and toward the K-901 Holding Pond, with numerous storm drains on the site discharging to Poplar Creek (Reference 4).

3.3.5.1 Tsunamis

The site, located in East Tennessee, is inland and not subject to threats from tsunamis.

3.3.5.2 Volcanism

The site, located in East Tennessee, is distant from active volcanism and not subject to threats from volcanic action.

3.3.5.3 Landslides

The topography of the former K-31 and K-33 facilities is relatively level and not prone to catastrophic landslide activity. The U.S. Geological Survey (USGS) landslide overview map rates the site as moderately susceptible with low incidence of landslides, or less than 1.5 percent of the area involved in landslides (Reference 11). As shown in Figure 3.3-4, highly permeable, well drained urban land fill covers the majority of the site, and Montevallo soils are the most common soil in the area. Since the fill soil is well drained and the Montevallo soil is hydrologic class D and thus has a high run-off potential, the

probability of land movement due to saturated soils is minimal (Reference 2, Reference 8, and Reference 12).

3.3.6 Karst and Subsidence

Along with the development of valleys and ridges, erosion of this varied carbonate strata has produced karstic terrain. Over time, dissolution of carbonate rock, especially fractured limestone and dolomite, produced sinkholes, underground streams, enlarged fissures, and even caverns. The prevalence of near surface limestone and dolomite in East Tennessee, along with humid conditions and variable water table levels, provide conditions that can support development of karst features (Reference 13 and Reference 14).

In the site region, karst is evident in both the Knox and Chickamauga Groups. While common, karst in the Chickamauga Group is isolated and poorly developed. Conversely, karst in the Knox Group is well developed and connected. Large springs often occur along the base of ridges underlain by the Knox Group adjacent to the aquitard of the Maynardville Limestone (Conasauga Group). Thus, the potential for karst collapse is greatest at the base of these Knox Group ridges (Reference 3 and Reference 5).

As displayed by the pre-construction 1941 Elverton Quadrangle topographic map, the K-31/K-33 footprint originally exhibited several sinkholes. Preparation activities for construction of the K-31 facility in 1951 and the K-33 facility in 1954 included relatively minor leveling of the site by removing some gentle hills and filling the sinkholes (Reference 2, Reference 4, and Reference 15).

3.3.7 References

1. Lemiszki, P.J., "Geological Mapping of the Oak Ridge K-25 Site, Oak Ridge, TN. Environmental Restoration Program," K/ER-111, January 1994.
2. U.S. Department of Energy, "Final Sitewide Remedial Investigation/Feasibility Study for East Tennessee Technology Park," November 2007.
3. U.S. Department of Energy, "Environmental Assessment - Transfer of Land and Facilities within the East Tennessee Technology Park and Surrounding Area, Oak Ridge, Tennessee," DOE/EA-1640, October 2011.
4. U.S. Department of Energy, "K-31/K-33 Area Groundwater Remedial Site Evaluation Report for East Tennessee Technology Park," DOE/OR/01-2765&D1, September 2018.
5. Oak Ridge National Laboratory, "Oak Ridge Reservation Physical Characteristics and Natural Resources," September 2006.
6. U.S. Department of Energy, ETTP Vision 2020 Reuse Historic Preservation and Stewardship, in ORSSAB Meeting. September 12, 2018.
7. Tennessee Department of Environment and Conservation, "East Tennessee Technology Park Perimeter Road Water Line and Sanitary Sewer Force Main Replacement, Stormwater Pollution Prevention Plan (SWPPP) and Notice of Intent (NOI)," January 6, 2021.
8. U.S. Department of Agriculture, "Custom Soil Resource Report for Roane County, Tennessee," April 21, 2021.
9. U.S. Geological Survey, "Geologic Map of East Tennessee with Explanatory Text," Bulletin 58, Part II, 1953.
10. U.S. Geological Survey, Earthquakes, 2021.
11. U.S. Geological Survey, Landslide Overview Map for the Conterminous U.S. Plate 1, 2016.

12. U.S. Department of Agriculture, "Chapter 7 - Hydrologic Soil Groups," Part 630 Hydrology - National Engineering Handbook, January 2009.

13. Weary, D.J. and D.H. Doctor, "Karst in the United States. A Digital Map Compilation and Database," USGS Open-File Report 2014-1156, 2014.

14. U.S. Geological Survey, Sinkholes, Website: https://www.usgs.gov/special-topic/water-science-school/science/sinkholes?qt-science_center_objects=0#qt-science_center_objects, accessed May 2, 2021.

15. U.S. Geological Survey, Elverton, Tennessee Quadrangle Topography, 1941.

Figure 3.3-1: Geology

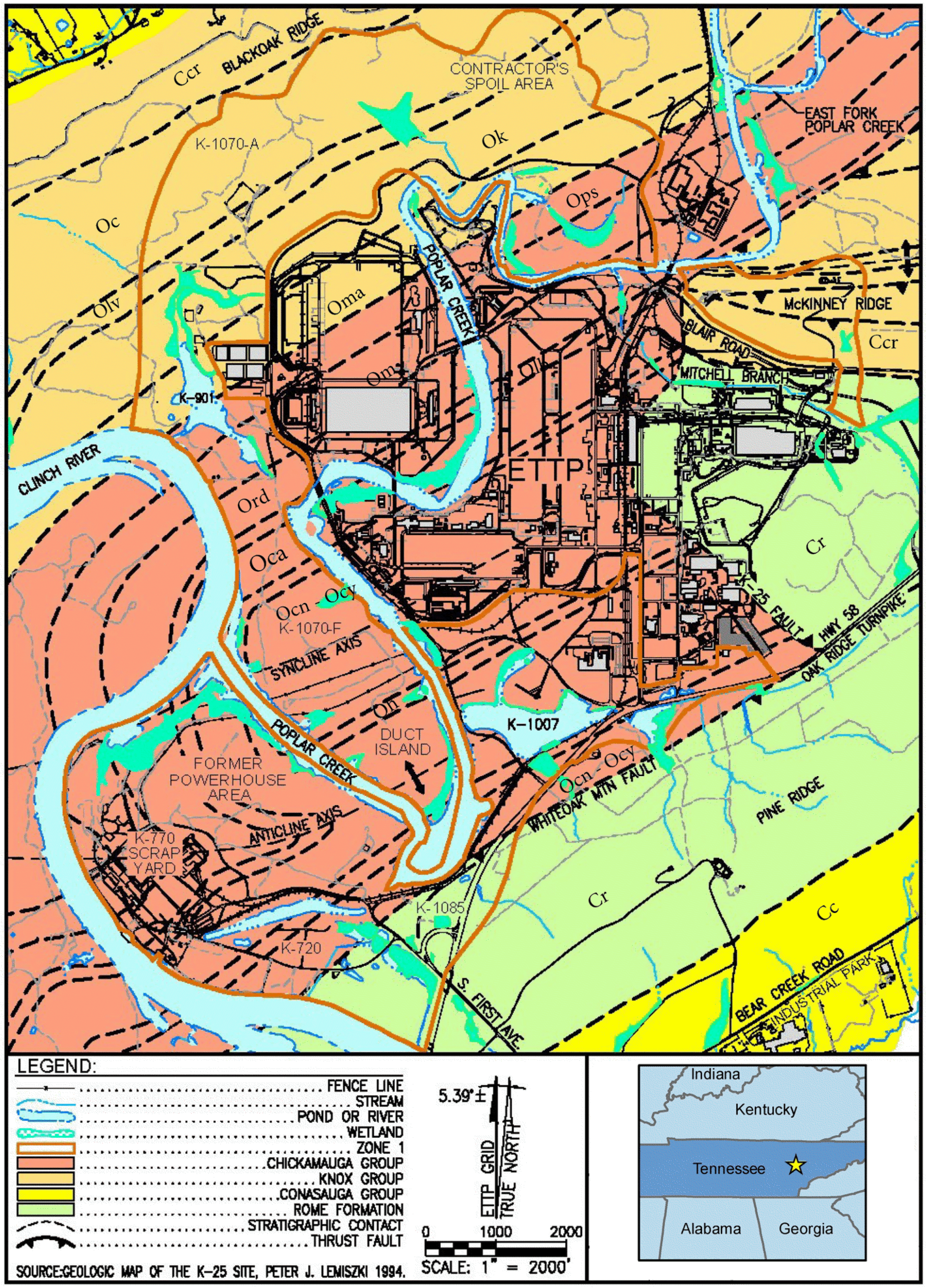


Figure 3.3-2: Stratigraphy

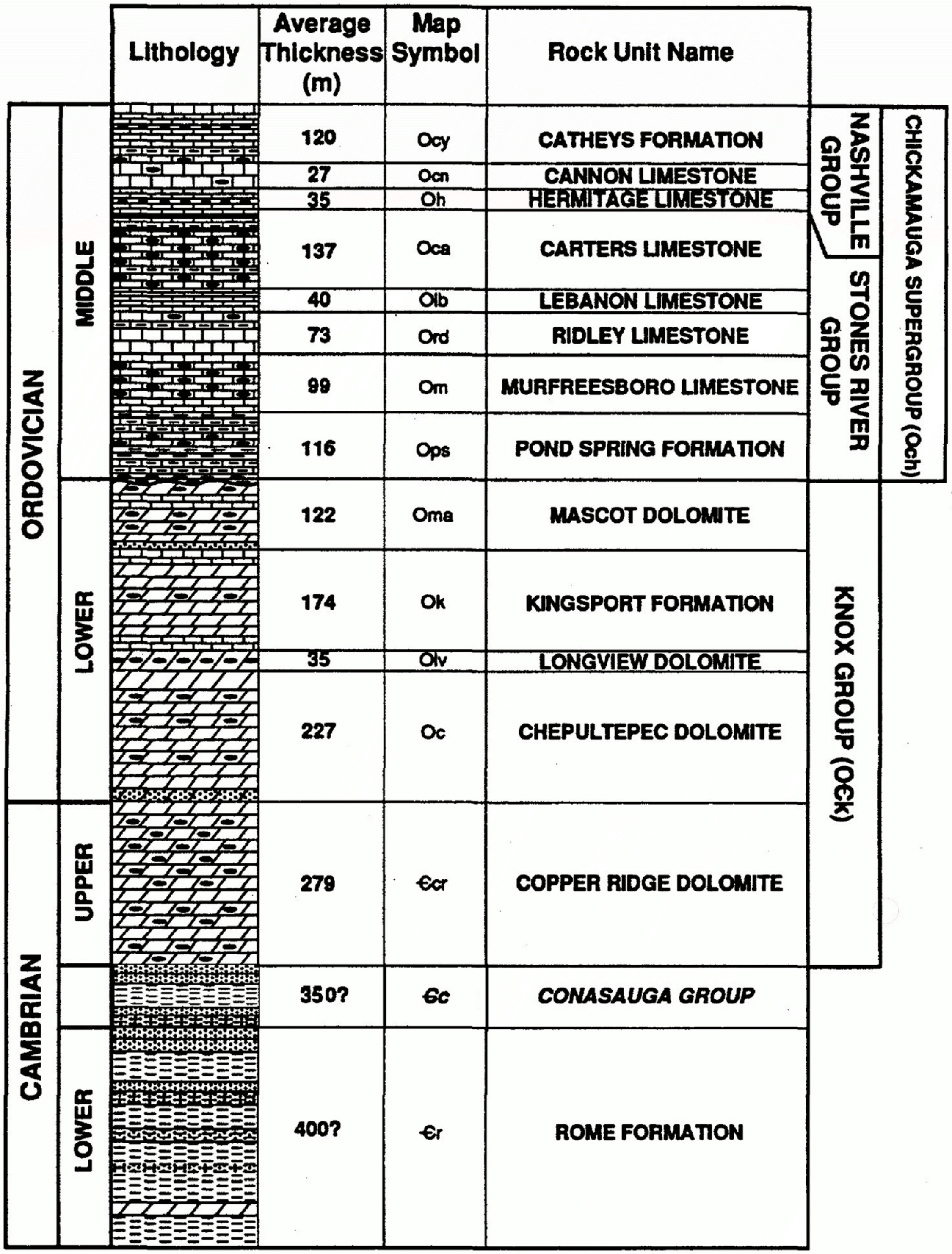


Figure 3.3-3: Geologic Cross-Section

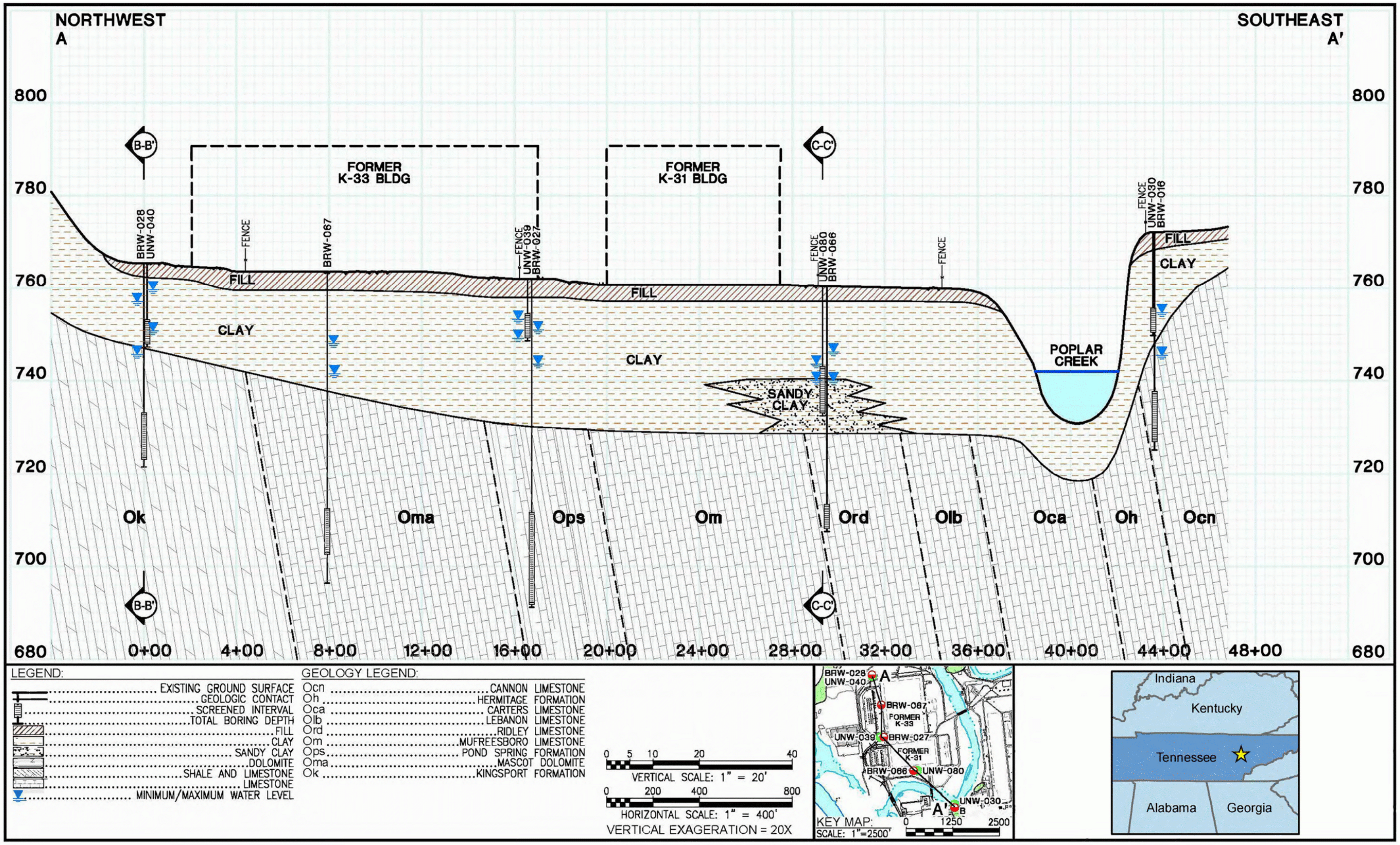


Figure 3.3-4: Area Soils

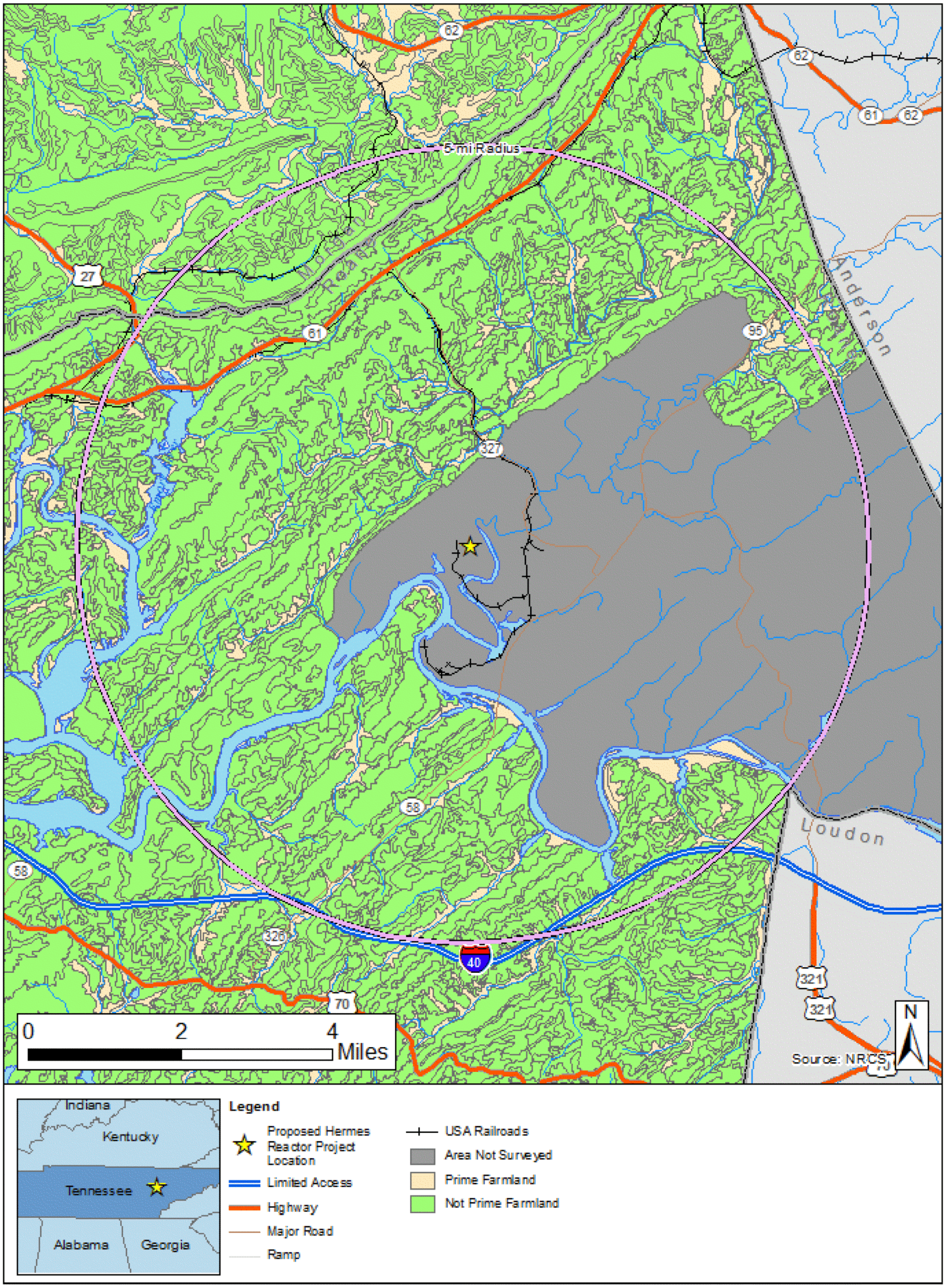
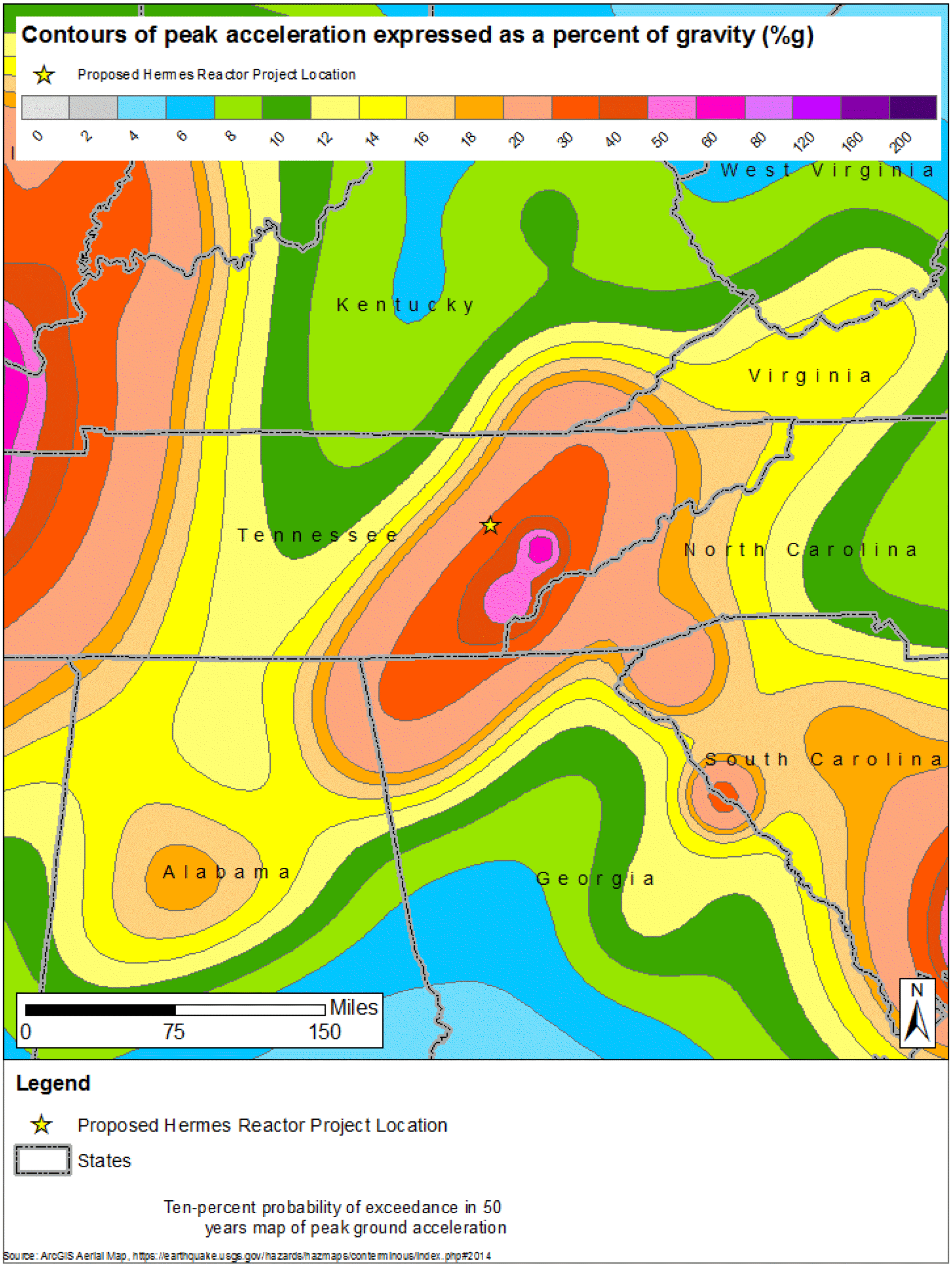


Figure 3.3-5: Seismic Hazards



3.4 WATER RESOURCES

3.4.1 Hydrology

3.4.1.1 Surface Water

The site is bounded on its eastern side by Poplar Creek, which is a tributary of the Clinch River arm of the Watts Bar Reservoir. The portion of Poplar Creek adjacent to the site is not free flowing. Instead, it is part of the Clinch River arm of the Watts Bar Reservoir. The Watts Bar Reservoir is an impoundment on the Tennessee River formed by Watts Bar Dam, which is owned and operated by the TVA. Major inflows into Watts Bar Reservoir include Fort Loudoun Dam on the Tennessee River, and Melton Hill Dam on the Clinch River. The impoundment of the Tennessee River also creates impoundments on tributaries and sub-tributaries of the Tennessee River, including the Clinch River (forming the Clinch River arm of the Tennessee River), and the southernmost portion of Poplar Creek. Therefore, water levels, flow rates, and flow directions in Poplar Creek adjacent to the site are controlled by TVA's operation of Watts Bar Dam, Fort Loudoun Dam, and Melton Hill Dam.

Historically, stormwater flow was directed to a stormwater drainage system that discharged to Poplar Creek or the Clinch River through registered outfalls. Areas with the potential for oil and grease contamination were directed to outfalls with oil/water separators. These outfalls were monitored on a scheduled basis as determined in the NPDES permit. The current system is also directed to the numbered outfalls, and the monitoring schedule has been modified to reflect the decommissioned status of the site.

3.4.1.1.1 Watershed Description

Surface waters that drain the ORR eventually reach the Tennessee River via the Clinch River, which forms the southern and western boundaries of the ORR. The ORR lies within the Valley and Ridge Physiographic Province, which is composed of a series of drainage basins or troughs containing many small streams feeding the Clinch River. Surface water hydrology on the ORR is characterized by a network of small streams that are tributaries of the Clinch River. Surface water at each of the major facilities of the ORR (e.g., ETTP) drains into a tributary or series of tributaries, streams, or creeks within different watersheds. Each of these watersheds drains into the Clinch River, affecting different sub-basins.

The largest of the drainage basins is that of Poplar Creek, which receives drainage from a 136 mi^2 area, including the northwestern sector of the ORR. As shown in Figure 3.4-1, Poplar Creek flows from northeast to southwest, approximately through the center of the ETTP, and discharges directly into the Clinch River arm of Watts Bar Reservoir at Clinch River mile (CRM) 12 (Reference 1). The ETTP and the site are located in the Lower Clinch River watershed. TVA manages this section of the Clinch River as a run-of-the-river impoundment, forming the Clinch River arm of Watts Bar Reservoir. Power generation and release schedules at Melton Hill Dam (upstream on the Clinch River), Watts Bar Dam (downstream), and Fort Loudoun Dam (upstream on the Tennessee River) influence water levels and flow patterns in the Clinch River arm of Watts Bar Reservoir and Poplar Creek.

The two primary tributary streams to Poplar Creek at the ETTP include Mitchell Branch (MIK) and an unnamed tributary to Poplar Creek that flows along SR 58 (see Figure 3.4-1). Mitchell Branch originates on Pine Ridge and flows through the northeastern portion of the ETTP before discharging into Poplar Creek. The unnamed tributary to Poplar Creek originates on Pine Ridge east of the ETTP, flows west adjacent to SR 58, and passes under SR 58 through a culvert before it eventually enters the K-1007-P1 Pond and Poplar Creek.

The construction of Watts Bar Dam and subsequent impoundment of the Clinch River in 1941 dramatically altered the geometry and flow dynamics of the Clinch River and Poplar Creek as well as groundwater discharge to these features. Prior to impoundment of the Clinch River, the river level elevation in the vicinity of the ETTP was between 721 and 724 feet, approximately 20 feet lower than the current high pool stage. Stage conditions are controlled by TVA operations at Watts Bar Dam (downstream), Melton Hill Dam (upstream on the Clinch River), and Fort Loudoun Dam (upstream on the Tennessee River) and result in seasonal, weekly, and daily stage fluctuations. During winter months when precipitation is greatest, commonly December through late March or early April, the river level is maintained at low pool stage (less than 736.5 feet), whereas from May through October the river level is maintained at high pool stage (greater than 739.5 feet). However, winter storms result in severe low-pool stage variations, with maximum low pool stages recorded as high as 745.3 feet.

During low pool conditions, stage fluctuations associated with winter storms last approximately 1 to 2 weeks. During high pool conditions in the dry season, there is a weeklong cycle, presumably related to reservoir operations, that produces a 2-feet stage increase. Stage fluctuations due to storm event precipitation are observed only during the winter, wet-season/low-pool-stage conditions. As a result of operations at Melton Hill, Watts Bar, and Fort Loudoun Dams, there are periods when the flow in the Clinch River is reversed, with backflow extending up Poplar Creek to above the confluence with East Fork Poplar Creek.

At high-pool stage, Poplar Creek ranges up to 220 feet wide with water depths ranging up to 22 feet, although most of the time it is less than 15 feet deep. During low-pool stage, the creek is on the order of 100 to 130 feet wide, largely restricted to the pre-impoundment channel. Periodic flow reversals have been observed from the mouth of Poplar Creek upstream to above the Black Oak Ridge water gap, although the magnitude of the flow reversals decreases progressively upstream. Water in Poplar Creek is commonly more turbid than in the Clinch River (Reference 2).

Flow and water quality in tributaries draining the ETTP are monitored at three weirs: the K-1700 Weir (Mitchell Branch), K-1007-P1 Holding Pond, and K-901-A Holding Pond. These three weirs serve as integration points for surface water, storm drain, and groundwater discharge from a significant portion of the site. However, the weirs at these discharge points are not constructed for accurate flow measurement under some high flow conditions (Reference 3). The ETTP maintains a NPDES stormwater permit (TN0002950) for monitoring and controlling stormwater runoff on site (Reference 4).

3.4.1.1.3 Soil and Land Cover

With few exceptions, bedrock at the site is mantled by unconsolidated overburden materials that range in thickness up to 70 feet. The heterogeneous soils overlying the bedrock include a mixture of fill and reworked soils. During construction of the ETTP, soils were modified by excavation and refilling of areas throughout the site, and few areas of undisturbed soils remain. Although the soils have largely been reworked, for the most part, soils at the site are fine-grained and generally consist of silty clay materials. However, coarser-grained soils are present in some fill areas. Section 3.3 includes a detailed description of the geology and soils for the site and surrounding area.

3.4.1.1.4 Streamflow

The closest monitoring site on Poplar Creek is maintained by the USGS Tennessee Water Science Center and is located just over 10 miles upstream of the site. The identifier for the stream site is USGS-03538225, and the site has a drainage area of 82.50 mi^2 (National Water Quality Monitoring Council 2021). According to the available data for this stream site, the average monthly discharge between 1960 and 1989 was 38 to 335 cubic feet per second (cfs) (Reference 5). Additionally, for this site there are 30 peak streamflow measurements recorded between 1928 and 1989, with a historic peak flow of 14,000

cfs in 1928, and 11,400 cfs recorded in 1977, while the lowest peak flow of 1,100 cfs was recorded in 1981 (Reference 6). As described in Section 3.4.1.1.1, streamflow in the Poplar Creek embayment downstream from the stream recording site is influenced by TVA operations at the downstream Watts Bar Dam and upstream Melton Hill Dam.

3.4.1.1.5 Dams and Reservoirs

Norris Dam and Reservoir is located about 50 miles upstream of the site. Norris Dam is a large multipurpose tributary dam which is used for navigation, flood control, hydropower, environmental benefits (stream flow, aquatic ecology etc.), water supply, and recreation. Norris Dam is fed by a 2,912 mi^2 drainage area along its 300-mile length (Reference 7).

Melton Hill Dam is located on the Clinch River at CRM 23.1, approximately 4 river miles upstream of the site, and forms the Melton Hill Reservoir. The dam was completed in 1963 and is 103 feet high and stretches 1,020 feet across the Clinch River. Melton Hill Dam is a hydroelectric facility with two generating units. These two generating units are capable of producing a net dependable capacity of 79 MWe. Melton Hill Reservoir has the only dam in the tributary reservoir system with a navigation lock, which has a 75-foot by 400-foot chamber and a maximum lift of 60 feet.

Unlike most of TVA's multipurpose tributary projects, Melton Hill Dam does not provide any significant flood damage reduction benefits, nor does it provide any significant seasonal flow regulation because of the little useful storage volume available. The average weekly discharge from Melton Hill Dam over its lifetime (1962-present) is 4,832 cfs with a maximum weekly discharge of 25,455 cfs. The minimum discharge requirement for Melton Hill is 400 cfs average daily flow, but the frequency of this minimum flow continuing for as long as seven days is less than 0.1 percent (Reference 7).

Watts Bar Dam is located at Tennessee River mile (TRM) 529.9, approximately 50 river miles downstream from the mouth of Poplar Creek and the site. Construction on Watts Bar Dam was completed in 1942. Watts Bar Dam is 112 feet high and stretches 2,960 feet across the Tennessee River. Outflows from Watts Bar Reservoir are controlled by releases at Watts Bar Dam. Regulated releases of surface water to Watts Bar Reservoir are made not only from Melton Hill Dam but also Fort Loudoun Dam, located at TRM 602.3, and Tellico Dam, located near TRM 601.1. Watts Bar Dam has one lock that is 60 feet by 360 feet and lifts and lowers barges as much as 70 feet between Watts Bar Reservoir and Chickamauga Reservoir downstream. The net dependable hydroelectric capacity at Watts Bar Dam is 182 MWe. In addition to forming a navigable reservoir on the Tennessee River, Watts Bar Dam also creates a slack-water channel for navigation up the Clinch River arm of Watts Bar Reservoir more than 20 miles to Melton Hill Dam and 12 miles up the Emory River.

The water level elevation is generally maintained between 735 mean sea level (msl) and 741 msl. The Probable Maximum Flood elevation is 768.3 msl at a flow rate of 550,000 cfs. The 500-year flood elevation is 747.1 msl with a flow of 260,000 cfs. River flow in Watts Bar Reservoir can be upstream, downstream or quiescent due to the release or retention of water at Melton Hill Dam, Fort Loudoun Dam, and Watts Bar Dam, with release from Fort Loudoun Dam, but not Watts Bar Dam, responsible for reverse flow (Reference 7).

3.4.1.1.6 Estuaries and Oceans

No estuaries or oceans are located near the site.

3.4.1.1.7 Applicable Regulations and Permits

Prior to construction, it would be necessary to obtain a construction storm water NPDES permit from the Tennessee Department of Environment and Conservation (TDEC) for discharges of stormwater

associated with construction activities. As part of the NPDES permit, the development and implementation of a SWPPP would be required to help minimize any pollution that might leave the site by stormwater. The SWPPP would contain a detailed site plan and schematics for the installation of temporary and permanent stormwater and erosion control devices to effectively manage the site during construction and facility operation.

Storm water runoff after construction activities are completed, and any discharge from facility operations to surface water, would be in accordance with limitation established under the applicable TDEC NPDES permit.

The site is not located within a Federal Emergency Management Agency (FEMA) 100-year floodplain (see Figure 3.4-2). The FEMA Flood Zone Designation for the site is Flood Zone X (unshaded). This is a low-risk zone for an area of minimal flood hazard that is determined to be outside the Special Flood Hazard Area and higher than the elevation of the 0.2-percent-annual-chance (or 500-year) flood (Reference 8).

3.4.1.2 Groundwater

Groundwater flow and occurrence at the ETTP are influenced by the complex geology, past cut and fill, transient interactions with bounding surface water bodies, and numerous anthropogenic features, including building sumps, leaking subsurface drains and utilities, and extensive areas covered by impermeable paved surfaces and roofed structures. Groundwater occurs in both the unconsolidated overburden and bedrock at the ETTP, primarily as a single, unconfined, water table aquifer. As part of studies in the Kairos Power PSAR, onsite soil borings encountered groundwater at depths between 6-8 feet. Characterization and monitoring of groundwater quality and potential groundwater contaminant sources in the K-31/K-33 Area has been ongoing since 1989. Monitoring wells were installed along the boundary of the site and in proximity to leak sites to monitor potential releases. Since inception of the monitoring efforts, DOE has reported low levels of mostly chromium, but also other sporadic metals, slightly above maximum contaminant level (MCL) levels. Efforts to get a final decision on the K-31/K-33 Area groundwater have been suspended several times since monitoring began (Reference 29).

3.4.1.2.1 Surficial Aquifer System

Previous reports have referred to a surficial aquifer, associated with the unconsolidated overburden, and a bedrock aquifer. However, available data suggest the bedrock and unconsolidated zone are hydraulically connected (Reference 9). Neither aquifer is an EPA-designated sole-source aquifer. The transitioning of the water table surface between the unconsolidated zone and the bedrock results in complicated groundwater flow paths in areas of the site. Depth to groundwater ranges from 1 to 65 feet below ground surface, largely depending on topographic position, occurring at greater depths at higher elevations (Reference 3).

Groundwater flow in the unconsolidated zone is expected to follow mapped potentiometric gradients. Groundwater in the area typically follows short flow paths to discharge to local surface water features such as springs or seeps. The Clinch River and possibly Poplar Creek are the probable points of discharge for both conduit and diffuse zone bedrock groundwater flow paths Figure 3.4-3. Additionally, because bedrock is exposed in much of Poplar Creek and nearly the entire Clinch River bottom, unconsolidated zone flow paths terminate at these surface water features (Reference 3).

Historically, building basement dewatering significantly altered the mapped potentiometric surface in areas of the ETTP. It also created areas of steep drawdown toward buildings that restricted and/or controlled the migration of dissolved-phase contaminants in the unconsolidated zone and possibly the bedrock (where dewatering lowered the water table to or below the top of bedrock). Storm drains also

served a dual role as either sinks or sources of recharge water to groundwater. A number of storm drains flow continuously, even in dry weather, suggesting they are discharging captured groundwater.

Poplar Creek and the Clinch River stage fluctuations dramatically control groundwater discharge seasonally, weekly, and daily, resulting in a complex transient boundary condition. High pool stage in the summer months increases the water table in a zone peripheral to the surface water bodies, while increased evapotranspiration and decreased overall rainfall in summer months limit recharge, resulting in a decrease in heads in the higher-elevation, recharge areas of the site. The net effect is to reduce the hydraulic gradients and overall groundwater flux. In the winter months, the opposite is true. Hydraulic gradients are greatest during winter months, and more overall flux occurs under wet-season/low-pool-stage conditions. In particular, flux has been demonstrated to occur in association with higher-intensity and -duration winter storms (Reference 3).

3.4.1.2.2 Bedrock Groundwater

On much of the site, the water table occurs within the unconsolidated zone above the bedrock layer. At several areas of the site, however, the water table occurs below the top of bedrock, typically in areas of thin overburden where bedrock relief is high and/or the depth to water is greater (Reference 9). Depth to groundwater is estimated to range from 1 to 65 feet below ground surface, largely depending on topographic position Figure 3.4-4. Groundwater is likely to occur at greater depths as elevation increases. The water table generally emulates the topography of the area with radial flow from elevated areas to the adjacent surface water features, including Poplar Creek, Clinch River and surrounding ponds and low-lying areas. Fluctuations in Clinch River and Poplar Creek stage directly impact groundwater hydraulic gradients in areas adjacent to these features (Reference 9).

Over most of the ETTP, the water table occurs in the overburden, and groundwater would follow the hydraulic gradients to produce radial flow from higher elevations on the site to surface waters, as described above. Depending on the specific type of overburden material (residual soil, fill materials, reworked soils, or alluvium), specific flow zones may impact flow directions slightly on a local scale, though flow is expected to generally follow hydraulic gradients. A conceptual model for ORR suggests that the most active locations for groundwater flow on the ORR is in the interface between bedrock and the unconsolidated zone and the uppermost surfaces of the bedrock (Reference 10). This is likely to be the case at the ETTP site as well.

Areas of the site where the water table exists below the top of the bedrock layer, groundwater flow would be dictated by both hydraulic gradients and bedrock structural features such as cavities. Such flowpaths would typically be oriented parallel to bedrock strike in the carbonate layer, but they are highly unpredictable in the areas of the site which are underlain by the Rome Formation. Groundwater at ETTP typically follows short flowpaths to discharge to local surface water features, including existing Clinch River, Poplar Creek, K-1007-P Ponds, K-901-A Pond, and various seeps and springs.

3.4.2 Water Use

Tennessee has abundant ground and surface waters, with surface waters of the Tennessee River system providing water for much of the state and region. Figure 3.4-5 shows a map of the United States with the likelihood of a multi-year drought using data from 1949-2009 by county. From this figure it is clear that Tennessee is located in an area with abundant water resources with a few counties in the state experiencing drought conditions over the 60 year study period. Local periodic drought and low water conditions are infrequent but some are to be expected over a 60 year period.

3.4.2.1 Regional Surface Water Use

The USGS typically reports water use information every 5 years by county. The USGS found that in 2015 the total water use in Roane County was 4.86 MGD with 3.5 MGD, or 72.0 percent, coming from surface water sources and 1.36 MGD (28.0 percent) coming from groundwater sources. Thermoelectric power generation accounted for 348.0 MGD of surface water withdrawals with 3.48 MGD (10 percent) used for pass-through cooling (Reference 11).

Roane County Tennessee serves 52,926 people in a 361 mi^2 area, with three separate water departments (Reference 12). Municipal water for Oak Ridge and the surrounding areas comes exclusively from Melton Hill Lake. A new water treatment plant is currently planned to replace the 70-year-old existing treatment plant located on Pine Ridge above the entrance to the Y-12 facility. Located at the city's water intake on Melton Hill Lake, the new modular ultrafiltration membrane system would be south of Bethel Valley Road and is expected to treat 16 MGD. While originally anticipated for completion by the end of 2022 (Reference 13), the project is anticipated to be tested and fully operational in 2024 or 2025.

Water for the current plant is pumped directly from Melton Hill Lake, treated, tested, and then distributed through water mains. The treatment process starts with the addition of an oxidant before water is pumped to the water treatment plant. The water is pumped into a mixing tank where coagulant polymer is added, causing flocculation where small particles (organic matter, sediment etc.) are bound together. These larger particles are heavy enough to settle in the basin and be removed. A small amount of chlorine is added, and the water is filtered through layers of fine coal and silica sand to help remove the particles and bad taste from the water. The water is then disinfected with a higher dose of chlorine, fluoride and a corrosion inhibitor are added, and the water is pumped into distribution lines (Reference 14).

Melton Hill Lake is considered reasonably susceptible to potential contamination due to geologic and human factors, which is the highest category in the source water assessment program. This program looks at potential sources of contamination within a specific area and rates how susceptible the water would be to those contaminants. Annual reporting shows regulated substances (lead, copper, turbidity, bacteria etc.) were below the allowable threshold throughout 2020 (Reference 14).

Potable water is produced from surface water with intakes on Melton Hill reservoir at the Y-12 facility. This site was originally built and operated by the DOE, but in May 2000 it was transferred to the city of Oak Ridge who now maintains the plant and distribution network (Reference 15). This plant includes 219 miles of water mains and regularly supplies 4.15 MGD of water to the citizens of Oak Ridge (Reference 16). This plant has a capacity of 12 MGD with the ability to occasionally produce 16 MGD.

There are 2 wastewater treatment plants in the city of Oak Ridge; a main wastewater treatment facility which has a 30.0 MGD capacity, and a much smaller Rarity Ridge Wastewater Treatment Plant which has a 0.6 MGD treatment capacity, which serves Clinch River industrial Park, ETTP, Horizon Center and Rarity Ridge (Reference 16). These facilities treat a combined 5.6 MGD of wastewater, which is 18 percent of its maximum capacity (Reference 15). The objectives of the wastewater treatment plants are to prevent disease and nuisance conditions (algal blooms etc.), avoid contaminating water supplies and navigable waterways, maintain water quality for fish and other aquatic organisms, and maximize water conservation for all uses (Reference 16).

Table 3.4-1 shows water withdrawal returned and consumed for the Tennessee River watershed. The main water use is for thermoelectric at 10,276 MGD, with all but 32 MGD returned to the system. Industry is the next largest water consumer with 1,205 MGD withdrawn and 263 MGD consumed. Public

water supply withdraws 662 MGD, and consumes 285 MGD, while agricultural irrigation withdraws and consumes 69 MGD.

Table 3.4-2 shows water withdrawals (surface, ground and total) along with return flows and consumption for several watersheds in the region. Watts Bar and Chickamauga watersheds have the largest total water withdrawal at 1,496 MGD and 1,691 MGD respectively. Watts Bar and Douglas watersheds have the largest consumptive water use at 129 MGD and 65 MGD respectively, while all other consumptive water use is below 25 MGD. Chickamauga watershed reportedly returns more water than is removed (84 MGD more returned than withdrawn). A large majority of the water withdrawals for the Tennessee watersheds are from surface water (3,890 MGD) versus ground water (45 MGD) (Reference 17).

Overall water usage statistics and forecasts are provided in Table 3.4-3, which cover 1995 through 2010 and then projects usage in 2035. In 2010, total water withdrawals for the whole TVA watershed were estimated at 11,951 MGD. Most of the freshwater usage was surface water, which totaled 11,747 MGD (98.3 percent), with groundwater accounting for the remaining 204 MGD (1.7 percent). The largest water use is for thermoelectric generation, which accounted for 10,046 MGD (84.1 percent), although this water is not consumed, but passes through cooling systems for electricity generation. The total return flow back to the river system after use was calculated as 11,480 MGD (96.1 percent), so 471 MGD (3.9 percent), of the water that flows within the Tennessee watershed is consumed through irrigation, evaporation, infiltration, or other losses. Total water use is expected to decrease 21 percent by 2035 compared with 2010 mainly due to reductions in thermoelectric generation (6,963 MGD; 31 percent reduction), with increases expected in industrial, public supply and irrigation sectors of 1,502 MGD (31 percent), 938 MGD (30 percent), and 46 MGD (35 percent) respectively. By 2035, consumptive water use is expected to increase to 712 MGD, a 51 percent increase over 2010 values (Reference 18).

3.4.2.2 Groundwater Use

In Tennessee, about 1/3 of the population relies on groundwater for part or all of their drinking water (Reference 19). According to the USGS, 1.36 MGD is derived from groundwater sources for Roane County, where the site is located (Reference 11). Due to historical activities at the site, the extraction, consumption, exposure to or use of groundwater on the site requires approval from DOE, EPA, and TDEC. Kairos Power does not intend to utilize onsite groundwater for construction, operation, or decommissioning.

Groundwater is a small part of the overall water use in the area surrounding the site. This is largely due to the abundance and availability of sufficient volumes of relatively clean surface water. Groundwater withdrawals from the surrounding areas are reported in Table 3.4.4. Total groundwater withdrawals are estimated at 21 MGD, compared with 2,223 MGD for surface water, representing 0.9 percent of total daily withdrawals (Reference 17).

Although groundwater withdrawals represent a small part of the overall water use, Tennessee has a wellhead protection program in place to maintain this resource. This program emphasizes prevention of groundwater contamination. The goal of a wellhead protection program is to minimize contamination in the well water recharge area (the area in and around the well) (Reference 19). All types of wells (municipal, industrial, residential etc.) must be permitted and approved by the state.

Total groundwater withdrawals are estimated at 21 MGD in Roane County, compared with 2,223 MGD for surface water, representing 0.9 percent of total daily withdrawals (Reference 17), with 1.36 MGD removed from groundwater for Roane County, where the site is located.

3.4.2.3 Facility Water Use

As discussed in Section 2.4.1, water used by the facility for cooling, sanitary, fire protection and other purposes would be obtained from municipal water suppliers. The total amount of water required for the site on a daily basis is estimated at 44 gpm (0.06 MGD), while the fire suppression system would infrequently require 3,170 gpm (4.56 MGD), with a makeup requirement of 793 gpm (1.14 MGD). There would be no direct use of surface water through an intake, or groundwater through production wells. Municipal water is supplied by the City of Oak Ridge and has a capacity of 12 MGD of water (Reference 16).

3.4.3 Water Quality

The site is located in a relatively water-rich part of the country that has numerous surface and groundwater resources. The site and the area immediately around the site have been used for nuclear research and production in the past, and some areas exhibit residual water quality impacts from that usage, including groundwater and surface water contamination. TVA manages the 652-mile Tennessee River system for navigation, flood reduction, power production, water quality and quantity, environmental benefits and recreation. The system consists of 49 dams, of which nine are on the Tennessee River (Reference 18).

3.4.3.1 Surface Water

Restoration of the ORR is one of the largest environmental cleanup sites in the United States. Cleanup efforts at the ETTP began in the early 2000s under the authority of the Tennessee Department of Environment and Conservation’s Division of Remediation, the DOE, Oak Ridge Office of Environmental Management, and the contractor UCOR, at a cost of $4.5 billion for the 2,200 acre site (Reference 20).

3.4.3.1.1 Water Quality

Historical activities in and around ETTP from the Manhattan project and other activities have impaired surface and groundwater quality. The main pollutants are mercury in soils (both terrestrial and submerged) and surface water, and volatile organic compounds (VOCs) and polychlorinated biphenyls (PCBs) in groundwater.

<u>Impaired Waters and Total Maximum Daily Load</u>

Both Poplar Creek and the Clinch River arm of Watts Bar Reservoir are considered impaired based on the EPA 303(d) impaired waters list. Poplar Creek is impaired for high levels of PCBs and mercury, while the Clinch River is listed for PCBs, mercury, and pesticides for the year 2020 (Reference 21). Since 2017, a mercury treatment facility has been operating on the Upper East Fork of Poplar Creek at Outfall 200 to mitigate downstream effects of mercury on Poplar Creek and downstream waterways (Reference 22).

Section 1453 of the 1996 Safe Drinking Water Act required that all states establish Source Water Assessment Programs. In 2000, water quality data in the Upper Tennessee River Basin were reported by the USGS for 1994 to 1998. Concentrations and distributions of pesticides, nutrients, bacteria, and VOCs in surface water and sediment were reported, along with the impact of industry and mining on water quality and the effects of toxic spills and releases. This study was part of the USGS National Water-Quality Assessment Program, which evaluated 51 study areas throughout the United States. The report compared water quality data from the Upper Tennessee River to data from the other study areas and to national water quality benchmarks, such as those for drinking water quality and protection of aquatic organisms. The report showed that surface water in the Upper Tennessee River Basin usually meets existing guidelines for drinking water, recreation, and the protection of aquatic life (Reference 23).

Specific findings from Hampson, et. Al. included (Reference 23):

- Bacteria levels frequently exceeded state standards in agricultural and urban areas. In agricultural areas, this was attributed to runoff from pastureland (animal production). In urban areas, this was attributed to wastewater infrastructures (aging sanitary sewers).
- Nutrients, including nitrogen and phosphorus, were found at elevated levels in some streams compared to national averages and EPA maximum values.
- Herbicides were detected in 98 percent of the stream samples collected, and insecticides were detected in 12 percent of samples, while pesticides were detected at 67 of the 74 stream sites sampled. Concentrations were typically within drinking water standards, but some concentrations exceeded aquatic life guidelines for some chemicals.
- Contamination from past industrial and mining activities was still present in many areas. Contamination had resulted in fish consumption advisories for PCBs, dioxin, and mercury. Semi-volatile organic compounds (SVOCs) were found in sediment at concentrations that exceeded aquatic life guidelines and were attributed to coal mining.
- Spills and releases had resulted in fish and mussel kills in many parts of the basin and posed a risk to isolated and endangered aquatic species.

Mercury was reported as a major contaminant downstream of the ORR, particularly on the Lower Clinch River Watershed, Watts Bar Reservoir, and Whiteoak Creek watershed, mostly due to past work associated with the Manhattan Project and subsequent activities. Mercury, PCBs, and cesium-137 are known to have migrated to areas downstream of the ORR. Most of the cesium-137 has been covered by subsequent sediment and does not pose a risk to human health if it is not disturbed. Fish-consumption advisories are also in effect for Watts Bar Reservoir due to bioaccumulation of mercury and PCBs in some fish species. A fish-consumption advisory was also in place for Melton Hill Reservoir due to the presence of PCBs and chlordane (Reference 23). Table 3.4-4 provides a list of surface water bodies near the site.

3.4.3.1.2 Project Surface Water Monitoring

No site-specific surface water quality monitoring has been conducted for the site. Surface water quality adjacent to and near the site has been the subject of multiple, ongoing monitoring programs.

The surface water in and around the site is expected to continue to be monitored as part of the Poplar Creek Mercury remediation at outfall 200, as well as required monitoring as part of the 303(d) impairments. In addition, the TDEC conducts monitoring of more than 7,700 stations throughout the state, with approximately 1,500 stations scheduled for sampling each year (Reference 24). Water quality monitoring includes biological, chemical, and bacteriological analyses in wetlands, rivers, streams, reservoirs, and lakes. There are 16 monitoring stations located on the Clinch River watershed of the Tennessee River basin immediately upstream and downstream of the site on the Watts Bar Reservoir, of which 6 are located upstream of the site and 10 are located downstream of the site (Reference 25).

3.4.3.2 Groundwater

No site-specific groundwater quality monitoring has been conducted for the site. Groundwater quality adjacent to and near the site has been the subject of multiple, ongoing monitoring programs, which are discussed below.

The site is located on the ORR, which includes three DOE facilities: the ORNL, Y-12 National Security Complex (Y-12), and ETTP. The ORNL is composed of subareas including Melton Valley, Bethel Valley, and White Oak Creek. The Y-12 facility includes Bear Creek Valley, Upper East Fork Poplar Creek, and Chestnut Ridge. These facilities were constructed as part of the Manhattan Project during World War II and were involved with nuclear weapons production and research.

Historical research and production activities in the area have produced a variety of chemicals and radionuclides, some of which are still present in groundwater. Contaminant classes present include VOCs and radionuclides (primarily uranium, tritium, and strontium-90) (Reference 26). Figure 3.4-6 presents a map showing the major groundwater plumes associated with the facilities. The DOE is continuing to monitor VOCs (ethane, ethylene, and methane), total and ferrous iron, anions (such as chloride, fluoride, sulfate, nitrate-nitrite, and sulfide), total organic carbon, as well as dechlorinating bacteria which were introduced to remove trichloroethene in and around ORNL (Reference 26).

Past, Present and Reasonably Foreseeable Actions

Section 4.13 provides an analysis of the cumulative effect of the site considering other past, present and reasonably foreseeable future actions. Industrial, agricultural, and municipal growth will likely add to surface water and groundwater demand in the foreseeable future in and around the site.

With respect to other potential uses of water resources, there are likely additional demands that will be placed on water supplies, wastewater treatment, and pollutant loading. The ORNL is currently starting a revitalization process adding industrial partners throughout the ORNL. These partners will have varying needs in regard to water demand, wastewater production, and pollution loading for both construction and operation. This area is in the beginning stages of this development with uncertainty around what industries will be in the area. Construction in and around the area could contribute additional pollutant loading associated with construction and operation. One of the proposed projects is a municipal airport on the ORNL site. This airport would likely have minimal impact on water resources in the area but could contribute to decreased water quality during construction.

There are no other identified domestic, municipal, industrial, mining, recreation, navigation, or hydroelectric power uses of any bodies of water or aquifers at distances close enough to affect or be adversely affected by the proposed facilities. Section 3.4.2.1 discusses other users of surface water from the system with no known substantial changes in surface water withdrawals. Section 3.4.3.1.1 discusses potential sources of surface water contamination with no known additional sources of surface water contamination other than those discussed in this section.

3.4.4 References

1. Oak Ridge National Laboratory, "Oak Ridge Reservation Physical Characteristics and Natural Resources," September 2006.

2. U.S. Department of Energy, "East Tennessee Technology Park Main Plant Groundwater Feasibility Study Oak Ridge, Tennessee - Volume 1: Main Text," DOE/OR/01-2835&D1, November 2019.

3. U.S. Department of Energy, "Final Sitewide Remedial Investigation/Feasibility Study for East Tennessee Technology Park," November 2007.

4. Oak Ridge Reservation. “Annual Site Environmental Report-2013 Appendix D. NPDES Noncompliance Summaries,” 2013. https://doeic.science.energy.gov/ASER/aser2013/Appendix%20D_NPDES%20Noncompliance%20Summaries%20for%202013.pdf.

5. U.S. Geological Survey, USGS 03538225 Poplar Creek, TN Surface Water Data for USA: USGS Surface-Water Monthly Statistics, Website: https://waterdata.usgs.gov/nwis/monthly?referred_module=sw&site_no=03538225&por_03538225_130224=1113045,00060,130224,1960-09,1989-09&format=html_table&date_format=YYYY-MM-

DD&rdb_compression=file&submitted_form=parameter_selection_list, accessed September 16, 2021.

6. U.S. Geological Survey, USGS 03538225 Poplar Creek Surface Water for USA: Peak Streamflow, Website: https://nwis.waterdata.usgs.gov/usa/nwis/peak/?site_no=03538225, accessed September 16, 2021.

7. Tennessee Valley Authority, "Clinch River Nuclear Site Early Site Permit Application - Part 3 Environmental Report Revision 2," March 2019.

8. Flood Partners, Flood Zones, Website: https://floodpartners.com/flood-zones/, accessed September 14, 2021.

9. U.S. Department of Energy, "Groundwater Remedial Site Evaluation Report for the Oak Ridge K-25 Site, Oak Ridge, Tennessee - Volume 1. Main Text," DOE/OR/01-1468V1&D1, 1996.

10. Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster, "Status Report: A Hydrologic Framework for the Oak Ridge Reservation," May 1992.

11. U.S. Geological Survey, Water Use Data for Tennessee, Website: https://waterdata.usgs.gov/tn/nwis/water_use?format=html_table&rdb_compression=file&wu_area=County&wu_year=2015&wu_county=145&wu_county_nms=Roane%2BCounty, accessed June 30, 2021.

12. CountyOffice.org, Water Departments in Roane County, Tennessee, Website: https://www.countyoffice.org/tn-roane-county-water-departments/, accessed August 6, 2021.

13. City of Oak Ridge Tennessee, City Finalizes WIFIA Loan for New Water Treatment Plant, Website: http://oakridgetn.gov/content.aspx?article=4794, accessed August 31, 2021.

14. City of Oak Ridge, "Annual Water Quality Report - Reporting Year 2020," PWSID#: TN0000522, February 23, 2021.

15. City of Oak Ridge Tennessee, Water Treatment, Website: http://www.oakridgetn.gov/department/PublicWorks/Divisions/Water-Treatment, accessed August 31, 2021

16. City of Oak Ridge Tennessee, Operations, Website: http://www.oakridgetn.gov/department/PublicWorks/Divisions/Services, accessed August 31, 2021

17. Hutson, S.S., C. Koroa, and M. Murphree, "Estimated Use of Water in the Tennessee River Watershed in 2000 and Projections of Water Use to 2030," Water-Resources Investigations Report 2003-4302, 2004.

18. Bohac, C.E. and A.K. Bowen, "Clinch River Small Modular Reactor Site," 2015.

19. Tennessee Department of Environment and Conservation, Wellhead Protection Program, Website: https://www.tn.gov/environment/program-areas/wr-water-resources/water-quality/wellhead-protection-program.html, accessed August 11, 2021.

20. Jones, V., "Former Tennessee uranium enrichment complex marks cleanup milestone," Washington Examiner, October 14, 2020. Retrieved from https://www.msn.com/en-us/news/us/former-tennessee-uranium-enrichment-complex-marks-cleanup-milestone/ar-BB1a1sXB

21. U.S. Environmental Protection Agency, How's My Waterway?, Website: https://geoconnex.us/epa/hmw/060102070405, accessed June 23, 2021.

22. U.S. Department of Energy, "Outfall 200 Mercury Treatment Facility, Startup Test Plan, Oak Ridge, Tennessee," UCOR-4931, August 2017.

23. Hampson, P.S., M.W. Treece Jr., G.C. Johnson, S.A. Ahlstedt, and J.F. Connell, "Water Quality in the Upper Tennessee River Basin, Tennessee, North Carolina, Virginia, and Georgia 1994-98," Circular 1205, 2000.

24. Tennessee Department of Environment and Conservation, "Fiscal Year 2019-2020 Surface Water Monitoring and Assessment Program Plan," July 2019.

25. Tennessee Department of Environment and Conservation, Lower Clinch River Watershed Water Monitoring Stations, Website: https://www.tn.gov/environment/program-areas/wr-water-resources/watershed-stewardship/watersheds-by-basin/upper-tennessee-river-basin0/lower-clinch-river-watershed.html, accessed July 14, 2021.

26. U.S. Department of Energy, "2015 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee - Data and Evaluations," DOE/OR/01-2675&D2, September 2015.

27. Tennessee Department of Environment and Conservation, "Year 2016 303(d) LIST - Final," December 2017.

28. Shi, D., N. Devineni, U. Lall, and E. Pinero, Columbia Water Center, America's Water Stress Index, Website: http://water.columbia.edu/research-themes/risk-and-financial-instruments/americas-water-stress-index/, accessed August 31, 2021.

29. U.S. Department of Energy. Addendum 2 to the Supplemental Sampling and Analysis Plan for the East Tennessee Technology Park Sitewide Residual Contamination Remedial Investigation K-31/K-33 Area, Oak Ridge, Tennessee. DOE/OR/01-2749&D1/A2/R2. July 2021.

30. U.S. Department of Energy. 2011 Third Reservation-wide CERCLA Five-Year Review for the U. S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee. DOE/OR/01-2516&D2. July 2012.

Table 3.4-1: Water Withdrawn, Consumed and Returned to the Environment in the Tennessee River Watershed in 2000

Use Type	Withdrawal	Return Flow	Consumption
Thermoelectric	10,276	10,244	32
Industry	1,205	942	263
Public	662	377	285
Irrigation	69	0	69
Values are in millions of gallons per day. Source: (Reference 17)			

Table 3.4-2: Water Withdrawn, Consumed and Returned to the Environment for Melton Hill Lake and Surrounding Watersheds for all Sources

Watershed	Surface water	Ground Water	Total Water	Return Flow	Consumption
Douglas	110.78	11.98	122.76	57.50	65
Fort Loudoun	77.52	1.60	79.12	56.39	23
Fontana	4.64	1.13	5.76	3.37	2
Santeetlah	0.44	0.0	0.44	0.0	0.4
Tellico	4.16	0.57	4.73	1.09	4
Norris	29.88	3.42	33.3	10.69	23
Melton Hill	500.36	1.58	501.94	479.33	23
Watts Bar	1,494.66	1.11	1,495.77	1,366.58	129
Chickamauga	1,667.10	24.02	1,691.12	1775.56	-84
Values are in millions of gallons per day. Source: (Reference 17)					

Table 3.4-3: Trends and Estimated Water Use in the Tennessee River Watershed from 1995 to 2035

Off-Stream Use	1995 (MGD)	2000 (MGD)	2005 (MGD)	2010 (MGD)	2035 (MGD)	Percent Change 2010-2035 (%)
Total withdrawals	10,008	12,211	12,437	11,951	9,449	-21
Thermoelectric	8,010	10,276	10,531	10,046	6,963	-31
Industrial	1,030	1,205	1,179	1,148	1,502	31
Public Supply	574	662	684	723	938	30
Irrigation	48	69	43	34	46	35
Source of Water						
Surface	9,750	11,996	12,237	11,747		
Ground	258	215	200	204		
Net water demand (consumptive use)		649	432	471	712	51
Source: (Reference 18)						

Table 3.4-4: Surface Water Bodies near the Site listed in 2016 303(d)

Water Body	Acres	Characteristics that Violate Water Quality Standards
Watts Bar Reservoir	34,075	PCBs in sediment
Fort Loudoun Reservoir	14,066 534	PCBs in sediment Atmospheric deposition of mercury
Tellico Reservoir	16,500	PCBs in sediment and atmospheric deposition of mercury
Norris Reservoir	23,198	Atmospheric deposition of mercury
Poplar Creek Embayment of Watts Bar Reservoir	154	PCBs from an industrial point source, mercury in contaminated sediments
Clinch River arm of Watts Bar Reservoir	2682	PCBs from industrial point source, chlordane in contaminated sediment, and atmospheric deposition of mercury
Melton Hill Reservoir	5960	PCBs and chlordane in contaminated sediment
Whiteoak Creek	5.3 (river miles)	Cesium, strontium, and loss of biological integrity
Emory River arm of Watts Bar Reservoir	283.36	Mercury, PCBs, and chlordane from an industrial point source, atmospheric deposition, and contaminated sediments
	454.98	Mercury, PCBs, and chlordane from atmospheric deposition and contaminated sediment
	362.64	Mercury, PCBs, and chlordane from atmospheric deposition and contaminated
Clinch River	7.4	Temperature and flow alterations due to upstream impoundments
Poplar creek	26.7	Nitrate, nitrite and total phosphorus due to municipal point sources and collection system failure
Source: (Reference 27)		

Figure 3.4-1: Surface Water

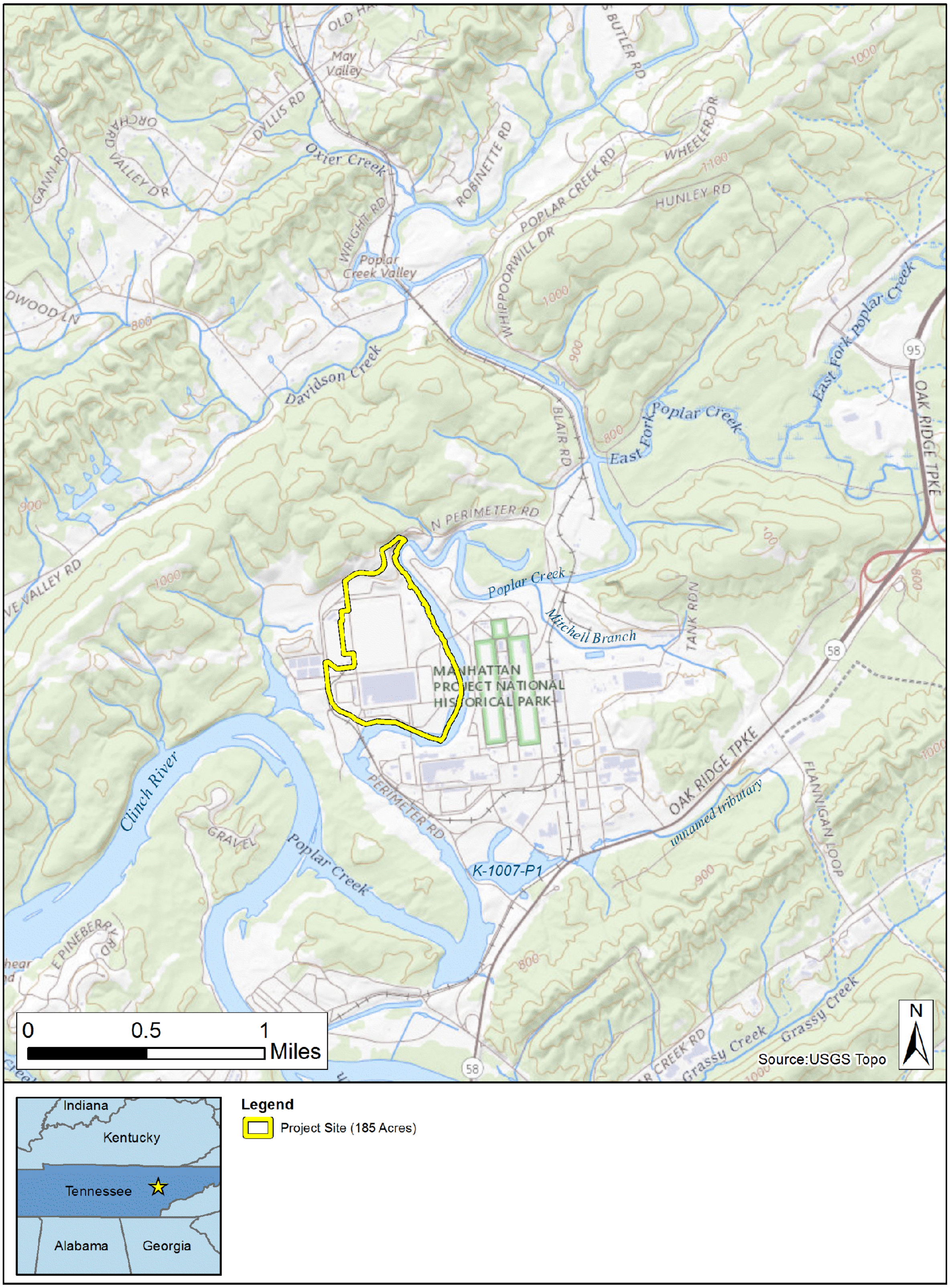


Figure 3.4-2: FEMA Flood Hazard

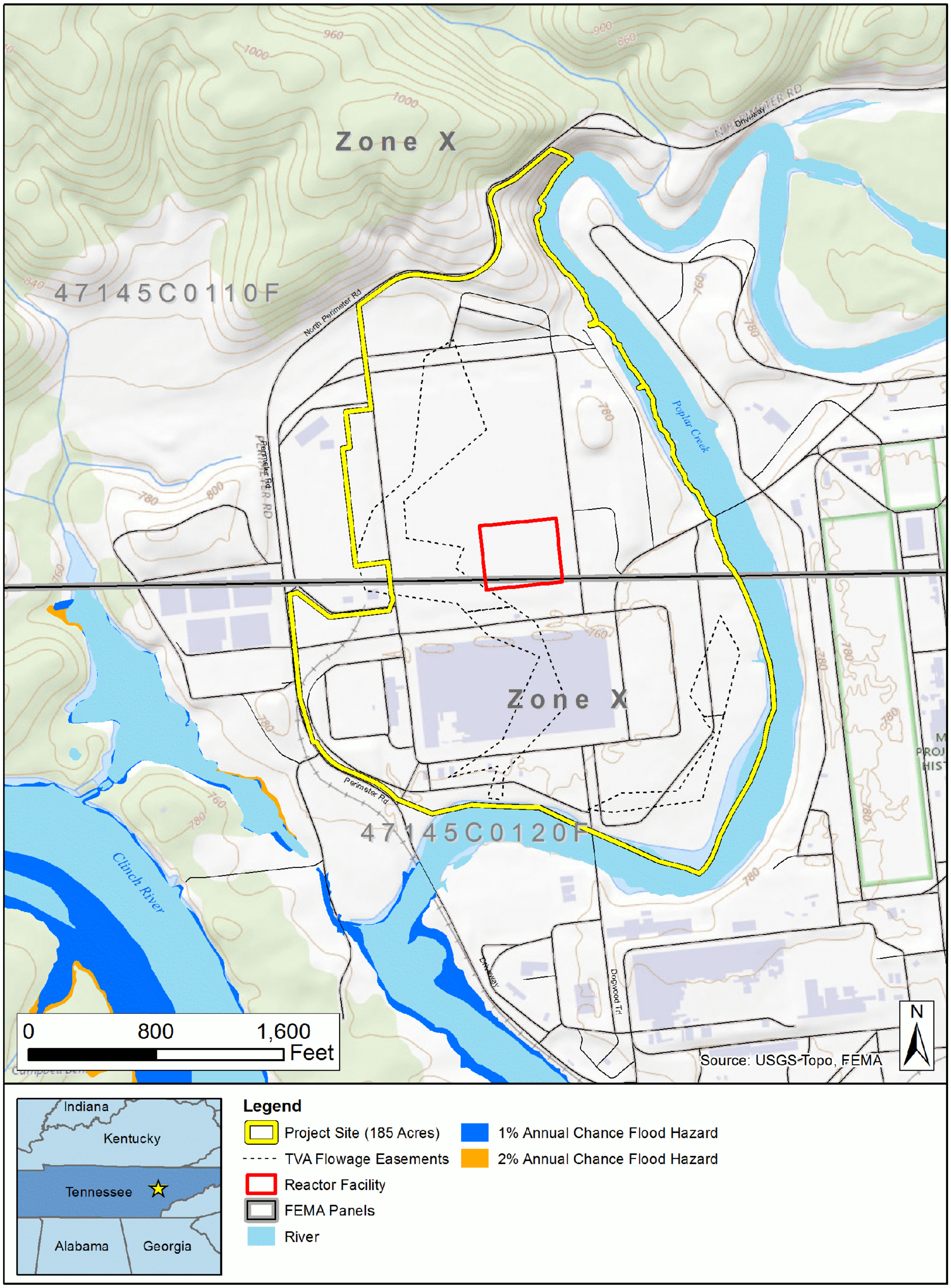
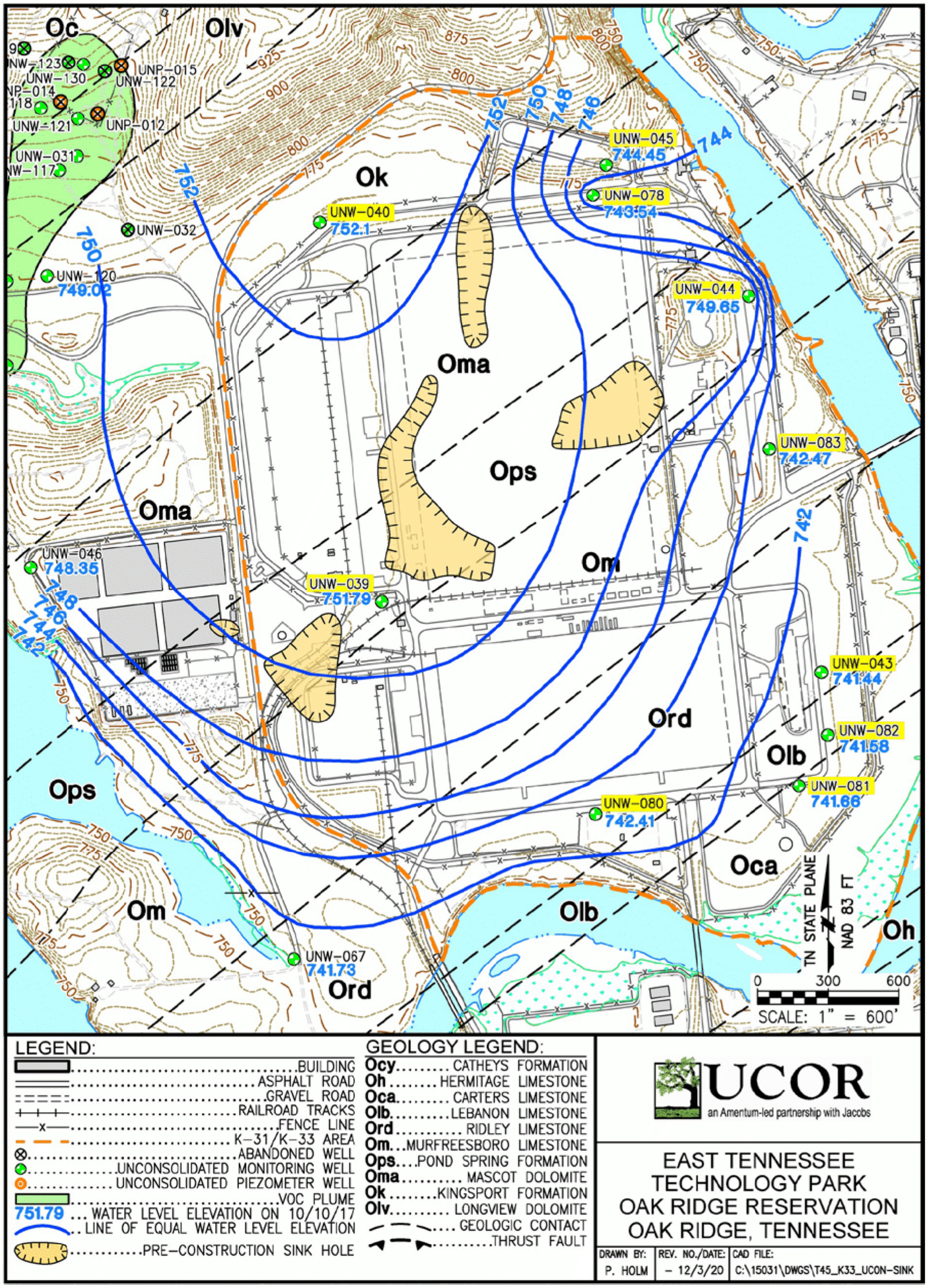
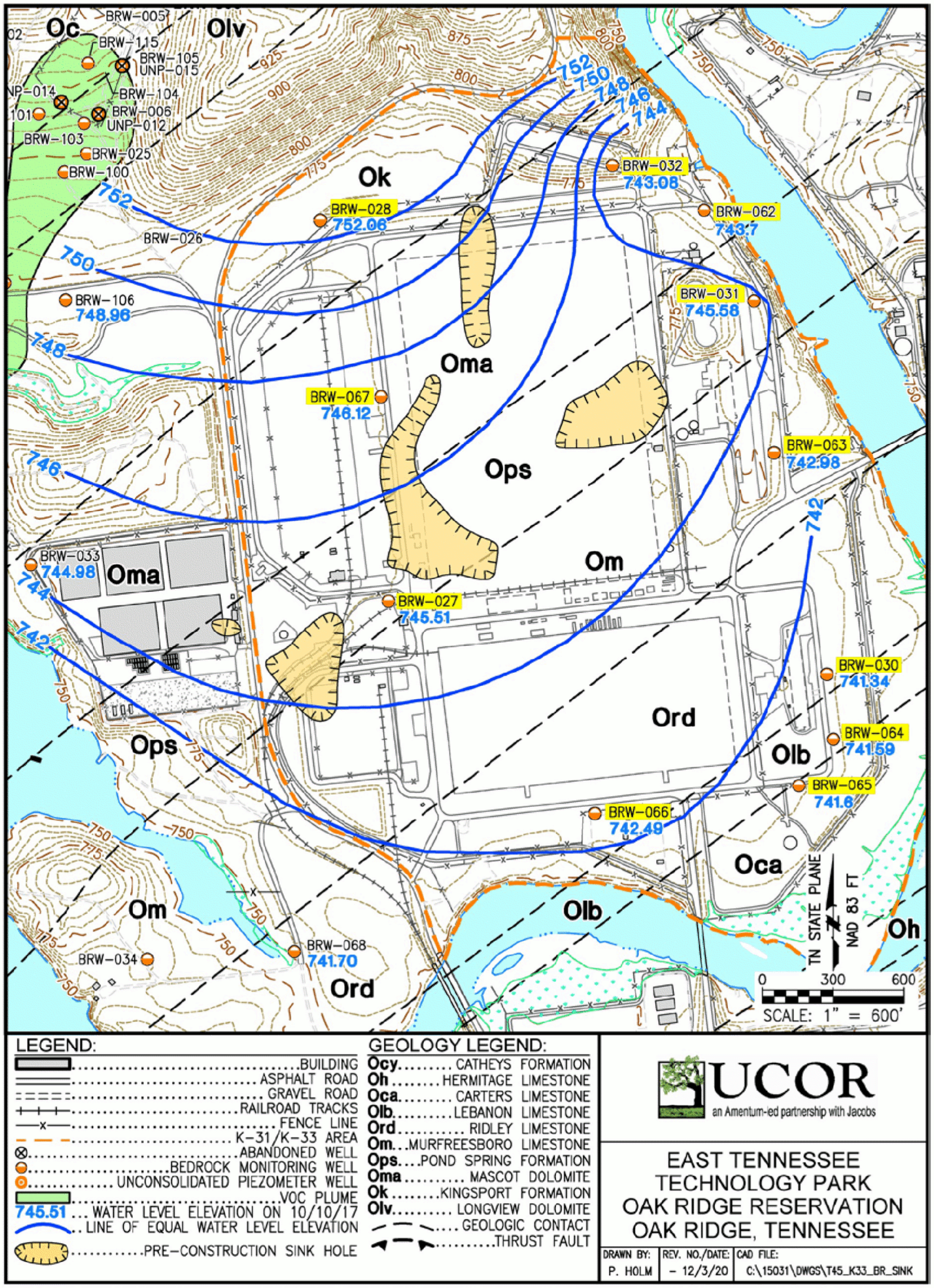


Figure 3.4-3: Unconsolidated Zone Potentiometric Surface



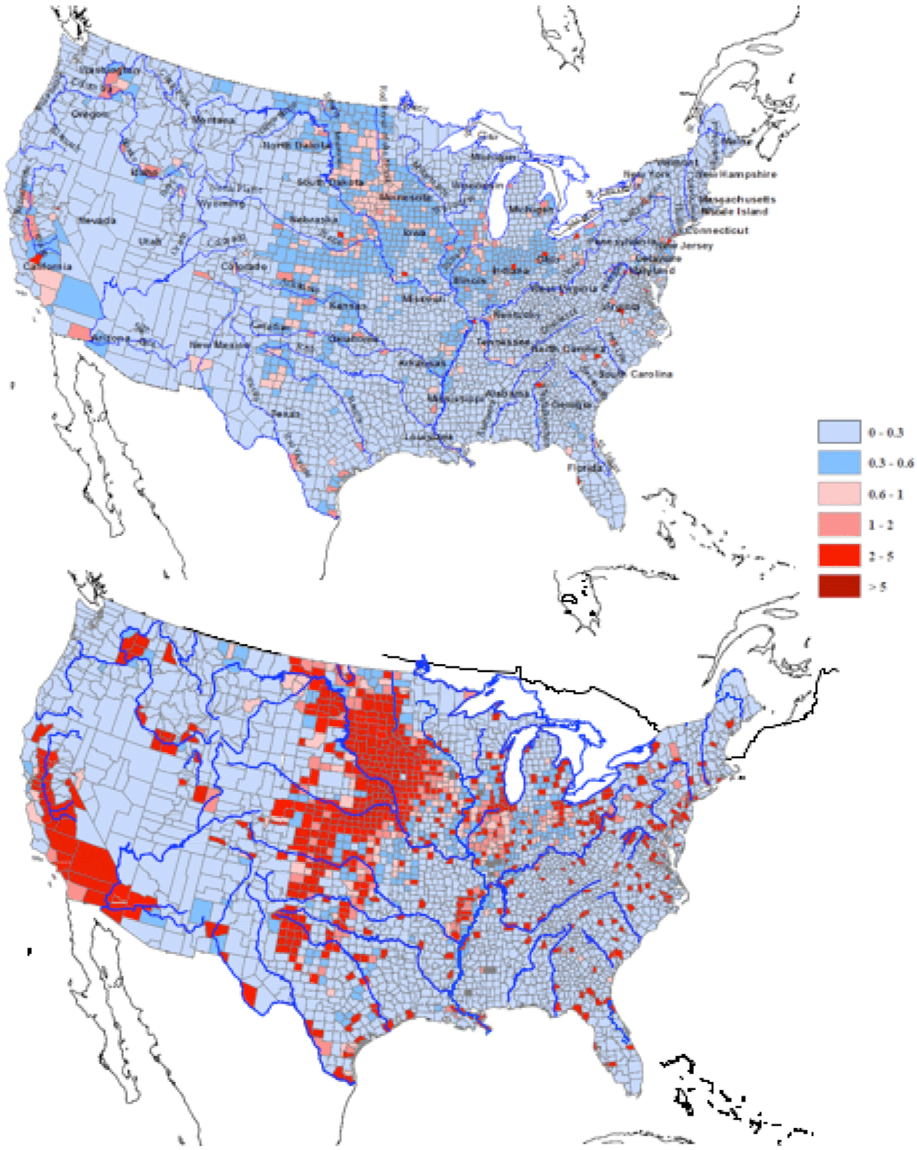
Source: (Reference 29)

Figure 3.4-4: Bedrock Potentiometric Surface



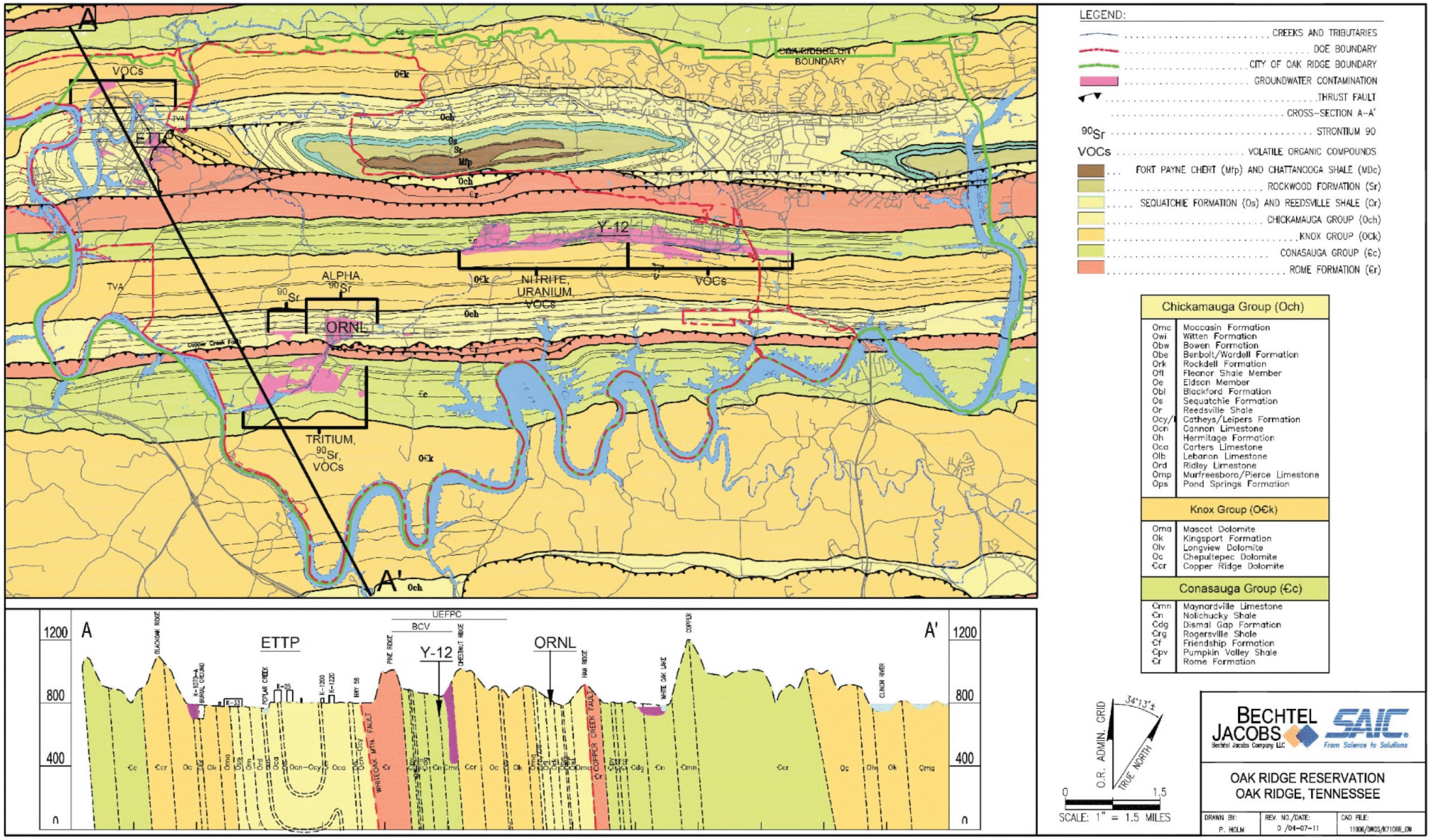
Source: (Reference 29)

Figure 3.4-5: Probability of Water Deficits and Drought Risk Across the Continental United States



Source: (Reference 28)

Figure 3.4-6: ORR Groundwater Contamination Map



Source: (Reference 30)

3.5 ECOLOGICAL RESOURCES

This section provides a description and characterization of the terrestrial and aquatic ecosystems potentially affected by the proposed construction and operation of the facility within the site.

3.5.1 Offsite Areas

The site is located within the Southern Limestone/Dolomite Valley and Low Rolling Hills level IV ecoregion. This is a heterogenous area comprised mainly of limestone and cherty dolomite. Major landforms are rolling ridges and valleys with soils of varying productivity. The area includes urban and industrial areas as well as extensive areas used for agriculture and forestry (Reference 1).

3.5.2 Site and Near-Site Areas

The site encompasses mainly open space containing mowed fields, roads, and concrete foundations remaining from the buildings and other structures demolished and removed from the area (see Figure 1.1-1). A narrow band of riparian forest is present within the site boundary along Poplar Creek, and small areas of upland forest are present at the north and east end of the site. Because of its industrial history, the site generally provides poor-quality habitat for ecological receptors compared to the extensive, naturally vegetated areas in other parts of the ORR. The site is likely to be used principally by common species that adapt well to human disturbance (Reference 2). Vegetation within the surrounding, near-site areas of the ETTP includes a mixture of mowed grasses with a few shrubs and trees (especially around buildings), small areas of mixed tree/shrub/grass associations, or mixed evergreen-deciduous vegetation. Many of the shrubs and trees in the landscaping are native species. Additionally, native species are often found in areas around ponds and along waterways.

Poplar Creek adjoins the site and flows approximately 2,040 feet (622 meters) along the eastern and southern boundary of the site. Downstream, Poplar Creek joins the Clinch River arm of Watts Bar Reservoir at CRM 12. There are no surface streams draining the site, and stormwater from most of the site runs off as overland sheet flow directly to Poplar Creek. Stormwater is also discharged to Poplar Creek through storm drains. In the westernmost part of the site, runoff and storm drains also discharge to the K-901-A Holding Pond, which drains to the Clinch River arm of Watts Bar Reservoir (Reference 3).

3.5.3 History

The site is the location of the former ORGDP where uranium enrichment operations occurred at the K-31 and K-33 gaseous diffusion cascade facilities. Poplar Creek bisects the general area, with facilities east of Poplar Creek supporting the original Manhattan Project (i.e., K-25), and facilities west of Poplar Creek supporting the later uranium enrichment processes. Prior to construction of the ORGDP, the area land use was a combination of cultivated fields and pastures with scattered wooded areas (Reference 4). When the ORGDP was active, the former K-31 and K-33 facilities mainly produced enriched uranium using the gaseous diffusion process. Portions of the area were also used for the distribution of electricity to power the uranium enrichment operations and for pumping and treatment of recirculated cooling water (Reference 4).

In 1951, the K-31 building began operations utilizing control rooms, shops, and equipment for the enrichment process. The K-33 building began its operations in 1954 as the last and largest cascade building constructed at ETTP. Enrichment operations were discontinued in 1985, and the K-31 and K-33 buildings were shut down. From 1998 to 2005, the buildings were decontaminated, and process equipment was removed. Portions of the buildings were then used for hazardous waste storage. Demolitions of the K-31 and K-33 buildings, and slab removal, were completed in 2015 and 2011, respectively. The former footprints of both buildings were covered with soil, seeded with grass, and are mowed on a routine basis during the growing season (Reference 4). Associated facilities located

immediately east of the K-33 and K-31 buildings, including the K-862 and K-892 pumphouses and the K-861 and K-892-G/H cooling towers and basins, also have been demolished and covered with soil and vegetation. The original topography of the site prior to construction of the facilities has not changed and remains relatively flat over most of the area (Reference 3).

3.5.4 Places and Entities of Special Interest

The lands of the ORR that encompass the site have had long-term environmental protection. The biological richness of the area combined with the available research capability and proximity of diverse scientific expertise has resulted in state, regional, national, and international designations. Environmental protection areas in the vicinity of the site include the following:

- Oak Ridge Wildlife Management Area (WMA): The entire ORR is a Tennessee Wildlife Management Area through an agreement between DOE and Tennessee Wildlife Resources Agency (TWRA). The agreement provides for protection of wildlife habitat and species (including several threatened and endangered species) and restoration of other wildlife habitat and species (Reference 5).
- Black Oak Ridge Conservation Easement (BORCE): The BORCE is a 3,000-acre area located in the northwestern part of the ORR. Its boundary is immediately north of the site (see Figure 3.5-1). The BORCE was placed in a conservation easement in April 2005. TWRA manages the land in accordance with a plan developed jointly by the TDEC and TWRA, with input from the public (Reference 6).

3.5.5 Aquatic Communities and Potentially Affected Water Bodies

The site is situated adjacent to Poplar Creek, which is a tributary to the Clinch River arm of Watts Bar Reservoir. The site is approximately 3 miles upstream of where Poplar Creek joins the reservoir. The Watts Bar Reservoir was created in 1942 when the TVA completed the Watts Bar Dam at TRM 529.9. The dam impounded the portion of the Clinch River that flows past Poplar Creek and the ETTP. The site is approximately 4 miles upstream of the mouth of Poplar Creek, and the reach of Poplar Creek adjacent to the site is also impounded (Reference 7). TVA's Melton Hill Dam, constructed in 1963, is located on the Clinch River approximately 11 river miles upstream of the mouth of Poplar Creek, and it also affects the flow in the Clinch River arm of Watts Bar Reservoir near the site.

Other aquatic habitats in the vicinity of the site include wetlands and holding ponds. The ecological characteristics of these potentially affected water bodies are described below, and wetlands are discussed in Section 3.5.6.

3.5.5.1 Clinch River arm of Watts Bar Reservoir

The Clinch River arm of Watts Bar Reservoir is approximately 0.25 miles southwest of the site at its closest point. The construction of dams upstream on the Clinch River (Norris Dam and Melton Hill Dam) and downstream on the Tennessee River (Watts Bar Dam) have substantially altered the aquatic community compared to the community that existed historically in the river when it was free flowing. The dams resulted in, for example, riverine habitat loss and fragmentation, temperature alteration, changes to the natural flow, changes in water level and quality, and increases in heavy metals (Reference 8 and Reference 9).

The Clinch River arm of Watts Bar Reservoir is assessed periodically, usually every 2 years, under TVA's reservoir ecological health monitoring program. Ecological health evaluations in 2018 assessed the Clinch River arm of Watts Bar Reservoir at the inflow location at CRM 19 to 22. This location received a rating of "good" for the fish assemblage and "fair" for the benthic macroinvertebrate community. These ratings contributed to the overall rating of "fair" for Watts Bar Reservoir (Reference 10). The Clinch River arm of Watts Bar Reservoir has been listed by the state of Tennessee as water-quality impaired due to the presence of mercury, PCBs, and chlordane (Reference 11).

Studies were conducted in 2011 on the fish, benthic macroinvertebrate, and plankton communities in the Clinch River arm of Watts Bar Reservoir upstream of the mouth of Poplar Creek, which is at CRM 12. These studies were done as part of a biological monitoring effort to characterize the aquatic community near the proposed CRN site upstream of Poplar Creek and the site. The two sampling locations extended from CRM 14 to 16 and from CRM 18 to 19.8, which are 2 river miles and 7.8 river miles, respectively, upstream from the mouth of Poplar Creek (Reference 12).

3.5.5.1.1 Fish Community

The construction of dams along the Clinch River and Tennessee River have substantially altered the natural riverine environments and the associated aquatic communities in the portions now impounded by reservoirs. A study conducted in 1968 after the Melton Hill Dam was constructed noted a decrease in nongame fish species (Reference 13). TVA conducted field studies in 2011 in the Clinch River arm of Watts Bar Reservoir to characterize the fish community in the vicinity of the proposed CRN site during winter, spring, summer, and fall. The studies were conducted within two 2-mile-long river segments centered at approximately CRM 18.5 and CRM 15, which are about 3.5 and 6 miles upstream from the mouth of Poplar Creek. Given the proximity of these studies to the site and the similarity of habitats in these segments to the reach of the Clinch River arm of Watts Bar Reservoir near the site, the characteristics of the fish community at these locations are expected to be similar (Reference 12).

In the 2011 fish community study, TVA used a fishery monitoring tool it previously developed, the Reservoir Fish Assemblage Index (RFAI), to characterize the fish community of the Clinch River arm of Watts Bar Reservoir in the vicinity of the CRN site. Sampling by electrofishing and gill netting was conducted in February, May, July, and October of 2011 to document variation in the fish community by season. The data were analyzed using RFAI methodology, which provides a balanced evaluation of fish community integrity based on 12 community metrics from four general categories: species richness (numbers of species) and composition; trophic composition; abundance; and fish health. The overall RFAI scores resulted in an ecological health rating for the fish community of “fair” for all seasons at the downstream location and all seasons at the upstream location except spring, when the rating was “good.” Although catch rates were low, species diversity was relatively high at both locations. Averages of 33 (28 indigenous) and 36 species (31 indigenous) fish species were collected at the downstream and upstream locations, respectively. Approximately 85 to 86 percent of the species collected were considered indigenous. The survey collected 34 recreationally valuable and 23 commercially valuable fish species. Recreationally valuable species are typically fish that are used for bait or sought by anglers. Commercially valuable species are fish that can be legally harvested using commercial fishing methods to sell for bait, roe, or meat (Reference 12).

Water intake structures have the potential to entrain ichthyoplankton (fish eggs and larvae), which could impact fish species numbers. Therefore, ichthyoplankton samples were also collected during the 2011 fish community studies (Reference 12). Data on the temporal occurrence, composition, and abundance of ichthyoplankton were collected at the two fish sampling locations. Sampling was conducted to characterize the seasonal spawning activity of the fish in this area. The total number of fish eggs and larvae collected were 7,814 and 3,949, respectively. Freshwater drum (Sciaenidae) made up the majority of eggs collected, followed by shad (Clupeidae) and temperate basses (Moronidae). Clupeids made up the majority of fish larvae collected, followed by suckers (Catostomidae), temperate basses, and sunfishes (Centrarchidae). A larval paddlefish was collected at CRM 18 during the survey. The paddlefish eggs are highly valued, and the paddlefish fishery has been of concern and closely monitored. The presence of this single larva demonstrated that minimal spawning of this species is occurring in the Clinch River arm of Watts Bar Reservoir (Reference 12).

TDEC has issued fish consumption advisories for Watts Bar Reservoir. These advisories are due to concentrations of PCBs in fish tissues, resulting in consumption limitations for catfish and sauger of one meal per month, and the recommendation that striped bass should not be eaten (Reference 14).

3.5.5.1.2 Benthic Macroinvertebrate Community

TVA and others have surveyed mussels along CRM 14 through 20 (Reference 12 and Reference 15) which is a few miles upstream from the site. The findings from these surveys and studies indicated that the ecosystem in that area supported a low abundance and species richness for mussels. It has been hypothesized that the construction of Melton Hill Dam, Norris Dam, and Watts Bar Dam, and the presence of contaminants from ORNL have been contributing to the poor mollusk community and habitat status (Reference 16). In the past, one of the more comprehensive surveys conducted on the lower Clinch River at CRM 15 through 17 found seven common and reservoir-tolerant mussel species. These findings were low compared to the 20 species of freshwater mussels found at 63 sites along the entire lower Clinch River (Reference 15).

In addition to fish community studies, TVA also conducted field studies during spring, summer, and fall in 2011 in the Clinch River arm of Watts Bar Reservoir to characterize the benthic macroinvertebrate community in the vicinity of the proposed CRN site. The studies were conducted at two transect locations at approximately CRM 18.8 and CRM 15, which are about 3.5 and 6 miles upstream from the mouth of Poplar Creek (Reference 12). Given the proximity of these studies to the site and the similarity of habitats in these segments to the reach of the Clinch River arm of Watts Bar Reservoir near the site, the characteristics of the benthic macroinvertebrate community at these locations are expected to be similar.

TVA assessed the benthic macroinvertebrate community using its Reservoir Benthic Index (RBI) methodology. RBI is used to assess relative conditions of benthic communities at selected locations within TVA reservoirs. Benthic community results were evaluated using seven metrics. Results for each metric were assigned a rating of 1 (poor), 3 (good), or 5 (excellent), depending on how they scored based on reference conditions developed for Tennessee River reservoir inflow sample sites. The ratings for the seven metrics were then summed to produce a benthic score for each sample site. Potential benthic scores ranged from 7 to 35. Ecological health ratings were then assigned based on the scores. Overall, the RBI scores were high, and the ecological health rating was good to excellent. The data were considered to indicate an ecologically healthy benthic macroinvertebrate community in the reservoir near the CRN site. However, the presence of high densities of zebra mussels was considered a concern because it indicated a potential for biofouling issues (Reference 12).

In addition to its 2011 RBI assessment of the benthic macroinvertebrate community at the CRN site, TVA also conducted an evaluation in 2011 that focused on the freshwater mollusk community of the reservoir adjacent to the CRN site. The 74 live mussels collected in the study comprised six species: pimpleback (*Quadrula pustulosa*), fragile papershell (*Leptodea fraglilis*), purple wartyback (*Cyclonaias tuberculate*), pink heelsplitter (*Potamilus alatus*), giant floater (*Pyganodon grandis*), and elephant ear (*Elliptio crassidens*). Shell remains of dead mussels (relics) of three endangered species were also documented: dromedary pearlymussel (*Dromus dromas*), fanshell (*Cyprogenia stegaria*), and spectaclecase (*Cumberlandia monodonta*). Other species that were also found only as shell remains were the black sandshell (*Ligumia recta*), butterfly (*Ellipsaria lineolata*), fluted kidneyshell (*Ptychobranchus fasciolaris*), longsolid (*Fusconaia subrotunda*), mucket (*Actinonaias ligamentina*), Ohio pigtoe (*Pleurobema cordatum*), pocketbook (*Lampsilis ovata*), pyramid pigtoe (*Pleurobema rubrum*), rabbitsfoot (*Quadrula cylindrica*), and round hickorynut (*Obovaria subrotunda*). Zebra mussels, which are non-native, invasive species, were abundant and infested (attached to) 96 percent of the live mussels collected (Reference 16).

The mussel survey concluded that the mussel community at the CRN site was in poor condition. Historical declines in the numbers of species present in the Clinch River arm of Watts Bar Reservoir in the vicinity of the CRN site supported the conclusion that habitat conditions to support mussels are generally inadequate, despite improvements in reservoir releases from Melton Hill Dam and Watts Bar Dam that began in 1991. The decline in numbers since 1982 was estimated to be approximately 60 percent. In addition, no evidence of recent mussel reproduction was found in the 2011 survey, because no juvenile mussels were found and individuals 15 years old or older were common (Reference 16).

3.5.5.1.3 Plankton Community

The 2011 TVA studies also investigated the plankton community in the Clinch River arm of Watts Bar Reservoir approximately 4 miles upstream of the mouth of Poplar Creek (Reference 12). Due to the proximity, these findings are likely similar to those that would be found in the Clinch River arm of Watts Bar Reservoir near the mouth of Poplar Creek. Plankton are drifting organisms that make up the base of the aquatic food chain and support higher-trophic-level organisms. Plankton include phytoplankton (algae), zooplankton (small animals and larval stages of larger animals), bacterioplankton (bacteria and single-celled organisms without a defined nucleus), and protists (organisms with a cell nucleus that is not animal, plant, or fungus) (Reference 12).

Chlorophyll a concentrations were measured, and the phytoplankton community was characterized during the 2011 survey. It was concluded that there were low concentrations of chlorophyll a, indicating limited phytoplankton growth, attributed to low light levels due to the turbulence of the water. The following plankton taxa and percentage of the assemblage of samples: 32 taxa of chlorophytes/green algae (90-99 percent across samples), 17 taxa of bacillariophytes/diatoms (>2 percent across samples), 16 taxa of cyanophytes/photosynthetic bacteria (>2 percent across samples), eight taxa of chrysophytes/golden-brown algae (approximately 1percent across samples), two taxa of cryptophytes/algae with two flagella for swimming (approximately 1 percent across samples), three taxa of euglenophytes/flagellate alga of the genus *Euglena* (>1 percent across samples), and three taxa of pyrrophytes/dinoflagellates (>1 percent across samples). Abundances of these organisms were noted to decrease during the fall because of decreases in light concentrations, nutrients, and water temperatures (Reference 16).

During the same 2011 survey, zooplankton were also collected and identified to various taxonomic groups. Eight taxa of cladocerans, seven taxa of rotifers, and three taxa of copepods were collected. Overall, zooplankton abundance was low and variable. Densities of zooplankton were noted to increase in the spring, peak in July, and decrease through December. Biomass of zooplankton community samples was generally low except during peak density months (June and July), which were associated with increased temperatures and low flow of the river. It was concluded that zooplankton communities had low abundance and diversity throughout the sampling area due to the high-water turbulence (Reference 16).

3.5.5.1.4 Aquatic Invasive Species

Aquatic invasive species are species that are non-native and are likely to cause environmental or economic harm. Invasive species can also be referred to as alien, exotic, non-indigenous, nuisance, or undesirable species (Reference 17). TVA has identified the common carp (*Cyprinus carpio*), grass carp (*Ctenopharyndogon idella*), alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), rusty crayfish (*Orconectes rusticus*), Asiatic clam, and zebra mussel as invasive species within the Tennessee Valley that pose the greatest threat to native species and aquatic community balance (Reference 18). The Asiatic clam and zebra mussel were confirmed to occur in the Clinch River arm of Watts Bar Reservoir during sampling conducted by TVA in 2011 (Reference 12). The Asiatic clam and zebra mussel

are hypothesized to be the most problematic as they contribute to the biofouling of water intake systems and could disrupt flow for facility intake or discharge structures. TVA has monitoring and eradication programs for these species at generating facilities, including chemical and heated-water treatments. Other impacts from nuisance species include effects on fishing and mussel harvesting and declines in native species due to predation or competition (Reference 17).

3.5.5.2 Poplar Creek

Poplar Creek borders the eastern and southern boundaries of the site and is considered the largest drainage basin on the ORR. Poplar Creek receives drainage from a 136 mi^2 watershed and conveys it to the Clinch River arm of Watts Bar Reservoir. Most of the Poplar Creek watershed is outside the ORR. East Fork Poplar Creek is a major tributary to Poplar Creek that drains 30 mi^2 of the western and northern ORR, including the City of Oak Ridge and the Y-12 National Security Complex (Reference 19).

East Fork Poplar Creek is a 4^{th}-order stream that enters Poplar Creek approximately 2 miles upstream of the site. Benthic invertebrate and fish diversity in East Fork Poplar Creek has been documented to be high. In 2011, 60 species were identified, including the Tennessee dace, spotfin chub, redline darter, blueside darter, and dusky darter. Other fish species documented were the carp, grass carp, and alewife (Reference 19). Monitoring of Lower East Fork Poplar Creek has been conducted to measure the concentration and mass flux of mercury discharged from the Upper East Fork Poplar Creek watershed, which originates from the Y-12 Complex (Reference 20).

Poplar Creek joins the Clinch River at CRM 12. The portion of Poplar Creek adjacent to and extending upstream of the site is impounded by the Watts Bar Reservoir dam. The aquatic community of the reach of Poplar Creek adjacent to and downstream of the site likely would be much more similar to the aquatic community of the Clinch River arm of Watts Bar Reservoir, described above, than to the free-flowing, upper reaches of the creek.

The monitoring of contamination in Poplar Creek continues to demonstrate decreases in the concentrations of PCBs in fish tissues since the late 1980s. Around 2010, channel catfish exhibited PCBs below fish advisory levels, but larger fish, such as the striped bass, have demonstrated higher levels of PCBs. Mercury also has been a concern, and fish have been monitored as part of an effort to determine the influence of mercury sources from East Fork Poplar Creek. The highest levels of mercury have been noted in fish from Poplar Creek, and levels decrease as distance downstream increases (Reference 21). TDEC has issued fish consumption advisories for the Poplar Creek embayment, where Poplar Creek joins the Clinch River arm of Watts Bar Reservoir, and upstream in Poplar Creek. Fish caught from Poplar Creek should not be eaten due to concentrations of mercury and PCBs (Reference 14).

3.5.5.3 K-901 Holding Pond

The K-901-A Holding Pond lies approximately 700 feet west-southwest of the site boundary at its closest point (see Figure 2.2-1). This area was assessed in a 2005 habitat-value assessment. From 1965-1966, the holding pond was constructed by installing a weir between wetlands and the Clinch River arm of Watts Bar Reservoir. This holding pond received chemicals and served to dispose of cylinders. The pond also received oil from the storm drain systems. In 1977, the holding pond was drained, and contents (cylinders, debris, and fish) were removed. After the draining, the pond was refilled with water from a natural high-water event. At the time of sampling in 2005, the pond had a maximum depth of approximately 10 feet and covered about 17 acres, which includes the adjacent wetlands to the north and southeast. The findings from the 2005 assessment indicated that the pond had a high-quality nearshore habitat zone, medium habitat value for waterfowl and fish, low numbers of sensitive fish species, and a high degree of riparian cover compared to other ETTP environments. The pond has

shallow embayments with wetlands, providing a high-value habitat for amphibians, which was confirmed by the large numbers of frogs observed. Few fish were observed in the pond (Reference 22).

Monitoring of the pond is being conducted to assess the establishment of aquatic vegetation and fish species diversity. Monitoring is also being conducted to determine if PCB concentrations in fish are below risk-based levels protective of human health (Reference 11). In 2021, monitoring results determined that mean PCB concentrations were above protective target concentrations in carp and below protective target concentrations in bluegill (Reference 20).

3.5.6 Wetlands

Wetlands have high ecological value and are regulated by federal and state agencies. Wetlands are defined by the United States Army Corps of Engineers (USACE) as areas "inundated or saturated by surface or ground water 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" (Reference 23). Wetlands perform important functions, such as support of aquatic species and wildlife diversity/abundance, flood flow alteration, stabilization of sediments, retention of sediment and toxicants, transformation of nutrients, and production export (Reference 24).

The main goal of the federal Clean Water Act is to maintain and restore the biological, chemical, and physical integrity of the Nation’s waters, including wetlands. Sections 401 and 404 of the Clean Water Act provide regulatory protection for wetlands and the regulation of discharge of dredged and fill material into waterbodies (Clean Water Act 1972). Furthermore, Executive Order 11990 mandates that all federal agencies must minimize the destruction, loss, or degradation of wetlands when carrying out the agency’s responsibilities. Federal agencies must also preserve and enhance the natural and beneficial values of wetlands. Prior to performing certain activities in wetlands, a Section 404 permit from the USACE may be required depending on wetland size and hydrologic connectivity to a navigable waterway. Section 401 provides states with the ability to verify whether activities allowed under Section 404 are compliant with state water quality standards (Reference 25).

TDEC is responsible for protecting wetlands of the state of Tennessee. Specifically, the Division of Water Resources requires that an Aquatic Resource Alteration Permit be obtained for any activity that may alter a wetland or other water body (Reference 2 and Reference 26). TDEC and the USACE jointly regulate wetlands-related activities. If any portion of transferred property within the ETTP is determined by the Nashville District USACE to be jurisdictional wetlands, development activities would need to comply with the USACE wetlands construction restrictions contained in 33 CFR Sections 320 through 330, as amended, and any other applicable federal, state, or local wetlands regulations (Reference 2).

The site encompasses approximately 185 acres, the majority of which historically have been intensively developed for industrial use. The only wetland on the site occurs within the floodplain along the shoreline of Poplar Creek at the south end of the site. This wetland, as well as four other wetlands in the vicinity of the site, are described below and shown in Figure 3.5-2. The descriptions of these five wetlands below are based on surveys conducted in the summer of 1994 to identify wetlands in the ETTP area (Reference 24). The wetlands lie within existing 100-year and 500-year floodplains (Reference 2).

Wetland 1 (W01) occupies 0.77 acres on the opposite bank of the upstream portion of Poplar Creek, across from the northeast side of the site. A backwater inlet, mudflats, and alluvial sands are present in the palustrine emergent persistent and palustrine scrub-shrub broad-leaved deciduous wetlands in this area. Dominant vegetation includes box elder, green ash, sycamore, red maple, smooth alder, silky dogwood, buttonbush, jewelweed, bugleweed, rice cut-grass, potato-bean, spotted water hemlock, creeping jennie, late-flowering thoroughwort, smartweed, joe-pye weed, spreading dayflower, and sedges (Reference 24).

Wetland 2 (W02) is a small, forested wetland within the floodplain of Poplar Creek on the southeast portion of the site. It consists of approximately 2 acres of riparian forest. This wetland was identified as atypical in 1994 because the wetland demonstrated dominant hydrophytic vegetation and wetland hydrology evidence but lacked hydric soil characteristics. The area was classified as a wetland due to its floodplain function. The soil was well-drained and had sandy silt loams that had not developed hydric soil characteristics (Reference 24). The dominant vegetation included American elm, box elder, green ash, hackberry, sycamore, wingstem, jewelweed, privet, false nettle, green dragon, smartweed, spotted water hemlock, and cardinal flower. In addition to the floodplain that has been described, there are wetlands present on two alluvial islands within Poplar Creek and mudflats that are seasonally flooded that separate the islands from the land. Different vegetation has been recorded in these areas, including box elder, green ash, black willow, ironweed, buttonbush, false nettle, hog peanut, potato-bean, joe-pye weed, Virginia wild-rye, and creeping jennie (Reference 24).

Wetland 3 (W03) is located on the opposite bank of Poplar Creek south of the site and lies on a floodplain that has been previously disturbed between the Perimeter Road bridge and the Avenue South bridge. This wetland occupies about 3.5 acres. Vegetation includes cottonwood, sycamore, green ash, box elder, joe-pye weed, cardinal flower, false nettle, greenbriar, Virginia wild-rye, mistflower, American potato-bean, Frank's sedge, jewelweed, and many other species of sedge. Flowing or ponding water was indicated by drainage patterns and the presence of water-stained leaves (Reference 24).

Wetland 4 (W04) is located near the water tower and in the Poplar Creek floodplain on the opposite bank from the south end of the site and southwest of Wetland 3. This wetland occupies about 1.9 acres. In previous studies, this area has been identified as an atypical situation due to the effects of human activities and natural events causing the wetland to not meet the three wetland criteria. This wetland displayed evidence of wetland hydrology and dominant hydrophytic vegetation: however, it lacked hydric characteristics. The soils were well-drained and had very sandy silt loams that had not developed hydric soil within the top 10 inches of the soil profile. This area was documented as a wetland and critical environment due to its floodplain functions, which could attenuate stormwater runoff and remove particulates and contaminants. Vegetation documented included box elder, American elm, hackberry, green ash, sycamore, wingstem, privet, jewelweed, green dragon, smart weed, false nettle, cardinal flower, and spotted water hemlock (Reference 24).

Wetland 5 (W05) is located to the west of the site, between the site and the Clinch River arm of Watts Bar Reservoir. This wetland consists of two areas in the north and south ends of the previously remediated K-901-A Holding Pond. The total area of Wetland 5 is approximately 9 acres (Reference 24). Vegetation was surveyed in 1994, when willow and buttonbush were documented to be the dominant vegetation in the northern portion. The southern portion has emergent wetland and open-water areas, and beaver activity was noted. In 1994, vegetation in the south portion included black willow, sycamore, beggar-tick, cutgrass, and false indigo-bush (Reference 24). Biologists conducted field surveys on June 16, 2021, which included surveying the edge of the southern end of this wetland. Dominant vegetation in this area currently includes American sycamore, black willow, honey locust, marsh-mallow, lanceleaf fogfruit, saw grass, goldenrod, and Pennsylvania smartweed.

3.5.7 Terrestrial Communities

The site is located within the ORR, which encompasses approximately 24,000 acres of forest, much of which is in large, continuous tracts (Reference 27). Forests and other habitats of the ORR support many terrestrial animal species, including approximately 213 bird species, 69 reptile and amphibian species, 49 mammal species, and numerous invertebrate species (Reference 5).

The site is in the Ridge and Valley level III ecoregion, which is characterized by parallel ridges and valleys dominated by limestone, dolomite, shale, siltstone, sandstone, chert, mudstone, and marble geological formations, as well as numerous springs and caves (Reference 1). Within the Ridge and Valley ecoregion, the site is in the Southern Limestone/Dolomite Valleys and Rolling Hills level IV ecoregion. Land cover in the Ridge and Valley Ecoregion includes areas of intensive agriculture, urban and industrial areas, and thick forests. Agriculture in this ecoregion is dominated by pastures on the steeper sloped areas and small fields in the bottom land. The forests are characterized as white oak forest, bottomland oak forest, sycamore-ash-elm riparian forest, chestnut oak forest, and mixed mesophytic forest. Also present are areas of grassland barrens, including cedar-pine glades (Reference 28).

As discussed in Section 1.1, the area of the ETTP where the site would be located is within an area that was first used to serve as the site of the Manhattan Project. During the Cold War, additional uranium enrichment facilities were built, including the K-33 and K-31 facilities that were located within the area now proposed for the site. K-33 and K-31 were added to produce low enriched uranium for nuclear power plant fuel. In 1987, Building K-33 was placed in permanent shutdown. Equipment removal and decontamination of Buildings K-33 and K-31 were conducted between 1997 and 2005. Demolition of Building K-33 was completed in 2011, and demolition of Building K-31 was completed in 2015. Following demolition, the cleared sites were revegetated with a mix of grasses and herbaceous vegetation to cover and stabilize the soil until future development of these brownfield sites within the ETTP.

The terrestrial ecological communities currently existing on and adjacent to the site reflect the effects of the area's history. The natural communities of the area have been modified by development and industrial use over many decades, followed by demolition and revegetation. The impacts to plant communities have in turn affected the habitats available to animal communities. Many surrounding areas of the ETTP and the ORR have been similarly impacted by historical development, and the species present on the site are expected to be similar to those surveyed and documented to occur in those areas. The CRN site, which is located on the Clinch River arm of Watts Bar Reservoir approximately 3 miles south of the site, was formerly cleared for development and currently is proposed for use as a small modular reactor facility. The species composing the vegetation and animal communities of the proposed CRN site were recently surveyed (Reference 29) and provide an indication of the species likely to occur in comparable habitats on the nearby site.

3.5.7.1 Plant Communities

The site covers approximately 185 acres, of which approximately 97 acres are vegetated. The remaining 88 acres are developed and covered by pavement, buildings and other structures, or the foundations and other remnants of buildings that have been demolished and removed (see Figure 3.1-1). The vegetation on the site comprises three community types. These communities and their approximate acreages within the site are the following:

- Herbaceous/grassland (72 acres)
- Deciduous forest (19 acres)
- Mixed evergreen/deciduous forest (6 acres)

As a result of historical development and industrial use, the site is predominantly covered by an herbaceous vegetation community of grasses and forbs associated with highly disturbed areas and consisting of species typical of primary and early secondary succession. The dominant vegetation expected to occur in this community includes various grasses and forbs. Species observed include goldenrod (*Solidago* spp.), ironweed (*Vernonia* sp.), Canada thistle (*Cirsium arvense*), blackberry (*Rubus* spp.), broomsedge (*Andropogon virginicus*), milkweed (*Asclepias* sp.), fescue grass (*Festuca* spp.), Johnson grass (*Sorghum halepense*), sericea lespedeza (*Lespedeza cuneata*), common asters

(Asteraceae), sweet clover (*Melilotus officinalis*), and yellow hop clover, red clover, and white clover (*Trifolium* spp.). Species that have been recorded in similar communities in the vicinity of the site (at the CRN site and within the ORR) also include black-eyed Susan (*Rudbeckia hirta*), Queen Anne's lace (*Daucus carota*), tickseed (*Coreopsis grandiflora*), and other common forbs. During a site visit in June 2021, vegetation that was observed included goldenrod, horse nettle (*Solanum carolinense)*, field clover (*Trifolium campestre),* broom- sedge*,* eastern red cedar (*Juniperus virginiana), and* Russian olive (*Diospyros virginiana).*

In addition to the extensive herbaceous community on the site, relatively small areas of forest communities are present in previously undeveloped areas. At the north end of the site are stands of mixed evergreen/deciduous forest containing loblolly pine (*Pinus taeda*), eastern red cedar (*Juniperus virginiana*), hackberry (*Celtis occidentalis*), chinkapin oak (*Quercus muehlenbergii*), American elm (*Ulmus americana*), osage orange (*Maclura pomifera*), persimmon (*Diospyros virginiana*), and autumn olive (*Elaeagnus umbellata*). Along Poplar Creek, deciduous riparian and wetland forest contains northern red oak (*Quercus rubra*), American sycamore (*Platanus occidentalis*), tuliptree (*Liriodendron tulipifera*), sugar maple (*Acer saccharum*), chinkapin oak, sassafras (*Sassafras albidum*), redbud (*Cercis canadensis*), hackberry, and eastern red cedar, with an understory of autumn olive, American holly (*Ilex opaca*), Carolina buckthorn (*Rhamnus caroliniana*), and Chinese privet (*Ligustrum sinense*). Other common trees and shrubs likely to occur include black willow (*Salix nigra*), box elder (*Acer negundo*), persimmon, silky dogwood (*Cornus amomum*), and multiflora rose (*Rosa multiflora*). Herbaceous species in this deciduous forest community may include netted chain fern (*Woodwardia areolata*), jewelweed (*Impatiens capensis*), lizard tail (*Saururus cernuus*), rose mallow (*Hibiscus* sp.), and various grasses, rushes, and sedges.

As shown in Figure 3.5-1, the areas surrounding the site are within the ORR. The areas to the east, south, and west of the site are predominantly developed, with buildings, roads, railways, and mowed fields that provide minimal habitat. The opposite bank of Poplar Creek supports a narrow band of riparian, deciduous forest. Areas to the north and west of the site are within the BORCE, which includes over 3,000 acres of mostly forest. The conservation easement is managed by the TWRA, in conjunction with TDEC and DOE, predominantly as a wildlife management area for hunting and hiking (Reference 30). To the southwest between the site and the Clinch River arm of Watts Bar Reservoir are forest fragments separated by open areas of herbaceous vegetation, emergent wetlands, and a pond (K-901-A Holding Pond). Immediately north of the site, forest has been fragmented by clearing for roads and transmission line ROWs.

3.5.7.2 Animal Communities

3.5.7.2.1 Mammals

The mammal species likely to occur within the site is limited due to the historical, intensive industrialization of the site and the relatively recent demolition of buildings and the establishment and maintenance of herbaceous vegetation. Mammalian species that are common in similar habitats of the surrounding environment of the ORR are expected to be representative of the species that may occur on or near the site. Mammals that have been observed in similar habitats of the surrounding areas, such as the CRN site, and could occur on the site, are common species that are regionally abundant. These include the white-tailed deer (*Odocoileus virginianus*), coyote (*Canis latrans)*, red fox (*Vulpes vulpes*), eastern gray squirrel (*Sciurus carolinensis*), eastern chipmunk (*Tamias striatus*), eastern cottontail (*Sylvilagus floridanus*), raccoon (*Procyon lotor*), Virginia opossum (*Didelphis virginiana*), and short-tailed shrew (*Blarina brevicauda*). Other mammals likely to occur in the open field habitats on the site include the hispid cotton rat (*Sigmodon hispidus*), eastern harvest mouse (*Reithrodontomys humulis*), and striped skunk (*Mephitis mephitis*). Mammals that may occur in the riparian forest, wetlands, and/or

waters of Poplar Creek and the Clinch River arm of Watts Bar Reservoir near the site include the beaver (*Castor canadensis*), muskrat (*Ondatra zibethicus*), and mink (*Neovison vison*).

3.5.7.2.2 Birds

Numerous species of birds have been reported from locations in the vicinity of the site. Species typical of open field habitats such as those on and near the site include the American crow (*Corvus brachyrhynchos*), northern mockingbird (*Mimus polyglottos*), killdeer (*Charadrius vociferus*), eastern meadowlark (*Sturnella magna*), and common grackle (*Quiscalus quiscula*).

Bird species typical of forest habitats in the vicinity and likely to occur in the forest areas on and near the site include the blue jay (*Cyanocitta cristata*), Carolina chickadee (*Poecile carolinensis*), Carolina wren (*Thryothorus ludovicianus*), tufted titmouse (*Baeolophus bicolor*), pileated woodpecker (*Dryocopus pileatus*), red-bellied woodpecker (*Melanerpes carolinus*), wild turkey (*Meleagris gallopavo*), barred owl (*Strix varia*), red-shouldered hawk (*Buteo lineatus*), Cooper's hawk (*Accipiter cooperii*), ruby-throated hummingbird (*Archilochus colubris),* yellow-billed cuckoo (*Coccyzus americanus*), red-eyed vireo (*Vireo olivaceus*), chuck-wills widow (*Caprimulgus carolinensis*), and whip-poor-will (*Caprimulgus vociferus*). During a field survey of the site in June 2021, a pair of American kestrels (*Falco sparverius*) was observed on a tower at the northwest corner of the site.

Bird species likely to occur along Poplar Creek include the great blue heron (*Ardea herodias*), green heron (*Butorides virescens*), belted kingfisher (*Megaceryle alcyon*), wood duck (*Aix sponsa*), and Canada goose (*Branta canadensis*). During a field survey of the site in June 2021, an osprey (*Pandion haliaetus*) nest was observed on a pole at the bridge over Poplar Creek near the northeast corner of the site. A forested wetland at the south end of the site has been referred to as the Lower Poplar Creek Rookery due to its use in some years as a nesting colony for herons. Another forested wetland area on Poplar Creek to the northeast of the site, referred to as the Upper Poplar Creek Rookery, also has been used in some years as a heron nesting site (Reference 31). During a field survey of the site in June 2021, no rookeries or other signs of herons were present in these areas.

3.5.7.2.3 Reptiles and Amphibians

Reptiles that potentially could occur at the site, which were observed on the proposed CRN site nearby, include the corn snake (*Elaphe guttata*), Cumberland slider (*Trachemys scripta troostii*), and common snapping turtle (*Chelydra serpentina*). Amphibians that potentially could occur at the site, which were observed on the proposed CRN site, include the gray treefrog (*Hyla versicolor*), American toad (*Bufo americanus*), green frog (*Rana clamitans*), pickerel frog (*Rana palustris*), and eastern narrow-mouthed toad (*Gastrophryne carolinensis*).

3.5.8 Invasive Species

The historical development of the site and the ETTP, as well as many other areas of the ORR, have allowed the establishment of non-native, invasive species, particularly in areas where native communities have been disturbed. Executive Order 13112 defines an invasive species as any species that is non-native to an ecosystem and that when introduced causes or is predicted to cause harm to the ecology, economy and/or human health (Reference 32). Invasive species have the potential to reduce biodiversity by displacing and outcompeting natural floral and faunal populations, reducing effective management practices, degrading wildlife habitats, and permanently altering the environment (Reference 33).

Based on field surveys and review of previously published data on the site and the surrounding ORR environment, 167 non-native, invasive species have been identified on the ORR (Reference 34). The invasive plant species that have been found in Tennessee and may have the potential to be present on

or adjacent to the site can be found in Table 3.5-1. In accordance with the Federal Noxious Weed Act of 1974, the *Invasive Plant Management Plan for the Oak Ridge Reservation* provides additional details on how invasive plants will be managed to reduce their negative impacts on native species and their habitats (Reference 35).

Invasive, non-native, mammals that have been found in Tennessee include the feral pig (*Sus scrofa*), coypu (*Myocastor coypus*), black rat (*Rattus rattus*), brown rat (*Rattus norvegicus*), and house mouse (*Mus musculus*) (Reference 36). According to Parr and Hughes (2006), only the brown rat and house mouse have been observed on the ORR (Reference 27). These two invasive mammal species have the greatest probability of being present on or adjacent to the site.

According to the TWRA, non-native and invasive birds that can be found in Tennessee include the house sparrow (*Passer domesticus*), European starling (*Sturnus vulgaris*), rock pigeon (*Columba livia*), Eurasian collared dove (*Streptopelia decaocto*), Muscovy duck (*Cairina moschata*), Chinese goose (*Anser cygnoides*), and mute swan (*Cygnus olor*) (Reference 37). Based on available habitats, the house sparrow and starling are the non-native birds that have the greatest potential to occur on the site. While typically these species are non-problematic, challenges may arise as these exotic species can alter water body chemistries and aquatic vegetation, build nests in unwanted areas such as vents, and ultimately challenge the existence and distribution of native avian species.

Due to the position of the site near Poplar Creek, the proposed facility also has the possibility of being impacted by non-native, invasive, aquatic species. According to the Tennessee Invasive Plant Council, there are three established and two emerging invasive, aquatic, plant species that occur in state of Tennessee of natural areas (Reference 38). Additionally, the Council has also identified other invasive aquatic plant species, which could pose a threat to the growth of native species within disturbed habitats of Tennessee (Reference 39). The invasive aquatic plant species for natural and disturbed areas are listed in Table 3.5-1.

Non-native, invasive aquatic organisms that may occur within the Clinch River arm of Watts Bar Reservoir and the reach of Poplar Creek near the site include fish, mollusks, and crustaceans. These species are the Asiatic clam (*Corbicula fluminea*), zebra mussel (*Dreissena polymorpha*), rusty crayfish (*Orconectes rusticus),* common carp (*Cyprinius carpo*), grass carp (*Ctenopharyndogon idella*), alewife (*Alosa pseudoharengus),* and blueback herring (*Alosa aestivalis*) (Reference 12, Reference 17, Reference 40, and Reference 29). These species are discussed in Section 3.5.5.1.4.

3.5.9 Procedures and Protocols

In 1989, the DOE formed the Office of Environmental Management (EM) to begin cleanup at the site, and the program has been working since then to transform portions of the site into a privately owned and operated multi-use industrial park. EM's goals for the ETTP are the following:

- Address remaining soil and groundwater contamination
- Complete remaining land transfers from government ownership for future beneficial reuse
- Complete construction on remaining historic preservation facilities specified in the 2012 Memorandum of Agreement
- Transfer long-term stewardship areas to DOE's Office of Legacy Management (Reference 41)

DOE, EPA, and TDEC, signed a Federal Facility Agreement, which establishes the guidelines and milestones for cleanup in Oak Ridge in accordance with the Comprehensive Environmental Response, compensation, and Liability Act and other laws. Species-specific survey protocols could be required as directed through consultations with the USFWS, USACE, TWRA, and/or TDEC prior to work at the

proposed site. Several management practices if implemented would decrease the potential for adverse impacts to ecological resources, including the following practices (Reference 2 and Reference 11):

- Conduct acoustic monitoring according to USFWS guidance to avoid potential disturbance of roosting Indiana and northern long-eared bats (the construction zone should be surveyed for the presence of potential roost trees, and tree removal should not occur between March 31 and November 15 to the extent practical).
- Incorporate stormwater flow and treatment planning in site design so that wetlands and other surface waters are not impacted.
- Use appropriate soil erosion prevention and sediment control measures.
- Plant native vegetation in all disturbed areas after construction is complete.
- Use native species if vegetation is incorporated in short-term erosion control during construction.
- Implement requirements identified by the USFWS during Endangered Species Act consultation.

Historically, the TWRA has been enrolled in a Comprehensive Management Strategy with the USFWS (Reference 42). The ORR Wildlife Ecologist coordinates with TWRA on planned activities to facilitate a variety of wildlife management programs, as directed by the ORNL Natural Resources Manager, DOE Reservation Management Branch Chief, and DOE Reservation Manager or designee (Reference 5).

3.5.10 Studies and Monitoring

3.5.10.1 ORR

The Biological Monitoring and Abatement Program (BMAP) has conducted extensive biomonitoring of aquatic sites within or near the DOE ORR. BMAP projects have ranged from short-term characterization studies to long-term (15+ year) evaluations. Bioaccumulation monitoring has been conducted in Poplar Creek by the BMAP since 1987 to address requirements of the NPDES permits issued by TDEC for the ETTP (Reference 43).

3.5.10.2 ETTP

The ETTP BMAP consists of two tasks designed to evaluate the effects of ETTP legacy operations on the local environment, identify areas where abatement measures would be most effective, and test the efficacy of those measures. These tasks are: (1) bioaccumulation studies, and (2) instream monitoring of biological communities.

Bioaccumulation monitoring for the ETTP BMAP has focused on evaluating the impact of PCB discharges into the environment because of historical operations at the ETTP complex. It was previously assumed that mercury flux into Poplar Creek and the Clinch River originated largely from Y-12 Complex discharges into East Fork Poplar Creek. However, more recent monitoring has shown that water in ETTP storm drains and biota from lower Mitchell Branch (which is located approximately 7 miles northeast of the site in the ETTP) have elevated mercury concentrations, suggesting mercury transport from locations other than Y-12. Mercury bioaccumulation monitoring is routinely conducted in the watersheds adjacent to the ETTP by the Y-12 and ORNL BMAPs, both on and off the ORR. Recent tabular results were provided in the FY 2019 ETTP BMAP Report.

Benthic macroinvertebrate communities in Mitchell Branch are sampled using ORNL and TDEC protocols. Evaluation of long-term trends of macroinvertebrate communities in the stream make it possible to document the effectiveness of pollution abatement activities or remediation efforts as well as to assess the potential consequences of unanticipated events as sitewide remediation continues (e.g., chromium release into Mitchell Branch). The major objectives of the benthic macroinvertebrate assessments are: (1) to help assess the ecological condition of Mitchell Branch, and (2) to evaluate

changes in stream ecology associated with changes in facilities operations and RAs within the Mitchell Branch watershed. To meet these objectives, the condition of the benthic macroinvertebrate community of Mitchell Branch has been monitored routinely since late 1986.

Fish population and community studies are used to evaluate the biotic integrity (or general ecological health) of Mitchell Branch. The fish community is sampled quantitatively at two sites in Mitchell Branch, MIK 0.4 (downstream of SD 190) and MIK 0.7 (downstream of SD 170), and at local reference streams each spring.

Site characterization data was obtained throughout the ETTP under the Dynamic Verification Strategy program. Four types of surveys were performed based on available data regarding site conditions and the level of anticipated contamination. The information collected by the Dynamic Verification Strategy program is documented in exposure unit group technical memoranda. Data collection began in 2004 and continued through 2006. Surface soils typically consisted of moist organic topsoil and silty clays/clays with trace gravels [RIFS].

Routine monitoring is also conducted at the ETTP at 12 locations (Reference 20). These locations monitor groundwater, storm water runoff, or ambient stream conditions. Depending on the location, samples are collected and analyzed for radionuclides and nonradiological parameters. Results of radiological monitoring are compared to DOE-derived concentration guidelines, and nonradiological results are compared to appropriate water quality standards. In general, monitoring results at 11 of the surveillance locations have remained less than 1 percent of the allowable derived concentration guidelines. The exception was at K-1700 which monitors the discharge from Mitchell Branch to Poplar Creek where the average was 1.75 percent of the allowable derived concentration guidelines (Reference 20).

3.5.11 Protected Species

Rare species may be protected under the federal Endangered Species Act and by regulations of the state of Tennessee. Such species are assigned a legally protected status of endangered or threatened, or they may be classified in other categories based on their rarity or the degree of concern for their vulnerability. Federal listed species identified by the USFWS Information for Planning and Consultation (IPaC) system as potentially occurring in the vicinity of the site are included in Table 3.5-2. No designated critical habitats were identified in the site vicinity (Reference 44). The table also includes species from the TDEC database that have a state or federal listing status and recorded occurrences in Roane County. A subset of these species was identified by the TDEC database as having been recorded in the USGS quadrangle that encompasses the site (Elverton quadrangle). The quadrangle covers a much smaller area than the county; thus, species recorded in the quadrangle may have a greater potential to occur in the area of the site if suitable habitat is present.

Table 3.5-2 includes a brief description of the habitat preferred by each species. Based on comparison of the habitat requirements and the habitats present on and adjacent to the site, the table provides an estimate of the potential for each species to occur in the area that may be affected by the Proposed Action (action area). Approximately 22 species are considered to have a low potential to occur in the action area because habitats on or adjacent to the site are only marginally supportive. One species (Indiana bat) may have a moderate potential to occur based on more suitable habitat. Of these 23 species, eight are federal and state listed as endangered or threatened (three bats and five mussels), and 15 have some type of state status designation. These species are discussed below.

3.5.11.1 Federal Listed Species

The federal listed species with a potential to occur on or adjacent to the site based on their ranges include three bats (gray bat, Indiana bat, and northern long-eared bat) and six freshwater mussels (fanshell, orangefoot pimpleback, ring pink, spectaclecase, sheepnose, and pink mucket). These species are discussed below.

Bats

Gray Bat (*Myotis grisescens*)

The endangered gray bat hibernates in caves in large numbers during winter months and migrates to warmer caves to form summer maternity colonies (composed of adult females and young) or bachelor colonies (composed of adult males). The gray bat is closely associated with rivers, lakes, and other large bodies of water over which it forages for mainly aquatic insects. The gray bat has responded positively to conservation measures, and the majority of its populations are stable or increasing. The gray bat forages over large areas, and it is known to forage along the Clinch River arm of Watts Bar Reservoir. Summer roosting gray bats have been documented in Marble Bluff Cave, located on the Tennessee River arm of Watts Bar Reservoir (mile 578.3), approximately 15 miles from the site (Reference 45).

The gray bat has been reported to occur in Roane County, and it was recorded on the nearby CRN site by surveys performed by TVA in 2011 and 2013. Gray bats were detected during every monitoring season (spring, summer, and fall), which suggests that winter and summer cave habitats exist for this species in the vicinity. The gray bat is likely to use the area near the reservoir for foraging. Gray bats have been detected foraging along a pond on the ORR approximately 1.5 miles east of the site (Reference 45). Although studies have shown that gray bats forage primarily over water bodies, they also have been found to venture short distances into adjacent terrestrial habitat to forage, or to cross terrestrial habitats to access streams, rivers, and reservoirs (Reference 45).

If gray bats forage near the site, their foraging activities are likely to occur primarily over Poplar Creek, the Clinch River arm of Watts Bar Reservoir, and associated riparian areas. It is likely that the presence of the gray bat is seasonal and restricted to summer, when this species is roosting in caves in the vicinity. At Marble Bluff Cave (approximately 9 miles away), the numbers of emerging gray bats have ranged from 0 to greater than 200 across past summer surveys. Potential numbers of gray bats that may forage near the site during the summer would be a small fraction of the number of bats roosting in caves in the vicinity. Gray bats may travel as much as 50 miles of river or lake shore to forage. This suggests that gray bats foraging near the site may originate from multiple caves (Reference 45).

Indiana bat (Myotis sodalis)

The endangered Indiana bat hibernates in caves and mines in winter and migrates to summer habitats in wooded areas. The large winter colonies disperse in spring, and reproductive females form smaller maternity colonies in trees within wooded areas. Males and nonreproductive females roost in trees but typically do not roost in colonies. The range of the Indiana bat extends from the northeast through the east-central United States. The Indiana bat typically forages in semi-open, forested habitats and forest edges as well as riparian areas. Suitable summer roosting habitat requires dead, dying, or living trees of sufficient size with sufficient exfoliating bark. Multiple roost sites generally are used. Primary summer roosts typically are behind the bark of large, dead trees, particularly those that are in gaps in the forest canopy or along forest edges so that they receive sufficient sun exposure. Indiana bats have smaller summer home ranges than gray bats and forage within 2.5 miles of roost trees. Numbers of the Indiana bat are stable or decreasing throughout portions of its range due to disease (white-nose syndrome) and loss of habitat (Reference 45).

The closest record of the Indiana bat to the site in the summer was a mist net capture of an adult male on the ORR in June 2013 over an inlet of Melton Hill Lake, approximately 20 miles from the site. The closest record of the Indiana bat to the site in winter was from a hibernaculum at Hill Cave in Norris Dam State Park approximately 27 miles to the northeast in Campbell County, Tennessee. However, no Indiana bats were observed in this cave during more recent winter surveys conducted in 2002, 2010, and 2011 to 2013. The closest records of summer roosting of the Indiana bat are from 27 to 29 miles to the southeast in the Cherokee National Forest (Monroe County, Tennessee). The site does not contain caves for use as hibernacula, and wooded areas that could provide roost trees are located on the periphery of the site in the Poplar Creek riparian zone and at the north end of the site. A survey of the site did not find trees with characteristics suitable for use as roost trees by the Indiana bat (Reference 45).

The mist net capture of an Indiana bat in June 2013 on the ORR and the 2013 acoustic detections on the CRN site support the possible presence of the Indiana bat at the site during spring and summer months (April-August). The lack of documented roost trees indicates that the Indiana bat may forage at the site along forest edges and riparian areas but is unlikely to roost there. Given the rarity of the Indiana bat, numbers present during the warm, non-hibernating season would be expected to be low to none in any given year (Reference 45).

*Northern Long-ear*ed *Bat* (*Myotis septentrionalis*)

The northern long-eared bat was listed as threatened in 2015 primarily due to the threat posed by white-nose syndrome, a fungal disease that has resulted in substantial mortality, particularly in the northeastern United States. Although declines in populations of this species have been observed in the southeast region, the declines have not been as dramatic as those in the northeast (Reference 45).

The northern long-eared bat has been captured or detected acoustically on the ORR and the CRNS site. These detections and their locations indicate the presence of the northern long-eared bat in association with forested areas and aquatic features on the ORR (Reference 45). The northern long-eared bat hibernates in caves during winter and migrates to roost on the landscape during summer, where they roost singly or in colonies beneath exfoliating bark or in crevices of dead or live trees. Although studies of their habitat use during summer are few or ongoing, available data suggest that summer habitat use by the northern long-eared bat is probably similar to that of the Indiana bat (Reference 45). The site does not include caves for use as hibernacula.

Northern long-eared bats have smaller summer home ranges than gray bats and forage within 1.5 miles of roost trees. No roost trees have been documented on the site. Although southeastern populations have declined, the northern long-eared bat is a relatively common species in this region, and its presence in the vicinity would be expected during the warm, non-hibernating season. Populations of the northern long-eared bat in this region are likely to be larger than those of the Indiana bat. These regional population relationships are likely to be reflected in the numbers of individual bats that occur in the vicinity of the site (i.e., numbers of individuals of the northern long-eared bat are likely greater than those of the Indiana bat) (Reference 45).

Mussels

Of the six mussels with the potential to occur in the types of aquatic habitats adjacent to the site (fanshell, orangefoot pimpleback, ring pink, spectaclecase, sheepnose, and pink mucket), only the pink mucket and sheepnose are considered extant by the Tennessee field office of the USFWS. A 2015 technical report that evaluated protected aquatic species also considered that the fanshell, orangefoot pimpleback, ring pink, and spectaclecase were extirpated and no longer occurring in the area (Reference 16). In addition, the 2011 mussel survey of the Clinch River arm of Watts Bar Reservoir at the CRN site did not detect live specimens of any of these extirpated species in the survey areas about 3.5 and 6

miles upstream from the mouth of Poplar Creek (Reference 16). Thus, the pink mucket and sheepnose are the only federal listed mussels with a potential to occur in the vicinity of the site, and they are discussed below.

Pink mucket (Lampsilis abrupta)

The pink mucket is federal and state listed as endangered. It was found historically in 25 river systems in the Tennessee, Cumberland, and Ohio River drainages, including the Clinch River. At the time a recovery plan was prepared by the USFWS in 1985, the pink mucket was known to exist in 16 rivers throughout these drainages. Reasons for the decline of this species include impoundment, siltation, and pollution. Reproduction is similar to other freshwater mussels. Females collect broadcast sperm, and larvae (glochidia) subsequently released by the female temporarily attach to a fish host for dispersal (Reference 46). The pink mucket spawns from August to September and releases larvae the following year between May and July. Fish hosts of the larval stage include largemouth bass, smallmouth bass, spotted bass, and walleye (Reference 16).

The pink mucket is usually found in medium to large rivers greater than 66 feet (20 meters) wide in moderate- to fast-flowing water (Reference 46). Individuals occasionally become established in small- to medium-sized tributaries of large rivers. The pink mucket inhabits rocky bottoms with swift current, usually in less than 3 feet of water. It appears to be tolerant of reservoir conditions with some flow (Reference 16). Given that the features of its preferred habitat are not characteristic of the reservoir and Poplar Creek near the site, its potential for occurrence there is low.

The recovery plan for the pink mucket states that, as of 1985, individuals had recently been found downstream of the Melton Hill Dam (Reference 46). A live pink mucket was collected in 1984 slightly upstream of the CRN site at CRM 19.1. However, the 2011 surveys of the Clinch River arm of Watts Bar Reservoir adjacent to the CRN site did not find any live or relic specimens of the pink mucket (Reference 16). Its absence there is further evidence that the pink mucket is unlikely to occur in the Clinch River arm of Watts Bar Reservoir near the site or in the reach of Poplar Creek adjacent to and downstream of the site. Therefore, the pink mucket is not considered further in this ER.

Sheepnose (*Plethobasus cyphyus*)

The sheepnose mussel is federal and state listed as endangered. The sheepnose is found in large streams in shallow shoals with moderate to swift currents, but it has also been recorded in reservoirs. Substrates inhabited include mainly coarse sand and gravel. Historically, the sheepnose occurred in at least 76 streams and rivers in the Mississippi, Ohio, and Tennessee River basins across 14 states. The sheepnose is currently known to exist in 25 streams and rivers in the same 14 states, including the Clinch River. Individuals have been recorded in the Clinch River as recently as 2006. Details of the life history of the sheepnose are little known. The sheepnose is thought to reach sexual maturity at a few years of age and spawn in early summer. It is believed to be a short-term brooder that releases glochidia in masses. The fish host is thought to be the sauger, though other fish that frequent medium to large rivers also may act as hosts. Habitat destruction and degradation are the reasons for the decline of this species (Reference 47).

The 2011 surveys of the Clinch River arm of the Watts Bar Reservoir adjacent to the CRN site did not find any live or relic specimens of the sheepnose (Reference 16). Given the extent to which zebra mussels have invaded this area and the lack of recent findings of sheepnose specimens indicate the sheepnose is unlikely to occur in the Clinch River arm of Watts Bar Reservoir near the site or in the reach of Poplar Creek adjacent to and downstream of the site. Therefore, the sheepnose is not considered further in this ER.

3.5.11.2 State Listed Species

Of the species with a state status and the potential to occur in the types of habitats present on or near the site (see Table 3.5-2), nine also have a federal listing status and are discussed above, and 14 (six animals and eight plants) have only a state status and are discussed below. Based on the types and quality of the habitats at the site and its industrial history, these 14 species are considered to have only a low likelihood of occurrence on or near the site.

<u>Animals</u>

Tri-colored Bat (*Perimyotis subflavus*)

The tri-colored bat has a state status of threatened. The USFWS was petitioned in June 2016 to list the species federally, a 90-day finding in December 2017 indicated the petitioned action may be warranted, and the USFWS has initiated a status review (Reference 48). The tri-colored bat uses habitats that are partly open, with large trees and woodland edges, but it occurs in a variety of terrestrial habitats, including old fields and grasslands, suburban areas, orchards, woodlands (especially hardwoods), and urban areas. It typically avoids large, open fields and deep woods. The tri-colored bat roosts in a wide variety of habitats, including caves, crevices, trees, and structures such as barns. It tends to feed over water bodies such as rivers or lakes, where insect populations are highest. It also tends to select more open foraging sites, with no canopy or a high canopy. The tri-colored bat hibernates in mines, caves, and buildings (Reference 49). Based on the presence of woodlands, edges, and open areas along Poplar Creek and the north end of the site, suitable foraging habitats and roosting habitats for the tri-colored bat may be present on and adjacent to the site.

Eastern Spotted Skunk (*Spilogale putorius*)

The eastern spotted skunk has a state status of rare. It utilizes a variety of habitats, including open prairies, fields, and brushy areas, which are similar to some habitats on the site.

Swainson's Warbler (*Limnothlypis swainsonii*)

Swainson's warbler has a state status of deemed in need of management. It breeds in mature, deciduous, floodplain and swamp forest. The riparian forest along Poplar Creek and the Clinch River arm of Watts Bar Reservoir may provide small areas of suitable habitat for this species.

Eastern Slender Glass Lizard (*Ophisaurus attenuatus longicaudus*)

The eastern slender glass lizard has a state status of deemed in need of management. It utilizes various dry, upland habitats, including grassy fields. Suitable habitat for this species may be present in the areas of herbaceous/grassland habitat on the site.

Four-toed Salamander (*Hemidactylium scutatum*)

The four-toed salamander has a state status of deemed in need of management. It utilizes woodland swamps as habitat and, accordingly, suitable habitat for this species may be present in the areas of riparian swamp along Poplar Creek and the Clinch River arm of Watts Bar Reservoir.

Valley Flame Crayfish (*Cambarus deweesae*)

The valley flame crayfish is a burrowing species that utilizes open habitats with high water tables. It potentially could occur on the site in open, grassy habitats adjacent to Poplar Creek if the water table is sufficiently close to the surface.

<u>Plants</u>

The eight plant species with a state status and a potential to occur in habitats on or near the site are listed below according to the general habitat type in which they may occur:

Woods
Schreber's aster (*Eurybia schreberi*)
Spreading false-foxglove (*Aureolaria patula*)
Shining ladies'-tresses (*Spiranthes lucida*)
American ginseng (*Panax quinquefolius*)
Heller's catfoot (*Pseudognaphalium helleri*)

Wetlands
Fetter-bush (*Leucothoe racemose*)
Tuberculed rein-orchid (*Plantanthera flava v. herbiola*)
River bulrush (*Bolboschoenus fluviatilis*)

Additional information about each species' state status and habitat preferences are provided in Table 3.5-2. The five plant species that require wooded habitats potentially could occur within the deciduous forest along Poplar Creek (approximately 19 acres total) or the small area of mixed evergreen/deciduous forest at the north end of the site (approximately 6 acres). The occurrence of these species or the specific woodland habitats they require has not been documented in these relatively small areas, and the likelihood of their occurrence is considered low.

For the three wetland plant species, suitable habitat potentially could be present on the site only in the wetlands within the Poplar Creek floodplain. The extent of these predominantly forested wetlands is approximately 2 acres. The occurrence of these species or the specific wetland habitats they require has not been documented in these small wetland areas, and the likelihood of their occurrence is considered low.

3.5.11.3 Migratory Birds

In addition to the rare species federally protected under the Endangered Species Act, birds are also federally protected under the Migratory Bird Treaty Act (MBTA) and the Bald and Golden Eagle Protection Act (BGEPA). Protected migratory birds include those identified above (federal and state listed species and species with other state status) as well as essentially all other native birds that inhabit the vicinity of the site (with the exception of the bobwhite, ruffed grouse, and wild turkey, which are non-migratory, state-managed game species).

The IPaC Trust Resources Report for the site (Reference 44) contains a list of migratory birds of conservation concern (BCC) that potentially could occur in the area. BCCs are species of particular concern to USFWS either because they are on the USFWS BCC list or warrant special attention at the site location. The six BCC species identified for the site vicinity and the seasons in which they may occur there are the following:

- Cerulean warbler (*Dendroica cerulea*) -- breeding (spring-summer)
- Kentucky warbler (*Oporornis formosus*) -- breeding (spring-summer)
- Prairie warbler (*Dendroica discolor*) -- breeding (spring-summer)
- Wood thrush (*Hylocichla mustelina*) -- breeding (spring-summer)
- Red-headed woodpecker (*Melanerpes erythrocephalus*) -- year-round
- Yellow-bellied sapsucker (*Sphyrapicus varius*) -- winter

Five of these six species (other than the prairie warbler) primarily occur in forest habitats, and the only habitats on the site they potentially would utilize are the deciduous forest along Poplar Creek (approximately 19 acres total) or the small area of mixed evergreen/deciduous forest at the north end of the site (approximately 6 acres). The open field habitats that cover most of the site do not provide suitable habitat for any of these species. Although the prairie warbler may occur in open, non-forested

habitats, it prefers more shrubby habitats than those provided by the periodically mowed fields of the site.

3.5.11.4 Bald Eagle

In addition to protection under the MBTA, eagles are also protected under the BGEPA of 1940, as amended (16 United States Code [U.S.C.] §668). The BGEPA provides protections to bald and golden eagles in addition to those provided by the MBTA. This act prohibits anyone, without a permit issued by the USFWS, from taking bald and golden eagles, including their parts, nests, or eggs. The Act defines "take" as to pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest, or disturb. To "disturb" means to agitate or bother an eagle to a degree that causes or is likely to cause, based on the best scientific information available: 1) injury to an eagle, 2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or 3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior. The National Bald Eagle Management Guidelines (Reference 50) provide recommendations to minimize disturbance to bald eagles in accordance with the BGEPA, such as buffers around nests. Bald eagles are not known to nest or forage on or adjacent to the site, so they are not considered further in this ER.

3.5.12 References

1. Arnwine, D.H., J.I. Broach, L.K. Cartwright, and G.M. Denton, "Tennessee Ecoregion Project 1994 - 1999," December 2000.

2. U.S. Department of Energy, "Environmental Assessment - Transfer of Land and Facilities within the East Tennessee Technology Park and Surrounding Area, Oak Ridge, Tennessee," DOE/EA-1640, October 2011.

3. U.S. Department of Energy, ETTP Vision 2020 Reuse Historic Preservation and Stewardship, in ORSSAB Meeting. September 12, 2018.

4. U.S. Department of Energy, "Covenant Deferral Request for the Proposed Title Transfer of The Former K-3 Area at The East Tennessee Technology Park, Oak Ridge, Tennessee," DOE/OR/01-2666, September 2015.

5. Carter, E., N.R. Giffen, K. McCracken, S.E. Darling, A. Deck, and G. Byrd, "Wildlife Management Plan for the Oak Ridge Reservation," ORNL/TM-2012/387/R1, October 2019.

6. Tennessee Wildlife Resources Agency, "Black Oak Ridge Conservation Easement - Final Management Plan," December 20, 2005.

7. Watts Bar Lake, Online Guide | Cabins, Homes, Marinas, Fishing & More, Website: https://www.wattsbar.com, accessed June 3, 2021.

8. Etnier, D.A. and W.C. Starnes, "The Fishes of Tennessee," 1993.

9. Parmalee, P.W. and A.E. Bogan, "The freshwater mussels of Tennessee,"

10. Tennessee Valley Authority, Watts Bar Reservoir, Website: https://www.tva.com/environment/environmental-stewardship/water-quality/reservoir-health-ratings/watts-bar-reservoir, accessed June 10, 2021.

11. U.S. Department of Energy, "East Tennessee Technology Park, Administrative Watershed Remedial Action Report, Comprehensive Monitoring Plan, Oak Ridge, Tennessee," DOE/OR/01-2477&D3, November 2016.

12. Tennessee Valley Authority, "Biological Monitoring to Characterize the Aquatic Community near the Site of the Proposed Clinch River Small Modular Reactor 2011," January 2013.

13. Fitz, R.B., "Fish Habitat and Population Changes Resulting from Impoundment of Clinch River by Melton Hill Dam," Journal of the Tennessee Academy of Science, Vol. 43, 1:7-75.

14. Tennessee Division of Water Resources, "Posted Streams Rivers & Reservoirs - Rev. 08," 2020.

15. Ahlstedt, S.A., "Twentieth Century Changes in the Freshwater Mussel Fauna of the Clinch River (Tennessee and Virginia)," Walkerana, Vol. 5, 13:73-122.

16. Howard, C.S., A.R. Henderson, and C.L. Phillips, "Clinch River Small Modular Reactor and Barge/Traffic Site Evaluation of Aquatic Habitats and Protected Aquatic Animals Technical Report," December 2015.

17. Tennessee Wildlife Resources Agency, "Tennessee Aquatic Nuisance Species Management Plan," February 2008.

18. Tennessee Valley Authority, "Reservoir Operations Study - Final Programmatic EIS - Section 4.11 Invasive Plants and Animals," 2004.

19. Baranski, M.J., "Aquatic Natural Areas Analysis and Evaluation: Oak Ridge Reservation," April 2011.

20. U.S. Department of Energy, "2021 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Site Oak Ridge, Tennessee. Data and Evaluations," DOE/OR/01-2869&D1, March 2021.

21. U.S. Department of Energy, "2010 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee - Data and Evaluations," DOE/OR/01-2437&D2, September 2010.

22. Efroymson, R.A., M.J. Peterson, N.R. Giffen, M.G. Ryon, J.G. Smith, W.K. Roy, C.J. Welsh, D.L. Druckenbrod, W.W. Hargrove, and H.D. Quarles, "Investigating Habitat Value in Support of Remedial Decisions: A Case Study of Six Sites at the East Tennessee Technology Park," BJC/OR2268, November 2005.

23. U.S. Army Corps of Engineers, "Wetlands Delineation Manual," Technical Report Y-87-1, January 1987.

24. Rosenteel, B.A. and D.J. Awl, "Wetland Survey of Selected Areas in the K-25 Site Area of Responsibility," ORNL/TM-13033, July 1995.

25. U.S. Environmental Protection Agency, "Wetlands Regulations," 2015.

26. Tennessee Department of Environment and Conservation, Aquatic Resource Alteration Permit (ARAP), Website: https://www.tn.gov/environment/permit-permits/water-permits1/aquatic-resource-alteration-permit--arap-.html, accessed September 16, 2021.

27. Parr, P.D. and J.F. Hughes, "2006 Oak Ridge Reservation Physical Characteristics and Natural Resources," ORNL/TM-2006/110, September 2006.

28. Griffith, G.E., J.M. Omernik, and S.H. Azevedo, "Ecoregions of Tennessee," EPA/600/R-97/022, February 1997.

29. Tennessee Valley Authority, "Clinch River Nuclear Site Early Site Permit Application - Part 3 Environmental Report Revision 2," March 2019.

30. U.S. Fish and Wildlife Service, Environmental Contaminants: DOE Natural Resources Trustee Council Completes First Restoration Project, Website: https://www.fws.gov/cookeville/borce.html, accessed September 13, 2021.

31. Baranski, M.J., "Natural Areas Analysis and Evaluation of Oak Ridge Reservation," November 2009.

32. U.S. Department of Agriculture, What are Invasive Species?, Website: https://www.invasivespeciesinfo.gov/what-are-invasive-species, accessed September 13, 2021.

33. Pysek, P. and D.M. Richardson, "Invasive Species, Environmental Change and Management, and Health," Annual Review of Environmenta and Resources, Vol. 35:25-55.

34. Drake, S.J., J.F. Weltzin, and P.D. Parr, "Assessment of Nonnative Invasive Plants in the DOE OakRidge National Environmental Research Park," ORNL/TM-2001/113, October 2002.

35. McCracken, M.K. and N.R. Giffen, "Invasive Plant Management Plan for the Oak Ridge Reservation," ORNL/TM-2004/98/R2, August 2017.

36. Tennessee Department of Environment and Conservation, Mammals In Tennessee, Website: https://www.tn.gov/twra/wildlife/mammals.html, accessed September 20, 2021.

37. Tennessee Wildlife Resources Agency, Birds of Tennessee, Website: https://www.tn.gov/twra/wildlife/birds.html, accessed September 13, 2021.

38. Tennessee Invasive Plant Council, Invasive Plants, Natural Areas List, Website: https://www.tnipc.org/invasive-plants/, accessed September 13, 2021.

39. Tennessee Invasive Plant Council, Invasive Plants List (Disturbed Habitats), Website: https://www.tnipc.org/disturbed-habitats-list/, accessed September 13, 2021.

40. U.S. Geological Survey, "Nonindigenous Aquatic Species Database Query–Major Drainage Area Hydrologic Unit Code 60102 for Upper Tennessee," TN5066, February 2017.

41. U.S. Department of Energy, Oak Ridge Environmental Management Program, ETTP Fact Sheet. 2019.

42. The Tennessee Wildlife Resources Agency, "Strategic Plan 2014-2020," March 2014.

43. Biological Monitoring and Abatement Program (BMAP), BMAP Site Specific Results, Website: https://www.esd.ornl.gov/BMAP/ornlmap.htm, accessed September 16, 2021.

44. U.S. Fish and Wildlife Service, Information for Planning and Consultation (IPaC), Database: https://ecos.fws.gov/ipac/location/WZYIFO3ZLBGJ7AWK7OWPUHVMPQ/resources#endangered-species, accessed May 24, 2021.

45. LeGrand, H.G., E.B. Hamrick, and J.T. Baxter Jr., "Clinch River Small Modular Reactor Site Terrestrial Animal Survey Report - Revision 7," L98 160302 026, November 20, 2015.

46. U.S. Fish and Wildlife Service, "Recovery Plan: Pink Mucket Pearly Mussel, Lampsilis orbiculata," January 24, 1985.

47. U.S. Fish and Wildlife Service, "Endangered and Threatened Wildlife and Plants; Determination of Endangered Status for the Sheepnose and Spectaclecase Mussels Throughout Their Range," Federal Register, Vol. 77, 49:14914-14949.

48. U.S. Fish and Wildlife Service, Conserving South Carolina’s At-Risk Species: Species facing threats to their survival, Tricolored bat. February 2019.

49. Center for Biological Diversity, Natural History: Tricolored Bat, Website: https://www.biologicaldiversity.org/species/mammals/tricolored_bat/natural_history.html, accessed September 13, 2021.

50. U.S. Fish and Wildlife Service, "National Bald Eagle Management Guidelines," May 2007.

51. Tennessee Department of Environment and Conservation, Natural Heritage Program, Rare Species by County – Roane County, Database: https://www.tn.gov/environment/program-areas/na-natural-areas/na-natural-heritage-inventory-program.html, accessed May 18, 2021.

52. Tennessee Department of Environment and Conservation, Rare Species by Quadrangle, Website: https://www.tn.gov/environment/program-areas/na-natural-areas/na-natural-heritage-inventory-program.html, accessed March 31, 2021.

Table 3.5-1: Tennessee Invasive Plant Species (Page 1 of 2)

Scientific Name	Common Name
Terrestrial Natural Areas	
Alliaria petiolata (Bieb.) Cavara & Grande	Garlic Mustard
Alternanthera philoxeroides (Mart.) Griseb.	Alligatorweed
Centaurea stobe L. ssp. *micranthos* (S.G.Gmel. ex Gugler) Hayek.	*Centaurea biebersteinii* DC., Spotted Knapweed
Fallopia japonica (Houtt.) Ronse Decr.	Fleeceflower, Japanese Knotweed, Mexican Bamboo, *Polygonum cuspidatum* Seib. & Zucc.
Lespedeza cuneata (Dum.-Cours) G. Don	Chinese Lespedeza, Sericea L*l*espedeza
Lythrum salicaria L.	Purple Loosestrife
Murdannia keisak (Hassk.) Hand.-Maz.	Asian spiderwort, Marsh Dayflower
Perilla frutescens (L.) Britton	Beefsteak Plant, Chinese basil, Perilla, Perilla Mint
Tussilago farfara L.	Coltsfoot
Acroptilon repens (L.) DC.	Centaurea repens (L.), Russian Knapweed
Heracleum mantegazzianum Sommier & Levier	Giant cow parsnip, Giant hogweed
Liriope spicata (Thunb.) Lour.	Creeping Lilyturf, Creeping Liriope, Lilyturf, Monkey-grass
Lygodium japonicum (Thunb. ex Murr.) Swartz	Japanese Climbing Fern
Persicaria perfoliata (L.) H. Gross	Asiatic Tearthumb, Mile-a-minute Weed
Ranunculus ficaria L.	_Ficaria verna_ Huds., Fig Buttercup, Lesser Celandine
Tribulus terrestris L.	Puncturevine
Arthraxon hispidus (Thunb.) Makino	Hairy Jointgrass, Small Carpetgrass
Bromus inermis Leyss.	Hungarian Brome, Smooth Brome
Microstegium vimineum (Trin.) A. Camus	Japanese Stiltgrass, Nepalese Browntop, Nepalgrass
Miscanthus sinensis Anderss.	Chinese Silver Grass, Eulalia Grass, Maiden Grass, Zebra Grass
Phragmites australis (Cav.) Trin. ex Steud.	Common Reed
Sorghum halepense (L.) Pers.	Johnson Grass
Arundo donax L.	Elephant Grass, Giant Reed
Imperata cylindrica (L.) Beauv.	Cogongrass, Japanese Bloodgrass
Phyllostachys aurea Carr. Ex A.& C. RivÃ¨re	Golden Bamboo
Rottboellia cochinchinensis (Lour.) W.D. Clayton	Itchgrass
Elaeagnus umbellata var. *parviflora* (Wall. ex Royle) C.K.Schneid.	Autumn Olive
Euonymus alatus (Thunb.) Sieb.	Burning Bush, Winged Euonymus
Lespedeza bicolor Turcz.	Bicolor Lespedeza, Shrubby Bushclover, Shrubby Lespedeza
Ligustrum sinense Lour.	Chinese Privet
Lonicera maackii (Rupr.) Herder.	Amur Bush Honeysuckle
Rosa multiflora Thunb. ex Murr.	Multiflora Rose
Rubus phoenicolasius Maxim.	Wine Raspberry, Wineberry
Spiraea japonica L.f.	Japanese Meadowsweet, Japanese Spiraea
Buddleja davidii Franch.	Butterfly Bush

Table 3.5-1: Tennessee Invasive Plant Species (Page 2 of 2)

Scientific Name	Common Name
Mahonia bealei (Fortune) Carr.	Beale's Barberry, Leatherleaf Mahonia
Nandina domestica Thunb.	Heavenly Bamboo, Nandina, Sacred Bamboo
Rhamnus cathartica L.	Common Buckthorn, European Buckthorn, Purging Buckthorn
Solanum viarum Dunal	Tropical Soda Apple
Ailanthus altissima (Mill.) Swingle	Tree of Heaven
Albizia julibrissin Durazz.	Mimosa, Silktree, Silky Acacia
Paulownia tomentosa (Thunb.) Sieb. & Zucc. ex Steud.	Empress Tree, Princess Tree, Royal Paulownia
Pyrus calleryana Dcne.	Bradford Pear, Callery Pear
Firmiana simplex (L.) W. Wight	*Firmiana platanifolia* (L. f.) Schott & Endl., *Sterculia platanifolia* L. f.), Chinese Parasol Tree, Phoenix Tree, Varnish Tree
Melia azedarach L.	Chinaberry
Triadica sebifera (L.) Small	Chinese Tallowtree
Celastrus orbiculatus Thunb.	Asian Bittersweet, Oriental Bittersweet
Clematis terniflora DC.	Sweet Autumn Clematis
Dioscorea polystachya Turez.	Chinese Yam, Cinnamon Vine, *Dioscorea oppositifolia* L.
Euonymus hederaceus Champ. & Benth.	*Euonymus fortunei* (Turcz.) Hand.-Mazz., Winter Creeper
Hedera helix L.	English Ivy
Lonicera japonica Thunb.	Japanese Honeysuckle
Pueraria montana var. *lobata* (Willd.) Maesen & S. Almeida	Kudzu
Vinca minor L.	Common Periwinkle
Wisteria sinensis (Sims) DC.	Chinese Wisteria
Wisteria floribunda (Willd.) DC.	Japanese Wisteria
Akebia quinata (Houtt.) Dcne.	Chocolate vine, Five-leaf akebia
Ampelopsis glandulosa var. *brevipedunculata* (Maxim.) Momiy.	Ampelopsis brevipedunculata (Maxim.) Trautv, *Ampelopsis heterophylla* (Thunb.) Siebold & Zucc., Amur peppervine, Creeper, Porcelain berry, Wild grape
Humulus japonicus Siebold & Zucc.	Japanese Hops
Aquatic	
Egeria densa Planch.	Brazilian Egeria, Brazilian Elodea, Brazilian Water-weed
Eichhornia crassipes (Mart.) Solms	Water Hyacinth
Ludwigia uruguayensis (Camb.) Hara	Uruguay Waterprimrose, Showy Waterprimrose
Najas minor All.	Water Nymph
Potamogeton crispus L.	Curly Pondweed
Rorippa nasturtium-aquaticum (L.) Hayek	Watercress
Hydrilla verticillata (L.f.) Royle	Hydrilla, Water Thyme
Myriophyllum aquaticum (Vell.) Verdc.	Brazillian Watermilfoil, Parrot Feather
Myriophyllum spicatum L.	Eurasian Water-milfoil
Salvinia molesta Mitchell	Aquarium Water-moss, Giant Salvinia
Trapa natans L.	Water Caltrop, Water Chestnut

Source: (Reference 38)

Table 3.5-2: Species with Federal or State Status and Recorded Occurrences in Roane County, Tennessee (Page 1 of 5)

Common Name Scientific Name	Habitat[3]	Potential to Occur[5]	Federal Status	State Status	State Rank
Mammals					
Gray bat [1, 2, 3] *Myotis grisescens*	Cave-obligate year-round; frequents forested areas; migratory.	Low	E	E	S2
Indiana bat [1] *Myotis sodalis*	Caves and mines during winter; large trees with exfoliating bark near riparian areas in summer.	Moderate	E	E	S1
Northern long-eared bat [1, 2] *Myotis septentrionalis*	A forest bat whose summer roosts may include caves, mines, live trees and snags; hibernates in caves and mines, often using small cracks and fissures.	Low	T	T	S1S2
Tri-colored bat [2] *Perimyotis subflavus*	Generally associated with forested landscapes but may roost near openings.	Low	–	T	S2S3
Eastern spotted skunk [2] *Spilogale putorius*	Rocky outcrops, open prairies, brushy areas, cultivated fields, and barnyards; more common in east Tennessee; reclusive.	Low	–	Rare, not state listed	S3
Southern bog lemming [2, 3] *Synaptomys cooperi*	Marshy meadows, wet balds, and rich upland forests.	None	–	D	S4
Long-tailed shrew [2] *Sorex dispar*	Mountainous, forested areas with loose talus; east Tennessee.	None	–	D	S2
Birds					
Swainson's warbler [2] *Limnothlypis swainsonii*	Mature, rich, damp, deciduous floodplain and swamp forests.	Low	–	D	S3
Bachman's sparrow [2] *Peucaea aestivalis*	Dry open pine or oak woods; nests on the ground in dense cover.	None	–	E	S1B
Reptiles					
Easter slender glass lizard [2] *Ophisaurus attenuatus longicaudus*	Dry upland areas including brushy, cut-over woodlands and grassy fields; nearly statewide but obscure; fossorial.	Low	–	D	S3
Northern pinesnake [2] *Pituophis melanoleucus melanoleucus*	Well-drained sandy soils in pine/pine-oak woods; dry mountain ridges; E portions of west TN, E to lower elevation of the Appalachians.	None	–	T	S3
Amphibians					
Hellbender [2, 3] *Cryptobranchus alleganiensis*	Rocky, clear creeks and rivers with large shelter rocks.	None	No Status	E	S3
Berry cave salamander [2] *Gyrinophilus gulolineatus*	Aquatic cave obligate; ridge and valley; formerly included with *G. palleucus*.	None	C	T	S1
Green salamander [2, 3] *Aneides aeneus*	Damp crevices in shaded rock outcrops and ledges; beneath loose bark and cracks of trees and sometimes in/or under logs.	None	–	Rare, not state listed	S3S4
Four-toed salamander [2] *Hemidactylium scutatum*	Woodland swamps, shallow depressions, and sphagnum mats on acidic soils; middle and east Tennessee.	Low	–	D	S3

Table 3.5-2: Species with Federal or State Status and Recorded Occurrences in Roane County, Tennessee (Page 2 of 5)

Common Name Scientific Name	Habitat[3]	Potential to Occur[5]	Federal Status	State Status	State Rank
Fish					
Blue sucker [2] *Cycleptus elongatus*	Swift waters over firm substrates in big rivers.	None	–	T	S2
Tennessee dace [2] *Chrosomus tennesseensis*	First order spring-fed streams of woodlands in Ridge and Valley limestone region; Tennessee River watershed.	None	–	D	S3
Spotfin chub [1, 2] *Erimonax monachus*	Clear upland rivers with swift currents and boulder substrates; portions of the Tennessee River watershed.	None	T	T	S2
Flame chub [2] *Hemitremia flammea*	Springs and spring-fed streams with lush aquatic vegetation; Tennessee and middle Cumberland River watersheds.	None	–	D	S3
Tangerine darter [2, 3] *Percina aurantiaca*	Large-moderate size headwater tribs to Tennessee River, in clear, fairly deep, rocky pools, usually below riffles.	None	–	D	S3
Mollusks					
Finerayed pigtoe [1, 2, 3] *Fusconaia cuneolus*	Riffles of fords and shoals of mod gradient streams in firm cobble and gravel substrates; middle and upper Tennessee River watershed.	None	E	E	S1
Shiny pigtoe [1, 2, 3] *Fusconaia cor*	Shoals and riffles of small-medium sized rivers with mod-fast current over sand-cobble substrates; upper Tennessee River watershed.	None	E	E	S1
Fanshell [2] *Cyprogenia stegaria*	Medium to large streams and rivers with coarse sand and gravel substrates; Cumberland and Tennessee river systems.	Low	E	E	S1
Pyramid pigtoe [2, 3] *Pleurobema rubrum*	Rivers with strong current and firm sand/gravel substrates. Tennessee and Cumberland river systems, incl KY Reservoir; W Uplands and W Highland Rim.	None	–	Rare, not state listed	S1S2
Rough rabbitsfoot [2] *Theliderma cylindrica strigillata*	Small-medium sized rivers, in clear, shallow riffles with sand-gravel substrates; Tennessee and Cumberland river systems; upland form.	None	E	E	S2
Alabama lampmussel [2, 3] *Lampsilis virescens*	Found in sand and gravel substrates in shoal areas of small-medium size rivers; middle and upper Tennessee R system; recently rediscovered in Emory River.	None	E	E	S1
Orangefoot pimpleback [2] *Plethobasus cooperianus*	Large rivers in sand-gravel-cobble substrates in riffle sand shoals in deep flowing water; Cumberland and Tennessee river systems.	Low	E	E	S1
Tennessee bean [2] *Venustaconcha trabalis*	Riffle areas of small rivers and streams in sand, gravel, & cobble substrates with swift current; upper Cumberland and upper Tennessee river systems.	None	E	E	S1

Table 3.5-2: Species with Federal or State Status and Recorded Occurrences in Roane County, Tennessee (Page 3 of 5)

Common Name Scientific Name	Habitat[3]	Potential to Occur[5]	Federal Status	State Status	State Rank
Ring pink [2] *Obovaria retusa*	Large rivers in gravel and sand bars; Tennessee and Cumberland river watersheds; many historic locations currently inundated.	Low	E	E	S1
Spectaclecase [2, 3] *Cumberlandia monodonta*	Medium to large rivers; in substrates from mud and sand to gravel, cobble, and boulders; Cumberland and Tennessee river systems.	Low	E	E	S2S3
Sheepnose [2] *Plethobasus cyphyus*	Large to medium-sized rivers, in riffles and coarse sand/gravel substrate; Tennessee and Cumberland river systems, incl KY Reservoir; W Uplands & Rim.	None	E	E	S2S3
Pink mucket [2] *Lampsilis abrupta*	Generally a large-river species, preferring sand-gravel or rocky substrates with mod-strong currents; Tennessee and Cumberland river systems.	Low	E	E	S2
Spiny riversnail [2] *Io fluvialis*	Shallow waters of shoals that are rapid to moderate and well-oxygenated. Tennessee River and main tributaries, E Tennessee.	None	–	Rare, not state listed	S2
Crustacean					
Valley flame crayfish [2, 3] *Cambarus deweesae*	Primary burrower; open areas with high water tables; northern ridge and valley	Low	–	E	S1
Incurved cave isopod [2] *Caecidotea incurva*	Aquatic cave obligate; known from two wet caves in east Tennessee	None	–	Rare, not state listed	S1
Flowering Plants					
Schreber's aster [2] *Eurybia schreberi*	Mesic woods and seepage slopes	Low	–	S	S1
Mountain honeysuckle [2] *Lonicera dioica*	Mountain woods and thickets	None	–	S	S2
Barrens silky aster [2] *Symphyotrichum pratense*	Barrens	None	–	E	S1
Nuttall's waterweed [2] *Elodea nuttalii*	Submersed aquatic -- streams and ponds	None	–	S	S2
Swamp lousewort [2] *Pedicularis lanceolata*	Wet acidic barrens and seeps	None	–	S	S1S2
Fen orchis [2] *Liparis loeselii*	Calcareous seeps	None	–	T	S1
Prairie goldenrod [2, 3] *Oligoneuron album*	Barrens	None	–	E	S1S2
Spreading false-foxglove [2, 3] *Aureolaria patula*	Oak woods and edges	Low	–	S	S3
Shining ladies'-tresses [2, 3] *Spiranthes lucida*	Alluvial woods and moist slopes	Low	–	T	S1S2
American ginseng [2, 3] *Panax quinquefolius*	Rich woods	Low	–	S - CE	S3S4
Virginia spiraea [1, 2] *Spiraea virginiana*	Stream bars and ledges	None	T	E	S2

Table 3.5-2: Species with Federal or State Status and Recorded Occurrences in Roane County, Tennessee (Page 4 of 5)

Common Name Scientific Name	Habitat[3]	Potential to Occur[5]	Federal Status	State Status	State Rank
White fringeless orchid [1, 2] *Platanthera integrilabia*	Acidic seeps and stream heads	None	T	E	S2S3
Fetter-bush [2] *Leucothoe racemosa*	Acidic wetlands and swamps	Low	–	T	S2
Northern bush-honeysuckle [2, 3] *Diervilla lonicera*	Rocky woodlands and bluffs	None	–	T	S2
Slender blazing-star [2, 3] *Liatris cylindracea*	Barrens	None	–	T	S2
Large-flowered Barbara's-buttons [2] *Marshallia grandiflora*	Rocky river bars	None	–	E	S2
Butternut [2] *Juglans cinerea*	Rich woods and hollows	None	–	T	S3
Missouri gooseberry [2] *Ribes missouriense*	Rocky woods	None	–	S	S2
Heller's catfoot [2, 3] *Pseudognaphalium helleri*	Dry sandy woods	Low	–	S	S2
Western wallflower [2] *Erysimum capitatum*	Rocky bluffs	None	–	E	S1S2
Branching whitlow-grass [2, 3] *Draba ramosissima*	Calcareous bluffs	None	–	S	S2
Naked-stem sunflower [2, 3] *Helianthus occidentalis*	Limestone glades and barrens	None	–	S	S2
Mountain bush-honeysuckle [2] *Diervillas essilifolia var. rivularis*	Dry cliffs and bluffs	None	–	T	S3
Tubercled rein-orchid [2] *Platanthera flava var. herbiola*	Swamps and floodplains	Low	–	T	S2
Earleaved false-foxglove [2, 3] *Agalinis auriculata*	Barrens	None	–	E	S2
Tall larkspur [2, 3] *Delphinium exaltatum*	Glades and barrens	None	–	E	S2
River bulrush [2] *Bolboschoenus fluviatilis*	Marshes	Low	–	S	S1
Small-headed rush [2] *Juncus brachycephalus*	Seeps and wet bluffs	None	–	S	S2
Nonvascular Plants					
A moss [2] *Myurella julacea*	Shale bluffs	None	–	S-P	SH
A liverwort [2] *Preissia quadrata*	Seepy limestone cliffs and bluffs	None	–	T	S1
Fern and Fern Ally					
Hart's-tongue fern [2] *Asplenium scolopendrium var. americanum*	Sinks	None	T	E	S1

Table 3.5-2: Species with Federal or State Status and Recorded Occurrences in Roane County, Tennessee (Page 5 of 5)

Common Name Scientific Name	Habitat[3]	Potential to Occur[5]	Federal Status	State Status	State Rank

Federal and State Listing Status Abbreviations (legal listing status under federal and state regulations):

E = Endangered

T = Threatened

S = Special Concern

R = Rare, not state-listed
D = Deemed in need of management
C = Candidate for listing

CE = Commercially exploited

P = Possibly extirpated

- = No federal status

State Rank Abbreviations (non-legal rank indicating rarity and vulnerability at the state level):

S1 = Extremely rare and critically imperiled
S2 = Very rare and imperiled
S3 = Vulnerable

S4 = Apparently secure, but with cause for long-term concern

S#S# = Denotes a range of ranks because the exact rarity of the element is uncertain (e.g., S1S2)

SH = Of historical occurrence in Tennessee
_B = Breeds in Tennessee

Sources:

[1] Source: (Reference 44)
[2] Source: (Reference 51)
[3] Source: (Reference 52)

[5] Potential to occur was estimated based on habitat requirements versus habitats observed on or in the vicinity of the site.

Figure 3.5-1: Black Oak Ridge Conservation Easement

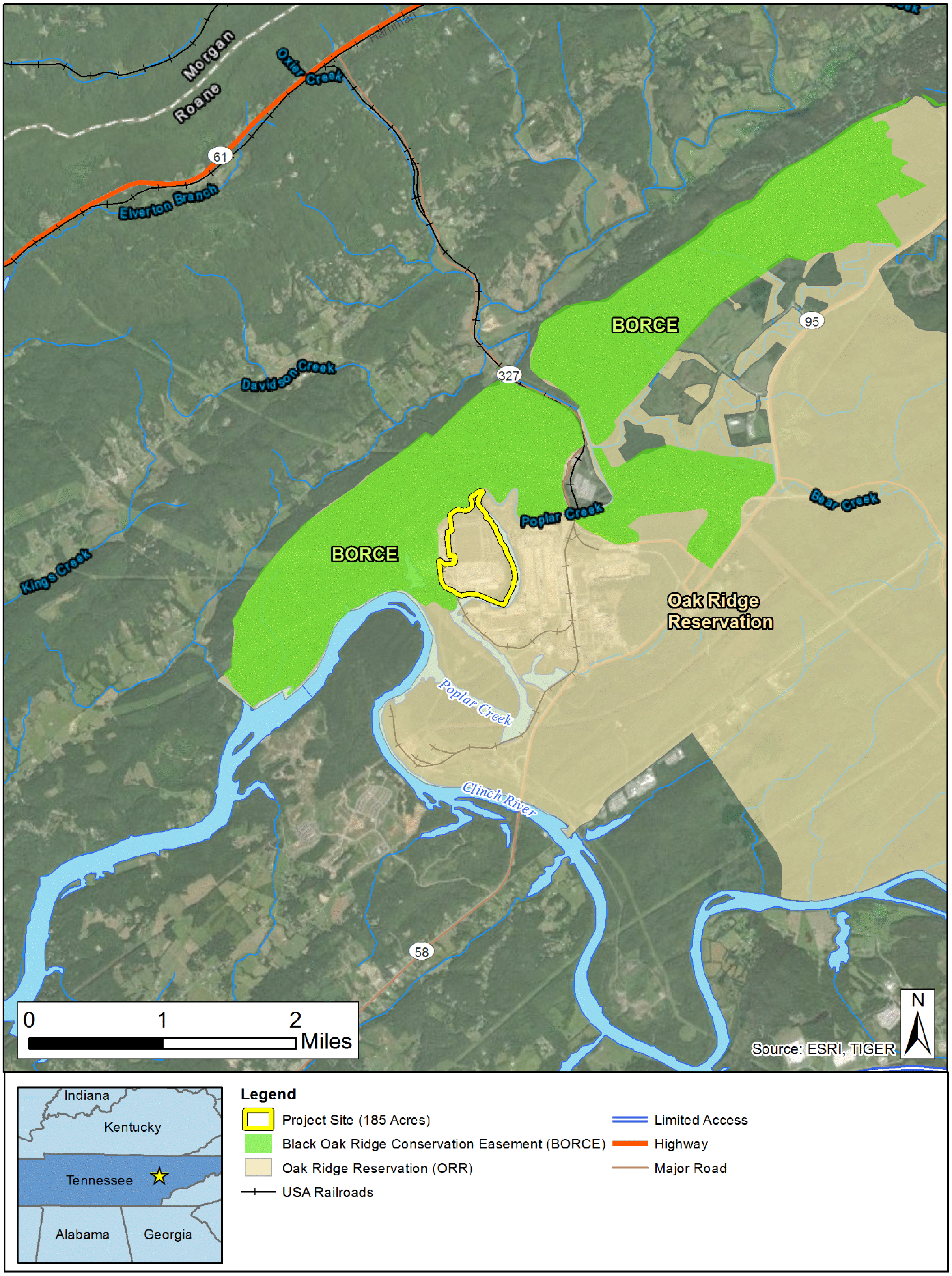
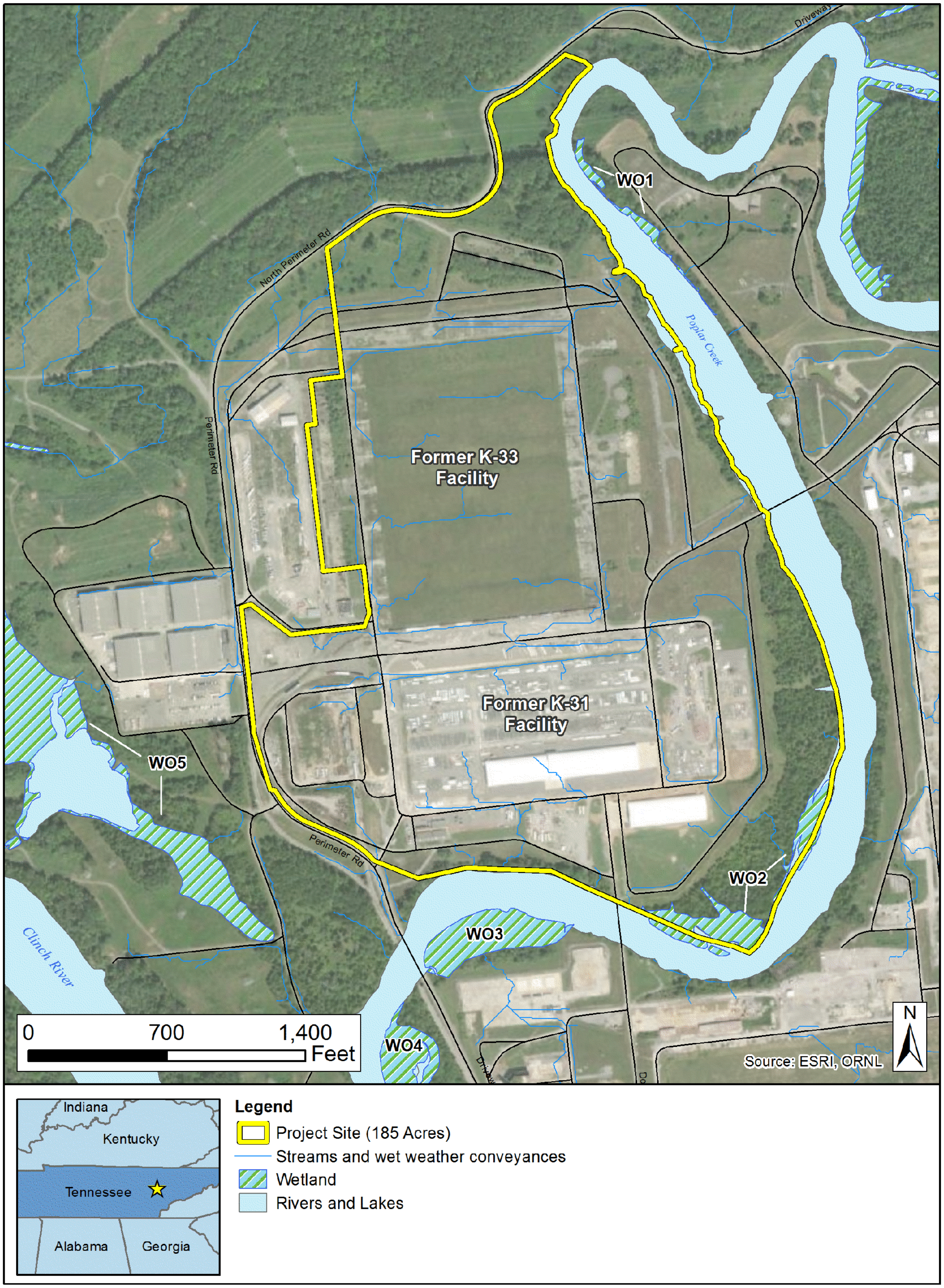


Figure 3.5-2: Wetlands



3.6 HISTORIC AND CULTURAL RESOURCES

This section describes the cultural and historic resources at and in the vicinity of the site located in Oak Ridge, Tennessee. Cultural resources include but are not limited to: prehistoric and historic era archaeological sites, artifacts, and remains; historic sites, districts, and buildings; and traditional cultural properties that are important to a group, such as an Indian Tribe, for maintaining their culture.

Cultural resource studies were performed for the site that consisted of a desktop survey and literature review, a geographical information system (GIS) analysis, and review of properties listed on the National Register of Historic Places (NRHP). GIS analyses and records reviews were performed on an area within a 10-mile radius of the site. While this radiusis not specified in the Final ISG Augmenting NUREG-1537, the use of 10 miles is consistent with guidance in Section 2.5.3 of NUREG-1555 regarding the radius appropriate for the collection of sufficient data to describe historic properties within the area surrounding a nuclear power plant. This guidance should bound the approach for a non-power test reactor.

3.6.1 Cultural Setting

The Eastern United States of America has been occupied by several Native American cultures since at least 14,000 years ago and perhaps even longer as demonstrated by archaeological investigations throughout the area. Within Eastern Tennessee, Native American cultures were present from at least 10,000 years ago through multiple cultural periods including the Paleo-Indian (10,000 B.C.-8,000 B.C.), Archaic (8,000 B.C.-1,000 B.C.), Woodland (900 B.C.-A.D. 900), Mississippian (A.D. 900 to A.D. 1600), and Overhill Cherokee (A.D. 1600 to A.D. 1838). Over time, in Eastern Tennessee, the Native American cultures progressed. The Paleo-Indian society was largely a subsistence-based economy. In the Archaic, hunter-gatherer groups lived largely in semi- or permanent base camps with a preference to locations in floodplain areas. Trade between geographically separated groups has been recognized in Eastern Tennessee beginning in the Archaic. During the Woodland Period, pottery, burial mounds, and agriculture become prevalent and trade becomes more widespread. Native American cultures reached a relative high point of social, cultural, and political complexity during the Mississippian Period. During this period larger, permanent settlements and an intensification of agriculture was common throughout the Mississippi Valley. These settlements included the building of large mounds for both civic and religious purposes. Wide-spread trade networks also existed during this period. The Overhill Cherokee Period includes towns with a more dispersed settlement pattern as compared to the later phases of the Mississippian Period. Various locations in Eastern Tennessee include traces of human habitation throughout all of these periods (Reference 1).

Though many tribes were likely present throughout what later became the Oak Ridge area over time, no known trial lands or resources used by Native American or other ethnic groups are currently located within the ORR. Additionally, no evidence has been identified that Native American groups retain legal rights to lands within the ORR (Reference 1).

Gradually, European hunters, trappers, explorers, and eventually settlers moved into the area around what became known as the Clinch River Valley in Eastern Tennessee. Hunting and trapping was common in the area throughout the seventeenth and eighteenth century. After the treaty with the Cherokee Indians in 1798, white settlers began arriving. When colonization began to reach the valleys, in the vicinity of what later became the DOE ORR, the area was sparsely populated and included four small communities (Scarboror, Robertsville, Wheat, and Elza) inhabited by approximately 1,000 families. The area largely consisted of small, self-sufficient farms. Some farmers supplemented income with light timbering until the woodstands were eventually depleted. Fruit orchards were cultivated at the turn of the nineteenth century, but never turned a profit. Coal mining became an increasingly important part of

the economy in the late nineteenth century. The population in the region continued to grow fairly steadily over time (Reference 1).

The Great Depression had a significant impact on Anderson and Roane Counties, in part due to the impact to the coal industry. The establishment of TVA in 1933 had a significant beneficial impact on the local economy and brought many jobs to the area. One of the mandates of the TVA was to implement flood control and establish hydroelectric power in the area. Thus, in 1933, TVA began the construction of the Norris Dam crossing the Clinch River in the northern tip of Anderson County. Though bringing many jobs and a source of electricity to the region, the creation of the dam also displaced long-time landowners and flooded much of the arable-bottom land farms. The existence and location of the Norris Dam were a significant contributing factor in the decision to place "Site X" of the top-secret Manhattan Project in the Clinch River Valley area. Other considerations were the area's remoteness, rural nature, the ridge and valley topography, accessibility of the area via highway and rail, the low cost for acquiring property, and the prevalence of non-farm workers in the area (Reference 1).

"Site X" eventually became the ORR and part of the Manhattan Project which had the goal of developing an atomic bomb. Land acquisition for the ORR began in 1942. The initial facilities constructed at the ORR included the X-10 nuclear reactor (the world's first graphite reactor) for the production of plutonium, Y-12 electromagnetic separation facility for the production of enriched uranium, and K-25 gaseous diffusion plant which also produced enriched uranium. While many existing structures were demolished to make way for the new ORR facilities, some structures were left in place, particularly in more remote areas of the ORR. Some of these were used for various purposes such as storage.

Shortly after World War II ended, Congress elected to continue to research and develop nuclear energy and the ORR became a permanent facility. Ultimately, the Atomic Energy Act of 1946 transferred the atomic research program from military to civilian control first under the AEC which later became the DOE. Population in the Oak Ridge area had peaked during the war and declined significantly during the post-war period, The ORR has continued to be a center of nuclear research and development (Reference 1).

The site is located on a parcel that previously housed Buildings K-31 and K-33, which were part of the K-25 complex and operated as the ORGDP. These facilities were later renamed ETTP (Reference 2). Uranium enrichment operations at the K-25 site ceased in 1986, and restoration, decontamination, and decommissioning activities began soon after. Reindustrialization of the ETTP began in 1996 by DOE in cooperation with the CROET in preparation for conversion of the site to a private sector industrial park, to be called the Heritage Center. ETTP has been transformed into a multi-use industrial park and conservation area. It is also part of the Manhattan Project National Historic Park (see Figure 3.6-1) (Reference 3).

Most ORR properties and facilities have historic and scientific significance based on their association with the Manhattan Project and Cold War periods. Additionally, scientific achievements made at these facilities are of significance in both national and world history. The X-10 graphite reactor is listed on the NRHP and is designated as a National Historic Landmark (Reference 1). In 2015, the Manhattan Project National Historical Park was established that includes several facilities at the ORR as well as additional locations in the states of Washington (Hanford Engineer Works) and New Mexico (Los Alamos). The location of the K-25 building is included within the national park boundaries (Reference 4).

3.6.2 Previous Investigations

Various cultural resource surveys have been conducted on and in the vicinity of the ORR over time, a majority of these have occurred since the 1970s. Surveys have generally been conducted in conjunction with large construction projects at the ORR or with the potential sale, lease, or transfer of DOE property.

Phase I and II surveys have identified prehistoric and historic sites in various locations on ORR property (Reference 5 Reference 6, Reference 7, and Reference 8). The Cultural Resource Management Plan, DOE ORR Anderson and Roane Counties, Tennessee (Reference 1) summarizes the known cultural resources within the ORR based on the results of these previous surveys.

A total of 44 archaeological sites have been identified and recorded at various locations across the ORR, 13 of which are eligible for inclusion in the NRHP (Reference 9). Evidence of prehistoric occupation within ORR property includes isolated sites and scattered habitation sites (based on evidence of postholes, circular structures, and wall-trench dwellings) and isolated burial mounds (Reference 1).

At least eight architectural and historical assessments/surveys have been conducted in vicinity of Oak Ridge, Tennessee. These surveys included historical significance and NRHP-eligibility determinations for various ORR properties (Reference 6 and Reference 10). The following list of historical assessments/surveys was cited in the ORR Cultural Resource Management Plan (Reference 1, Reference 8, Reference 9, Reference 11, Reference 12, Reference 13, and Reference 14).

The 1996 report, An Evaluation of Previously Recorded and Inventoried Archaeological Sites on the ORR, Anderson and Roane Counties, Tennessee (Reference 9) evaluated the NRHP eligibility of 254 known DOE-owned pre-World War II structures on the ORR. From this evaluation, 41 structures were determined to be individually eligible for inclusion in the NRHP. Out of those 41, the following 6 individual structures at three locations were identified as previously included in the NRHP (Reference 1):

- New Bethel Baptist Church and Cemetery (consists of three structures: the church and two grave houses)
- George Jones Memorial Baptist Church
- Freels Cabin (consisting of a dwelling and an outbuilding)

The 1996 survey also identified two potential historic archeological districts within the ORR: the Wheat Community and the Gravel Hill District. Neither of these districts overlaps the site (Reference 9).

The previous surveys have identified eight sites within ORR which include burial mounds and or are known human burial sites and which could, therefore, be considered sacred sites. The AEC originally identified 69 historic cemeteries located within ORR property. An assessment conducted in 1985 by Marjorie Parsly (1985) as part of an Oak Ridge Bicentennial project reviewed the 69 cemeteries on the AEC list plus three additional cemeteries that had been identified at a later time. Parsly’s team was unable to locate eight of the cemeteries. The cemeteries range in size from a single grave to more than 150 graves. A total of 32 cemeteries were still located with the ORR as of 2001 (Reference 1). No known cemeteries are present within or immediately adjacent to the site.

3.6.3 Results of Cultural Resource Investigation

There has been no Phase I archaeological investigation as no archaeological features would remain intact based on the site’s previous 100 percent disturbance and current status as a Brownfield.

3.6.4 State Agency Consultation

The DOE has completed two Memorandum of Agreements with the Tennessee State Historic Preservation Officer (SHPO) that apply to the site. In 1998, the DOE and SHPO signed a Memorandum of Agreement (MOA) to address the decontamination, and decommissioning as well as removal, recycling, and/or disposal of equipment associated with Buildings K-29, K-31, and K-33 as well as other ancillary activities.

The area of potential effect of the undertaking as defined in 36 CFR 800.2(c), was determined to be the interior and exterior of the gaseous diffusion Buildings K-29, K-31, K-33, and auxiliary facilities.

Consultation with the SHPO determined that all of these structures were eligible for inclusion on the NRHP. Therefore, the MOA established the following stipulations, and the DOE ensured the following measures were carried out (Reference 15):

- DOE produced and provided the SHPO with a project summary including maps. These maps are also retained in the DOE files.
- DOE collected and provided the SHPO with black and white photographs documenting the design and current conditions and surrounding landscapes of buildings K-29, K-31, and K-33 and auxiliary facilities. These photographs are also retained in the DOE files.
- DOE provided the SHPO with structural and architectural drawing documenting major equipment components. These drawings are also retained in the DOE files.
- DOE retains a document titled 'The Picture Book of Gaseous Diffusion' in the DOE Oak Ridge Operations Office files.
- DOE relocated a classified display of gaseous diffusion equipment components. This is accessible to individuals with appropriate security clearance.
- DOE retained unclassified gaseous diffusion components.

In 2001, the DOE and SHPO agreed to one modification of this MOA. This amendment specified which diffusion equipment and displays would be retained. Following the establishment of the MOA, and completion of the stipulations, Buildings K-29, K-31, and K-33 and the ancillary facilities were demolished.

In 2012, the DOE Oak Ridge Office of Environmental Management (DOE-OREM) proposed to continue and complete its undertaking involving historic properties located at the ETTP, formerly known as the Oak Ridge K-25 site. These activities included the decontamination, decommissioning, and demolition of historic properties in furtherance of DOE-OREM's overall responsibilities to complete the environmental restoration of the ETTP. Concurrently, the United States Senate proposed to create a new "Manhattan Project National Historical Park" that would specifically include the K-25 site at the ETTP. The proposed Manhattan Project National Historical Park Act contained provisions calling interdepartmental agreements, including provisions for public access, management, interpretation, and historic preservation. At the time of the signing of this MOA, multiple MOAs regarding the K-25 site had already been signed and executed, including storage of artifacts, oral history interviews, photographic studies, storage of all unclassified architectural and engineering designs, and site interpretations. The 2012 MOA contained 27 stipulations which the DOE-OREM committed to satisfy, the majority of which are associated with the K-25 site and/or the formation of the national park. The DOE provides regular reports to the consulting parties with regard to meeting stipulations of this 2012 MOA (Reference 16).

No additional consultation has occurred with the SHPO with regard to the site at this time.

3.6.5 References

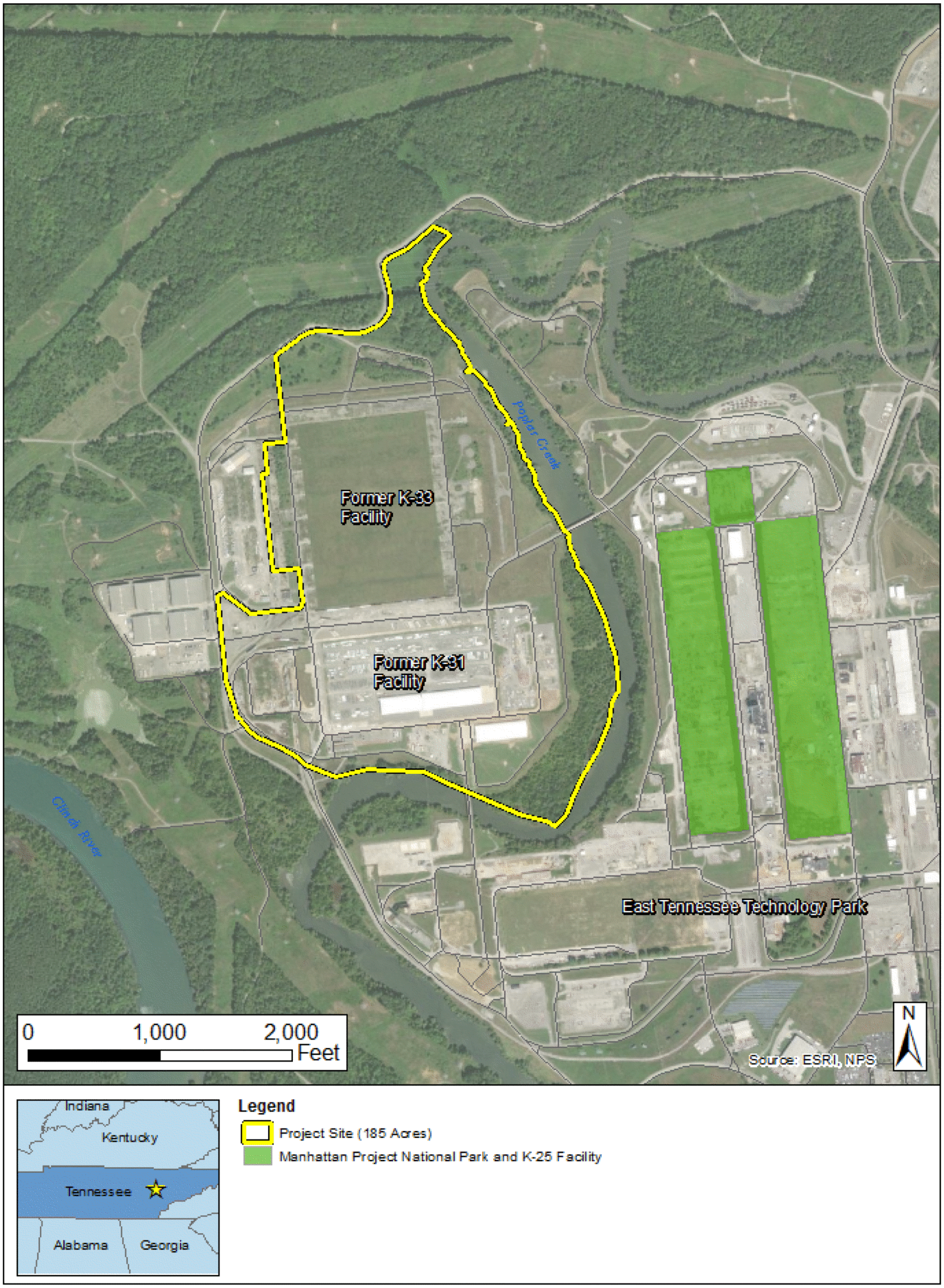
1. Souza, P.A., G.D. DuVall, and M.J. Hart, "Cultural Resource Management Plan Department of Energy Oak Ridge Operations Office Anderson and Roane Counties, Tennessee," DOE/ORO-2085, July 2001.

2. U.S. Department of Energy, Oak Ridge Environmental Management Program, ETTP Fact Sheet. 2019.

3. Flessner, D., "Oak Ridge, Tennessee, site cleans up 75-year waste legacy," Chattanooga Times Free Press, Retrieved from https://www.timesfreepress.com/news/local/story/2020/oct/13/oak-ridge-cleans-75-year-waste-legacy/534035/

4. National Park Foundation, Manhattan Project National Historical Park, Website: https://www.nationalparks.org/connect/explore-parks/manhattan-project-national-historical-park, accessed July 18, 2021.
5. Fielder, G.F., "Archaeological Survey with Emphasis on Prehistoric Sites of the Oak Ridge Reservation, Oak Ridge, Tennessee," ORNL-TM-4694, October 1974.
6. Fielder, G.F., S.R. Jr. Ahler, and B. Barrington, "Historic Sites Reconnaissance of the Oak Ridge Reservation, Oak Ridge, Tennessee," ORNL/TM-5811, April 1977.
7. GAI Consultants Inc., "Cultural Resources Survey and Evaluation of the Tennessee Synfuels Associates Site, Oak Ridge Reservation, Roane County, Tennessee," 1981. (As cited in U.S. Department of Energy, Cultural Resource Management Plan, DOE/ORO 2085).
8. Faulkner, C.H., "Archaeological Investigations of the Jenkins House Site (40RE188) and the Jones House Site (40RE189), Copper Ridge, Oak Ridge Reservation, Roane County, Tennessee, in Site Characterization Report for the Proposed Transuranic Waste Handling and Packaging Plant," 1988. (As cited in U.S. Department of Energy, Cultural Resource Management Plan, DOE/ORO 2085).
9. DuVall, G.D. and P.A. Souza, "An Evaluation of Previously Recorded and Inventoried Archeological Sites on the Oak Ridge Reservation, Anderson and Roane Counties, Tennessee," ORNL/M-4946, January 1996.
10. Fielder, G.F., "Cultural Resource Survey of the Exxon Nuclear Facility, Oak Ridge, Tennessee: An Interim Report," May 1975.
11. Thomason, P. and K. Murphy, "Historic and Architectural Resources of Oak Ridge. Multiple Property National Register Nomination for the Bear Creek Road Checking Station, Bethel Valley Road Checking Station, George Jones Memorial Baptist Church, Freels Cabin, Hackworth House, Jones House, New Bethel Baptist Church, Oak Ridge Historic District, Oak Ridge Turnpike Checking Station, and the Woodland-Scarboro Historic District, Oak Ridge, Tennessee," 1991.
12. DuVall, G.D., "An Archaeological Reconnaissance of a 14 Mile Section of the East Fork Poplar Creek for the Environmental Restoration Project, Anderson and Roane Counties, Tennessee," 1992.
13. Thomason, P., "Historic and Architectural Analysis Oak Ridge Associated Universities Properties, Oak Ridge, Tennessee," 1993. (As cited in U.S. Department of Energy, Cultural Resource Management Plan, DOE/ORO 2085).
14. Jacobs Environmental Restoration Team, "Archaeological Reconnaissance, K-25 Site, Oak Ridge Reservation, Oak Ridge, Tennessee (Draft)." (As cited in U.S. Department of Energy, Cultural Resource Management Plan, DOE/ORO 2085).
15. U.S. Department of Energy Oak Ridge Operations Office and Tennessee State Historic Preservation Office. “Memorandum of Agreement Pursuant to 36 Part 800.5€(4) Regarding the Three Building Decontamination and Decommission and Recycling Project at the K-25 Site on the Oak Ridge Reservation, Roane County, Tennessee” Amended 2001.
16. U.S. Department of Energy. “Transmittal of the Executed Memorandum of Agreement, Execution Plan and Mitigation Plan for Historical Properties at East Tennessee Technology Park.” November 9, 2012.

Figure 3.6-1: Manhattan Project National Historical Park



3.7 SOCIOECONOMICS

This section characterizes the current socioeconomic conditions within the region of influence (ROI) surrounding the site and provides a basis for assessing potential socioeconomic impacts as a result of construction and operation. The socioeconomic characterization addresses demographics (resident and transient population growth rates, race and ethnicity), community characteristics (the economy, housing availability, public services, local transportation), and tax payment information.

Data is analyzed at various geographic levels for the purpose of comparison. The nature and extent of socioeconomic characterization is consistent with the Final ISG Augmenting NUREG-1537, Part 1, Section 19.3.7.

3.7.1 Demography

3.7.1.1 Resident Population

3.7.1.1.1 Resident Population of Communities in Region of Influence

The ROI is identified as the five-county region nearest the site (Anderson, Knox, Loudon, Morgan, and Roane) as illustrated in Figure 3.7-1 (Reference 1). The ROI is defined by the areas where construction and operations workers and their families are most likely to reside, and spend their wages, salary, and benefits on goods and services, which impact the socioeconomic environment in the region. Population data was gathered using 2015-2019 American Community Survey 5-year estimates.

Table 3.7-1 shows the historic resident population for counties in the ROI and the State. Between 1990 and 2019, population in the ROI increased 32.9 percent overall, from 499,781 to 664,125. Rates of growth varied from 11.4 percent (Anderson County) to 67.5 percent (Loudon County). During the same period, population grew 37.6 percent in the State, from 4,877,185 to 6,709,356 (Reference 2, Reference 3, Reference 4, and Reference 5).

In 2019, the City of Oak Ridge, Tennessee located in Anderson and Roane Counties approximately 8.9 miles southwest of the site, had population of 29,039. The City of Knoxville, Tennessee, located in Knox County approximately 26.5 miles west of the site, had a population of 187,603 (Reference 5). ROI counties are part of the Knoxville-Morristown-Sevierville, Tennessee Combined Statistical Area (CSA) (Reference 6).

3.7.1.1.2 Region of Influence Resident Population Growth Projection

Table 3.7-2 shows projected population in the ROI and the State. Population is projected to increase 7.0 percent (from 664,125 to 710,778) between 2019 and 2026 in the ROI. Growth is projected in all counties. Roane County is projected to grow the least (0.5 percent); Loudon County is projected to grow the most (11.2 percent). During the same period, the State is projected to grow 7.4 percent (from 6,709,356 to 7,203,404) (Reference 5 and Reference 7).

Population growth of 3.1 percent is projected in the ROI between 2026 and 2031. As shown in Table 3.7-2, ROI population is projected to increase from 710,778 to 732,719 by 2031. Growth is projected for all ROI counties during this period, with the exception of Roane County, which is projected to decrease 0.6 percent. Loudon County is projected to grow the most (4.5 percent). During the same period, the State is projected to grow 3.3 percent (from 7,203,404 to 7,438,692) (Reference 5 and Reference 7).

3.7.1.1.3 Transient Population within 5 Miles

Transient populations are temporary or seasonal populations residing in the area, such as in lodging accommodations, dormitories or classrooms on a college campus. According to the results of the

desktop research, there are no colleges, universities, or lodging facilities within 5 miles of the site. Thus, there are no transient populations in the area (Reference 1).

3.7.1.1.4 Race and Ethnicity of the Resident Population in the Region of Influence

As shown in Table 3.7-3, in 2019 the minority population in the ROI was 15.4 percent, less than the State (26.2 percent) and the nation (39.3 percent). Knox (17.7 percent) and Loudon (12.3 percent) Counties had the largest proportion of minority populations within the ROI. Roane County had the smallest minority population (7.3 percent). The largest minority groups within the ROI included African American (6.9 percent) and Hispanic/Latino groups (4.2 percent) (Reference 8).

3.7.2 Community Characteristics

Community characteristics refer to socioeconomic attributes of the local economy, local housing statistics, public services, infrastructure including major transportation, facilities, and tax payment information. The data presented below reflect community characteristics in the ROI. Economic data was gathered using 2015-2019 American Community Survey 5-year estimates and the Bureau of Economic Analysis.

3.7.2.1 Economy

The economy of the ROI is evaluated by examining per capita and household income, division of the labor force, unemployment rates, and poverty rates.

3.7.2.1.1 Income (Population and Household)

As shown in Table 3.7-4, per capita income for 2019 within the ROI ranged from $20,204 (Morgan County) to $33,229 (Knox County). During the same period, the state's per capita income ($29,859) was within the range of the ROI values. The nation's per capita income was greater than the ROI and the State ($34,103) (Reference 9).

In 2019, median household income for the ROI ranged from $41,333 (Morgan County) to $58,065 (Loudon County). The United States had higher median household income ($62,843) than the ROI, while the value for Tennessee ($53,320) fell within the ROI range (see Table 3.7-4) (Reference 9).

3.7.2.1.2 Labor Force and Unemployment

Table 3.7-5 shows unemployment rates and the number of individuals in the labor force in 2019. Unemployment rates for Anderson (6.1 percent), Morgan (6.6 percent), and Roane (6.1 percent) counties were higher than both the State (5.3 percent) and the nation (5.3 percent) while Knox (4.3 percent) and Loudon (4.7 percent) counties had lower rates of unemployment (Reference 9). Table 3.7-6 shows the total number of people employed as well as the types of employment. In the State, health care/social assistance (10.4 percent) and government (10.8 percent) categories comprised the highest percentage of jobs. This is also reflected in the United States data. Within the ROI government jobs are the highest percentage in Morgan (26.8 percent) and Roane (15.2 percent) counties with Anderson (10.5 percent), Knox (10.7 percent), and Loudon (9.9 percent) counties reflecting similar percentages to that of the State. The manufacturing sector provided the highest percentage of jobs in Anderson County (23.2 percent) and Loudon County (15.7 percent). In Knox County health care and social assistance provided the highest number of jobs with 12.4 percent of the labor force employed in the sector (Reference 10).

As shown in Table 3.7-7, 89.5 percent of federal and contractor employees who work at the DOE Oak Ridge facilities reside in the ROI (Reference 11). Technical and educational attributes of DOE-related

workers are assumed to be substantially similar to the attributes of workers employed at the site. Kairos employees would likely reside in the ROI.

3.7.2.1.3 Poverty Rates

As shown in Table 3.7-8, in 2019 the low-income population in the ROI was 14.7 percent, representing the percentage of the individuals with income below the poverty level. During the same period, the poverty rate was 15.2 percent and 13.4 percent in the State and nation respectively. In 2019, the percentage of families with income below the poverty level was 10.0 percent. During the same period, the poverty rate was 11.1 percent and 9.5 percent in the State and nation respectively (Reference 9).

3.7.2.2 Housing

Table 3.7-9 shows the total number of housing units (298,372) in the ROI in 2019. The number of occupied and vacant units was 267,055 and 31,317 respectively. The rental vacancy rate for the ROI was 10.5 percent, lower than Tennessee (12.4 percent) and the nation (12.1 percent). Rental vacancy rates ranged from 8.9 percent (Knox County) to 18.5 percent (Roane County). The median home value for the ROI ranged from $102,000 - $222,500 while the State’s median home value was $167,200 and the nation’s median home value was $217, 500 (Reference 2).

3.7.2.3 Transportation

The area around the site is served by a transportation network of federal and state highways; three freight rail lines; one major navigable river; one commercial passenger airport (McGhee Tyson Airport), and one reliever airport (Knoxville Downtown Island Airport). Figure 3.7-2 illustrates the road, highway, railroad, and airport systems in the area.

3.7.2.3.1 Roads and Highways

Major transportation corridors in the region are I-40, the major east-west Interstate Highway (located 5 miles south of the site) and I-75, (approximately 10 miles southeast of the site) which travels in a generally north-south direction, as well as Interstate 140, approximately 16 miles east of the site. Six other federal highways provide access to the area: U.S. 11, U.S. 27, U.S. 70, U.S. 129, U.S. 321, and U.S. 441.

Nearby Tennessee state highways include TN 58, TN 326, TN 327, and TN 95, TN 61, TN 62, and TN 1. The state roads closest to the site are TN 58 (<1 mile), TN 327 (1 mile) and TN 95 (2 miles). TN 58 runs northeast to southwest, while TN 95 runs north to south and connects to the City of Oak Ridge business district approximately 10 miles to the northeast. The junction of TN 58 and TN 95 is located approximately 2.5 miles north-northeast of the nearest border of the Site (see Figure 3.7-1).

Onsite construction workers and plant staff would be required to commute because there are no available housing options at the site. Access to and from the site would be from either TN 327 (Blair Rd), or TN 58 (Oak Ridge Turnpike), see Figure 3.7-1 for access roads. For workers commuting from the north and south, there are interchanges on I-40 for both TN 58 and TN 95. Regardless of which access road is used, workers would access the site via the perimeter road. Major roads that serve the area surrounding the site are listed below:

- State Route 58 (Oak Ridge Turnpike) is a 4-lane divided principal arterial roadway that carries approximately 12,600 vehicles per day according to the Tennessee Department of Transportation (TDOT) with a 55-mph speed limit. It has 10-foot-wide paved shoulders and a paved two-way left-turn median. This roadway intersects I-40 to the southwest and continues towards Oak Ridge to the northeast.

- State Route 95 (White Wing Road) is a 4-lane divided principal arterial roadway that carries approximately 5,800 vehicles per day according to TDOT with a 50-mph speed limit. This roadway intersects I-40 to the south and intersects at an interchange with State Route 58.
- State Route 327 (Blair Road) is a 2-lane undivided major collector that carries approximately 2,500 vehicles per day according to TDOT with a 35-mph speed limit. This roadway intersects with State Route 61 to the north of the site and runs along the eastern side of the study area. Blair Road intersects with Oak Ridge Turnpike at a signalized intersection.

A Traffic Assessment was completed in July 2021 . This traffic assessment utilized adjusted annual average daily traffic (AADT) volumes obtained from Streetlight Data Inc (Streetlight). Streetlight uses anonymized location records collected and processed from smartphones and navigation devices in vehicles to estimate traffic volumes. AADTs from the year 2019 were utilized for the existing conditions for the assessment. This year was chosen due to the COVID-19 Pandemic occurring in 2020-2021 and causing a disruption to traffic patterns. The anticipated peak year of construction would occur in the Build Year of 2025. AADTs from 2019 were grown by a growth rate of 2 percent per year for 6 years to obtain estimated 2025 AADTs for the roadways near the study area. The growth rate was obtained as a conservative estimate based on historical area AADTs (2014-2018) obtained from TDOT traffic counts website. Blair Road traffic has increased by approximately 1.4 percent per year east of the site near State Route 58 while Blair Road north of the ETTP near State Route 61 has decreased by 2.6 percent per year. Oak Ridge Turnpike use has grown by approximately 4 percent per year in the same time frame. Traffic within the ETTP complex would likely not grow at the same rate as Oak Ridge Turnpike, so 2 percent is a conservative estimate of traffic growth within the site .

Figure 3.7-3 shows the site location, traffic count locations, and 2019 daily traffic volumes obtained from Streetlight. Using the Florida Department of Transportation Quality/Level of Service Handbook Tables as a reference, the following traffic volume thresholds for various levels of service (LOS) on two-lane undivided roadways are shown in Table 3.7-10. It should be noted this information is based on planning applications from the Highway Capacity Manual and should not be used for detailed corridor or intersection design. Typically, LOS C is the threshold used in transitioning areas (not considered urbanized or rural and with a population over 5,000) for planning level capacity analysis. In addition, 2019 AADTs in the vicinity of the site were obtained on Perimeter Road (just northwest of Connector Rd); Perimeter Road Bridge over Poplar Creek; Bridge over Poplar Creek (east of site); Road near complex entrance (east of Poplar Creek Bridge); and N Perimeter Road (northeast of site).

Based on the existing analysis, the roadways providing access to the site are under capacity as shown in Table 3.7-11 and none of these roadway segments exceed the LOS C volume threshold over a given 24-hour day. Table 3.7-12 shows the estimated 2025 AADTs based on a 2 percent growth rate for 6 years applied to the existing 2019 AADT for each roadway.

3.7.2.3.2 Transit

The East Tennessee Human Resource Agency (ETHRA) provides bus transportation to the sixteen-county area of East Tennessee including Anderson, Knox, Loudon, and Roane Counties (Reference 12). The ETHRA provides special purpose bus transportation service and medical transportation (not on fixed, scheduled routes) to the general public (Reference 13). ETHRA also operates Oak Ridge Transit, which provides bus service within Oak Ridge city limits (Reference 14). Knoxville Area Transit provides fixed route bus service, downtown trolley routes, University of Tennessee campus service, and paratransit services (Reference 15).

3.7.2.3.3 Rail

Figure 3.7-2 shows railways within the area surrounding the site. In Oak Ridge, the Heritage Railroad Corporation operates the 9.5-mile Heritage Railroad shortline serving ETTP (Reference 16). There is also an 18-mile shortline railroad operated by Knoxville and Holston River Railroad, from Knoxville through Knox County (Reference 16). Both of these lines connect with rail lines operated by Norfolk Southern Railway Company. CSX operates a rail line 12 miles northeast of the site, while Norfolk Southern rail lines are located approximately 8 miles west and 12 miles southeast of the site. The line to the southeast travels through Knoxville, Tennessee, connecting Chattanooga, Tennessee with Johnson City and Kingsport, Tennessee (Reference 17).

3.7.2.3.4 Air

McGhee Tyson Airport is a large commercial airport located near Knoxville, Tennessee. The Bureau of Transportation Statistics reported 1,117,000 arrivals and 1,200,000 departures in 2020 but total passengers decreased 52 percent to 528,000 and 531,000 for arrivals and departures respectively for 2021 (reporting periods end in April each year) likely, in part, due to COVID 19 travel restrictions (Reference 18). The McGhee Tyson Airport is located in Alcoa, Tennessee, approximately 25 miles east-southeast of the site. There is also a regional airport, the Oak Ridge Airport, planned at the ETTP in Oak Ridge Tennessee in 2025 which is in the early stages of development and planning (Reference 19). Other Airports in the area include Rockwood Municipal Airport (17 miles west), Oliver Springs Airport (9 miles north northeast), Meadow Lake Airport (10 miles southwest), Cox Farm Airport (10 miles southeast), Big T Airport (8 miles southeast), Skyranch Airport (25 miles east), Knoxville Downtown Island (30 miles east), Village Airport (23 miles south southeast), and Roberson Farm Airport (19 miles east).

3.7.2.3.5 Waterways

The site is adjacent to the Clinch River (Clinch River arm of the Watts Bar Reservoir) between approximately CRMs 11 and 13. The Clinch River is a major tributary of the Tennessee River, which has a navigable channel 652 miles long. The Tennessee River begins in Knoxville Tennessee and merges with the Ohio River in Paducah, Kentucky. This waterway is controlled by a series of nine dams and locks which are part of TVA's integrated river control system. This larger control system has a total of 49 dams and 15 navigation locks (Reference 20). There are 61 miles of commercially navigable river on the Clinch River extending from its mouth near Kingston, Tennessee upstream to Clinton, Tennessee (Reference 21). The navigable portion of the Clinch River includes a navigation lock at the Melton Hill Dam. The lock is 75 feet by 400 feet and has a maximum lift of 60 feet (Reference 22).

3.7.2.4 Tax Payment Information

The sales tax is Tennessee's principal source of state tax revenue accounting for approximately 60 percent of all tax collections. The sales tax is comprised of two parts, a state portion and a local portion. The general state tax rate is 7 percent (Reference 23). In Tennessee, any county or incorporated city, by resolution or ordinance, may levy the local sales and use tax on the same privileges that are subject to the state's sales or use tax. The local tax rate may not be higher than 2.75 percent and must be a multiple of 0.25. All local jurisdictions in Tennessee have a local sales and use tax rate. The local sales tax rate and use tax rate are the same rate. Local sales and use taxes are filed and paid to the Department of Revenue in the same manner as the state sales and use taxes (Reference 24). The Roane County sales tax rate is 2.5 percent and the Oak Ridge city tax rate is 2.75 percent (Reference 25).

Property taxes are also collected either by the county or local government. As the facility is located within Roane County, a property tax rate of $2.26 per $100 assessed value would apply (Reference 26). Added to this would be the City of Oak Ridge property tax of 2.3136 percent, for a total of $4.5736 per

$100 of assessed value (Reference 27). County funds for the Oak Ridge Schools come from two primary sources, property and sales tax, and are allocated to school systems based on their proportion of students in the County. Overall, city funding represents approximately 25.34 percent of total school revenues, providing $18,077,939 for fiscal year 2021 (Reference 28).

3.7.2.5 Public Services

Public water supply and wastewater treatment in the site ROI is provided locally. As shown in Table 3.7-13, the majority of public water in the region is supplied by surface water. Several of these systems purchase surface water from other suppliers. In addition, public water supply in the region is operating below capacity. Public wastewater systems for the region are shown in Table 3.7-14. This section provides a description of the water supply and wastewater systems in region (Reference 29, Reference 30, Reference 31, and Reference 32).

Public Water Supplies

With intakes along the Melton Hill Lake section of the Clinch River and using a conventional water treatment plant, potable water for the site is supplied by the City of Oak Ridge Public Works Department (Reference 33). The current system regularly supplies a total of 6 to 8 MGD with a regularly deliverable maximum of 12 MGD. Along with fire hydrants and elevated fire water storage tanks, the water distribution system includes:

- two in-ground water storage tanks
- 11 water pumping stations
- 219 miles of water main piping
- 9,050 service laterals
- 12,040 water meters

The water system is operating near capacity, supplying an average 4.15 MGD to city water customers (Reference 34 and Reference 35).

A new ultrafiltration membrane drinking water treatment plant is anticipated to be fully tested and operational in 2024 or 2025. Located at the city's water intake on the Clinch River, the new water plant will be south of Bethel Valley Road (Reference 33). When completed, the modular ultrafiltration system will provide between 12 to 16 MGD with the modular design allowing expansion up to 20 MGD. Improvements will also include upgraded raw water screens and pumps along with a new water transmission line (Reference 33).

Wastewater Treatment Systems

Along with potable water, the City of Oak Ridge also supplies wastewater services to the Heritage Center Industrial Park in Oak Ridge, Tennessee. The City of Oak Ridge provides wastewater treatment at its two Clinch River facilities. The city wastewater system includes 236 miles of collection piping along with manholes and pumping stations. The main plant has the capacity to treat 30 MGD. The secondary plant has the capacity to treat 0.6 MGD and serves the Heritage Center Industrial Park (Reference 34). The City of Oak Ridge currently treats a total of 5.6 MGD and 2.1 billion gallons per year with its two wastewater treatment plants (Reference 34).

Wastewater treatment for the Heritage Center Industrial Park is provided by the secondary Clinch River facility. This facility was initially designed to service Rarity Ridge, a planned residential development on the opposite side of the Clinch River. Because this plant operates at peak capacity, 0.6 MGD, during wet weather, the plant is currently under evaluation for future growth.

3.7.2.5.1 Local Public Schools

The Tennessee Department of Education oversees school districts in the state; adopting academic standards to establish desired learning outcomes. Districts establish curriculums to help students meet these goals. Part of the East District of Tennessee schools, the five counties in the site region include more than 150 public schools offering instruction from prekindergarten through high school. As shown in Table 3.7-15, during 2020, public schools in this five-county area served more than 90,000 students (Reference 36 and Reference 37).

The closest school to the site is Dyllis Springs Elementary School, which is located approximately 5.7 miles to the northeast at 120 Ollis Road in Oliver Springs, Tennessee. In 2020, this Roane County school provided prekindergarten to 5th grade instruction for 368 students (Reference 36).

3.7.2.5.2 Public Recreational Facilities

Recreational activities that could be affected by the construction and operation of the facility include mainly outdoor, nature-oriented activities such as boating, fishing, hunting, camping, bicycling, and hiking. There are several locations in the vicinity if the site that are available for these activities, mainly national and state parks, including many reservoirs along the Tennessee River system

There are six national parks in the site vicinity: Manhattan Project National Park, Chickamauga Chattanooga National Military Park, Big South Fork National River and Recreation Area, Cumberland Gap National Historical Park, Obed Wild and Scenic River, and Great Smoky Mountains National Park. Annual visitor totals can be found in Table 3.7-16. The site is located adjacent to parts of the Manhattan Project National Park, Oak Ridge. The nearby K-25 site is part of this park. Other parts of the national park are located throughout the Oak Ridge area. Activities associated with the Manhattan Project National Park include a bus tour through the former Manhattan Project facilities, the American Museum of Science and Energy, and A. K. Bissel Park (Reference 38). The Big South Fork National River and Recreation Area is located approximately 39 miles north-northwest of the site and recorded an annual visitor count of 772,625 persons in 2020 (Reference 39). Obed Wild and Scenic River is located approximately 14 miles northwest of the site and recorded 237,837 persons in 2020 (Reference 40). The national park with the largest transient population is Great Smoky Mountains National Park. Located approximately 53 miles southeast, the Great Smoky Mountains National Park recorded an annual visitor count of 12,547,743 persons in 2020 (Reference 41). The Chickamauga & Chattanooga National Military Park saw 678,414 visitors in 2020, while Cumberland Gap National Historical Park registered 735,447 visitors in the same year (Reference 39).

State parks in the region include Frozen Head State Park (approximately 10 miles north), Fort Loudoun State Historic Park (approximately 25 miles south-southeast), Cove Lake State Park (approximately 28 miles northeast), Big Ridge State Park (approximately 33 miles northeast), Cumberland Mountain State Park (approximately 33 miles west), Head of Sequatchie Cumberland Trail State Park (approximately 35 miles west-southwest), Justin P. Wilson Cumberland Trail State Park (approximately 35 miles southwest), and House Mountain State Natural Area (approximately 37 miles northeast). Annual visitor numbers can be found in Table 3.7-17. Generally, activities include camping, hiking, bicycling, fishing, and boating.

Within the City of Oak Ridge, there are 17 community parks with opportunities for hiking, athletics, swimming, large social events and picnicking (Reference 42). In nearby Kingston, there are many opportunities for recreational activities including parks, an amphitheater, a sports complex, a community center, an outdoor pool, a dock, a fort, boat slips, a dog park and walking trails (Reference 43).

There are nine TVA dams on the Tennessee river with a number of uses including drinking water, cooling water, shipping, and hydroelectric generation (Reference 44). Outdoor recreation is an important pastime in Tennessee and a large attraction for transient populations coming into the region. The Tennessee River system flows northeast to southwest through the 50-mile region. This river system includes several large and well-known fishing and recreational reservoirs.

1. The Watts Bar Dam and Reservoir is located about 30 miles away from the site. The Watts Bar Reservoir is approximately 39,000 acres with 780 miles of shoreline attracting millions of visitors a year.
2. The Chickamauga Reservoir is located approximately 75 miles southwest of the site. The Chickamauga Reservoir has been ranked as a top 10 lake by Bassmaster, for the past several years. This reservoir lake is 59 miles long, has 36,240 acres of surface water and 810 miles of shoreline (Reference 45).
3. Fontana Reservoir is located about 50 miles southeast of the site, and the 2,000-mile long Appalachian Trail crosses Fontana Dam. This is the highest dam east of the Rocky Mountains and the lake has 10,230 acres of surface water and 238 miles of shoreline with 514,000 acre-feet (ac-ft) of flood storage (Reference 46).
4. Douglas Reservoir is located 60 miles east of the site, and has a surface area of 30,400 acres, and 550 miles of shoreline (Reference 47).
5. Norris Reservoir is located approximately 25 miles north-northeast of the site on the Clinch River with a surface area of 33,840 acres and 809 miles of shoreline and 126 megawatts of generation capacity (Reference 48).
6. Melton Hill Reservoir is fed by Norris Reservoir and is about 13 miles east of the site. This lake has 5,470 acres of surface area, 193 miles of shoreline and has 79 MW of electrical generation capacity (Reference 22).
7. Fort Loudoun Lake is located approximately 20 miles southeast of the site and is the uppermost of the 9 TVA navigable reservoirs with 14,600 surface acres, 379 miles of shoreline, has 111,000 ac-ft of water with a daily 151 MW capacity (Reference 49).
8. Cherokee Reservoir is located about 55 miles northeast of the site. It has county and municipal parks, a state park, and state wildlife management area as well as resorts (Reference 50). The reservoir has a surface area of 28,780 acres and almost 400 miles of shoreline with a storage capacity of 749,400 ac-ft of water and produces 122 MW of energy during the summer (Reference 50).
9. Tellico Dam is about 14 miles southeast of the site and is an extension of the Fort Loudoun Reservoir diverting water via canal into Fort Loudoun Reservoir (Reference 49 and Reference 50).

3.7.3 References

1. ESRI, Tennessee Map, 2021.
2. National Bureau of Economic Research, 1900 Census U.S. Decennial County Population Data, 1900-1990, Website: https://www.nber.org/research/data/census-us-decennial-county-population-data-1900-1990, accessed July 23, 2021.
3. U.S. Census Bureau, 2000 Total Population - 2000 Decennial Census. Table: P001, Website: https://data.census.gov/cedsci/table?q=P001&g=0100000US_0400000US47_0500000US47001,47093,47105,47129,47145_1600000US4755120&y=2000&tid=DECENNIALSF12000.P001&hidePreview=true&tp=true, accessed July 23, 2021.
4. U.S. Census Bureau, 2010 Census - Table Results, Website: https://data.census.gov/cedsci/table?text=population&g=0100000US_0400000US47_0500000U

S47001,47093,47105,47129,47145_1600000US4755120&y=2010&d=DEC%20Summary%20File %201&tid=DECENNIALSF12010.P1&hidePreview=true&cid=P001001&tp=true, accessed July 23, 2021.

5. U.S. Census Bureau, ACS Demographic and Housing Estimates - 2019 American Community Survey 5 Year Census - Table Results, Website: https://data.census.gov/cedsci/table?q=dp05&g=0100000US_0400000US47_0500000US47001,47093,47105,47129,47145_1600000US4755120&tid=ACSDP5Y2019.DP05&hidePreview=true&tp=true, accessed

6. U.S. Census Bureau. Tennessee - Combined Statistical Areas (CSAs) and Counties. 2013. Website: https://www2.census.gov/geo/maps/metroarea/stcbsa_pg/Feb2013/cbsa2013_TN.pdf, accessed June 4, 2021

7. Tennessee State Data Center. 2019- Boyd Center for Business and Economic Research, Boyd Center Population Projections, Website: https://tnsdc.utk.edu/estimates-and-projections/boyd-center-population-projections/, accessed July 23, 2021

8. U.S. Census Bureau, Hispanic or Latino Origin by Race Table B03002, Website: https://data.census.gov/cedsci/table?q=B03002&g=0500000US47001,47093,47105,47129,47145_1600000US4755120&tid=ACSDT5Y2019.B03002&hidePreview=true&moe=false, accessed July 23, 2021

9. U.S. Census Bureau, Selected Economic Characteristics - Table DP03, Website: https://data.census.gov/cedsci/table?g=0400000US47_0500000US47001,47093,47105,47129,47145_1600000US4755120&y=2019&tid=ACSDP5Y2019.DP03&hidePreview=true&moe=false, accessed July 23, 2021

10. Bureau of Economic Analysis. 2019 - CAEMP25N Total Full-Time and Part-Time Employment by NAICS Industry 1/. Website: https://apps.bea.gov/iTable/iTable.cfm?reqid=70&step=30&isuri=1&major_area=4&area=47131&year=2018&tableid=33&category=733&area_type=4&year_end=-1&classification=naics&state=47000&statistic=-1&yearbegin=-1&unit_of_measure=levels, accessed July 23, 2021

11. U.S. Department of Energy, "Economic Impact in Tennessee," 2017. https://eteconline.org/wp-content/uploads/2018/05/DOE-EIS-FY17-Report.pdf

12. East Tennessee Human Resource Agency, Our Locations, Website: https://www.ethra.org/locations/, accessed September 15, 2021.

13. East Tennessee Human Resource Agency, Public Transit, Website: https://www.ethra.org/programs/16/public-transit/, accessed September 15, 2021.

14. City of Oak Ridge Tennessee, Oak Ridge Transit System, Website: https://www.oakridgetn.gov/content.aspx?article=2835, accessed September 15, 2021.

15. Knoxville Area Transit, Schedules & Maps, Website: https://www.katbus.com/148/Schedules-Maps, accessed September 15, 2021.

16. Center for Transportation Research - The University of Tennessee and The University of Memphis, "Tennessee’s Short-Line Railroads - Programs Policies and Perspectives," October 2016.

17. Norfolk Southern Company, Norfolk Southern 2016 System Map, 2016.

18. Bureau of Transportation Statistics, McGhee Tyson (TYS) Airport Summary Data, Website: https://www.transtats.bts.gov/airports.asp?20=E&Nv42146=glf&Nv42146_anzr=X01A8vyyr,%20ga:%20ZpTurr%20gB510&pn44vr4=SNPgf, accessed 2021.

19. City of Oak Ridge Tennessee, Oak Ridge Airport Frequently Asked Questions (FAQs), Website: http://www.oakridgetn.gov/content.aspx?article=5203.

20. Tennessee Valley Authority, "Tennessee River Waterway Management Plan 2020," January 2020.

21. Tennessee Valley Authority, Navigation on the Tennessee River, Website: https://www.tva.com/environment/managing-the-river/navigation-on-the-tennessee-river, accessed August 5, 2021.

22. Tennessee Valley Authority, Melton Hill, Website: https://www.tva.com/energy/our-power-system/hydroelectric/melton-hill-reservoir, accessed June 18, 2021.

23. Tennessee Department of Revenue, Sales and Use Tax, Website: https://www.tn.gov/revenue/taxes/sales-and-use-tax.html, accessed September 15, 2021.

24. Tennessee Valley Authority, Local Sales Tax and Single Article, Website: https://www.tn.gov/revenue/taxes/sales-and-use-tax/local-sales-tax-and-single-article.html, accessed September 15, 2021.

25. Tennessee Valley Authority, Tennessee Sales and Use Tax County and City Local Tax Rates, Website: https://www.tn.gov/content/dam/tn/revenue/documents/taxes/sales/taxlist.pdf, accessed September 15, 2021.

26. Roane County Tennessee, Assessor of Property, Website: https://roanecountytn.gov/assessor-of-property/, accessed September 15, 2021.

27. City of Oak Ridge Tennessee, Tax Rates, Website: https://www.oakridgetn.gov/department/Finance/Tax-Rates, accessed September 15, 2021.

28. Oak Ridge Board of Education, "Oak Ridge Schools RY 2021 Adopted Budget," May 18, 2020.

29. Robinson, J.A., "Public-Supply Water Use and Self-Supplied Industrial Water Use in Tennessee, 2010," Scientific Investigations Report 2018–5009, 2018.

30. Robinson, J.A., "Public-Supply Water Use and Self-Supplied Industrial Water Use in Tennessee, 2010. Appendices 1-7," U.S. Geological Survey Scientific Investigations Report 2018-5009, 2018.

31. U.S. Environmental Protection Agency, Tennessee Water System Summary, Website: https://ofmpub.epa.gov/apex/sfdw/f?p=108:103::::RP::, accessed July 8, 2021.

32. Tennessee Valley Authority, "Clinch River Nuclear Site Early Site Permit Application - Part 3 Environmental Report Revision 2," March 2019.

33. Huotari, J., "Construction of new water plant could start in May, be complete next year," Oak Ridge Today, February 7, 2021. Retrieved from https://oakridgetoday.com/2021/02/07/construction-of-new-water-plant-could-start-in-may-be-complete-next-year/.

34. City of Oak Ridge Tennessee, Operations, Website: http://www.oakridgetn.gov/department/PublicWorks/Divisions/Services.

35. City of Oak Ridge, "Annual Water Quality Report - Reporting Year 2020," PWSID#: TN0000522, February 23, 2021.

36. Tennessee Department of Education, Report Card Data, Website: https://www.tn.gov/content/tn/education/data/data-downloads.html, accessed August 2, 2021.

37. Tennessee Department of Education, "Annual Statistical Report of the Department of Education for Year Ending June 30, 2020," 2020.

38. National Park Service, Oak Ridge, TN, Website: https://www.nps.gov/mapr/oak-ridge.htm, accessed September 15, 2021.

39. National Park Service, Annual Visitation Report by Years: 2010 to 2020, Website: https://irma.nps.gov/STATS/SSRSReports/National%20Reports/Annual%20Visitation%20By%20Park%20(1979%20-%20Last%20Calendar%20Year), accessed June 17, 2021.

40. National Park Service, Obed Wild and Scenic River, Website: https://irma.nps.gov/STATS/SSRSReports/Park%20Specific%20Reports/Annual%20Park%20Recreation%20Visitation%20(1904%20-%20Last%20Calendar%20Year)?Park=OBRI, accessed June 7, 2021.

41. Smokies., V.M., Great Smoky Mountains National Park Sees Near-Record Number of Visitors in 2020, Website: https://www.visitmysmokies.com/blog/smoky-mountains/great-smoky-mountains-national-park-visitors-record/, accessed March 1, 2021.

42. City of Oak Ridge, Community Parks, Website: http://orrecparks.oakridgetn.gov/parks/, accessed September 15, 2021.

43. Kingston TN, Kingston City Park, Website: https://parks.kingstontn.gov/facilities/, accessed September 15, 2021.

44. Watts Bar Lake, Watts Bar Lake Online Guide, Website: https://www.wattsbar.com, accessed June 3, 2021.

45. Bassmaster, A look at Chickamauga, Website: https://www.bassmaster.com/slideshow/look-chickamauga, accessed October 15, 2020.

46. Tennessee Valley Authority, Fontana, Website: https://www.tva.com/energy/our-power-system/hydroelectric/fontana, accessed June 3, 2021.

47. LakesOnline.com, Douglas Lake, Tennessee - Community and Visitors Guide, Website: http://www.douglaslake.info/, accessed June 17, 2021.

48. Tennessee Valley Authority, Norris Dam, Website: https://www.tva.com/energy/our-power-system/hydroelectric/norris, accessed June 18, 2021.

49. Tennessee Valley Authority, Fort Loudoun, Website: https://www.tva.com/energy/our-power-system/hydroelectric/fort-loudoun, accessed June 4, 2021.

50. Tennessee Valley Authority, Cherokee Website: https://www.tva.com/energy/our-power-system/hydroelectric/cherokee, accessed June 4, 2021.

51. USCB 2019. Selected Housing Characteristics. Table DP04. https://data.census.gov/cedsci/table?q=Occupancy%20Status%20housing%20units&g=0100000US_0400000US47_0500000US47001,47093,47105,47129,47145&tid=ACSDP5Y2019.DP04&hidePreview=true&moe=false

52. Clinton Utilities Board, "Guide to New Residential Construction. Water and Sewer," November 1, 2019.

53. First Utility District of Knox County, Water Treatment Plant, Website: https://fudknox.org/departments/water-treatment-plant/, accessed July 13, 2021.

54. Hallsdale-Powell Utility District, Distribution System, Website: https://www.hpud.org/distribution-system/, accessed July 13, 2021.

55. Witt, G., "South Knox water treatment plant opens," Knoxville News Sentinel, September 25, 2014. Retrieved from https://archive.knoxnews.com/news/local/south-knox-water-treatment-plant-opens-ep-634525743-354221371.html/

56. Knoxville Utilities Board, KUB Service Areas, Website: https://www.kub.org/about/about-kub/kub-service-areas/, accessed July 13, 2021.

57. First Utility District of Knox County, Wastewater Treatment Plant, Website: https://fudknox.org/departments/wastewater-treatment-plant/, accessed July 13, 2021.

58. Hallsdale-Powell Utility District, Collection System, Website: https://www.hpud.org/collection-system/, accessed July 13, 2021.

59. Tennessee Division of Water Resources, DWR Permits in Tennessee, Website: https://dataviewers.tdec.tn.gov/pls/enf_reports/f?p=9034:34001, accessed July 11, 2021

Table 3.7-1: Historic Population and Growth Rates of ROI Counties

County	1990	2000	2010	2019	Percent Change 1990 - 2019
Anderson	68,250	71,330	75,129	76,061	11.4%
Knox	335,749	382,032	432,226	461,104	37.3%
Loudon	31,255	39,086	48,556	52,340	67.5%
Morgan	17,300	19,757	21,987	21,545	24.5%
Roane	47,227	51,910	54,181	53,075	12.4%
Total ROI	499,781	564,115	632,079	664,125	32.9%
Tennessee	4,877,185	5,689,283	6,346,105	6,709,356	37.6%
Sources: (Reference 2, Reference 3, Reference 4, and Reference 5)					

Table 3.7-2: Projected Population and Growth Rates of ROI Counties

County	2019	Projected 2026	Projected 2031	Percent Change 2019 - 2026	Percent Change 2026 - 2031
Anderson	76,061	78,715	79,613	3.5%	1.1%
Knox	461,104	498,375	516,952	8.1%	3.7%
Loudon	52,340	58,178	60,808	11.2%	4.5%
Morgan	21,545	22,152	22,325	2.8%	0.8%
Roane	53,075	53,357	53,021	0.5%	-0.6%
Total ROI	664,125	710,778	732,719	7.0%	3.1%
Tennessee	6,709,356	7,203,404	7,438,692	7.4%	3.3%
Sources: (Reference 5 and Reference 7)					

Table 3.7-3: Demographic (Race and Ethnicity) Characteristics of ROI Counties (Page 1 of 2)

County	Total Population	White		Minority		Black or African American		American Indian and Alaska Native	
		Total	%	Total	%	Total	%	Total	%
Anderson County	76,061	67,777	89.1	8,284	10.9	2,671	3.5	378	0.5
Knox County	461,104	379,329	82.3	81,775	17.7	39,908	8.7	1,069	0.2
Loudon County	52,340	45,899	87.7	6,441	12.3	482	0.9	70	0.1
Morgan County	21,545	19,833	92.1	1,712	7.9	1,226	5.7	80	0.4
Roane County	53,075	49,220	92.7	3,855	7.3	1,227	2.3	208	0.4
Total ROI	**664,125**	**562,058**	**84.6**	**102,067**	**15.4**	**45,514**	**6.9**	**1,805**	**0.3**
Tennessee	6,709,356	4,951,558	73.8	1,757,798	26.2	1,114,068	16.6	15,553	0.2
United States	324,697,795	197,100,373	60.7	127,597,422	39.3	39,977,554	12.3	2,160,378	0.7
Source: (Reference 8)									

Table 3.7-3: Demographic (Race and Ethnicity) Characteristics of ROI Counties (Page 2 of 2)

County	Asian		Native Hawaiian and Other Pacific Islander		Other Race		Hispanic or Latino		Two or More Races	
	Total	%	Total	%	Total	%	Total	%	Total	%
Anderson County	982	1.3	66	0.1	174	0.2	2,215	2.9%	1,798	2.4%
Knox County	10,094	2.2	191	0.0	1,008	0.2	19,707	4.3%	9,798	2.1%
Loudon County	375	0.7	-	-	44	0.1	4,595	8.8%	875	1.7%
Morgan County	11	0.1	-	-	-	-	287	1.3%	108	0.5%
Roane County	399	0.8	19	0.0	28	0.1	980	1.8%	994	1.9%
Total ROI	**11,861**	**1.8**	**276**	**0.0**	**1,254**	**0.2**	**27,784**	**4.2**	**13,573**	**2.0**
Tennessee	116,563	1.7	3,387	0.1	11,794	0.2	364,174	5.4%	132,259	2.0%
United States	17,708,954	5.5	540,511	0.2	789,047	0.2	58,479,370	18.0%	7,941,608	2.4%
Source: (Reference 8)										

Table 3.7-4: Median Household and Per Capita Income Levels in ROI Counties

	Anderson County	Knox County	Loudon County	Morgan County	Roane County	Tennessee	United States
Median Household Income (dollars)	50,392	57,470	58,065	41,333	53,367	53,320	62,843
Per Capita Income (dollars)	28,455	33,229	31,478	20,204	30,209	29,859	34,103
Source: (Reference 9)							

Table 3.7-5: Civilian Labor Force and Unemployment Rates

	Anderson County	Knox County	Loudon County	Morgan County	Roane County	Total ROI	Tennessee	United States
Civilian Labor Force	34,721	242,417	22,449	7,888	23,646	331,121	3,282,671	163,555,585
Unemployment Rate	6.1%	4.3%	4.7%	6.6%	6.1%	NA	5.3%	5.3%

Source: (Reference 9)
NA - Not applicable, as only rates reported by official sources are reported.

Table 3.7-6: Employment by Industry

	Anderson County		Knox County		Loudon County		Morgan County		Roane County		Tennessee		United States	
	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%
Total employment (number of jobs)	50,998	-	328,096	-	24,095	-	5,093	-	26,015		4,205,777	-	203,809,500	-
Farm employment	445	0.9	942	0.3	1,027	4.3	444	8.7%	538	2.1%	74,710	1.8	2,601,000	1.3
Construction	2,215	4.3	18,787	5.7	1,779	7.4	287	5.6%	NA	NA	234,340	5.6	11,282,500	5.5
Manufacturing	11,818	23.2	13,932	4.2	3,771	15.7	403	7.9%	1178	4.5%	370,414	8.8	13,570,100	6.7
Retail trade	4,367	8.6	37,450	11.4	2,670	11.1	415	8.1%	2,436	9.4%	418,037	9.9	19,084,500	9.4
Health care and social assistance	5,081	10	40,667	12.4	1,710	7.1	412	8.1%	2,136	8.2%	435,691	10.4	23,091,800	11.3
Accommodation and food services	3,529	6.9	28,054	8.6	1,851	7.7	NA	NA	1,447	5.6%	336,390	8.0	15,286,900	7.5
Other services (non-government)	2,556	5	18,730	5.7	1,698	7.0	435	8.5%	1,307	5.0%	259,744	6.2	11,748,900	5.8
Government and government enterprises	5,367	10.5	35,073	10.7	2,389	9.9	1,365	26.8%	3,961	15.2%	454,048	10.8	24,736,000	12.1

Source: (Reference 10)
NA – Not shown to avoid disclosure of confidential information; estimates are included in higher-level totals.

Table 3.7-7: DOE-related Workers in ROI Counties

County of Residence	Number of Employees	Percent of Total
Anderson	3,426	27.2%
Knox	5,190	41.1%
Loudon	674	5.3%
Morgan	376	3.0%
Roane	1,624	12.9%
Total DOE-related Employees in ROI	11,290	89.5%
Source: (Reference 11)		

Table 3.7-8: Percent of Individuals and Families Living Below the Census Poverty Threshold in ROI Counties

	Anderson County	Knox County	Loudon County	Morgan County	Roane County	Total ROI	Tennessee	United States
Percentage of Individuals whose Income in the Past 12 Months is below Poverty Level	16.7%	14.5%	11.3%	22.8%	13.8%	14.7%	15.2%	13.4%
Percentage of Families whose Income in the Past 12 Months is below Poverty Level	13.2%	9.5%	7.8%	17.4%	9.3%	10.0%	11.1%	9.5%
Source: (Reference 9)								

Table 3.7-9: Housing Utilization

	Anderson County	Knox County	Loudon County	Morgan County	Roane County	Total ROI	Tennessee	United States
Total housing units	34,971	205,620	23,083	9,041	25,657	298,372	2,963,486	137,428,986
Occupied housing units	30,541	187,319	20,669	7,625	20,901	267,055	2,597,292	120,756,048
Vacant housing units	4,430	18,301	2,414	1,416	4,756	31,317	366,194	16,672,938
Vacancy Rate	12.7%	8.9%	10.5%	15.7%	18.5%	10.5%	12.4%	12.1%
Median Home Value	$146,200	$183,200	$222,500	$102,000	$150,300	NA	$167,200	$217,500
Source: (Reference 51) NA - Not applicable, as only rates reported by official sources are reported.								

Table 3.7-10: Planning LOS Traffic Volume Thresholds

Roadway Type	LOS C	LOS D	LOS E
2 Lane Undivided (35 mph or less)	6,500	13,300	14,200

Table 3.7-11: Existing 2019 Study Area Planning Level-of-Service and Volume to Capacity Ratios

#	Road Name	RoadwayType	2019 AADT	LOS	Volume / Capacity Ratio
1	Perimeter Road (just NW of Connector Rd)	2-Lane Undivided	1,185	C	0.182
2	Perimeter Road Bridge over Poplar Creek	2-Lane Undivided	858	C	0.132
3	Bridge over Poplar Creek (east of site)	2-Lane Undivided	193	C	0.030
4	Road near complex entrance (east of Poplar Creek Bridge)	2-Lane Undivided	446	C	0.069
5	N Perimeter Road (northeast of site)	2-Lane Undivided	490	C	0.075

Table 3.7-12: Projected 2025 Study Area Planning Level-of-Service and Volume to Capacity Ratios

#	Road Name	2025 AADT	LOS	Volume / Capacity Ratio
1	Perimeter Rd (just NW of Connector Rd)	1,335	C	0.205
2	Perimeter Rd Bridge over Poplar Creek	966	C	0.149
3	Bridge over Poplar Creek (east of site)	217	C	0.033
4	Road near complex entrance (east of Poplar Creek Bridge)	502	C	0.077
5	N Perimeter Rd (northeast of site)	552	C	0.085

Table 3.7-13: Public Water Supply Systems

County	PWS ID	Water System	Primary Water Source	Average Daily Consumption[1] (MGD)	Maximum Daily Capacity[2] (MGD)	2021 Population[3]
Anderson	TN0000514	Anderson County Water Authority	SW	2.87	--	24,622
Anderson	TN0000120	Clinton Utilities Board	SW	2.26	3.3[4]	17,890
Anderson	TN0000513	Norris Water Commission	GW	0.28	0.53	2,081
Anderson	TN0000522	Oak Ridge Department of Public Works[5]	SW	8.00	12	38,162
Anderson	TN0000383	Rocky Top Water Department	SWP	0.25	--	3,240
Knox	TN0000369	First Utility District of Knox County	SW	12.70	34[6]	89,521
Knox	TN0000280	Hallsdale-Powell Utility District	SW	7.47	16[7]	71,092
Knox	TN0000367	Knox-Chapman Utility District	SW	4.00	10[8]	34,955
Knox	TN0000366	Knoxville Utilities Board	SW	34.10[9]	62.6[9]	241,714
Knox	TN0000515	Northeast Knox Utility District	SW	1.98	6.91	24,390
Knox	TN0000371	West Knox Utility District	SW	5.57	18	65,346
Loudon	TN0000396	Lenoir City Utility Board	SW	2.11	3.9	30,885
Loudon	TN0000409	Loudon Utilities Board	SW	9.53	14	13,801
Loudon	TN0000871	Tellico Village Property Owners Association	SWP	1.04	--	11,564
Morgan	TN0000729	Plateau Utility District	SW	1.13	--	12,982
Roane	TN0000531	Cumberland Utility District	SW	1.39	2.3	13,247
Roane	TN0000287	Harriman Utility Board	SW	2.01	3.2	15,219
Roane	TN0000360	Kingston Water System	SW	0.94	2.8	9,953
Roane	TN0000523	Oliver Springs Water Board	SWP	0.89	--	5,293
Roane	TN0000457	Roane Central Utility District	SWP	0.43	--	6,236
Roane	TN0000590	Rockwood Water System	SW	2.48	6	11,732
Roane	TN0000969	Watts Bar East Utility District	SWP	0.21	--	3,393

GW = groundwater
MGD = million gallons per day
PWS ID = public water system identification number
SW = surface water
SWP = purchased surface water
[1] Source: (Reference 30)
[2] Source: (Reference 32)
[3] Source: (Reference 31)
[4] Source: (Reference 52)
[5] New ultrafiltration plant providing 12 to 16 MGD with expansion capability to 20 MGD anticipated by 2025.
[6] Source: (Reference 53)
[7] Source: (Reference 54). System includes provisions to easily increase capacity another 4 MGD (Reference 54).
[8] Source: (Reference 55). System has room to increase capacity another 4 MGD (Reference 55).
[9] Source: (Reference 56)
Additional Source: (Reference 31)

Table 3.7-14: Public Wastewater Systems

County	Permit No	Site Name	City	Average Design Flow (MGD)	Average Daily Demand (MGD)
Anderson	TN0074071	Anderson County Water Authority Airbase STP	Briceville	0.01	--
Anderson	TN0026506	Clinton STP #1	Clinton	3	1.6
Anderson	TN0020630	Norris STP (Norris Water Commission)	Norris	0.2	0.06 - 0.5
Anderson	TN0024155	Oak Ridge Turtle Park STP	Oak Ridge	30	5 – 7
Anderson	TN0025127	City of Rocky Top STP	Rocky Top	0.95	0.3 - 0.4
Knox	TN0023353	First Utility District of Knox County - Turkey Creek STP [(a)]	Farragut	18	7
Knox	TN0059323	Hallsdale-Powell Raccoon Valley STP	Knoxville	0.3	--
Knox	TN0061743	Knoxville Utilities Board - East Bridge STP	Knoxville	1.33	0.6
Knox	TN0023574	Knoxville Utilities Board - Fourth Creek STP	Knoxville	10.8	7.3
Knox	TN0023582	Knoxville Utilities Board - Kuwahee STP	Knoxville	44	35.1
Knox	TN0021822	Knoxville Utilities Board - Loves Creek STP	Knoxville	10.3	3.3
Knox	TN0078905	Hallsdale Powell Utility District STP [(b)]	Powell	9.7	--
Loudon	TN0020494	Lenoir City Utilities Board WWTP	Lenoir City	3	--
Loudon	TN0058181	Loudon STP	Loudon	14	8.1
Morgan	TN0058530	Town of Oakdale WWTP	Oakdale	0.01	--
Morgan	TN0059765	Brushy Mountain State Penitentiary	Petros	0.5	--
Morgan	TN0058564	Petros - Joyner School STP	Wartburg	0.02	--
Morgan	TN0028622	Wartburg STP	Wartburg	0.75	--
Roane	TN0025437	Harriman STP	Harriman	5	0.9-1.0
Roane	TN0061701	Kingston STP	Kingston	2	0.45
Roane	TN0078051	City of Oak Ridge - Rarity Ridge WWTP	Oak Ridge	0.6	0.1 - 0.6
Roane	TN0020885	Oliver Springs STP	Oliver Springs	0.74	0.4
Roane	TN0024473	Roane County STP	Rockwood	1	--
Roane	TN0026158	Rockwood STP	Rockwood	1.65	1.3

MGD = million gallons per day
STP = sewage treatment plant
WWTP = wastewater treatment plant
[(a)] Average design flow confirmed at (Reference 57). Expansions in west Knox County have necessitated the expansion from a 1 MGD system in 1974 to today's 18 MGD system at Turkey Creek (Reference 57).
[(b)] Beaver Creek Wastewater Treatment Plant utilizes a 6.0 MGD biological reactor operating in parallel with a 3.7 MGD oxidation train. Flow in Excess of 11.9 MGD is stored for delayed treatment (Reference 58, Reference 59)
Sources: (Reference 31, Reference 57, Reference 58, and Reference 59)

Table 3.7-15: Schools. Public Schools in the Site Region

	Total Number of Schools		Number of Schools	Number of Students in 2020	Total Number of Students in 2020	Expenditure per Student
Anderson County	21	Elementary	13	3,619	7,410	$10,397.01
		Middle	3	970		
		High	3	2,190		
		Specialized	2	631		
City of Oak Ridge [(a)]	8	Elementary	5	1,829	4,775	$13,041.51
		Middle	2	1,446		
		High	1	1,500		
		Specialized	0	0		
Knox County	91	Elementary	52	27,490	61,545	$9,341.65
		Middle	16	14,009		
		High	16	18,188		
		Specialized	7	1,858		
Loudon County	9	Elementary	4	1,938	4,876	$9,298.47
		Middle	2	1,174		
		High	1	666		
		Specialized	2	1,098		
Lenoir City [(b)]	3	Elementary	1	540	2,435	$9,566.81
		Middle	1	637		
		High	1	1,258		
		Specialized	0	0		
Morgan County	8	Elementary	1	513	2,806	$9,919.61
		Middle	1	286		
		High	2	429		
		Specialized	4	1,578		
Roane County	17	Elementary	6	2,983	6,514	$9,855.51
		Middle	5	1574		
		High	5	1913		
		Specialized	1	44		

[(a)] The City of Oak Ridge is a separate system in Anderson County.
[(b)] And Lenoir City is a separate system in Loudon County.
Sources: (Reference 36 and Reference 37)

Table 3.7-16: Yearly Visitor Totals to National Parks Near Proposed Facility

Park	Annual visitors	Year
Great Smoky Mountains National Park	12,547,743	2020
Chickamauga & Chattanooga National Military Park	678,414	2020
Big South Fork National River and Recreation Area	772,625	2020
Cumberland Gap National Historical Park	735,447	2020
Obed Wild and Scenic River	237,837	2020
Sources: (Reference 39 and Reference 41)		

Table 3.7-17: Yearly Visitor Totals to State Parks Near Proposed Facility

Park	Annual Visitors	Year
Frozen Head State Park	215,008	2020
Fort Loudoun State Historic Park	144,964	2020
Cove Lake State Park	501,566	2020
Big Ridge State Park	Not reported	
Cumberland Mountain State Park	633,749	2020
Head of Sequatchie Cumberland Trail State Park	Not Reported	
Justin P. Wilson Cumberland Trail State Park	109,827	2020
House Mountain State Natural Area	Not Reported	
Sources: (Reference 39)		

Figure 3.7-1: Region of Influence

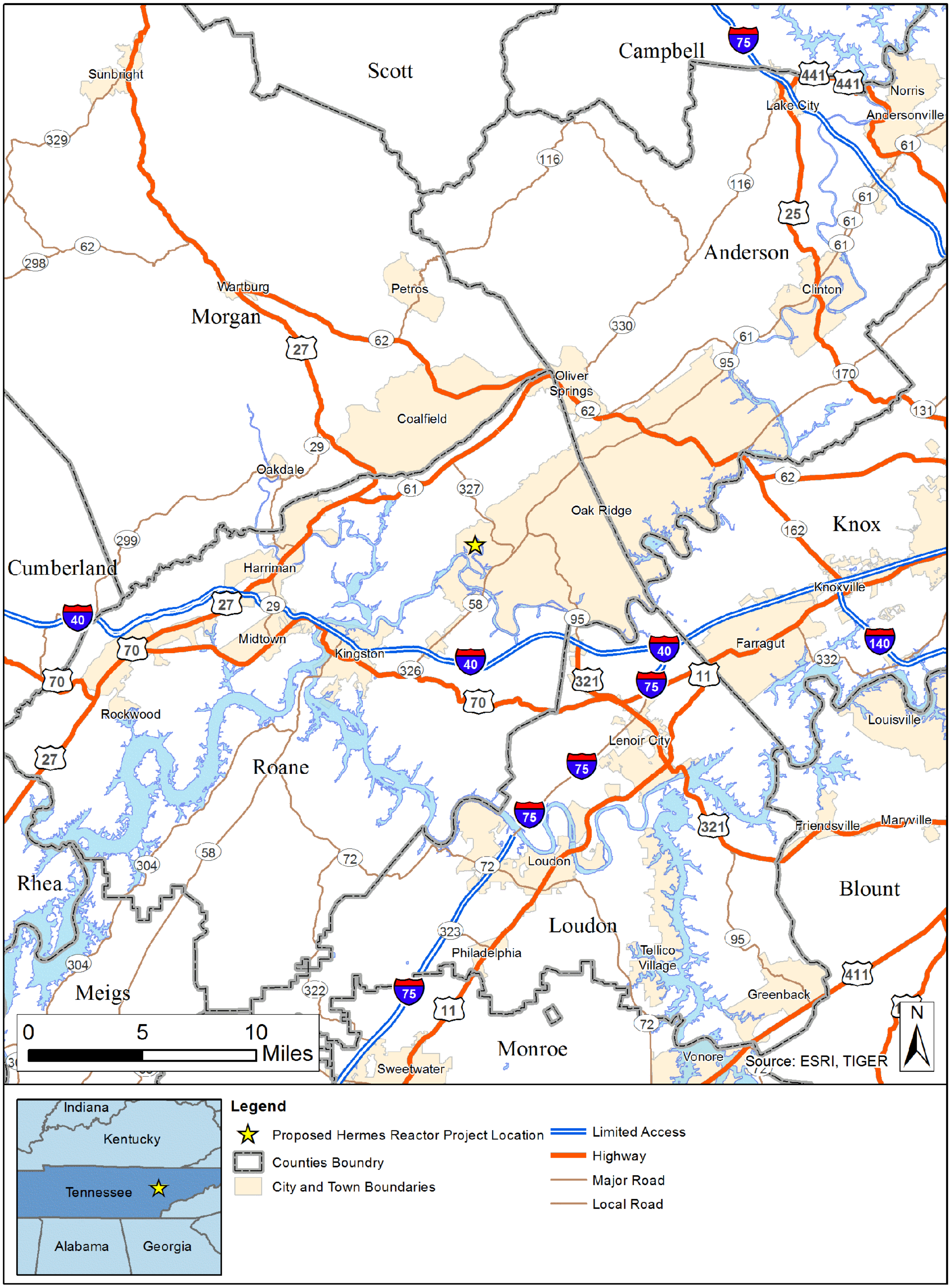


Figure 3.7-2: Road, Highway, Railroad, and Airport Systems in the Area

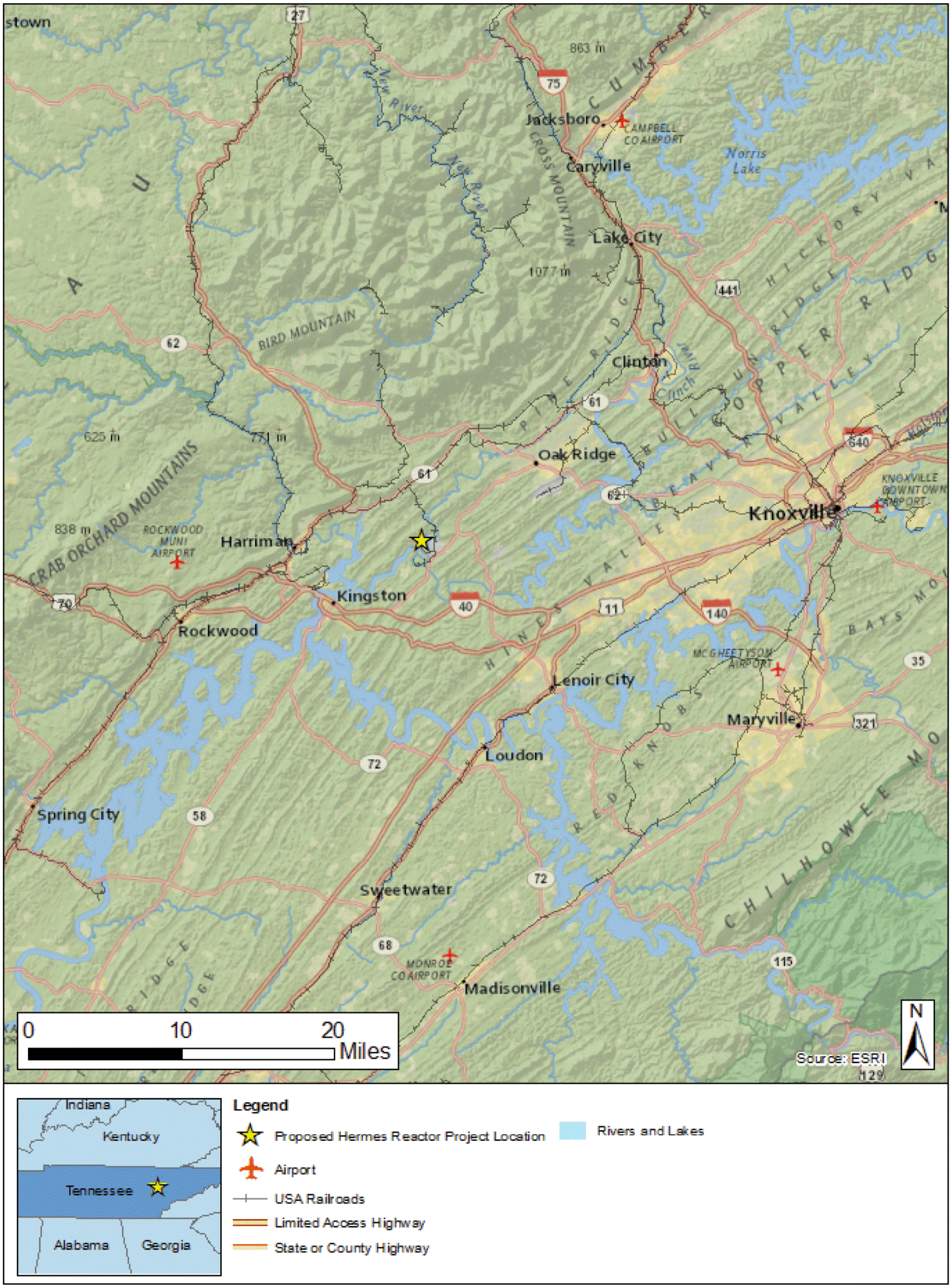
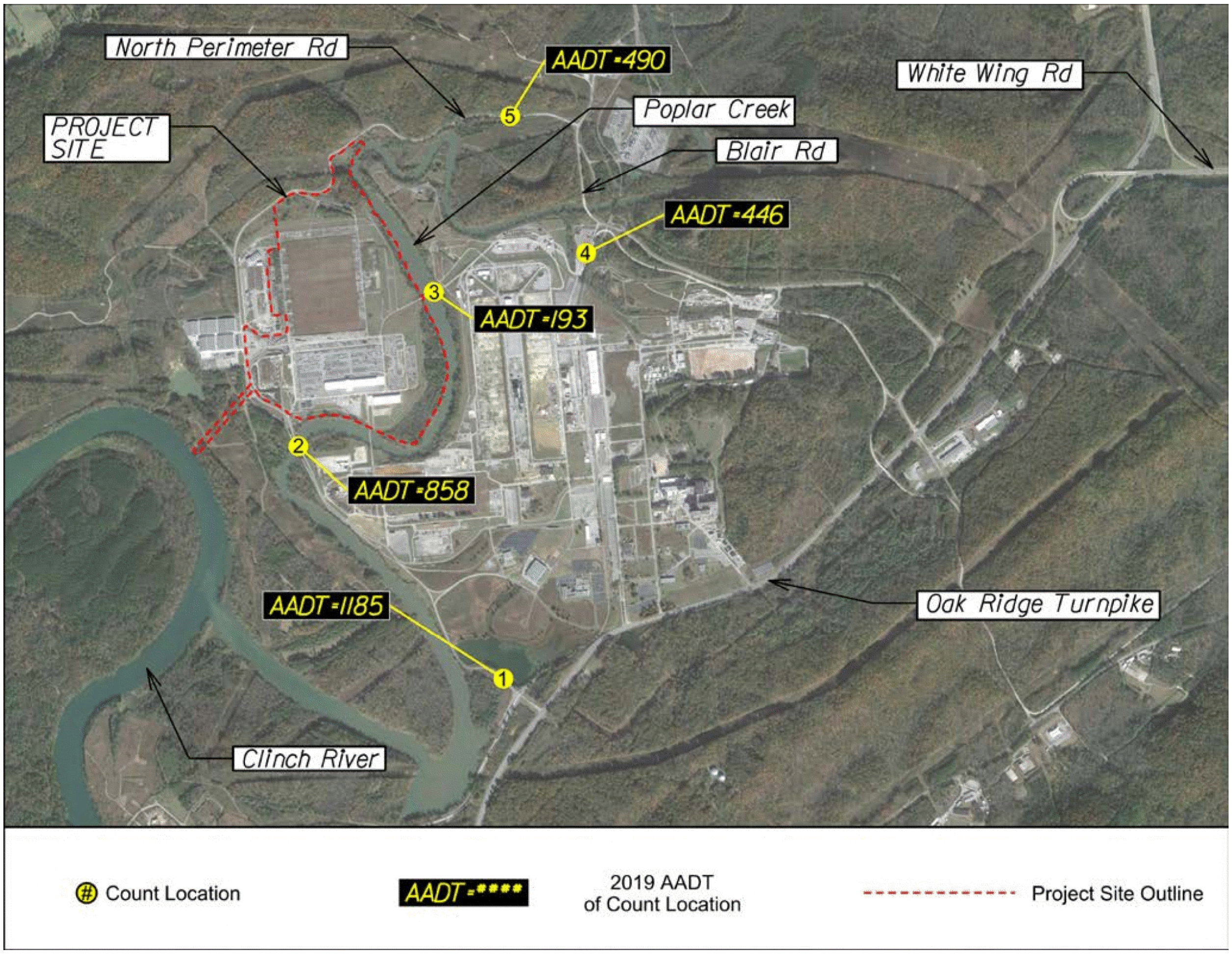


Figure 3.7-3. Existing 2019 Average Daily Traffic Volumes



3.8 HUMAN HEALTH

Existing public and occupational health issues are discussed in this section.

3.8.1 Maps of Potentially Sensitive Surrounding Facilities

Figures 3.8-1 shows distances to the nearest full-time resident and nearest sensitive receptors, respectively. Sensitive receptors include:

- Residents
- Parks
- Educational facilities
- Medical facilities
- Religious facilities
- Community centers
- Animal facilities

The site boundary distances are summarized in Table 3.8-1 and nearby locations are shown in Figure 3.8-1. The nearest full-time resident is 0.7 miles from the site boundary and the closest park-like area/greenway (BORCE) borders the site boundary. The nearest school is Dyllis Springs Elementary School 5.7 miles away and the nearest hospital is Roane Medical Center about 10.5 miles from the site.

3.8.2 Background Radiation Exposure

As detailed below, there is no background radiation from natural or man-made sources in the vicinity of the site that would result in abnormal radiation hazards to the public. Average background radiation to the public is 620 millirem per year (mrem/yr) in the United States, with approximately half from medical procedures and man-made sources and half from natural sources (Reference 1).

3.8.2.1 Natural Sources

Natural sources of radiation can be divided into three categories: cosmic, internal, and terrestrial. Cosmic radiation comes from extremely energetic particles from the sun and stars that enter Earth's atmosphere. Internal contamination occurs when people swallow or inhale radioactive materials, or when radioactive materials enter the body through an open wound or are absorbed through the skin. Terrestrial radiation is due to the decay of radioactive materials in the earth. This source represents the majority of the background radiation for an average member of the public (Reference 2).

3.8.2.1.1 Cosmic Radiation

Cosmic radiation comes from extremely energetic particles from the sun and stars that enter Earth's atmosphere. Some particles make it to the ground, while others interact with the atmosphere to create different types of radiation. Radiation levels increase as you get closer to the source, so the amount of cosmic radiation generally increases with elevation. The higher the altitude, the higher the dose. The average dose from cosmic radiation is about 33 mrem/year. (Reference 1).

Cosmic rays are of two kinds: galactic and solar. Galactic cosmic radiation comes from the remnants of supernovas, which are powerful explosions during the last stages of massive stars that either collapse to black holes or are destroyed. The energy released in these explosions accelerates charged particles outside our solar system, making them highly penetrating and extremely hard to shield. In essence, supernovas act like large, natural particle accelerators. The Earth is constantly exposed to galactic cosmic radiation (Reference 3).

Solar cosmic radiation is comprised of charged particles emitted by the sun, predominantly electrons, protons and helium nuclei. Some of this radiation (called solar wind) is continuously emitted from the

sun's corona. The remainder comes from solar particle events – sudden and sporadic outbursts of electrically charged particles accompanied by electromagnetic emissions that occur when magnetic fields on the Sun's surface stretch and twist (Reference 3).

3.8.2.1.2 Internal Radiation

Naturally occurring internal radiation in humans comes primarily from radioactive potasium-40 (K-40) and carbon-14 (C-14) along with uranium and thorium isotopes. Internal radiation can also occur as a result of ingesting naturally radioactive materials including many foods. Some types of radioactive materials stay in the body and are deposited in different body organs. Other types are eliminated from the body through natural excretions. The average internal dose from internal radiation is 30 mrem/yr with K-40 providing 20 mrem/yr. This internal source of background radiation represents a radiation source from humans. Traces, about 0.01 percent, of radioactive K-40, are found in all naturally occurring potassium in the soil, food, and water ingested by people. The body metabolizes K-40 in the same manner as the more common nonradioactive isotopes of potassium distributing the radioactive and nonradioactive potassium throughout the body (Reference 1, and Reference 5).

3.8.2.1.3 Terrestrial Radiation

Terrestrial radiation is due to the decay of radioactive materials in the earth itself. Terrestrial radiation is created by the natural breakdown—or radioactive decay—of radioisotopes in natural materials such as rocks, soil, vegetation, and groundwater. The radioactive decay of potassium and uranium, along with the decay of daughter products including thorium, radium, and radon provide both an external and an internal exposure. Levels of internal terrestrial radiation exposure are often ten times greater than external radiation levels (Reference 1 and Reference 6).

The overall levels of terrestrial external radiation are low. The average annual dose due to terrestrial external radiation exposure is 21 mrem (Reference 1).

Another pathway for exposure to terrestrial radiation is inhalation of naturally occurring radon and other daughter products of naturally occurring uranium and thorium. This type of exposure constitutes the majority of natural background radiation for the average person in the United States (Reference 6 and Reference 7).

3.8.2.2 Man-Made Sources

A portion of background radiation comes from human activities. Man-made sources of radiation to the public include medical sources, consumer products, and nuclear reactor facilities as discussed below. Trace amounts of radioactive elements have dispersed in the environment from nuclear weapons tests and accidents like the one at the Chernobyl nuclear power plant in Ukraine. Normally operating nuclear reactors emit small amounts of radioactive elements (Reference 1).

3.8.2.2.1 Medical Sources

Medical procedures like X-rays and CT scans provide the majority of man-made radiation exposure to the public. Medical personnel may receive a higher radiation dose than the non-medical public. Radiation exposures from diagnostic medical examinations are generally low and are almost always justified by the benefits of accurate diagnosis of possible disease conditions. There is no direct evidence of radiation causing any harm at the exposure levels encountered with diagnostic radiological examinations. Therapeutic uses of radiation naturally involve higher exposures and physicians will consider the risks of the treatment against the potential benefits. In diagnostic uses, there are theoretical models that suggest the possibility of cancer risks, but these models all extrapolate results from higher exposures to these low levels, and it is uncertain whether any real risks are involved. The

exposures are usually comparable to those that are received routinely from natural sources of radiation (Reference 8).

3.8.2.2.2 Consumer Products

A variety of consumer products contain radioactive materials, although contribution to overall background radiation is low. Sometimes the radioactive material is a working part of the product. In others, radiation is present because some component contains naturally occurring radioactive materials. Although background radiation dose from consumer products to the general public is highly individual, the average is 10 mrem/yr (Reference 1 and Reference 9). Examples of consumer products with radioactive components or emissions include (Reference 10) smoke detectors, some luminous clocks and watches, certain glassware, fertilizers containing naturally radioactive constituents, and some illuminated exit signs.

3.8.2.2.3 Nuclear Reactor Facilities

An accident at a nuclear reactor could result in offsite radiological exposure. The risk of this happening at nuclear power plants is very small because of the diverse and redundant barriers and safety systems in place at nuclear power plants, the training and skills of the reactor operators, testing and maintenance activities, and regulatory requirements and oversight. Even in the unlikely event of such an accident, impacts would be local and would not contribute significantly to background radiation.

The nuclear fuel cycle also creates various waste products; these waste products are also subject to strict regulation such that the contribution to background radiation is very minor. (Reference 2)

Radiation sources from nuclear reactor facilities in the vicinity of the site include contributions from normal operations at TVA's Watts Bar Nuclear Plant and the ORR facilities. Routine releases during normal operations of radiological projects and facilities are used to determine the effective dose to a hypothetical maximally exposed individual (MEI) member of the public.

TVA's Watts Bar Nuclear Plant is located on TRM 528, approximately 50 miles north of Chattanooga and about 30 miles southwest of the site. The total body dose to the maximally exposed offsite individual from normal operations at Watts Bar Nuclear Unit 1 and Unit 2 is estimated as 0.28 mrem/yr (or less than $1/1000^{th}$ of background radiation) (Reference 11).

3.8.3 Radioactive and Nonradioactive Hazardous Material Stored Onsite

No radioactive materials or hazardous materials are currently stored on the site. As such, there are no liquid, gaseous, or solid waste management systems of effluent control systems at the site. However, as described in Section 3.8.4, the site was once the home of the K-31 and K-33 gaseous diffusion plants. The site has been remediated to acceptable risk levels, but the possibility exists that residual radioactive and nonradioactive contaminants could still be present at detectable levels above background but below the risk-based standards. Therefore, there could be residual radioactive and nonradioactive contaminants at the site and in the site groundwater that are detectable above background but below the risk-based standards.

3.8.4 Current Onsite or Nearby Sources and Levels of Exposure to Members of the Public and Workers from Radioactive Materials

The DOE prepared environmental baseline surveys for the former K-33 and K-31 areas in support of property transfers (Reference 12 and Reference 13). The Former K-33 and K-31 areas included the gaseous diffusion plant, uranium hexafluoride canister storage area, switch yards, cooling towers and water treatment facilities. The environmental baseline surveys for the Former K-33 and K-31 areas rely upon documentation in the relevant Phased Construction Completion Reports for the environmental

data evaluation and human health risk evaluation. It summarizes no further action determinations that have been approved by EPA Region 4 and TDEC for the soils, slabs, and subsurface structures of the Former K-33 Area. The no further action determinations under an industrial land use risk scenario documented in the referenced Phased Construction Completion Reports were reached using the DOE Environmental Management Program's Dynamic Verification Strategy (DVS) process.

The remedial action objectives for the K-33 and K-31 areas were developed by the DVS to support the future use as a mixed-use commercial and industrial park. Therefore, remediation criteria were designed for the protection of the future industrial workerand to restrict future land use to industrial/commercial activities (Reference 12 and Reference 13). Based on the results of the DVS evaluation and the remedial actions completed, the transfer of the property was approved by the regulatory agencies for unrestricted industrial use as the areas did not pose and unacceptable cumulative excess lifetime cancer risk of more than 1E-04 or a hazard index of more than 1 (Reference 12 and Reference 13).

Nearby facilities managing radioactive materials include the ORR facilities and Energy*Solutions* Bear Creek Facility. Other sources of radiation would include transient exposures from transport of radioactive materials such as medical isotopes and radioactive waste along the I-40 and I-75 corridors.

Operations on the ORR release small quantities of radionuclides to the environment. In the 2019 ORR Annual Site Environmental Report, detailed analysis of the effective dose received by the MEI from air pathways was determined to be 0.4 mrem/yr. The effective dose to the MEI from water, including drinking, bathing, irrigating, recreating, and fish consumption, was determined to be 2 mrem/yr. The effective dose from consumption of wildlife harvested on the ORR, including turkeys, geese, and deer, was determined to be 0.07 mrem/yr. Combined, the annual dose to the hypothetical MEI from normal operations at ORR is 3 mrem/yr (Reference 14). This is approximately 1 percent of the average background radiation dose in the United States.

3.8.5 Historical Operations

The ORNL was established in 1943 under the wartime Manhattan Engineer District as a temporary pilot plant for the atomic energy works to be constructed at Richland, Washington. The graphite reactor, a chemical separations pilot plant ("Hot Pilot Plant"), and radiochemical laboratories for analyses and research were constructed. A number of large underground concrete tanks (about 10^6 gallon total capacity) were installed for storage of radioactive chemical and uranium wastes that would accumulate during the life of the Laboratory, which was then expected to be about one year. However, continuation of the Laboratory and expansion of its program in 1943 and later years increased the volume of liquid wastes beyond the capacity of the tanks. This necessitated means for waste disposal to supplement the tank storage system. Waste management philosophy at ORNL during the period 1943 to 1950 was to dilute and disperse the large volumes of low-activity liquid wastes within the safe disposal capacity of the Clinch and Tennessee Rivers and to concentrate and store the higher-activity wastes for which dilution and dispersion were not practicable. The purpose was to contain most of the radioactive constituents and by this means to minimize the quantities of radioactivity released to the environment (Reference 15).

Construction of Building K-33 began in July 1952, and it was placed in operation in March 1954 as the largest and last of the ORGDP cascades for the isotopic enrichment of uranium. Enrichment operations were discontinued in 1985 and K-33 building was shut down in 1987. Portions of the building were then used for hazardous waste storage. From 1998 to 2005, the building was decontaminated, and process equipment was removed. The demolition of the building began in 2010 and was completed in 2011. During the preparation stages of the demolition, the soil beneath the slab was characterized using DVS. Removal of the slab began immediately following demolition of the building and was completed in 2012.

Following slab removal, the area within the building foundation footprint was graded and seeded with grass (Reference 13).

The K-31 building was a two-story structure with a total floor area of approximately 32 acres. The building was part of the low-enriched uranium gaseous diffusion cascade at the ORGDP and began operations in 1954. Enrichment operations were discontinued in 1985 and Building K-31 was shut down in 1987. Building K-31 and associated equipment have historical radiological and chemical contamination from past operations and are being addressed under the ORR Federal Facility Agreement under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) authority. Between 1997 and 2005, a CERCLA removal action was undertaken by DOE to remove the process equipment and to decontaminate the facilities. Process and non-process equipment and associated piping, ducting, and electrical services were removed from the K-31 building prior to demolition (Reference 12).

3.8.6 Description of Nearby Operating Facilities' Effluent Monitoring Programs

ORR covers 52 square miles of land in Anderson and Roane counties and is home to two major DOE operating components: the ORNL and the Y-12 National Security Complex . Other ORR facilities include the ETTP; the Oak Ridge Institute for Science and Education South Campus, which includes training facilities, laboratories, and support facilities; and several smaller, government-owned, contractor-operated entities involved in environmental cleanup (Reference 14).

Environmental monitoring of ORR activities consists primarily of effluent monitoring and environmental surveillance. Effluent monitoring involves the collection and analysis of environmental samples or measurements of liquid and gaseous effluents. Effluent monitoring measurements provide data for official reporting to demonstrate compliance with regulatory standards and permit requirements and for assessment of public exposures to radiation and chemicals. Environmental surveillance consists of direct measurement, collection, and analysis of samples taken from the site and its environs, exclusive of effluents. These surveillance activities provide information on contaminant concentrations in air, water, groundwater, soil, foods, biota, and other media (Reference 14).

Energy*Solutions* operates the Bear Creek Processing Facility approximately 2 miles southeast of the site. The Bear Creek facility's primary function is processing and packaging of LLRW for permanent disposal. The facility houses radioactive material processing capabilities including bulk waste assay, decontamination, recycle, compaction, incineration, metal melting, and a variety of specialty waste stream management options. The facility operates under regulatory authority of the TDEC Division of Radiological Health in agreement with the NRC. As such, liquid and airborne releases from the facility are controlled to limit offsite doses to within regulatory limits and the facility does not contribute significantly to the local background radiation. Radioactive and nonradioactive hazardous materials from the Bear Creek Facility are reported annually to the site's regulators.

3.8.7 Relevant Occupational Injury Rates and Occupational Fatal Injury Rates

Occupational injury and fatal injury rates for construction, operation, and decommission of the facility are discussed in this subsection.

A total of approximately 5,330 workers died from a work-related injury in the United States in 2019, up 2 percent from the 2018 total of 5,250. The fatal work injury rate in 2019 was 3.5 fatalities per 100,000 full-time equivalent workers, which was the rate reported in 2018 (Reference 16).

According to the U.S. Bureau of Labor Statistics (BLS) Employer-Related Workplace Injuries and Illnesses News Release, which it published on November 4, 2020, the annual total number of injuries per 100 full-

time workers remained unchanged at 2.8. Prior to 2018, this figure has dropped steadily over the prior 15 years, remaining unchanged from year to year only twice.

The BLS's workplace injury statistics published in 2020 indicate that construction laborers account for approximately 250 incidents per 10,000 full-time equivalent. The BLS's 2019 Survey of Occupational Injuries & Illnesses also provided a list of the occupations with the most workplace non-fatal injuries and illnesses. The data from this survey also showed that job-related injuries were far more common than job-related illnesses; and, for the most part, the occupations with the most injuries were also those with the most illnesses. Construction, specifically, accounted for 195,600 workplace injuries and 3,600 workplace illnesses in 2019 (Reference 16).

An estimate of relevant occupational injury rates for construction, operation, and decommission of the site was developed from BLS data. During the construction and decommissioning phases, the total number of recordable cases per construction worker in the construction industry is 2.8 per 100 full-time workers. During the operation phase, facility workers would be engaged in multiple industries; therefore, an estimate of operational injuries ranges from 0.2 for workers engaged in nuclear electric power generation to 2.8 for all private occupations (Reference 16).

An estimate of fatality rates for construction, operation, and decommission of the facility was developed from BLS data. During the construction and decommissioning phases, the total number of fatality injury cases per construction worker in the construction industry is 0.129 per 100 full-time workers. During the operation phase, facility workers would be engaged in multiple industries; therefore, an estimate of operational injuries resulting in fatalities ranges from 0.02 for workers engaged in utilities work to 0.035 for all private occupations (Reference 16).

3.8.8 References

1. U.S. Environmental Protection Agency, Radiation Sources and Doses, Website: https://www.epa.gov/radiation/radiation-sources-and-doses, accessed July 14, 2021.
2. U.S. Nuclear Regulatory Commission, Sources of Radiation, Website: https://www.nrc.gov/about-nrc/radiation/around-us/sources.html, accessed August 18, 2021.
3. International Atomic Energy Agency, Cosmic Radiation: Why We Should not be Worried, Website: https://www.iaea.org/newscenter/news/cosmic-radiation-why-we-should-not-be-worried, accessed July 14, 2021.
4. Not Used
5. Nuclear Power. Internal Source of Radiation. Website: https://www.nuclear-power.com/nuclear-engineering/radiation-protection/sources-of-radiation/internal-source-of-radiation/, accessed August 14, 2021.
6. Radiation Dosimetry, What is Terrestrial Radiation – Definition, Website: https://www.radiation-dosimetry.org/what-is-terrestrial-radiation-definition/, accessed August 15, 2021.
7. U.S. Geological Survey, "The Geology of Radon," 1992.
8. Stabin PHD CHP, M.G., Doses from Medical Radiation Sources, Website: https://hps.org/hpspublications/articles/dosesfrommedicalradiation.html, accessed July 14, 2021.
9. U.S. Environmental Protection Agency, "Assessment of Variations in Radiation Exposure in the United States," July 15, 2005.

10. U.S. Environmental Protection Agency, What kinds of consumer products contain radioactive materials?, Website: https://www.epa.gov/radiation/what-kinds-consumer-products-contain-radioactive-materials, accessed July 14, 2021.

11. U.S. Department of Energy, "Final Supplemental Environmental Impact Statement for the Production of Tritium in a Commercial Light Water Reactor_Summary," DOE/EIS-0288-S1, February 2016.

12. U.S. Department of Energy, "Environmental Baseline Survey Report for the Proposed Title Transfer of the Former K-33 Area at the East Tennessee Technology Park, Oak Ridge, Tennessee." DOE/OR/01-2658. September 2015.

13. U.S. Department of Energy, "Environmental Baseline Survey Report for the Proposed Title Transfer of the Former K-31 Area at the East Tennessee Technology Park, Oak Ridge, Tennessee." DOE/OR/01-2677. July 2015.

14. U.S. Department of Energy, “Oak Ridge Reservation Annual Site Environmental Report - 2020.” DOE/CSC-2514. Chapter 7. September 2021.

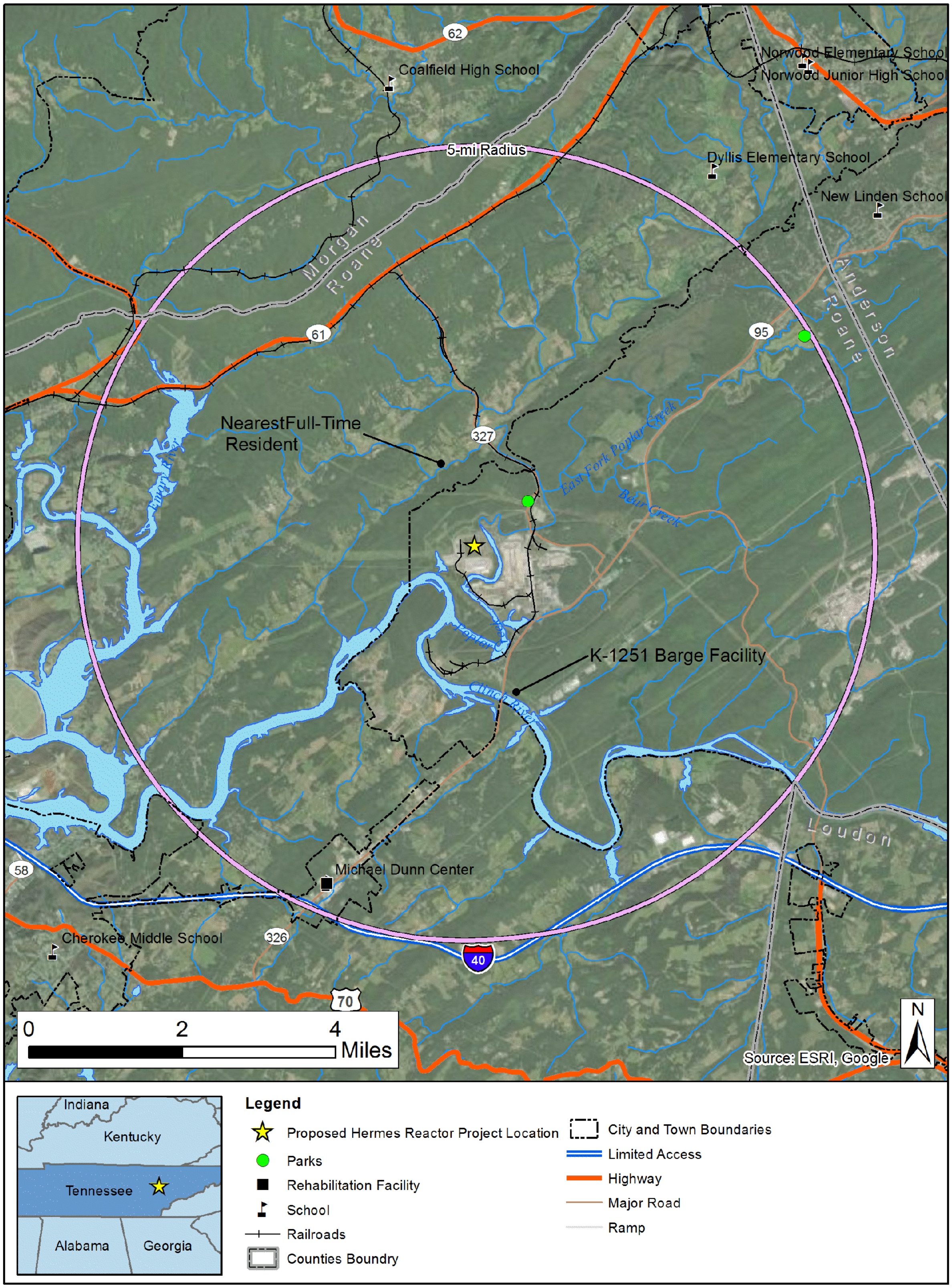
15. Oak Ridge National Laboratory, "Comprehensive Report of the Clinch River Study," ORNL-4035, April 1967.

16. Bureau of Labor and Statistics, Hours-based fatal injury rates by industry, occupation, and selected demographic characteristics, Website:

Table 3.8-1: Distance to Nearest Sensitive Receptors

Facility Type	Location of Interest	Distance to Site Boundary (miles)
Residential	Nearest Full-time Resident	0.7
Park	Black Oak Ridge Conservation Easement	Adjacent
	Oak Ridge Country Club	4.9
	Melton Hill Reservoir	13
Medical	Roane Medical Center	10.5
	Methodist Medical Center	13
	Fast Pace Urgent Care	13
Educational	Dyllis Springs Elementary School	5.7
Rehabilitation	Michael Dunn Center	4.6
Community Center	Bradbury Community Center	4.5
	Kingston Community Center	7.6
Religious Institutions	Orchard View Baptist Church	3.8
	Dyllis Baptist Church	1.6
Animal Production	Rainy Knob Ranch	10.3

Figure 3.8-1: Distance to Nearest Full-time Resident and Other Sensitive Receptors



3.9 ENVIRONMENTAL JUSTICE

On February 11, 1994, President Clinton signed Executive Order 12898 *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*. Executive Order 12898 directs federal executive agencies to consider environmental justice under the National Environmental Policy Act of 1969 (NEPA). This Executive Order ensures that minority and/or low-income populations do not bear a disproportionate share of adverse health or environmental consequences of the building of the facility.

Guidance for addressing environmental justice is provided by the Council on Environmental Quality's (CEQ's) *Environmental Justice Guidance under the National Environmental Policy Act;* NRC *Policy Statement on the Treatment of Environmental Justice Matters in NRC Licensing Actions;* and NRC Office Instruction No. LIC 203, Revision 3, *Procedural Guidance for Preparing Categorical Exclusions, Environmental Assessments and Considering Environmental Issues* (Reference 1, Reference 2, and Reference 3).

In identifying minority and low-income populations, the following CEQ definitions of minority individuals and populations and low-income populations were used:

- Minority individuals - Individuals who identify themselves as members of the following population groups: American Indian or Alaskan Native, Asian, Native Hawaiian or Other Pacific Islander, Black, Hispanic, or two or more races.
- Minority populations - Minority populations are identified where (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. For the purposes of this analysis, "meaningfully greater" is defined as greater than 20 percent of the minority population percentage in the county in which the affected population is located. The thresholds for each county used in the analysis are located in Table 3.9-1 .
- Low-income populations - Low-income populations in an affected area are identified with the annual statistical poverty thresholds from the U.S. Census Bureau's (USCB) Current Population Reports, Series P-60, on Income and Poverty. In this analysis, low-income populations are identified where: (1) the population of an affected area exceeds 50 percent low-income based on the Census data, or (2) the percentage of low-income population in the affected area is "meaningfully greater", defined as greater than 20 percent of the low-income population percentage in the county. The thresholds for each county used in the analysis are located in Table 3.9-1.

According to CEQ guidance, USCB data are typically used to determine minority and low-income population percentages in the affected area of a project in order to conduct a quantitative assessment of potential environmental justice impacts. The geographic unit used in the analysis to identify any environmental justice communities of concern is the census block group. For the purposes of this analysis, a census block group constitutes an environmental justice community if one of the two criteria described above for either minority or low-income populations are met (Reference 1).

As the location for the proposed project, Roane County would experience the majority of environmental impacts as compared to other ROI counties. Block Group 1, Census Tract 9801 encompasses the proposed site; however no one resides there. Therefore, a total of 14 census block groups located within a 5mile radius of the site was evaluated for potential environmental justice impacts. Consistent with the Commission's Policy Statement (69 FR 52040) and Environmental Impact Statements for the SHINE and Northwest Medical Isotopes production facility construction permits (Reference 4 and Reference 5), affected populations are defined as minority and low-income populations who reside within a 5-mile (8-

km) radius of the proposed facility site. The area of interest for environmental justice encompasses block groups in parts of Roane and Morgan Counties. Table 3.9-1 identifies thresholds for each county for the identification of minority and low-income communities within the 5-mile radius traversing the counties. The thresholds were derived by adding 20 percent to the aggregate minority percentage and low-income percentage in Roane and Morgan Counties as applicable (Reference 6 and Reference 7).

3.9.1 Methodology

The following methodology was used to identify populations that may be the subject of environmental justice considerations.

The geographic area of analysis is the 5-mile area around the site. The analysis followed the CEQ guidance for identifying minority and low-income populations in the ROI as defined above and used the “block group” method recommended by the NRC to identify the locations of minority and low-income populations of the geographic area of analysis. The block group is the smallest geographical unit for which the USCB tabulates data required for environmental justice analysis (Reference 2). Data from 2015-2019 American Community Survey 5-Year Estimates, along with GIS software, were used to determine the minority and low-income characteristics of resident populations by block group. If any part of a block group was located within 5 miles of the site, the entire block group was included in the analysis. As shown in Table 3.9-2 and Table 3.9-3 a total of 14 block groups met these criteria and were evaluated against the thresholds shown in Table 3.9-1 (Reference 6 and Reference 7).

3.9.1.1 Minority Populations

Table 3.9-2 shows the percentage of minority populations in each block group within the 5-mile radius, and the county in which the block group is located. None of the 14 block groups met the “greater than 50 percent” minority population threshold indicating potential environmental justice populations. None of the minority percentages in any of the 14 block groups within the 5-mile radius exceeded the “20 percent greater” thresholds (27.3 percent in Roane County and 27.9 percent in Morgan County) as shown in Table 3.9-1 (Reference 6). Therefore, there are no minority populations subject to consideration as potential environmental justice communities of concern in a 5 mile radius of the proposed site.

Overall, the aggregate minority population of block groups in the 5-mile study area was 6.2 percent (Reference 4). As shown in Table 3.7.3, this is significantly less than the 5 county ROI (15.4 percent) and the state (26.2 percent).

3.9.1.2 Low-Income Populations

Table 3.9-3 shows the percentage of low-income populations in each block group within the 5-mile radius, and the county in which the block group is located. None of the 14 block groups met the “greater than 50 percent” low-income population threshold indicating potential environmental justice populations. None of the 14 block groups exceeded the “20 percent greater” thresholds (33.8 percent in Roane County and 42.8 percent in Morgan County) as shown in Table 3.9-1 indicating the presence of low-income populations subject to consideration as potential environmental justice communities of concern (Reference 7). Therefore, there are no low-income populations subject to consideration as potential environmental justice communities of concern (Reference 7) within a 5-mile radius of the site.

Overall, the aggregate low-income population of block groups in the 5-mile study area was 12.6 percent (Reference 7). As shown in Table 3.7-8, this is less than the 5 county ROI (14.7 percent) and significantly less than the State (15.2 percent).

3.9.2 References

1. Council on Environmental Quality. Environmental Justice: Guidance Under the National Environmental Policy Act. December 10, 1997
2. U.S. Nuclear Regulatory Commission. Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions (69 FR 52040), August 24, 2004.
3. U.S. Nuclear Regulatory Commission. Office Instruction No. LIC 203, Revision 3, Procedural Guidance for Preparing Environmental Assessments and Considering Environmental Issues, July 1, 2013.
4. NUREG-2183, “Environmental Impact Statement for the Construction Permit for the SHINE Medical Radioisotope Production Facility,” October 2015.
5. NUREG-2209, "Environmental Impact Statement for the Construction Permit for the Northwest Medical Isotopes Radioisotope Production Facility," May 2017.
6. U.S. Census Bureau. (2019). Hispanic Or Latino Origin By Race. Website: https://data.census.gov/cedsci/table?q=B03002&g=0500000US47129,47145,47145%241500000&tid=ACSDT5Y2019.B03002&hidePreview=true&moe=false
7. U.S. Census Bureau. TIGER/Line with Selected Demographic and Economic Data. Low-Income Populations. Website: https://www.census.gov/cgi-bin/geo/shapefiles/index.php, accessed October 19, 2021.

Table 3.9-1: 2019 Thresholds for Identification of Minority and Low-income Environmental Justice Communities in ROI Counties

County	Minority Threshold (Rate + 20%)	Low-income Threshold (Rate + 20%)
Morgan	27.9%	42.8%
Roane	27.3%	33.8%
Source: (Reference 6 and Reference 7)		

Table 3.9-2: Minority Population Statistics for Block Groups within a 5-Mile Radius of the Site

Block Group	Total Population	Aggregate Minority Population	Percent Minority Population
Block Group 1, Census Tract 301, Roane County, Tennessee	1,544	204	13.2
Block Group 2, Census Tract 301, Roane County, Tennessee	1,715	229	13.4
Block Group 1, Census Tract 302.01, Roane County, Tennessee	1,431	40	2.8
Block Group 4, Census Tract 302.01, Roane County, Tennessee	918	41	4.5
Block Group 5, Census Tract 302.01, Roane County, Tennessee	1,192	132	11.1
Block Group 5, Census Tract 302.02, Roane County, Tennessee	2,299	128	5.6
Block Group 1, Census Tract 307, Roane County, Tennessee	1,039	43	4.1
Block Group 4, Census Tract 308, Roane County, Tennessee	1,206	114	9.5
Block Group 2, Census Tract 309, Roane County, Tennessee	870	16	1.8
Block Group 3, Census Tract 309, Roane County, Tennessee	710	0	0.0
Block Group 4, Census Tract 309, Roane County, Tennessee	1,174	50	4.3
Block Group 5, Census Tract 309, Roane County, Tennessee	1,356	14	1.0
Block Group 1, Census Tract 9801, Roane County, Tennessee	0	0	0.0
Block Group 3, Census Tract 1104, Morgan County, Tennessee	844	0	0.0
Total Block Groups in 5-mile Radius	**16,298**	**1,011**	**6.2**
Roane County, Tennessee	53,075	3,855	7.3
Morgan County, Tennessee	21,545	1,712	7.9
Source: see Reference 6			

Table 3.9-3: Low-Income Population Statistics for Block Groups within a 5-Mile Radius of the Site

Area	Total Population	Persons Below Poverty Level	Percent of Persons Below Poverty Level
Block Group 5, Census Tract 309, Roane County, Tennessee	1,356	343	25.3
Block Group 1, Census Tract 301, Roane County, Tennessee	1,544	11	0.7
Block Group 4, Census Tract 302.01, Roane County, Tennessee	918	0	0.0
Block Group 5, Census Tract 302.02, Roane County, Tennessee	2,299	299	13.0
Block Group 2, Census Tract 309, Roane County, Tennessee	870	15	1.7
Block Group 5, Census Tract 302.01, Roane County, Tennessee	1,192	28	2.3
Block Group 1, Census Tract 307, Roane County, Tennessee	1,039	279	26.9
Block Group 1, Census Tract 302.01, Roane County, Tennessee	1,431	356	24.9
Block Group 4, Census Tract 308, Roane County, Tennessee	1,206	362	30.0
Block Group 3, Census Tract 309, Roane County, Tennessee	710	96	13.5
Block Group 4, Census Tract 309, Roane County, Tennessee	1,174	160	14.2
Block Group 2, Census Tract 301, Roane County, Tennessee	1,715	26	1.5
Block Group 1, Census Tract 9801, Roane County, Tennessee	0	0	0
Block Group 3, Census Tract 1104, Morgan County, Tennessee	822	73	8.9
Total	**16,200**	**2,048**	**12.6**
Roane County, Tennessee	53,075	7,237	13.8
Morgan County, Tennessee	21,545	4,232	22.8
Source: (Reference 7)			

Kairos Power

Chapter 4

Impacts of Proposed Construction, Operations, and Decommissioning

Hermes Non-Power Reactor

Environmental Report

Revision 0

October 2021

TABLE OF CONTENTS

List of Tables

List of Figures

CHAPTER 4 IMPACTS OF PROPOSED CONSTRUCTION, OPERATIONS, AND DECOMMISSIONING

This chapter provides an analysis of the impacts of construction, operation, and decommissioning of the facility. Overall impact rankings are given to each environmental resource evaluated. Unless otherwise defined, criteria followed the guidance given in NRC Impact Rankings in 10 CFR 51 Subpart A, Appendix B, Table B-1, Footnote 3 as follows:

- SMALL (S) – Environmental effects are not detectable or are so minor that they would neither destabilize nor noticeably alter any important attribute of the resource.
- MODERATE (M) – Environmental effects are sufficient to alter noticeably, but not to destabilize, important attributes of the resource.
- LARGE (L) – Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

4.1 LAND USE AND VISUAL RESOURCES

This section assesses the impacts of construction and operation on land use and visual resources for the site and region. As described in Section 3.1, the land use for the site and region is analyzed using the National Land Cover Database 2016. Impacts include effects from activities associated with construction and operation, including excavation, grading, placement of fill material, temporary staging and construction laydown, construction of permanent features, and potential operational disturbances.

4.1.1 Land Use

This section discusses the land use impacts from construction and operation of the facility.

4.1.1.1 Site and Region

As described in Section 3.1, the site consists of an approximate 185 acre parcel located within the Department of Energy (DOE) East Tennessee Technology Park (ETTP) in Oak Ridge, Tennessee. The site is located on a parcel that previously housed Buildings K-31 and K-33, which were part of the K-25 complex and operated as the Oak Ridge gaseous diffusion plant (ORGDP). The region surrounding the site is defined in Subsection 3.1.1.2 as the area within a 5-mile radius of the site center point. The entire region is located within Roane, Loudon, and Morgan Counties, Tennessee.

The land use impacts to the site and near offsite areas are based on the conversion of the site from a Brownfield to an active industrial area. As described in Section 3.1, the entire site is classified as a Brownfield due to the previous disturbances associated with use of the site for the K-33 Building as part of the K-25 Gaseous Diffusion Plant for the Manhattan Project. Therefore, the site has been historically industrial in nature. While the site is currently vegetated and unused, it remains part of the ETTP which is an industrial park. As such, impacts to land use from construction and operations would be SMALL.

The source of uranium for the TRISO fuel has not been finalized. For the purposes of evaluating potential impact, this report assumes it would be sourced from an in-situ leach mine within the U.S., converted to gaseous uranium hexafluoride, and enriched to a maximum of 19.55 weight percent using commercially available centrifuge technology at an existing facility located within the U.S. While the uranium requirements, and thus land use requirements, for high-assay, low-enriched fuel could be greater than for standard low-enriched fuel, Hermes will use significantly less uranium over its lifetime than a light-water power reactor. Approximately 2.33 metric tons of uranium (MTU) would be needed over the 10-year licensed operating life compared to an average of 20 to 33 MTU per year for light-water power reactors. Therefore, the impacts on land use would be SMALL and bounded by impacts described in

Table S-3 of 10 CFR 51.51 which considers the impacts from a generic reactor requiring an average of 33 MTU per year. Optionally, enriched uranium could be sourced from international supplies, or from existing stores in the U.S., either of which option would reduce the overall environmental impacts within the U.S. compared to the assumed option.

4.1.1.2 Special Land Uses

As discussed in Subsection 3.5.4, there are two special land use areas in the region (Oak Ridge Wildlife Management Area [WMA] and Black Oak Ridge Conservation Easement [BORCE]), with neither area located onsite. Permanent and temporary impacts from construction and operation of the facility occur onsite and in near offsite areas, but not within either of these special land use areas. No direct or indirect impacts occur to special land use classification areas. Therefore, impacts to special land use classification areas would be SMALL.

4.1.1.3 Agricultural Resources and Facilities

As described in Subsection 3.3.3.2, no prime farmland or farmland of state-wide importance occurs within the site boundaries as the site is classified as a Brownfield. No other significant agricultural resources within the region of the site are located offsite in the region, as discussed in Subsection 3.1.1.2, and therefore, would not be impacted by construction and operations-related impacts. As such, direct and indirect impacts to agricultural resources and facilities from construction and operations would be SMALL.

4.1.1.4 Major Population Centers and Infrastructure

Section 3.1 summarizes the major population centers and infrastructure located within Roane, Loudon, and Morgan Counties, which include the population center of Oak Ridge. The nearest major population center is the City of Knoxville located approximately 25 miles east of the site in Knox County. Permanent and temporary impacts from construction and operations of the facility occur on-site and immediately adjacent to the boundary of the site. Therefore, construction and operations-related direct and indirect impacts on major population centers and infrastructure would be SMALL.

4.1.1.5 Impacts from Decommissioning

The facility is expected to begin operational activities in 2025 or 2026. The licensed life of the facility is expected to be 10 years. As a result, decommissioning activities would be expected to commence in 2036. Decommissioning activities, however, are similar to construction activities and involve heavy equipment to dismantle buildings and remove roadway and parking facilities. Resultant land uses following decommissioning are undetermined but may consist of returning the site to a Brownfield or open space. As such, direct and indirect impacts from decommissioning are anticipated to be similar to the impacts associated with construction and would be SMALL.

4.1.2 Visual Resources

The visual setting of the area affected by the construction and operation of the site is described in Subsection 3.1.2. A design simulation of the proposed facility is shown in Figure 4.1-1. The existing site is composed entirely of land used for industrial purposes. Although the site has been previously disturbed, it is currently a Brownfield and there are no existing architectural features, established structures, or natural or built barriers, screens, or buffers. Consequently, the facility would alter the on-site condition and would partially obstruct views of the existing landscape. However, the aesthetic and scenic quality of the site is already low because of the historic activities at the site and surrounding industrial areas (see Subsection 3.1.2). Approximate dimensions of the Reactor Building complex for the visual impact

assessment include a height of 100 feet, a length of 260 feet, and a width of 250 feet. (The Reactor Building would have an approximate width of 100 feet and the Auxiliary Systems Building would have an approximate width of 150 feet, for a combined width of 250 feet.) The footprint within the fenced area would be approximately 600 feet wide by 600 feet long. The facility's main Reactor Building would have ventilation stacks with a height of 100 feet. Figure 4.1-1 presents a conceptual rendering of the facility and the arrangements on-site based upon approximate dimensions. As discussed in Subsection 4.2.1, air emission impacts are expected to be low and air quality modeling is not required for non-Title V permitting. Therefore, air quality impacts on visual resources is expected to be minimal.

In addition to the Reactor Building and Auxiliary System Building, the site would include an Administration Building and a Maintenance and Storage Building that would be lower than the Reactor Building. The facility would not utilize cooling towers, radar towers, or other large structures that visibly intrude upon the existing landscape. Therefore, based upon these site characteristics, the bounded dimensions of the facility as illustrated in Figure 4.1-1, and the relatively low profile of the proposed facility structures, and anticipated impacts to the viewshed would be SMALL.

As described in Subsection 3.1.2, the viewshed to the south and east of the proposed facility is industrial, while the viewshed to the north and west are predominantly forested. The area immediately surrounding the proposed facility is a highly-developed industrial setting including numerous paved parking lots, impervious surfaces, and structures on the ETTP. Together with the paved lots and surfaces, previously-developed areas now overgrown with low-quality vegetation, and structures on the ETTP, the facility does not significantly alter the visual setting. Therefore, impacts to visual resources from construction and operation of the facility would be SMALL.

In order to further assess potential impacts to visual resources from the construction and operation of the proposed facility, renderings were produced using baseline photos captured from six (6) key observation point (KOP) locations. Beginning with 11 possible KOP locations, that list was ultimately reduced to six specific locations using the bare-earth viewshed in Global Mapper 21.0, a program which uses local topography to estimate areas from which the facility could potentially be visible to the public. An arbitrary height of 100 feet was chosen as the tallest structural component. This program does not account for intervening vegetation and/or other existing structures in the viewshed. Additional KOPs were identified to address potentially sensitive locations, such as nearby neighborhoods and recreational areas. Figure 4.1-2 shows the final KOP locations chosen for visual analysis.

Photo-realistic renderings were created using Autodesk's 3ds Max Design program. A 3d model of the proposed buildings was created. Using the known location of where the baseline photo was captured, as well as the height of the camera (ground elevation plus eye height), a camera in the program was created at this location using the focal length the camera used. Existing elements within the photo (i.e., transmission line towers) were then located using aerial photos and modeled to help orient the camera to match the viewpoint of the photo. The time and data of the photo were also used to match the lighting in the photo at the time of collection. Therefore, the final rendering at each KOP is a composite of the modeled buildings and the baseline photo.

The following six locations were identified for rendering generation and visual analysis:

- KOP 3 – this location represents the Black Oak Ridge Conservation Easement Parking Area and the entrance to the Dyllis Orchard Road Hiking Trail (Figure 4.1-3).
- KOP 7 – this location represents the K-25 Overlook and Visitor Center (Figure 4.1-4).

- KOP 8 – this location represents the Hatleyberry Street sidewalk in a neighborhood located southwest of the proposed facility (Figure 4.1-5).
- KOP 9 – this location represents an additional view from a neighborhood to the southeast of the proposed facility from Parkberry Street (Figure 4.1-6).
- KOP 10 – this location represents a waterfront location within the same neighborhood referenced above in KOPs 8 and 9 (Figure 4.1-7).
- KOP 11 – this location represents the Welcher Cemetery, south of the proposed facility (Figure 4.1-8).

From the locations of all the KOPs (3, 7, 8, 9, 10, and 11), the view of the proposed facility is blocked by existing vegetation. During the winter months, when some trees lose their leaves, the proposed facility may be visible in the far distance. Additionally, the facility could be visible from points near the exact KOP locations that were not identified. For KOP 10, there are existing industrial structures within the viewshed already, including transmission lines and industrial development. The addition of a small industrial complex would not alter this view significantly. A rendering was not generated for KOP 11 as the proposed facility would be completely blocked from view by the cemetery, its perimeter walls, and intervening vegetation.

Overall, the renderings confirm that the proposed facility would be well-screened by riparian trees from most KOP locations. The surrounding hills and mountains also help to soften the visual impacts of this project because they are larger than the facility and make it seem smaller and less imposing, and the existing industrial setting of the site would further reduce visual impacts. From a distance of greater than approximately 1.2 miles, the visibility of the proposed facility would be greatly diminished due to intervening vegetation and the diminished perceived size of the facility due to the increased distance. This would be true even in winter months under leaf-off conditions; therefore, the visual intrusion due to construction and operation of the proposed facility would be SMALL.

Figure 4.1-1: Simulation of the Proposed Facility

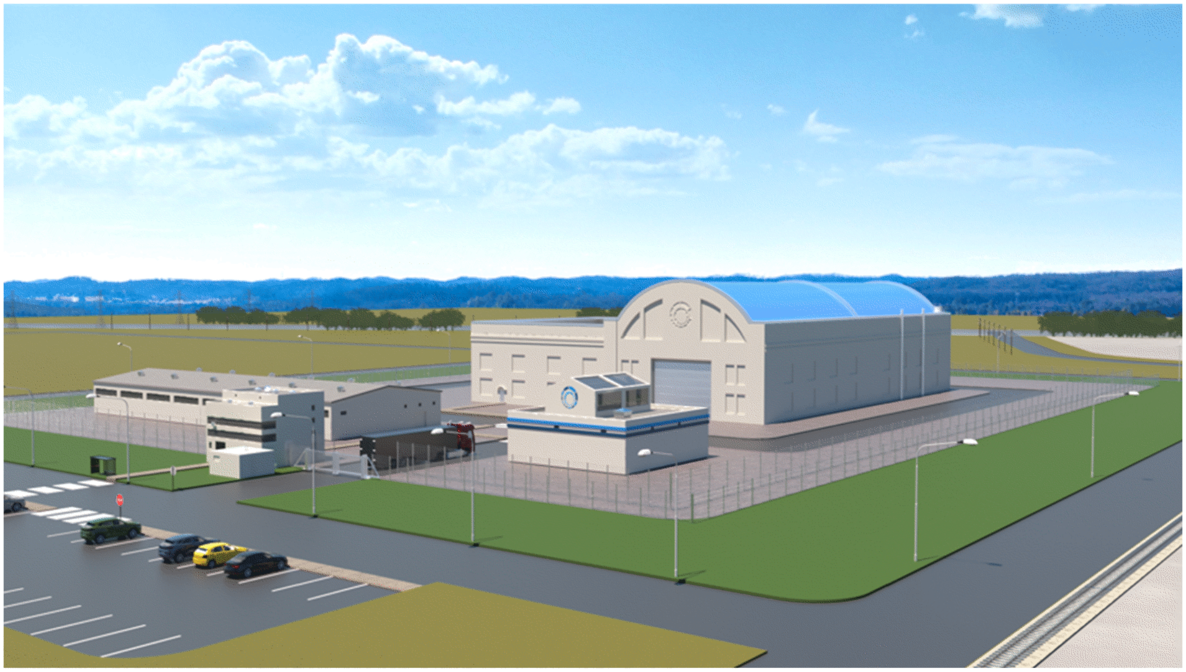


Figure 4.1-2: KOP Locations used for the Renderings

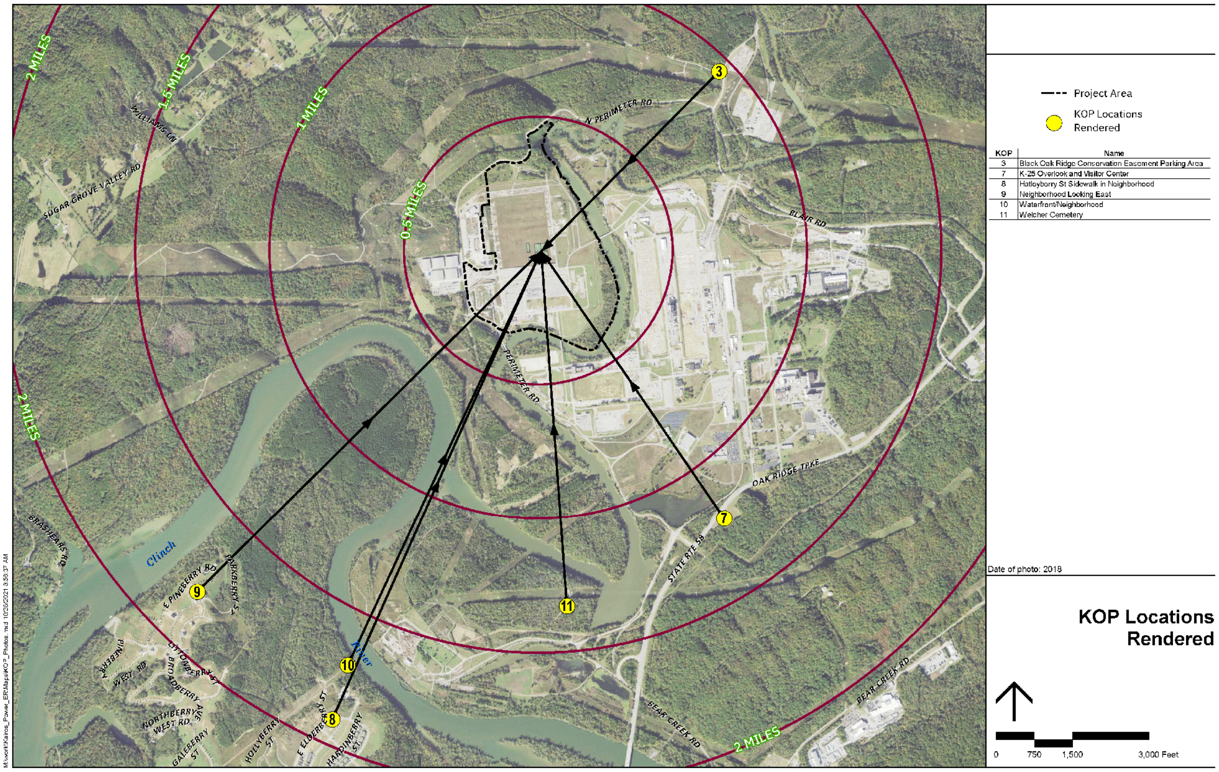


Figure 4.1-3: A rendering of the proposed facility from KOP 3 (facility not visible)

Figure 4.1-4: The rendering of the proposed facility from KOP 7 (facility not visible)

Figure 4.1-5: The rendering generated from KOP 8 (facility not visible)

Figure 4.1-6: The rendering generated for KOP 9 (facility not visible)

Figure 4.1-7: The rendering generated at KOP 10 (facility not visible)

Figure 4.1-8: The photograph taken from KOP 11 (facility not visible)

4.2 AIR QUALITY AND NOISE

4.2.1 Air Quality

4.2.1.1 Impacts from Construction

Construction activities result in localized increases in air emissions. Earthmoving, excavation, clearing, pile driving, erection, batch plant operation, and construction-related traffic generate fugitive dust and fine particulate matter that potentially impact both onsite workers and offsite residents of the community. Vehicles and engine-driven equipment (e.g., generators and compressors) generate combustion product emissions such as carbon monoxide (CO), nitrogen oxides (NOx) and, to a lesser extent, sulfur dioxide (SO_2). Painting, coating, and similar operations also generate emissions from the use of volatile organic compounds. People living near or working at or near construction sites may be subject to the physical impacts of construction activities. Activities associated with the use of construction equipment may result in varying amounts of dust, air emissions, noise, and vibration. The magnitude and area of extent of the impacts from these emissions depends in part on atmospheric conditions at the time of the activity. The magnitude of these potential impacts is typically related to the specific construction activities that occur at a given site, the nature and effectiveness of implemented environmental controls, and the proximity of the site to populated areas. Contractors, vendors, and subcontractors are required to adhere to appropriate federal and state occupational health and safety regulations. These regulations set limits to protect workers from adverse conditions, including air emissions.

On-site equipment usage and traffic due to construction activities can also result in local increases in emissions. Section 4.7 and Section 4.9 provide information regarding the type and volume of traffic generated by the facility during construction. Guidance from the Final Interim Staff Guidance (ISG) Augmenting NUREG-1537 suggests that emissions from on-site and offsite vehicle use (including fugitive dust) should be estimated. Based upon a larger project of a similar nature, the Versatile Test Reactor (Reference 1), the emissions of individual criteria pollutants such as SO_2, NOx, CO, particulate matter with an aerodynamic diameter of 10 microns or less (PM_{10}), and particulate matter with an aerodynamic diameter of 2.5 microns or less ($PM_{2.5}$) during the 2-year construction period for the facility would not exceed 100 tons per year (tpy). In addition, hazardous air pollutants (HAPs) are expected to be below 10 tpy for any single pollutant, and below 25 tpy for all HAPs combined. The low level of expected emissions during construction (and lower for the operational and decommissioning phases) allows the project to apply for a minor (non-Title V) permit from the Tennessee Department of Environment and Conservation (TDEC), and no dispersion modeling is required by TDEC for a minor source permit application.

Construction equipment usage and generated traffic volumes are expected to be relatively minor compared to other regional traffic generated emissions, so potential air quality impacts from construction are limited. Implementation of controls and limits at the source of emissions on the construction site would result in reduction of impacts offsite. For example, the dust control program reduces dust due to construction activities to minimize dust reaching site boundaries. Transportation and other offsite activities result in emissions from vehicle usage. Offsite transportation activities generally occur on improved surfaces, limiting fugitive dust emissions.

Specific mitigation measures to control fugitive dust may include any or all of the following:

- Stabilizing construction roads and spoil piles
- Limiting speeds on unpaved construction roads

- Periodically watering unpaved construction roads
- Performing housekeeping (e.g., remove dirt spilled onto paved roads)
- Covering haul trucks when loaded or unloaded
- Minimizing material handling (e.g., drop heights, double-handling)
- Phased grading to minimizes the area of disturbed soils
- Re-vegetating road medians and slopes

While emissions from construction activities and equipment are unavoidable, implementation of mitigation measures minimize impacts to local ambient air quality and the nuisance impacts to the public in proximity to the project. The mitigation may include any or all of the following:

- Implementing controls to minimize daily emissions such as reducing engine idle time, using cleaner fuels (e.g., ultra-low sulfur diesel fuel or biodiesel), using pollution control equipment on construction equipment (e.g., diesel oxidation catalysts and particulate matter filters), and curtailing or controlling the time-of-day construction activities are performed.
- Requiring proper maintenance of construction vehicles to maximize efficiency and minimize emissions.

In summary, air emission impacts from construction would be controlled at the source where practicable; maintained within established regulatory limits designed to minimize impacts; and generally localized on the site. Therefore, the impacts to air quality would be SMALL.

4.2.1.2 Impacts from Operation

PSAR Chapters 5, 9, and 11 provide information regarding the cooling and heating dissipation systems and the waste systems for the facility. The design of the facility includes a cooling system that does not require the use of external mechanical or natural draft cooling towers.

The site is located in Roane County, Tennessee. The Clean Air Act and its amendments establish National Ambient Air Quality Standards (NAAQS) for ambient pollutant concentrations that are considered harmful to public health and the environment. Similarly, Tennessee has established the Tennessee Ambient Air Quality Standards. Primary standards set limits to protect public health and secondary standards set limits to protect public welfare such as decreased visibility, and damage to animals, crops, vegetation, and buildings. The principal (criteria) pollutants for which NAAQS have been set are CO, NO_2, lead, SO_2, PM_{10}, $PM_{2.5}$, and ozone (O_3). One or more averaging times are associated with each pollutant for which the standard must be attained.

Areas having air quality as good as, or better than, the NAAQS are designated as attainment areas. Areas having air quality that is worse than the NAAQS are designated as nonattainment areas. Roane County, TN is designated as attainment for all pollutants and averaging periods except for $PM_{2.5}$. Census Block Group 47-145-0307-2 is the portion of Roane County that is designated as maintenance for the 1997 and 2006 $PM_{2.5}$ standards. An area is redesignated from nonattainment to maintenance when mitigation measures are initiated by the state to improve air quality and an area meets the ambient air quality standards and other redesignation requirements under the Clean Air Act. This maintenance area is located approximately 5 miles southwest of the site. However, the area in the immediate vicinity of the site in Roane County is in attainment for $PM_{2.5}$.

The criteria pollutant operational emissions from the project are estimated to be well below 100 tpy for all criteria pollutants. Also, the HAPs are estimated to be below 10 tpy for any single pollutant and

below 25 tpy for all HAPs combined. As a result, the project is subject to non-Title V requirements. No air quality modeling is required for non-Title V permitting.

4.2.1.2.1 Gaseous Effluents

Air emissions of nonradiological gaseous criteria pollutants and HAPs would be emitted during the operations phase from: (1) intermittent use of diesel-powered or natural gas powered standby power generation sources such as generators or combustion gas turbines, (2) intermittent use of propane-fired heaters for the intermediate coolant located in the primary heat rejection system (PHRS) during maintenance activities, (3) diesel-powered trucks that deliver material and haul off wastes, and (4) worker commuter vehicles. Radiological air emissions would be produced in the operations phase from the primary heat rejection stack, decay heat removal system vents, Reactor Building ventilation stack, and spent fuel cooling stack.

4.2.1.2.2 Evaluation of Emission Impacts on Air Quality

Vehicle and Other Emissions

During the operations phase, vehicular air emissions occur from the commuting workforce and from routine deliveries to/from the facility. The volume of traffic generated during operations is considerably lower than that expected during construction. Additionally, the lands on the developed site are either developed surfaces (buildings, paved parking/access road) or have been landscaped. Limitation of routine vehicle usage to paved areas reduces the emissions of fugitive dust. Impacts from vehicular air emissions and fugitive dust are far less than during the construction phase. Therefore, impacts during the operations phase would be SMALL.

Release Point Characteristics

There would also be intermittent emissions from standby power generation sources such as generators or combustion gas turbines. These generators would operate less than 500 hours per year. If used exclusively for replacement or standby service and at or less than 500 hours per year, these generator units would not require a construction or operating permit, as outlined in Chapter 1200-3-9-04 (Construction and Operating Permits) of the Tennessee Air Pollution Control Regulations. In addition, the potential to emit for the generator units based on 500 hours of operation would produce insignificant emissions (less than 5 tons per year for criteria pollutants and less than 1,000 pounds per year for an individual hazardous air pollutant [HAP]), as defined in Chapter 1200-03-09 of the Tennessee Air Pollution Control Regulations; therefore, impacts would be SMALL.

Uranium Fuel Cycle

Hermes will use significantly less uranium over its lifetime than a light-water power reactor. Approximately 2.33 MTU would be needed over the 10-year licensed operating life compared to an average of 20 to 33 MTU per year for light-water power reactors. Therefore, the environmental impacts from air emissions generated during mining, enrichment, and fuel fabrication activities would be SMALL and bounded by impacts described in Table S-3 of 10 CFR 51.51 which considers the impacts from a generic LWR requiring an average of 33 MTU per year.

4.2.1.2.3 Greenhouse Gas (GHG) Emissions

Greenhouse gases trap heat in the atmosphere, absorbing and emitting radiation in the thermal infrared range. The most important of these gases are carbon dioxide (CO_2), methane, nitrous oxide, and

fluorinated gases. Greenhouse gases (GHG) are reported as CO_2 equivalent (CO_2e) and refer to the climate change potential of the greenhouse gas or gases being emitted.

Activities associated with the proposed site that are expected to contribute to the GHGs include:

- Construction activities at the site resulting in principally emissions of CO_2; GHG emissions associated with construction activities include the commuting of the construction workforce and operation of construction equipment at the site.
- Plant operation activities associated with the operation of plant equipment and the operations workforce
- Decommissioning activities associated with the decommissioning workforce and decommissioning equipment
- Life cycle activities related to the mining, processing, and transport of materials and waste storage

As noted in Section 3.2.5, a program to avoid and control GHG emissions associated with the facility will be developed. It is anticipated that the impacts from GHG to air quality would be SMALL and with implementation of mitigation procedures, would be further reduced.

4.2.1.2.4 Mitigative Measures

Emission-specific strategies and measures would be developed and implemented to ensure compliance within the applicable regulatory limits defined by the National Primary and Secondary Ambient Air Quality Standards (40 CFR 50) and National Emission Standards for Hazardous Air Pollutants (40 CFR 61).

Contractors, vendors, and subcontractors are required to adhere to appropriate federal and state occupational health and safety regulations. These regulations set limits to protect workers from adverse conditions, including air emissions. Implementation of controls and limits at the source of emissions on the construction site result in reduction of impacts offsite. With implementation of these mitigative measures, impacts from operations would be SMALL.

4.2.1.3 Impacts of Decommissioning

Following the completion of operations and shutdown of the site, the first disposition activity is to deactivate the facilities. Deactivation minimizes risks by protecting workers, the public, and the environment. Decommissioning includes decontamination and dismantling facilities to the ultimate end state of demolition. During decommissioning, hazardous and radioactive materials and contamination are removed or fixed in place to ensure protection of workers, public health and safety, and the environment. Demolition is construction in reverse and includes the recycling of demolition materials to the extent practical and the disposal of non-recyclable materials. During the decommissioning phase, activities, equipment usage and their associated emissions are expected to be similar, but less than that of the construction phase as decommissioning activities are less extensive than construction. Therefore, impacts during the decommissioning phase would be SMALL.

4.2.1.4 Required Permits

Section 1.4 describes the air quality permits are that required to support the construction and operation of the facility. Table 1.4-1 indicates that an Air Pollution Control Construction Permit pursuant to the Tennessee Administrative Code Chapter NR 406, and an Air Pollution Control Operation Permit pursuant to the Tennessee Administrative Code Chapter NR 407 are required.

As mentioned in Table 1.4-1, TDEC requires air pollution control construction and operation permits. Because all criteria pollutants are expected to be below 100 tpy, the following non-Title-V permits would

be required: Facility Identification Form (APC 100), Emission Point Source Description Form (APC 101), Process or Fuel Burning Source Description Form (APC 102), and Concrete Batch Plant Source Description Form (APC 111).

To simplify GHG analyses, total GHG emissions from a source are often expressed as a CO_2e, which is calculated by multiplying the emissions of each GHG by its global warming potential and adding the results together to produce a single, combined emission rate representing all GHGs. While methane and nitrous oxide have much higher global warming potentials than CO_2, CO_2 is emitted in such greater quantities that it is the overwhelming contributor to global CO_2e emissions from both natural processes and human activities. Under the *Mandatory Reporting of Greenhouse Gases Rule*, stationary sources that emit 25,000 metric tons or more per year of CO_2e are required to report their annual GHG emissions to the Environmental Protection Agency (EPA). It is expected that during construction, the facility could produce up to 8,190 metric tons of CO_2e per year. During operation, the facility could produce up to 1,460 metric tons of CO_2e per year. Because the emissions are expected to be under 25,000 metric tpy, the facility would not be subject to GHG regulations.

4.2.1.5 Air Quality and Meteorological Monitoring

The Oak Ridge Reservation (ORR) conducts an extensive air and meteorological monitoring program, as documented in their 2021 environmental monitoring plan (Reference 2). They have 10 monitoring stations scattered around the ORR, including around the ETTP complex, that monitor radiological particulates and tritiated water vapor. See Figure 4.2-1 for the locations of the monitoring stations. Sampling of the air is continuous with samples being collected weekly to biweekly. Samples are analyzed for gross alpha, gross beta, gamma-emitting radionuclides such as Potassium-40 and Beryllium-7, Uranium-234, Uranium-235, Uranium-238, Technetium-99, Tritium, and other radionuclides and isotopes that contribute 0.1 or more mrem to ORR's effective dose from airborne emissions. Data from the environmental monitoring program are analyzed to assess the environmental impact of DOE operations on the entire reservation and the surrounding area.

Nonradiological criteria pollutants are monitored by the TDEC Division of Air Pollution Control. The monitors are documented in the TDEC's 2021 Tennessee Annual Monitoring Network Plan (Reference 3). Table 4.2-1 lists the closest criteria pollutant state and local air monitoring stations to the site. The monitors are also shown in Figure 4.2-2.

Local meteorological data sources are described in Subsection 3.2.4.2.

Per the Oak Ridge Reservation Annual Site Environmental Reports (available at Home of the Oak Ridge Reservation Annual Site Environmental Report (ASER), Reference 8), ORR meteorological monitoring satisfies onsite monitoring requirements for the DOE (Reference 6) and the Environmental Protection Agency (EPA) (Reference 7). The provided data are 100 percent complete, although some substitution of data from collocated instrumentation has taken place to handle missing values for individual sensors. See Table 2.4-2 for more details on these towers.

4.2.2 Noise

4.2.2.1 Impacts of Construction

Construction would have temporary adverse effects on noise and vibration during the likely 2-year duration of the project between 2023 and 2025. Construction activities would cause temporary increases and fluctuations in ambient noise levels around the site depending on the number and type of

equipment in use at any given time. Typical maximum noise levels from equipment likely to be used during construction are listed in Table 4.2-3.

As discussed in Section 3.2, the nearest noise receptors around the site include:

- A greenway 1 mile northeast of the site
- A residential area approximately 1.25 miles north of the site, with a forest located between the site and the residential area

Because the existing ambient noise level during the quietest daytime hours when construction activities would occur was measured as 38 dBA in L_{eq}, the predicted noise impacts from the equipment would be likely not be perceptible (i.e., a 3-dBA or less increase over the ambient level of 38 dBA) in the nearest sensitive receptors as shown in Table 4.2-3. However, when pile driving activities and/or multiple heavy equipment operate simultaneously, a readily perceptible noise increase would likely be perceived by the nearest sensitive receptors. Given the temporary nature of construction activities and the distances from the site, the impact of noise from construction equipment operation on nearby residences, schools, churches, and parks would be SMALL.

Traffic associated with the construction workforce traveling to and from the site also generates noise. The increase in noise relative to ambient background conditions would be most noticeable during the shift changes in the morning and late afternoon. Given the short duration of such potential traffic noise increase, potential noise impacts to the community are intermittent and limited primarily to shift changes. The impact from noise from construction-related traffic to nearby residences schools, churches, and parks would be SMALL.

4.2.2.2 Impacts of Operation

Operation of the facility would involve equipment that would emit noise levels typical of industrial activities. The continuously operated equipment would include heat exchange fans and exhaust fans in addition to intermittently or infrequently used equipment, such as compressors and standby generators. However, most equipment would be indoors within enclosures resulting in minimal outdoor noise emissions. These enclosures mainly include:

- Reactor Building
- Auxiliary Systems Building
- Maintenance and Storage Building

Outdoor equipment (i.e., heat exchange fans and several exhaust and ventilation stacks), employee vehicle trips, and routine maintenance activities involving trucks would be perceptible in the immediate vicinity of the facility, particularly during nighttime hours when ambient noise levels are low. The residential area would be the most sensitive to surrounding noise during nighttime operation; However, the residential area is 1.25 miles away from the project site and is separated by the forest, creating a sound buffer. Therefore, operational noise is unlikely to be perceptible to those in the residential area. As a result, the facility operation would not result in significant noise impacts.

Consequently, operational impacts relative to the noise environment would be SMALL.

4.2.2.3 Impacts of Decommissioning

Decommissioning is the removal of a nuclear facility from service and reduction of residual radioactivity to a level that permits release of the property for unrestricted use and termination of the license. During the decommissioning phase, activities, equipment usage, and the noise associated with typical

decommissioning operations are expected to be similar or less than that of the construction phase. Therefore, impacts during the decommissioning phase would be SMALL.

4.2.3 References

1. U. S. Department of Energy. “Draft Versatile Test Reactor Environmental Impact Statement: Chapter 4: Environmental Consequences”. VTR EIS. DOE/EIS-0542. December 2020.

2. U.S. Department of Energy. “Environmental Monitoring Plan for the Oak Ridge Reservation - Calendar Year 2021”. DOE/ORO-2228/R12. December 2020.

3. Tennessee Department of Environment and Conservation – Air Pollution Control Division. “2021 Tennessee Annual Monitoring Network Plan.” July 1, 2021.

4. Not Used.

5. Not Used.

6. U.S. Department of Energy. “HANDBOOK: Environmental Radiological Effluent Monitoring and Environmental Surveillance.” DOE-HDBK-1216-2015.

7. U.S. Environmental Protection Agency. “Meteorological Monitoring Guidance for Regulatory Modeling Applications.” Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. EPA-454/R-99-005. 2005.

8. U.S. Department of Energy. “Oak Ridge Reservation Annual Site Environmental Report (ASER)” (https://doeic.science.energy.gov/ASER/)

Table 4.2-1: TDEC Criteria Pollutant Air Quality Monitors Near the Site

Pollutant	Monitor Location	AIRS ID	Years of Data	Latitude	Longitude
Carbon Monoxide (CO)	Nashville, TN	47-037-0040	2014-Present	36.142400	-86.734100
Ozone (O_3)	Freels Bend/Oak Ridge, TN	47-001-0101	1992-Present	35.964969	-84.223170
Nitrogen Dioxide (NO_2)	Nashville, TN	47-037-0040	2014-Present	36.142400	-86.734100
	Nashville, TN	47-037-0011	1990-Present	36.205055	-86.744720
Sulfur Dioxide (SO_2)	Kingsport-Bristol-Bristol, TN-VA	47-163-6001 (6002, 6003, 6004) Four monitors located in the same vicinity.	6001: 2016-Present 6002: 2016-Present 6003: 2019-Present 6004: 2018-Present	36.532616 36.521066 36.526359 36.513026	-82.516306 - 82.502454 - 82.528677 - 82.550498
	Freels Bend/Oak Ridge, TN	47-001-0101	2013-2019	35.964969	-84.223170
Particulate Matter 2.5 microns or less ($PM_{2.5}$)	Rule High School, Knoxville, TN	47-093-1017	1999-Present	35.980000	-83.950000
	AIR LAB, Knoxville, TN	47-093-1013	2018-Present	35.980675	-83.925773
Particulate Matter 10 microns or less (PM_{10})	AIR LAB, Knoxville, TN	47-093-1013	2018-Present	35.980675	-83.925773
Lead (Pb)	Former CMC Steel Plant, Knox County, TN	47-093-0023	2011-Present	35.981040	-83.954311
	Former CMC Steel Plant, Knox County, TN	47-093-0027	2009-Present	35.983056	-83.952253

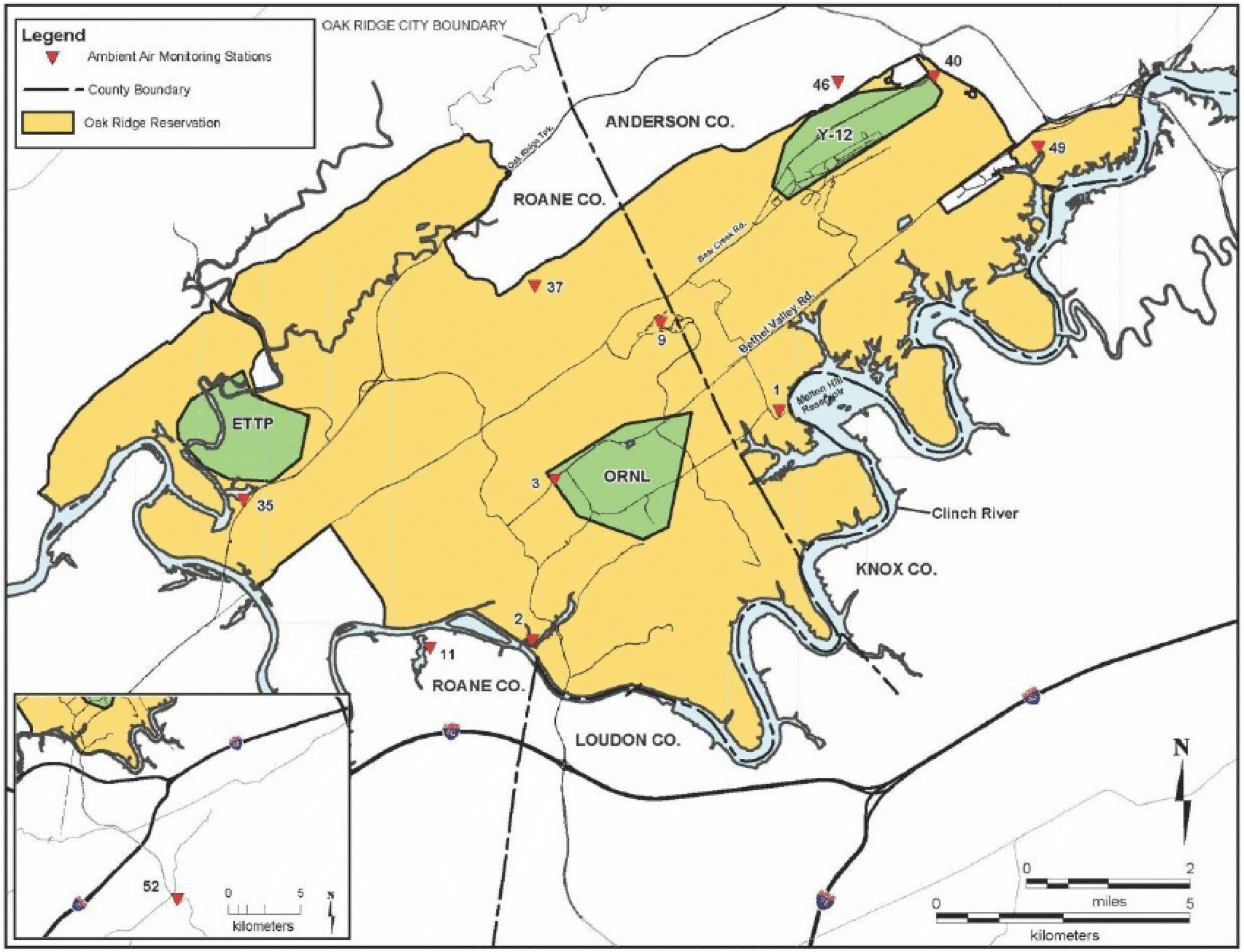
Table 4.2-2: Meteorological Towers Near the Site

Meteorological Tower	Location	Data Collected	Data Collection Period
ORR Tower J	Latitude: 35.930142° N Longitude: 84.394355° W Elevation: 792 ft-msl UTM: Zone 16 Northing: 3979.338 km Easting: 735.073 km	20-m Wind 20-m Temperature Precipitation	June 1, 2017-Present
ORR Tower L	Latitude: 35.925199 ° N Longitude: 84.394196 ° W Elevation: 750 ft-msl UTM: Zone 16 Northing: 3978.790 km Easting: 735.102 km	60-, 10-m Wind 60-, 10-m Temperature Precipitation Atmospheric Pressure Solar Radiation Relative Humidity 60-, 10-m Sigma-Theta ______ 30-, 10-m Wind 30-, 10-m Temperature Precipitation Atmospheric Pressure Solar Radiation ______ 30-, 15-m Wind 30-, 15-, 2-m Temperature Dewpoint Precipitation Atmospheric Pressure Solar Radiation 30-, 15-m Sigma-Theta 15-m Relative Humidity	January 1,2000- December 31, 2000 ______ January 1, 2001- November 1, 2017 (Precipitation and Atmospheric Pressure missing for 2004) ______ November 1, 2017-May 6, 2021
ORR Tower D	Latitude: 35.924992° N Longitude: 84.324946° W Elevation: 858 ft-msl UTM: Zone 16 Northing: 3978.936 km Easting: 741.352 km	60-, 35-, 15-m Wind 60-, 35-, 15-, 2-m Temperature 15-, 2-m Dewpoint Precipitation Atmospheric Pressure Solar Radiation 60-, 35-m Sigma-Theta 15-, 2-m Relative Humidity	April 1, 2014-Present

Table 4.2-3 Typical Noise in dBA from Construction Equipment

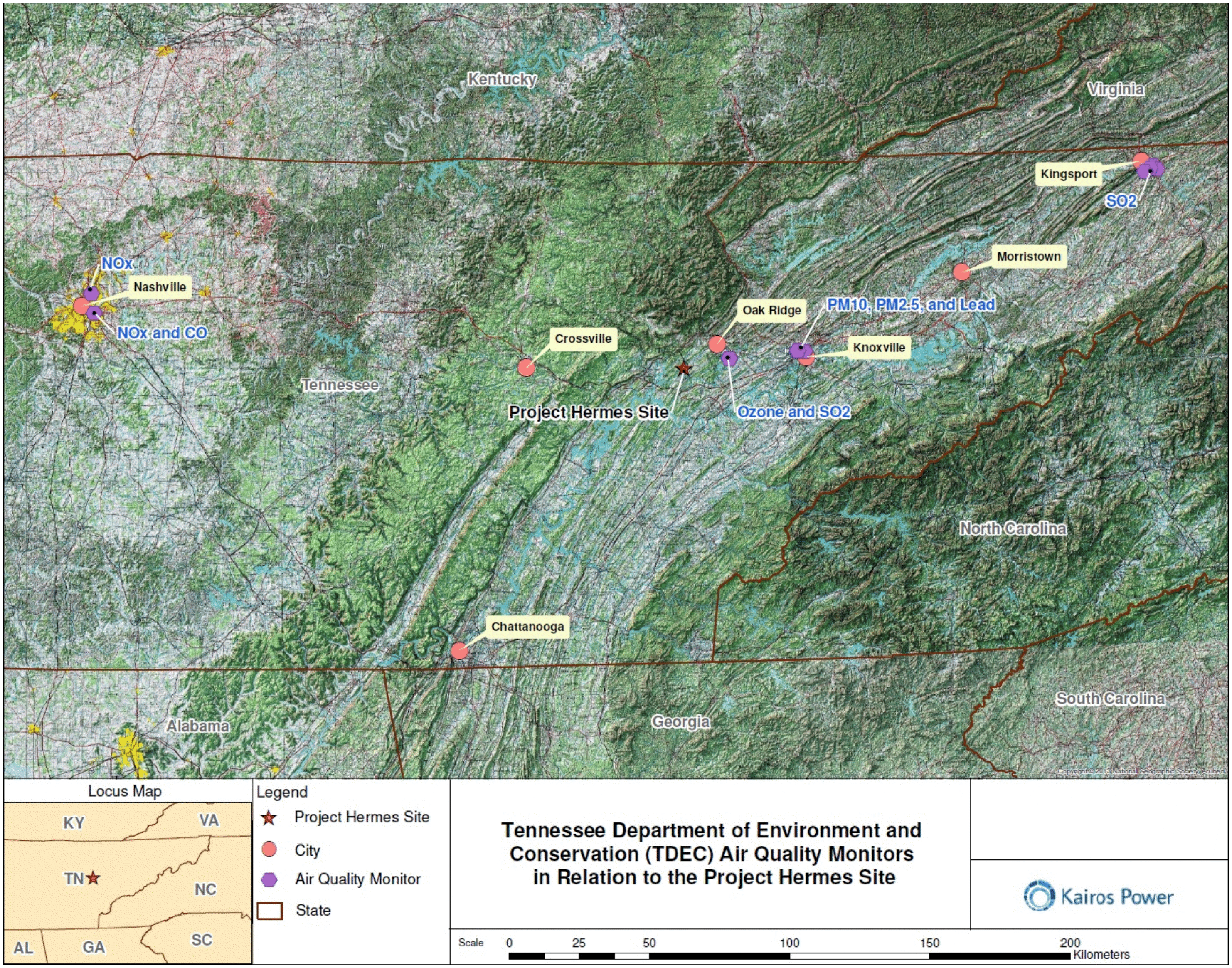
Equipment	Lmax Noise Level at 50 feet	Leq Noise Level at 50 feet	Leq Noise Level at 1 mile (nearest park)	Leq Noise Level at 1.25 miles (nearest residence)
Air Compressor, 370 cfm	80	76	34	31
Asphalt Paving Machine, 130 HP	85	82	40	37
Backhoe Cat 428, 1.3 CY 85 HP	80	76	34	31
Compactor Cat 433B, Smooth Drum roller	85	81	39	36
Concrete Pump, 100 yph	82	75	33	30
Concrete saw, hand	85	78	36	33
Crane Hydraulic 60 ton	85	77	35	32
Crane Truck, 85 ton	85	77	35	32
Dozer - Cat D8, 305 HP	85	81	39	36
Demo Hammer, 7,500#	85	78	36	33
Excavator Cat 330, 26'-6" dig depth	85	81	39	36
Farm Tractor	84	80	38	35
Finisher – Concrete	82	75	33	30
Hydromulcher	85	78	36	33
Lift, boom JLG800, 80' articulating	85	78	36	33
Lift, Fork 8000 lb	80	73	31	28
Lift, Scissor 24'	80	73	31	28
Wheel Loader, Cat 950 4 CY	80	76	34	31
Pile Driver Vibratory Hammer	95	88	46	43
Power Tools	85	78	36	33
Trencher, < 5' deep	85	81	39	36
Truck, Dump 18 CY	85	81	39	36
Truck, flatbed 16	85	81	39	36
Welding Machine 400 amp	84	80	38	35
Welding torch- oxygen/acetylene	84	80	38	35
Well Drilling, Air Track Drill up to 4" diameter	85	78	36	33
Source: (Reference 8)				

Figure 4.2-1: Locations of ORR's Radiation-Monitoring Stations



Source: (Reference 2)

Figure 4.2-2: TDEC Criteria Pollutant Air Quality Monitors Near the Site



4.3 GEOLOGIC ENVIRONMENT

Potential impacts to geologic and soil resources during the construction, operation, and decommissioning of the proposed facility include regional-scale hazards and local hazards. The regional-scale hazards include earthquakes, volcanic activity, landslides, subsidence, and erosional processes. Local hazards are associated with site-specific properties of the soil and bedrock and include soil disturbance due to excavation, exposure of contaminated soil, blasting of bedrock (if required for construction), the volume of material excavated or used during construction, impacts to rare or unique geologic resources, and impacts to economic rock, mineral, or energy resources.

4.3.1 Impacts of Regional-Scale Hazards

The probability of regional-scale impacts due to the geologic factors discussed in Section 3.3 is low. The seismologic regime of the region demonstrates that the site is located in a relatively active seismic zone of low to moderate intensity. As discussed in Section 3.3.4, the Seismic Hazard over a 50-year period only has a 10 percent probability of peak ground acceleration exceeding 30 percent of the acceleration due to gravity.

The geologic environment features that are associated with landslides, subsidence, and erosional processes are discussed in Section 3.3. While landslides and subsidence can occur, the risk within Roane County is not considered high. As discussed in Section 3.3.5, the topography of the site is relatively level and not prone to substantial landslide activity. During pre-construction of the original K-31 and K-33 buildings, several sinkholes were observed at the site and filled in. The information from the geotechnical investigation presented in Section 3.3 did not report any evidence of recent or active subsidence at the site. The subsurface soils were found to be medium firm to very hard, concrete foundations were found at a depth of less than 12 feet, and bedrock refusal occurred at depths from 14 to 54 feet in borings, and 13 to 20 feet in trenches. A visit to the site in June 2021, found no evidence of erosion. Consequently, impacts relative to the geologic environment would be SMALL.

4.3.2 Other Impacts on Soils and Geology

The construction of the facility would include the excavation of the Reactor Building area to an approximate depth of approximately 30 feet below a final grade of 765 feet. The resulting final elevation of the base of the excavation is 735 feet amsl. The maximum frost depth is 1 foot below ground surface, and all underground utilities would be designed accordingly, with a preliminary estimation of utility excavation depth of 5.0 feet below ground surface.

As discussed in Section 3.4.3.2, no groundwater quality monitoring has been conducted for the site However, groundwater quality adjacent to and near the site has been the subject of multiple, ongoing monitoring programs. There are a variety of previously existing volatile organic compounds (VOC) and radionuclide contaminants potentially in the groundwater beneath the site. Because the facility will not use groundwater for any of its processes, groundwater contamination is not expected to present any issues to the facility operation. Dewatering during construction is discussed in Subsection 4.4.1.1.1. Secondary support systems containing water could experience small amounts of tritiated water migration. Tritium monitoring and capture programs are covered in the facility tritium management system (TMS), as discussed in the PSAR, Section 9.1.3.

An analysis of the geology of Roane County indicates that it is similar to the geology of much of the east Tennessee region in that it is comprised of intensely folded limestones and dolomites that are not unique or rare geologic resources.

As noted in Section 3.3.2, bedrock at the site ranges from a depth of 30 feet below ground surface on the southern portion of the site to 55 feet below ground surface on the northern portion of the site. There is no record of rock, sand, gravel, mineral, or energy production on the site.

Excavation depth of the Reactor Building and Auxiliary Systems Building is bounded at approximately 30 feet below finished grade. For estimation of excavation quantities, a depth of 10 feet below finished grade was used for the other area buildings. Direct impacts associated with excavation and topsoil removal for underground utilities and site grading has also been estimated.

Materials excavated during site grading and construction would be stockpiled onsite and used as backfill. Topsoil and other materials not suited for use as structural fill would be stockpiled on-site and placed as non-structural fill. A sediment and erosion control plan would mitigate potential indirect impacts associated with the release of sediment or other runoff constituents to offsite areas.

Based on the above assumptions, the estimated quantity of geologic material required for the completion of this project, exclusive of concrete acquired from commercial concrete mixing plants for construction of the buildings, would be:

- Backfill: 111,333 cubic yards around structures in main excavation (reuse of suitable material excavated onsite)
- Topsoil: 533 cubic yards, acquired from onsite sources
- Granular road base: 4,642 cubic yards
- Asphaltic pavement: 8,923 cubic yards
- Gravel surfacing: 500 cubic yards
- Underground utilities: 1,172 cubic yards for backfill (reuse of suitable material excavated onsite)
- Site grading: quantity is to be determined, and to be acquired from material excavated onsite.

In order to reduce impacts, onsite materials would be utilized as appropriate and no offsite borrow areas are anticipated. Consequently, direct impacts to the geologic environment would be SMALL and no mitigation measures beyond compliance with local building codes have been identified.

4.4 WATER RESOURCES

4.4.1 Hydrology

4.4.1.1 Surface Water

4.4.1.1.1 Facility Construction

The site is bounded on its eastern side by Poplar Creek, which is a tributary of the Clinch River. The site is bounded on the western and southern sides by the Clinch River which is part of the Watts Bar Reservoir. However, no direct impacts to these water bodies are expected as all construction activities would occur on land. No intake or discharge facilities are expected to be constructed or renovated as part of this project although the proposed stormwater pond would be discharged to an existing outfall. Installation of a stormwater management system would include the construction of a stormwater pond and potentially vegetated swales and/or other required best management practices (BMPs). Temporary soil disturbing activities may be required to install these systems, which may lead to short-term water quality degradation (sediment, turbidity, etc.) from stormwater runoff. These actions would be in accordance with the construction stormwater pollution prevention plan (SWPPP) and the impacts would be short-term and SMALL to hydrology and water quality in Poplar Creek.

During construction, potential impacts to surface water hydrology could occur due to stormwater runoff into surface water surrounding the site. These impacts would be similar to those resulting from the construction of any commercial or industrial facility. As discussed in Table 1.3-1, federal, state and local regulations and permit procedures intended to protect both surface water hydrology and quality are applicable to construction, operation, and decommissioning of the project. Under the federal Clean Water Act and Tennessee Water Quality Control Act, a notice of intent for coverage under a National Pollutant Discharge Elimination System (NPDES) permit for stormwater discharges associated with construction would be obtained and implemented. The NPDES permit is expected to include a requirement for a construction SWPPP, Common Plan of Development, and Soil Erosion and Sediment Control Plan that specify structural and engineering controls and use of BMPs to minimize erosion and reduce the potential for offsite transport of sediment and hazardous materials into adjacent surface water bodies, such as Poplar Creek.

An assessment of stormwater runoff patterns in the vicinity of the site indicates that the drainage area upstream of the site is approximately 136 square-miles, based on the Oak Ridge National Laboratory (ORNL) description of physical characteristics (Reference 1). Drainage patterns on the site are complex due to the areas underlying geology, past cut and fill operations, transient interactions with bounding surface water bodies, and numerous anthropogenic features, including building sumps, leaking subsurface drains and utilities, and extensive areas covered by impermeable paved surfaces and roofed structures. There are currently no impoundments or significant detention/retention areas on the site that provide detention/retention of storm runoff.

Construction-phase dewatering may be required due to both the measured groundwater level being at or above the deepest excavation and the possibility of rainfall accumulation in the excavation. Thus, there would be a minor effect on surface water quantity or flow characteristics due to drawdown of groundwater or discharge of construction phase dewatering effluent.

Due to historical activities at the site, the extraction, consumption, exposure to or use of the of groundwater on the site requires approval from DOE, EPA, and Tennessee Department of Environment and Conservation (TDEC). Kairos Power does not intend to utilize onsite groundwater for construction, operation, or decommissioning. However, as described above, groundwater could be encountered and

removed during construction. If necessary, approval would be obtained, and groundwater extracted for dewatering would be managed in accordance with agency requirements.

The construction NPDES permit would govern the amount of discharge to surface water and would establish parameters to minimize potential negative impacts. In addition, such withdrawals would be short-term in duration, and would cease after construction is complete. Direct and indirect impacts of construction of the facility on surface water would be SMALL.

Overall, minimal disturbance to adjacent water bodies would occur, and compliance with a construction SWPPP during construction would minimize direct and indirect impacts to the surface waters. Therefore, both direct and indirect impacts to surface water during construction would be SMALL.

4.4.1.1.2 4.4.1.1.2 Facility Operations

As discussed in Section 2.2.4, demineralized water used to support operations is expected to be acquired from a vendor and delivered by truck, and all potable water used at the site is expected to be obtained from the City of Oak Ridge Public Works. All sanitary wastewater would be discharged directly to the Rarity Ridge Wastewater Treatment Plant sanitary sewer system. Additionally, the facility is expected to be designed to have minimal liquid discharge from the Reactor Building area. Consequently, there would be no use or release of water from the facility to the adjacent environment that would affect surface water hydrologic systems. Direct impacts to surface water from plant operations would be SMALL.

The facility site layout is illustrated in Figure 2.2-31. The site plan includes impervious areas including rooftops, paved drives, and parking lots. These impervious surfaces are not directly connected to each other, and stormwater shed off of each would flow across or through pervious areas as it drains across the site. These pervious areas would allow for infiltration and slow stormwater flow rates, thus controlling stormwater quantity (volume and peak rate) as well as quality. State and local requirements for maintenance of on-site infiltration by use of BMPs would be met or exceeded. Additionally, an Industrial Storm Water Discharge Permit for discharge of operational stormwater flows would be required. In compliance with this permit, stormwater runoff would be retained in a stormwater pond to be later discharged to Poplar Creek via an existing discharge structure. Another requirement of this permit would likely include monitoring of the water quality at the outfalls, minimizing inadvertent pollution from entering the creek. Indirect impacts of site runoff on surface waters would be SMALL.

4.4.1.1.3 Facility Decommissioning

As described above, the site is bounded on its eastern side by Poplar Creek, which is a tributary of the Clinch River. The site is bounded on the western and southern sides by the Clinch River, part of the Watts Bar Reservoir. However, no decommissioning activities would occur within these water bodies. Therefore, no direct impacts to surface water would occur.

During decommissioning activities, a SWPPP, similar to that required for construction, and including a sediment and erosion control plan, would be required and would mitigate the potential indirect impacts associated with the release of sediment or other runoff constituents to offsite areas. There would be an onsite stormwater pond for stormwater management during operations. It is anticipated that this pond would continue to be used for stormwater management during decommissioning activities, providing further protection from potential runoff issues.

During decommissioning, dewatering may be required if removal of foundations occurs, because the measured groundwater level is at or above the bottom of the deepest level. Thus, there would be a minor effect on quantity or flow characteristics of adjacent surface water in Poplar Creek due to drawdown of groundwater or discharge of decommissioning phase dewatering effluent. Similar to

operations, groundwater removed during dewatering would be managed as described in Section 4.4.1.1.1. Consequently, indirect impacts of decommissioning of the facility on surface water would be SMALL.

4.4.1.2 Groundwater

4.4.1.2.1 Construction, Operations and Decommissioning

Groundwater flow and occurrence at the ETTP are influenced by the complex geology, past cut and fill, transient interactions with bounding surface water bodies, and numerous anthropogenic features, including building sumps, leaking subsurface drains and utilities, and extensive areas covered by impermeable paved surfaces and roofed structures. The construction of the facility would include the excavation of the Reactor Building area to a depth of approximately 30 feet below a final grade of 765 feet (Section 4.3.2). The resulting final elevation of the base of the excavation would be approximately 745 feet. Depth to groundwater ranges from 1 to 65 feet below ground surface, largely depending on topographic position, occurring at greater depths at higher elevations (Reference 2). However, the depth of excavation would be more than 10 feet lower than the measured high groundwater elevation of 755 feet (North American Vertical Datum 88 [NAVD 88]). Consequently, dewatering during construction and decommissioning may be required, resulting in a minor direct impact to groundwater flow. However, once construction and decommissioning are complete, no additional impacts to groundwater are anticipated.

Water used by the facility would be obtained from the City of Oak Ridge Public Works and sanitary wastes would be discharged directly to the Rarity Ridge Wastewater Treatment Plant sanitary sewer system. Excavation dewatering may be required during construction and decommissioning of the facility. Groundwater removed during dewatering will be properly managed as described in Section 4.4.1.1.1. Groundwater withdrawal or returns would not be required during operation of the facility. Consequently, direct and indirect impacts to groundwater during construction, operations, and decommissioning would be SMALL.

4.4.2 Water Use

4.4.2.1 Surface Water

As discussed in Section 2.2.4, potable water used at the site during construction, operation, and decommissioning would be obtained from the City of Oak Ridge Public Works. Demineralized water used to support operations would be acquired from a vendor and delivered by truck. All sanitary wastewater would be discharged directly to the Rarity Ridge Wastewater Treatment Plant sanitary sewer system. Additionally, the facility is expected to be designed to have minimal liquid waste from the Reactor Building area. Consequently, there would be no use or release of water from the facility to the adjacent environment that would affect surface water hydrologic systems. Therefore, direct impacts to surface water from plant construction, operations, and decommissioning would be SMALL.

The average estimated water usage by the facility during operations would be 0.07 million gallons per day (MGD). As noted in Section 3.4.2.3, the City of Oak Ridge Public Works provides 4.15 MGD of water to the City of Oak Ridge and has the capacity to produce 12 MGD. Because there is excess capacity within the City of Oak Ridge Public Works, potential indirect effects of the demand from the facility would also be SMALL.

Indirect impacts could occur if the volume of additional wastewater generated by the facility is too large to be treated at the Rarity Ridge Wastewater Treatment Plant. The Rarity Ridge Wastewater Treatment Plant has a 0.6 MGD treatment capacity and the facility would generate only 0.02 MGD of wastewater;

therefore, the treatment plant has the capacity to manage the wastewater and therefore indirect impacts to water quality would be SMALL.

4.4.2.2 Groundwater

Construction, operation, and decommissioning activities would not involve the use of groundwater. Any groundwater produced during construction and decommissioning from dewatering would be properly managed as discussed in Section 4.4.1.1.1. No groundwater withdrawal or returns would be required during operation of the facility. Water utilized onsite will be obtained from the City of Oak Ridge Public Works. Consequently, direct impacts of water use on groundwater would be SMALL.

4.4.3 Water Quality

Potential surface water and groundwater quality impacts of site construction and operation are discussed in this section.

4.4.3.1 Surface Water

4.4.3.1.1 Facility Construction and Decommissioning

During construction and decommissioning, potential impacts to surface water quality could occur due to stormwater runoff into surface water surrounding the site. These impacts would be similar to those resulting from the construction of any commercial or industrial facility. As discussed in Sections 4.4.1.1.1 and 4.4.1.1.3, a construction SWPPP, which would require the implementation of erosion and sediment control measures, would be developed and followed throughout construction and decommissioning activities.

In addition to sediment resulting from soil erosion, hazardous materials used onsite during construction, including fuels, paints, and lubricants, could be released to Poplar Creek. It is estimated that 31,800 gallons of diesel fuel would be used during construction. As part of the construction SWPPP, fuel storage associated with construction and decommissioning would have secondary containment to minimize the potential for releases, as well as inspection and spill response requirements.

Construction-phase dewatering may be required where the groundwater level is at or above the level of excavation. As discussed in Section 4.4.1.1.1, dewatered groundwater would be properly managed. The construction NPDES permit would govern the amount of discharge to surface water and would establish parameters to minimize potential negative impacts. Consequently, direct and indirect impacts of construction and decommissioning of the facility on surface water quality would be SMALL.

4.4.3.1.2 Facility Operation

During operations, potential impacts to surface water quality could occur due to stormwater runoff into surface water surrounding the site. As discussed in Section 4.4.1.1.2, an Industrial Storm Water Discharge Permit for discharge of operational stormwater flows would require that the facility design comply with state and local stormwater management requirements. The NPDES permit would require monitoring of stormwater discharge outfalls, which would alert the facility to potential contaminants entering adjacent surface waters. If that occurred, management would implement BMPs and other response actions to eliminate the contaminants of concern, preventing potential degradation of surface water quality. Therefore, direct impacts to surface water during operations would be SMALL.

The Rarity Ridge Wastewater Treatment Plant has a 0.6 MGD treatment capacity and the facility would generate only 0.02 MGD of wastewater. Therefore, the treatment plant has the capacity to absorb the facility wastewater and the indirect impacts to water quality would be SMALL.

4.4.3.2 Groundwater

4.4.3.2.1 Construction, Operation, and Decommissioning

Possible direct impacts on groundwater quality could occur during construction, operation or decommissioning if spills of fuels from vehicles, equipment, or storage areas penetrate asphalt or concrete surfaces, flow to adjacent pervious surfaces and infiltrate to groundwater, or results in contamination of stormwater that then infiltrates to groundwater. Due to the protections in place during construction and decommissioning (NPDES permit and SWPPP), stormwater potentially seeping to the groundwater would not contain contaminants. During operations, the facility would include storage of approximately 21,555 gallons of diesel fuel in an onsite fuel tank for the standby diesel generator. All equipment and material storage areas would be in compliance with appropriate regulations requiring secondary containment of stored liquids and materials including a SWPPP.

Construction, operation, and decommissioning activities would not involve the use of groundwater. Groundwater may be produced as a result of dewatering for excavation of foundations during construction and decommissioning and would be properly managed as discussed in Section 4.4.1.1.1. In addition, such withdrawals would be short-term in duration, and would cease after construction is complete. Consequently, direct impacts of groundwater withdrawal on groundwater quality would be SMALL.

4.4.4 Monitoring

Stormwater runoff would be collected in a stormwater pond and discharged to Poplar Creek in accordance with the facility NPDES permit requirements. For this Environmental Report (ER), it is assumed that stormwater would be discharged through an existing discharge location.

Because of the absence of direct impacts to groundwater, the low potential for indirect impacts, and the use of management measures and controls to prevent releases to groundwater, no nonradiological groundwater monitoring activities are planned for the site.

4.4.5 References

1. Parr, Patricia Dreyer, and Joan F Hughes. “Oak Ridge Reservation Physical Characteristics and Natural Resources.” Oak Ridge National Laboratory, September 2006.

2. U.S. Department of Energy. "Final Sitewide Remedial Investigation/Feasibility Study for East Tennessee Technology Park," November 2007.

4.5 ECOLOGICAL RESOURCES

This section addresses the impacts of construction and operation of the facility on the ecological resources and within the vicinity of the site. The impacts discussed below are based on the characterization and description of terrestrial and aquatic ecosystems from Section 3.5. Impacts include effects from activities associated with construction and operation, including excavation, grading, placement of fill material, temporary staging and construction laydown, construction of permanent features, and potential operational disturbances. This evaluation indicates the magnitude of potential impacts and whether mitigation measures are required.

As described in Section 3.5, the site consists of a 185-acre parcel that has mostly been intensively developed for historical industrial use. Demolition of Building K-33 was completed in 2011, and demolition of Building K-31 was completed in 2015. Following demolition, the cleared sites were revegetated with a mix of grasses and herbaceous vegetation to cover and stabilize the soil until future development of these brownfield sites within the ETTP. Thus, ecological resources at the site are limited by current and historical development on the site and by a lack of surface water bodies on the site. Because baseline conditions on the site within areas that would be affected by construction of the facility consist solely of land lacking native terrestrial or aquatic habitats, post-construction ecological monitoring and maintenance plans are not deemed necessary.

4.5.1 Impacts from Construction

This section describes the potential construction-related ecological impacts to the site and nearby offsite areas based on the proposed facility layout (see Figure 2.2-1). Activities such as earthmoving, excavation, erection of structures, and construction-related traffic would generate potential disturbances to ecological resources during the construction phase of the project. Direct and indirect impacts associated with construction-related activities would be limited to lands within the site. Figure 2.2-3 depicts the buildings of the facility proposed to be constructed on the site. Given the developed nature of the site, land clearing would not be necessary. Furthermore, the project does not involve clearing along streams or in wetlands.

The site encompasses approximately 185 acres, of which approximately 97 acres are vegetated. The remaining 88 acres are developed and covered by pavement, buildings and other structures, or the foundations and other remnants of buildings that have been demolished and removed. The site generally encompasses the locations formerly occupied by Buildings K-33 and K-31. Construction activities for the facility would temporarily disturb 138 acres of land, of which approximately 30 acres would be permanently impacted by facility operations (see Figure 2.2-1).

Direct impacts from construction within the site would convert approximately 30 acres of open land that has been developed historically at low to high intensity for construction and operation of the facility. Once the facility reaches the end of its useful life, it would be decommissioned. Radioactive equipment and materials would be disposed according to local and federal laws and regulations. Permanent conversion of the developed land to industrial facilities would include the construction of facility buildings, employee parking lot, facility access roadway, and stormwater detention area. Areas temporarily impacted during construction would be restored following construction.

4.5.1.1 Places and Entities of Special Interest

Places and entities of special interest are described in Section 3.5.4. There are no places or entities of special interest on the site. The site is bounded by Poplar Creek immediately to the east, and the Clinch River arm of Watts Bar Reservoir at its closest point is approximately 0.4 miles to the south. Wetlands associated with these waterbodies (see Figure 3.5-2) are outside the site and/or the areas to be

disturbed by construction of the proposed facility. The two state protected areas within a 5-mile radius of the site (see Figure 3.5-1), the Oak Ridge WMA and the BORCE, would not be impacted by construction of the facility.

Impacts from construction on places and entities of special interest would be SMALL because such resources are not present on the site or near the location of the proposed facility where construction would occur. Specific mitigation measures and management controls are not needed.

4.5.1.2 Aquatic Communities and Wetlands

Poplar Creek is adjacent to the site and the Clinch River arm of Watts Bar Reservoir is within 0.4 miles of the site (see Table 2.2-2). Other waterbodies within 5 miles of the site are the Emory River, and East Fork Poplar Creek and Bear Creek, tributaries to Poplar Creek. Wetlands associated with Poplar Creek, the Clinch River arm of Watts Bar Reservoir, and the proposed stormwater pond are within the limits of the proposed area of disturbance for construction of the facility (see Figures 2.2-1 and 3.5-2).

The facility would not withdraw or discharge water for cooling or other processes from surface water bodies or groundwater. Process water and potable water for the facility would be obtained from the City of Oak Ridge Public Works. Wastewater would be treated by the Rarity Ridge Wastewater Treatment Plant. Facility water and sewer pipelines would be connected to existing nearby utility pipelines via current utility right of ways (ROWs). Construction would not affect waterbodies near the site. Facility stormwater systems would be designed to meet NPDES permit requirements. Stormwater would flow to a stormwater pond and then be discharged to Poplar Creek. In addition, a SWPPP for the facility would be prepared and implemented. Groundwater removed during construction for dewatering will be properly managed as discussed in Section 4.4.1.1.1.

Streams, wetlands, and ponds present near the site support aquatic communities. Because these resources would not be directly impacted by construction, any potential construction-related impacts to wetlands and aquatic resources would be limited to indirect offsite impacts associated with runoff and siltation.

BMPs would be employed in accordance with the facility SWPPP, as required by TDEC, to prevent soil erosion, sediment transport, and subsequent siltation in streams and other waterbodies receiving stormwater runoff during construction. Wetlands and other aquatic communities are not present on the site and would not be directly impacted by construction. The implementation of construction BMPs and the distance to offsite water bodies would prevent or minimize the potential for sedimentation impacts off the site. Thus, direct and indirect impacts to aquatic communities and wetlands from construction would be SMALL. Additional mitigation measures and management controls beyond BMPs are not needed.

4.5.1.3 Terrestrial Communities

The vegetation cover on the approximately 185-acre site is predominately herbaceous/grassland (Table 4.5-1). Deciduous forest covers approximately 19 acres associated with the riparian zone along Poplar Creek, and mixed evergreen/deciduous forest covers approximately 6 acres located at the north end of the site. The remaining 88 acres of the site are developed and covered by pavement, buildings and other structures, or the foundations and other remnants of buildings that have been demolished and removed. As discussed in Section 2.1, construction activities would affect approximately 138 acres of land, of which approximately 30 acres would be used for facility operations. Only herbaceous/grassland vegetation occurs within the areas that would be impacted by construction of the facility.

As summarized in Table 4.5-1, direct construction impacts would convert up to approximately 30 acres of herbaceous/grassland vegetation to components of the facility, including the construction of facility

buildings, employee parking lot, facility access road/driveway, vegetated stormwater drainage swales, and access road drainage ditches. Construction impacts also could include direct temporary impacts to up to 58 acres of herbaceous/grassland vegetation that may be used for construction parking areas, construction material staging or lay down areas, and temporary disturbance from water and sewer line installation. After construction, temporary impact areas would be restored with herbaceous/grassland vegetation.

The terrestrial communities on the site and adjacent areas are described in Section 3.5.7. The vegetation communities identified above provide habitat for terrestrial animals, including mammals, birds, reptiles, and amphibians. Given the historical disturbance and development of the site, the lack of water resources on the site, and the periodic mowing of herbaceous/grassland that constitutes the most extensive habitat on the site, the wildlife community on the site is expected to be low in abundance and diversity. Use of the site would be sporadic given the lack of cover, shelter, and water supply. With the dominance of grassland/herbaceous vegetation and former developed areas on the site and lack of wildlife habitat, wildlife use on the site would be minimal.

The areas to the east, south, and west of the site are predominantly developed, with buildings, roads, railways, and mowed fields allowing minimal wildlife habitat. The opposite bank of Poplar Creek supports a narrow band of riparian, deciduous forest. Areas to the north and west of the site are within the Black Oak Ridge Conservation Easement, which includes over 3,000 acres of forested area. The minor loss of existing vegetative habitat to industrial facilities would not be significant when compared to the available habitat remaining within a 5-mile radius of the site (see Table 4.5-1). Furthermore, lands on-site not utilized for development of industrial facilities would be restored to herbaceous/grassland. As such, impacts to wildlife and terrestrial communities from construction would be SMALL. Specific mitigation measures and management controls are not needed.

Mobile wildlife species would avoid the area during construction. Avian collisions with construction equipment, such as cranes would be SMALL based on the findings of NUREG-1437 which, while not directly applicable to non-power reactors, demonstrated that the effects of avian collisions with existing structures at nuclear power plants are small; the same conclusion is reasonable for smaller, non-power reactors. The potential for impacts from bird collisions during construction would be SMALL, and specific mitigation measures and management controls are not needed.

Wildlife species have the potential to be affected from artificial lighting during nighttime construction activities. For example, frogs have been found to inhibit their mating calls when exposed to excessive light at night, and the feeding behavior of some bat species may be altered by artificial lighting (Reference 1). Amphibian and bat species, however, are generally lacking from the site due to the absence of appropriate habitat.

Artificial lighting could create or exacerbate an avian-collision hazard for work during nighttime construction. Based on the general lack of suitable habitat at the site for amphibians, bats, and most bird species, and the BMPs to mitigate effects to wildlife as needed, the direct and indirect impacts of artificial illumination at nighttime during the construction phase would be SMALL thus specific mitigation measures and management controls would not be needed.

4.5.1.4 Invasive Species

Several invasive plant and animal species were observed in various land cover types offsite, as discussed in Section 3.5.8. Disturbance associated with construction activities such as earthmoving and excavation can create conditions for opportunistic invasive species to become established. Temporary impact areas and other areas not permanently converted to industrial uses would be appropriately restored. Invasive species are controlled in restored areas on the Oak Ridge Reservation (ORR) as has been done for the

past several decades. Invasive plant species are controlled through mowing or similar maintenance activities. Thus, the invasive species impacts from construction are considered SMALL and monitoring or maintenance plans are not anticipated at this time.

4.5.1.5 Protected Species

Federal listed species identified by the U.S. Fish and Wildlife Service (USFWS) Information for Planning and Consultation (IPaC) system as potentially occurring in the vicinity of the site are included in Table 3.5-2. The table also includes state listed species from the TDEC database for recorded occurrences in Roane County. A subset of these species was identified by the TDEC database as having been recorded in the U.S. Geological Survey (USGS)'s Elverton Quadrangle that encompasses the site. The quadrangle covers a much smaller area than the county; thus, species recorded in the quadrangle may have a greater potential to occur in the area of the site, if suitable habitat is present. These database searches identified 39 Federal and/or state listed endangered or threatened species potentially occurring in Roane County and/or the site and immediate vicinity (Table 4.5-2). No designated critical habitat was identified onsite or in the vicinity of the site.

The potential to occur on the site was estimated based on habitat requirements and presence on the site or in the vicinity. The likelihood of occurrence is shown in Table 4.5-3. Based on habitats present on the site that would support potentially occurring endangered or threatened species, six species have no potential to occur, 3 species have low potential, and 1 species has a moderate potential to occur on the site. The species with a moderate potential to occur is the Indiana bat (*Myotis sodalis*). However, no trees are present within the disturbed area of the site, and no suitable bat trees that would support this species were observed in the undisturbed riparian corridor adjacent to the site.

Because of the general lack of habitat on the site, absence of onsite aquatic communities and wetlands, the distance to offsite streams from the site, the high infiltration rate of the soils near the site, and the implementation of BMPs onsite, direct and indirect impacts to any protected plant species associated with riparian areas from construction would be SMALL. Protected plant species are not expected to occur on the site and any protected animal species on the upland portion of the site would avoid construction activity. Specific mitigation measures would not be required.

4.5.2 Impacts from Operations

This section provides a description of the potential impacts of operation of the site facility on terrestrial and aquatic ecosystems.

4.5.2.1 Places and Entities of Special Interest

Places and entities of special interest, as described in Section 3.5.4, include a description of habitats of special interest, other sensitive or susceptible areas, and important ecological systems. There are no places or entities of special interest on the site. Communities and habitats of special interest near the site (within 5 miles) include wetlands associated with Poplar Creek and the Clinch River arm of Watts Bar Reservoir near the site. Habitats of special interest offsite include wetlands and endangered resources (see Sections 3.5.6 and 3.5.11) identified by TDEC in Roane County. There are two state natural areas and one national historic park within a 5-mile radius of the site. The site is situated within the Mississippi Flyway. Roane County is approximately 91 percent upland and 9 percent water (major rivers are the Tennessee, Clinch, and Emory). Important ecological systems near the site include upland forest, riparian areas, and aquatic habitats. None of these places or entities of special interest would be impacted by operations at the site.

Due to the complete prior conversion of the lands of the site to developed uses and conversion of the immediate environs to other developed uses, none of the described places and entities of special

interest are present either on the site or in immediately adjacent offsite areas. Habitats of the site and adjacent lands are not considered to be high value or important ecological systems.

The principal air emissions from the facility during normal reactor operating conditions would be waste heat from the PHRS, decay heat removal system (DHRS), and spent fuel cooling stacks. The heat rejection stacks would be approximately 100 feet above site grade, and heat emissions are not expected to impact on-site or offsite communities and habitats of special interest. Additionally, the facility does not utilize cooling towers. Consequently, there would be no operational impacts associated with wind drift (i.e., gaseous or particulate emissions to the air from cooling towers). Herbicide application for lawn maintenance would be minimal and only used on the site, and operational impacts to offsite areas identified as places and entities of special interest would be minimized. Thus, operation impacts to the offsite areas identified as places and entities of special interest would be SMALL. Mitigation measures and management controls are not needed.

4.5.2.2 Aquatic Communities and Wetlands

Aquatic resources and wetlands near the site are described in Sections 3.5.5 and 3.5.6, respectively. Aquatic resources near the site include wetlands associated with Poplar Creek and the Clinch River arm of Watts Bar Reservoir offsite include wetlands and endangered resources (see Section 3.5.11) identified by the TDEC in Roane County. Poplar Creek is adjacent to the site and the Clinch River arm of Watts Bar Reservoir is within 0.4 miles of the site (see Table 2.2-2). Other waterbodies within 5 miles of the site are the East Fork Poplar Creek and Bear Creek, which are tributaries to Poplar Creek upstream of the site, and the Emory River. Wetlands associated with Poplar Creek and the Clinch River arm of Watts Bar Reservoir, as well as various holding ponds in the ETTP near the site, would be outside the limits of disturbance (see Figures 2.2-1 and 3.5-2).

The facility will not withdraw water from surface waterbodies or from groundwater; rather, water would be provided by the City of Oak Ridge Public Works. Thus, there would be no operational impacts associated with impingement or entrainment of aquatic biota. Furthermore, the facility would not discharge directly into any nearby waterbody and waste heat is discharged to the atmosphere thus avoiding any pollutant or thermal effects on aquatic resources. Facility stormwater systems would be designed to meet NPDES permit requirements. In addition, a SWPPP for the facility would be prepared and implemented. An onsite stormwater pond would be used to control stormwater runoff which, when combined with the distance to the nearest offsite waterbodies, minimizes runoff and siltation to offsite receiving streams. Thus, operational impacts on aquatic communities and wetlands would be SMALL.

4.5.2.3 Terrestrial Communities

Terrestrial plant communities are characterized in Section 3.5.7.1 for the site and areas in proximity to the site. The terrestrial communities of the site and areas in close proximity to the site are mainly developed for other uses. Herbicide application is occasionally used around buildings and driveways as part of lawn maintenance activities to control weedy species. Operational impacts to plant communities would be SMALL.

Plant and animal communities of the site and nearby areas are described in Section 3.5.7. With the dominance of herbaceous/grassland vegetation established on the majority of the site following building demolition, the quality of wildlife habitat is low, and wildlife use of the site is minimal. With the dominance of grassland/herbaceous vegetation and former developed areas on the site and lack of wildlife habitat, wildlife use on the site would be minimal. Mobile wildlife species generally would avoid the area due to operational activity. Additionally, there are no known occurrences of threatened or endangered species on the site. Thus, operational impacts to wildlife would be SMALL.

The facility and associated buildings would not result in significant bird mortality from bird collisions, though infrequent bird collisions with buildings resulting in mortality can occur. As is discussed in Section 4.1.2 most buildings on the site would have a relatively low profile. Consequently, effects on bird populations from collisions with buildings would be minimized. Therefore, the operational impacts to bird species and populations from collisions would be SMALL.

The construction and operation of the facility would result in a localized minor increase in noise (Section 4.2.2). But noise levels during construction would be temporary and operational noise would be localized to the site. Thus, construction and operation impacts to wildlife from noise would be SMALL. Specific measures and controls would not be needed.

4.5.2.4 Invasive Species

Most of the site and much of the adjacent areas have been extensively developed. Non-native and invasive plant, mammal, bird, and aquatic species can be found throughout Tennessee on developed lands, agricultural lands, and in riparian corridors and aquatic systems. Invasive aquatic organisms that may occur within the Clinch River arm of Watts Bar Reservoir and the reach of Poplar Creek near the site include fish, mollusks, and crustaceans. Based on field surveys and previously published data on the site and the surrounding environment, 167 non-native, invasive species have been identified on the ORR (Reference 2), and upland invasive species have the potential to occur on the site. Information on these species can be found in Section 3.5.8. Invasive species on the ORR are managed in accordance with the ORR *Invasive Plant Management Plan for the Oak Ridge Reservation*. Additionally, there are no plans to implement invasive species management/control activities at the facility or the site. Operational impacts associated with invasive species would be SMALL. Specific measures and controls would not be needed.

4.5.2.5 Protected Species

No federal or state-listed threatened, endangered or special concern plant species have been observed on or in the immediate vicinity of the site.

A SWPPP for the facility would be implemented during construction and operations and the only emissions from the facility would be waste heat discharged to the atmosphere. There is a potential for groundwater to infiltrate into the excavation during construction, necessitating dewatering activities. Groundwater removed during dewatering will be properly managed as discussed in Section 4.4.1.1.1. As such, potential operational impacts on protected species potentially occurring on the site or in near offsite areas would be SMALL. Specific mitigation measures and management controls would not be needed.

4.5.3 Impacts from Decommissioning

Following the cessation of operation, the facility would be decommissioned. Decommissioning activities would be similar to construction activities and involve heavy equipment to dismantle buildings and remove roadway and parking facilities. As such, impacts from decommissioning would be similar to the impacts associated with construction and would be SMALL. Specific mitigation measures would not be required.

4.5.4 References

1. Chepesiuk, R. Missing the Dark, Health Effects of Light Pollution, Environmental Health Perspectives, Vol. 117, No. 1, January 2009.

2. Drake, S.J., Weltzin, J.F., Parr, P.D. "Assessment of Nonnative Invasive Plants in the DOE Oak Ridge National Environmental Research Park," ORNL/TM-2001/113, October 2002.

3. Tennessee Department of Environment and Conservation. Rare Species by Quadrangle, Website: https://www.tn.gov/environment/program-areas/na-natural-areas/na-natural-heritage-inventory-program.html, accessed March 31, 2021.

4. U.S. Fish and Wildlife Service, Information for Planning and Consultation (IPaC), Database: https://ecos.fws.gov/ipac/location/WZYIFO3ZLBGJ7AWK7OWPUHVMPQ/resources#endangered-species, accessed May 24, 2021.

Table 4.5-1: Vegetation Community Impacts from Construction

Vegetation Type	Site Total		Temporary Impact		Permanent Impact	
	Acres	Percent[1]	Acres	Percent[2]	Acres	Percent[2]
Herbaceous/Grassland	72	39	58	80	30	42
Deciduous Forest	19	10	0	0	0	0
Mixed Evergreen/ Deciduous Forest	6	3	0	0	0	0

[1] Percent = (vegetation type acres/185 acres site) x 100
[2] Percent = (impacted vegetation acres/vegetation type total acres) x 100

Table 4.5-2: Species with Federal or State Protected Status Potentially Occurring in Roane County, Site Vicinity, and on the Site

Geographic Location	Endangered Status	Threatened Status	Total Species
Roane County	23	16	39
Site Vicinity[1]	9	3	12
Site[2]	4	5	9

[1] Reference 3
[2] Based on USFWS IPaC search (Reference 4).

Table 4.5-3: Likelihood of Occurrence of Protected Species on the Site and in the Vicinity

Location	No Potential (No. of Species)	Low Potential (No. of Species)	Moderate Potential (No. of Species)
Site Vicinity[1]	8	4	0
H Site[2]	6	3	1

[1] Reference 3
[2] Based on USFWS IPaC search (Reference 4).

4.6 HISTORIC AND CULTURAL RESOURCES

4.6.1 Construction, Operation, and Decommissioning

As is described in Section 3.6.3, no onsite historic properties are associated with the site. The nearest listed National Register of Historic Places (NRHP) property is the K-25 Gaseous Diffusion Plant which is part of the Manhattan Project National Park in Oak Ridge, Tennessee. The K-25 Gaseous Diffusion Plant site is located less than 1-mile southeast of the site. Both sites are located within the ETTP (see Figure 3.6-1). No direct impacts would be expected to occur to the K-25 Plant or the Manhattan Project National Park in association with either construction or operational activities of the site. Additionally, given the intervening structures between the site and the K-25 Plant as well as the low profile of the proposed structures on the site, no visual or other indirect impacts occur. Therefore, potential impacts to historic and archaeological resources would be SMALL.

Due to the absence of historic cemeteries and prehistoric mounds within the boundaries of the site, and the previous disturbance of the site, the potential for the presence of human burials or human remains would be SMALL. To minimize impacts, an Archaeological Monitoring and Discovery Plan would be developed to specify procedures for addressing and handling the unexpected discovery of human remains or archaeological material during construction. In accordance with the Archaeological Monitoring and Discovery Plan, if human remains are discovered, the construction personnel will contact a representative of Kairos Power. The representative of Kairos Power will contact the appropriate local law enforcement and the DOE historic preservation officer and communicate that human remains have been discovered. If the human remains are determined to be archaeological in nature, the DOE historic preservation officer in conjunction with Kairos Power will determine what further actions will be taken.

Following the cessation of operation, the facility would be decommissioned. Decommissioning activities would be similar to construction activities and involve heavy equipment to dismantle buildings and remove roadway and parking facilities. As such, impacts from decommissioning would be similar to the impacts associated with construction and would be SMALL.

4.7 SOCIOECONOMICS

This subsection describes potential impacts to the socioeconomic environment, including transportation system impacts associated with the construction, operation and decommissioning of the facility. The evaluation of potential socioeconomics impacts addresses potential changes in the regional population, economy, housing availability, and public services. The evaluation of transportation system impacts addresses routes and modes that are involved with transporting materials, workers, and equipment to the site.

4.7.1 Socioeconomics Impacts

This section evaluates impacts to the population, housing, public services (e.g., water supply), public education, and tax-revenues in the region of influence (ROI), that result from constructing, operating, and decommissioning the facility. The ROI is identified as the five-county region nearest the site (Anderson, Knox, Loudon, Morgan, and Roane) as illustrated in Figure 3.7-1 (Reference 1). Potential impacts of constructing the facility are attributable to the size of the construction workforce, the expenditures needed to support the construction program, and the tax payments made to political jurisdictions. Because direct impacts are those that occur onsite, the only direct impacts are associated with the presence of the workforce at the site. All other socioeconomic impacts are considered to be indirect, as they occur offsite. The analysis presented in this subsection is based on the bounding parameters for the projected workforces for construction, operation, and decommissioning. As noted in Table 4.7-1, the peak onsite construction phase (contractor) workforce is 425 (212 off-peak) workers, and the maximum onsite operational phase workforce is 68 workers. This analysis assumes a 24-month schedule of construction-related activities. Decommissioning is estimated to start in 2036 and would involve a peak month onsite workforce of 340 (168 average) workers.

4.7.1.1 Population Impacts

In 2019, population in the ROI was 664,125 (Reference 2). Growth projections show that the population in the ROI in 2026 would be approximately 710,778, and the population in the ROI in 2031 would be approximately 732,719 (see Table 3.7-2) (Reference 3). The analysis of population impacts considers the population growth potential due to the workforce requirements for construction, operational and decommissioning phases. Workforce estimates are based on 2016 data from the U.S. Census Bureau (USCB) County Business Patterns and Bureau of Labor Statistics (BLS) (Reference 4, Reference 5), the latest year for which this information is available.

As shown in Table 3.7-5, in 2019 the total ROI labor force was 331,121 (Reference 6). Table 4.7-1 shows the estimated number of construction workers for the major labor categories in the ROI was 24,238 in 2016. As a conservative measure, Table 4.7-1 delineates 20 percent of the construction workforce as labor available to Kairos, for an available labor pool of 4,848 workforce (Reference 5). These estimates show that substantially all of the peak requirement (425 construction workers) are present within the ROI labor. There are no estimated labor force deficiencies by occupation. Thus, the estimated ROI labor force in the construction trades is demonstrated to be abundant relative to construction workforce requirements, which greatly reduces the potential for large numbers of trade workers to relocate in the ROI. It is possible that some workforce may commute or temporarily relocate to the site from non-ROI counties, but these numbers would not be significant or cause a perceptible increase in the ROI's 2019 population of 664,125 (Reference 3). Therefore, the impact of the construction of the facility on population would be SMALL.

Table 4.7-1 shows the estimated number of operations workers for the major labor categories in the ROI was 22,358 in 2016. As a conservative measure, Table 4.7-1 delineates 10 percent of the construction

workforce as labor available to Kairos, for an available labor pool of 2,236 workforce (Reference 5). These estimates show that substantially all of the required 68 permanent operations workers are available in the ROI. It is possible that some workforce may commute or relocate to the site from non-ROI counties to pursue job opportunities, but these numbers would not be significant or cause a perceptible increase in the ROI's population of 710,778 in 2026, the year operations is expected to commence (Reference 3). Therefore, the impact of the construction of the facility on population would be SMALL.

As shown in Table 4.7-1, the estimated number of decommissioning workers for the major labor categories in the ROI was 7,531 in 2016. As a conservative measure, Table 4.7-1 delineates 20 percent of the decommissioning workforce as labor available to Kairos, for a total of 1,506 (Reference 5). These estimates show that substantially all of the required 340 decommissioning workers are available in the ROI. It is possible that some workforce may commute or relocate to the site from non-ROI counties to pursue job opportunities, but these numbers would not be significant or cause a perceptible increase in the ROI's projected population of 732,719 in 2031, which is five years before the estimated decommissioning in 2036 (Reference 3). Therefore, the impact of the construction of the facility on population would be SMALL.

4.7.1.2 Housing Impacts

Section 3.7.2.2 and Table 3.7-9 provide a summary of housing utilization sourced from 2015-2019 American Community Survey 5-Year Estimates. This data is used to evaluate the number of housing units that may be available to accommodate housing demands resulting from construction, operations and decommissioning.

In 2019, there were 31,317 vacant housing units in the ROI (see Table 3.7-9) (Reference 2). The amount of housing availability within the ROI is substantially greater than the total estimated demand for housing due to construction of the facility, which is negligible because Table 4.7-1 shows that substantially all of the peak requirement for construction, operations and decommissioning are available in the ROI labor force. Thus, workers do not need to relocate to the ROI to support construction phase peak needs, operational workforce needs or decommissioning. There is clearly an adequate supply of vacant housing to accommodate the requirements of new workers or families who may choose to relocate to the site for temporary or permanent housing (Reference 5).

The potential impacts on housing would be SMALL due to the large number of available vacant housing units in the ROI and the lack of demand related to the construction, operations and decommissioning workforce.

4.7.1.3 Public Services Impacts

Construction of the facility requires potable water to support the needs of the construction work force. During construction and operations, the City of Oak Ridge Public Works would supply water to the site, including potable water uses, fire protection uses, and typical construction uses (e.g., dust suppression and concrete mixing). The average per capita water usage in the United States is 82 gallons per day (gpd) per person including personal use, bathing, laundry and other household uses (Reference 7). At a conservatively assumed 41 gpd for each construction worker who is onsite for 8 to 12 hours per day, an average onsite workforce of 212 needs 8,692 gpd for potable and sanitary use. During peak usage, an estimated 426 construction workers would be onsite, and would need 17,425 gpd for potable and sanitary use. As discussed in Section 3.7.2.5, the City of Oak Ridge Public Works has excess water capacity of 4-6 MGD. Therefore, impacts on public water supply by the onsite construction workforce would be SMALL.

The impact to the local water supply systems from facility-related population growth can be estimated by multiplying the amount of water that is required per capita by the estimated number of individuals who relocate to the ROI. Section 3.7.2.5 describes the public water supply systems in the area, permitted capacities, and current demands. The average per capita water usage in the United States is approximately 82 gpd per person including personal use, bathing, laundry and other household uses (Reference 7). As shown in Table 4.7-1 substantially all of the peak requirement for construction, operations and decommissioning are present within the ROI labor. There are no estimated labor force deficiencies by occupation. Thus, the estimated ROI labor force in the construction trades is demonstrated to be abundant relative to construction workforce requirements, which greatly reduces the potential for large numbers of trade workers to relocate in the ROI. Thus, workers do not need to relocate to the ROI construction phase peak, operational workforce needs or decommissioning. The estimated total construction and operation-related population increase within the ROI of 68 permanent employees and 212-425 construction personnel (construction and operations workforces and their families) already reside in the ROI. Therefore, there would be no impact to local water supply systems from facility related population growth. While possible that some workforce may commute or temporarily relocate to the site from non-ROI counties, these numbers would not be significant or cause a perceptible increase to local water supply systems. Therefore, impacts to the municipal water supplier due to the estimated population increase would be SMALL.

Public wastewater treatment facilities are directly related to public water supply facilities. The impact to the local wastewater treatment systems from facility-related population increases can be determined by calculating the amount of water that is used and disposed of by these individuals. The average person in the United States uses approximately 50-70 gpd (Reference 7). As discussed above, facility-related population increase is not expected as substantially all of the peak requirement for construction, operations and decommissioning are present within the ROI labor. While possible that some workforce may commute or temporarily relocate to the site from non-ROI counties, these numbers would not be significant or cause a perceptible increase to local wastewater systems. Therefore, impacts to wastewater treatment facilities would be SMALL.

4.7.1.4 Public Education Impacts

Schools and student populations are discussed in Section 3.7.2.5.1. For the ROI, the numbers and types of schools and the numbers of students by district are summarized in Table 3.7-15. Knox County has the largest school district in the ROI by measure of student enrollment. The public schools in the ROI that are in closest proximity to the site are units of the Anderson County School District and the City of Oak Ridge School District, a separate system located in Anderson County. In the school year ending June 30, 2020, the reported ratio of students per licensed teacher full time equivalency was about 13 for both the Anderson County School District and the City of Oak Ridge School District, which compares well to the Tennessee statewide ratio of 15 students per teacher full time equivalency (2019-2020). The Anderson County School District enrollment for the 2019-2020 school year was 7410 and the City of Oak Ridge School District was 4775 (Reference 8, Reference 9). The student age cohort (age 5 to 18) accounts for 15 percent of the ROI total population (Reference 10).

Population increase due to construction workforce and operational workforce requirements is not expected. The estimated ROI labor force in the construction trades is demonstrated to be abundant relative to construction, operations, and decommissioning workforce requirements, which greatly reduces the potential for large numbers of trade workers to relocate in the ROI. It is possible that some workforce may commute or temporarily relocate to the site from non-ROI counties, but these numbers would not be significant or cause a perceptible increase in the area’s population or result in any

perceptible change in school enrollment. Therefore, the level of impact to the local public education system would be SMALL.

4.7.1.5 Tax Revenue Related Impacts

Tax revenues associated with the construction, operation, and decommissioning of the facility include payroll taxes on wages and salaries of the construction and operations work forces, sales and use taxes on purchases made by Kairos Power and the construction, operations and decommissioning workforces, and property taxes on owned real property and improvements. Increased tax collections are a benefit to the state, county, and municipal-level jurisdictions as well as school districts.

4.7.1.6 Personal and Corporate Income Taxes

Workforce payroll taxes (federal and state) are generated by construction, operations and decommissioning activities and purchases as well as taxes generated by workforce expenditures. State tax payments are distributed throughout the ROI and extend beyond the ROI, based on the expectation that some construction, operations and decommissioning employees reside outside of the ROI. The relocation of workers to the ROI and surrounding counties, including some expected to relocate to Tennessee from other states, results in an increase in payroll taxes paid to Tennessee.

4.7.1.7 Sales Taxes

Workers commuting to the site from within and outside of the ROI contribute sales tax revenues to the State of Tennessee and to Roane County and any other counties where they live. The vast majority of sales tax revenues from the ROI are collected by the State, as Roane sales tax rate is very low. But the ROI does experience an increase in the amount of sales taxes collected, reflecting the concentration of re-located workers. Sales tax revenues also result from direct purchases by Kairos Power for materials, equipment and services supporting the construction project, long term operations, and decommissioning. The distribution of these tax revenues is determined by the business locations of the material and service providers and likely reflects a broad area including the ROI and beyond to multiple states. The amount of sales taxes collected over a potential 10-year licensed operating period that are attributable to the facility is significant but is relatively minor when compared to the total amount of taxes collected in the ROI.

4.7.1.8 Property Taxes

The facility would be located in Roane County. As such, property taxes are paid to Roane County. These jurisdictions all provide public services that benefit Kairos Power's business and employees.

4.7.1.9 Summary of Tax Impacts

Overall tax revenues generated by construction, operation and decommissioning of the facility would be significant in absolute dollars across the lifetime of the facility. However, the overall tax revenues are relatively small in comparison to the established tax base of Roane County. The maximum increase in property tax revenues after expiration of the tax increment financing agreement is expected to be substantially less than 10 percent of the total tax revenue at the city and county levels. Therefore, total tax revenues from Kairos Power would result in SMALL positive impacts at the community level.

4.7.1.10 Other Socioeconomics Related Impacts

Socioeconomics related impacts in addition to those specifically described above include the potential for supportive business expansion and associated land use changes in Roane County as a result of the investments from Kairos Power. Land use changes due to housing needs are not expected due to the large number of existing vacant housing units. Potential land use changes include those to provide for

expansion of existing small businesses or locations for new small businesses that might support the facility and facility employees. If realized, such business expansions and/or new business developments are likely to occur in the ROI in locations where conditions are appropriate for business development. Any such land use changes are subject to local zoning regulations and associated impacts on socioeconomic conditions would be SMALL.

4.7.1.11 Mitigation Measures to Minimize Socioeconomic Impacts

As described in the sections above, the socioeconomic impacts on the ROI resulting from construction, operation, and decommissioning of the facility would be SMALL and no mitigation measures are required to minimize socioeconomic impacts.

4.7.2 Transportation

The area around the site is served by a transportation network of federal and state highways; three freight rail lines; one major navigable river; one commercial passenger airport (McGhee Tyson Airport), and one reliever airport (Knoxville Downtown Island Airport). Figure 3.7-2 illustrates the road, highway, railroad, and airport systems in the area. The effects on the local transportation infrastructure as a result of construction and operations are measured against the existing traffic conditions and the future no-build traffic conditions. Goods and services to support the facility would reach the site using existing roadway and rail networks.

4.7.2.1.1 Roads and Highways

Section 3.7 describes the transportation infrastructure at the site in detail. Access to and from the site would be from either TN 327 (Blair Rd), or TN 58 (Oak Ridge Turnpike), see Figure 3.7-1 for access roads. For workers commuting from the north and south, there are interchanges on I-40 for both TN 58 and TN 95. Regardless of which access road is used, workers would access the site via Perimeter Road.

A Traffic Assessment was completed in July 2021. While capacity of the existing roadway segments is not expected to be a major issue with the proposed development, the logistics and preferred route to and from the site were considered. Listed below are possible routes to be taken to the site along with benefits and considerations for each route. Figure 4.7-1 shows a graphical representation of the likely routes taken to/from the site.

Route 1: Oak Ridge Turnpike to Perimeter Road

- Perimeter Road intersects with Oak Ridge Turnpike at an unsignalized intersection. There is a two-way left-turn lane on Oak Ridge Turnpike in the area to accommodate left turning vehicles entering and exiting the site and separate left and right turn lanes on Perimeter Road at the intersection under stop control.
- Easily accessible from I-40. Truck and commuter traffic coming from interstate to/from the southwest would likely use this route. Traffic from Oak Ridge would likely take this route coming to/from the east into the site.
- The weight capacity on the Perimeter Road bridge over Poplar Creek to handle increased traffic to the site should be considered.
- This is the most direct route to the site from the interstate and Oak Ridge.

Route 2: Blair Road to North Perimeter Road

- Traffic accessing the site from the towns to the north of the site would likely use Blair Road.
- Traffic coming from Oak Ridge Turnpike would access Blair Road at a signalized intersection.
- North Perimeter Road provides direct access to the site.

Route 3: Blair Road to Roadway south of North Perimeter Road

- This is the least direct route to/from the site and requires multiple turns once off Blair Road.
- May prove difficult for trucks to maneuver within the site from this route.
- This would likely be the least traveled route to/from the site.
- The bridge over Poplar Creek (Route 3) may not be suitable for large vehicles and increased commuter and truck traffic. However, the bridge over Poplar Creek (Route 3) is currently scheduled for closure by DOE. Should Kairos Power negotiate to keep this route open during construction and/or operation, they will conduct a detailed study of the condition of the bridge and the maximum weight capacity limitations and take responsibility for upgrades and long-term maintenance.

Based on the existing analysis, the roadways providing access to the site are under capacity as shown in Table 3.7-11 and none of these roadway segments exceed the level of service (LOS) C volume threshold over a given 24-hour day. Table 3.7-12 shows the estimated 2025 annual average daily traffic (AADTs) based on a 2 percent growth rate for 6 years applied to the existing 2019 AADT for each roadway. Increased traffic from truck and equipment deliveries and construction workers would likely cause occasional congestion and delays on surface roads in and around the site during the time of construction, operation, through decommissioning. The overall impact of construction (deliveries, personnel, etc.), operation, and decommissioning would be SMALL.

The construction and operation of the facility does not alter existing transportation routes for conveying materials and/or personnel to the site. Therefore, the impacts to transportation routes would be SMALL.

The construction and operation of the facility does not alter existing traffic patterns to and from the site. Therefore, the impacts to traffic patterns would be SMALL.

Based on the traffic assessment, there are no transportation infrastructure mitigation requirements in the vicinity of the site.

4.7.2.1.2 Rail

Figure 3.7-2 shows railways within the area surrounding the site. There are 2 shortline railroads in the vicinity of the site as well as lines for CSX and Norfolk Southern in the area. There may be some deliveries transported by rail for this project which would then be unloaded at a freight yard and shipped by tractor trailer to the site. There are no expected disruptions to rail service in or around the project area due to construction, operation, or decommissioning. The expected impacts to rail service would be SMALL.

4.7.2.1.3 Air

Section 3.7.2.3.4 discusses existing airports in the vicinity of the site. There are several commercial and regional airports in the area surrounding the site. There is likely to be a minor increase in air travel due to workers coming to and departing from the site during various stages of construction and decommissioning. These increases would be minimal and temporary. No expected increases in air travel would be expected during plant operation. The impact to air travel would be SMALL.

4.7.2.1.4 Waterways

The site is adjacent to the Clinch River (Clinch River arm of the Watts Bar Reservoir) between approximately Clinch River miles (CRMs) 11 and 13. The Clinch River is a major tributary of the Tennessee River, which has a navigable channel 652 miles long. There are 61 miles of commercially navigable river on the Clinch River extending from its mouth near Kingston, Tennessee upstream to Clinton, Tennessee (Reference 11). The navigable portion of the Clinch River includes a navigation lock at

the Melton Hill Dam. The lock is 75 feet by 400 feet and has a maximum lift of 60 feet (Reference 12). It is not expected that waterways would be used to move equipment or people during construction, operation, or decommissioning, therefore the impact to waterways would be SMALL.

4.7.3 Public Recreational Facilities

As there are no public recreation facilities or opportunities at the site; therefore, direct impacts to recreation due to construction, operation, and decommissioning of the facility would be SMALL.

Traffic, visual impairments, and other negative impacts to surrounding recreational facilities would be minimal due to their distance from the site, as well as hills and trees which would mitigate sounds and limit construction impacts from these locations. Indirect impacts due to noise at the nearby Manhattan Project National Historical Park may occur. Tours and museum visits may be slightly disrupted by noise from the construction and decommissioning, these impacts would be SMALL as they would be minimal and temporary. During operation, noise from the facility would be limited by walls and other physical barriers, therefore operational impacts due to noise would be SMALL.

Indirect impacts due to increased traffic in the vicinity of the site may occur. Increased traffic during construction and decommissioning could lead to increased travel times and congestion while driving to and from the recreational parks in the area. However, the majority of the parks in the vicinity are over 10 miles distant, so this disruption would be minimal. During construction, the increased traffic around the site is not expected to have a significant impact on the existing roadway network, therefore, indirect impacts to recreation at this time would be SMALL. During operations, these impacts would also be SMALL as fewer vehicles would be traveling the roads than those associated with construction and decommissioning.

4.7.4 References

1. ESRI 2021. Tennessee Map, 2021.
2. U.S. Census Bureau, ACS Demographic and Housing Estimates - 2019 American Community Survey 5 Year Census - Table Results, Website: https://data.census.gov/cedsci/table?q=dp05&g=0100000US_0400000US47_0500000US47001,47093,47105,47129,47145_1600000US4755120&tid=ACSDP5Y2019.DP05&hidePreview=true&tp=true, accessed July 23, 2021.
3. Tennessee State Data Center 2019 - Boyd Center for Business and Economic Research, Boyd Center Population Projections, Website: https://tnsdc.utk.edu/estimates-and-projections/boyd-center-population-projections/, accessed July 23, 2021.
4. U.S. Census Bureau. County Business Patterns: 2016. April 19. 2018. Website: https://www.census.gov/data/datasets/2016/econ/cbp/2016-cbp.html.
5. Bureau of Labor Statistics. Occupational Employment and Wage Statistics. Retrieved from: https://data.bls.gov/oes/#/home, 2016.
6. Bureau of Economic Analysis. 2019. CAEMP25N Total Full-Time and Part-Time Employment by NAICS Industry 1/. Website: https://apps.bea.gov/iTable/iTable.cfm?reqid=70&step=30&isuri=1&major_area=4&area=47131&year=2018&tableid=33&category=733&area_type=4&year_end=-1&classification=naics&state=47000&statistic=-1&yearbegin=-1&unit_of_measure=levels, accessed July 23, 2021
7. U.S. Geological Survey. Estimated Use of Water in the United States in 2015. Website: https://pubs.usgs.gov/circ/1441/circ1441.pdf, accessed September 27, 2021.

8. Tennessee Department of Education, Report Card Data, Website: https://www.tn.gov/content/tn/education/data/data-downloads.html, accessed August 2, 2021.

9. Tennessee Department of Education, "Annual Statistical Report of the Department of Education for Year Ending June 30, 2020," 2020.

10. U.S. Census Bureau. Quickfacts. Website: https://www.census.gov/quickfacts/fact/table/morgancountytennessee,loudoncountytennessee,knoxcountytennessee,andersoncountytennessee,roanecountytennessee/HSD310219, accessed July 23, 2021

11. Tennessee Valley Authority, Navigation on the Tennessee River, Website: https://www.tva.com/environment/managing-the-river/navigation-on-the-tennessee-river, accessed August 5, 2021.

12. Tennessee Valley Authority, Melton Hill, Website: https://www.tva.com/energy/our-power-system/hydroelectric/melton-hill-reservoir, accessed June 18, 2021.

Table 4.7-1: Projected ROI Labor Availability and Onsite Labor Requirements at Peak Month of Construction, Operations and Decommissioning Schedules

Occupation	Kairos Peak Need[(a)]	Estimate of Labor Force by Occupation in The ROI [(b)]						ROI Labor Force Deficiency [(d)]
		Anderson	Knox	Loudon	Morgan	Roane	Estimate Available for Kairos [(c)]	
Construction Phase								
Heavy and Civil Engineering Construction	166	75	1,096	77	ND	ND	250	0
Specialty Trade Contractors	86	796	6,013	296	103	179	1,477	0
Foundation, Structure, and Building Exterior Contractors	53	93	635	43	ND	29	160	0
Building Equipment Contractors	13	460	3,295	141	ND	80	795	0
Truck Transportation	9	155	3,528	1270	23	240	1,043	0
Architectural, Engineering, and Related Services	98	1,346	2,718	22	ND	13	820	0
TOTAL CONSTRUCTION PHASE	**425**	**3,039**	**18,572**	**1,908**	**126**	**593**	**4,848**	**0**
Operations Phase								
Professional, Scientific, and Technical Services	57	8,324	10166	563	17	505	1,958	0
Management, Scientific, and Technical Consulting Services	11	1765	801	186	ND	31	278	0
TOTAL OPERATIONS PHASE	**68**	**10,089**	**10,967**	**749**	**17**	**536**	**2,236**	**0**
Decommissioning Phase								
Commercial and Institutional Building Construction	200	97	929	41	ND	ND	213	0
Heavy and Civil Engineering Construction	133	75	1,096	77	ND	ND	250	0
Truck Transportation	7	155	3,528	1270	23	240	1,043	0
Total DECOMMISSIONING PHASE	**340**	**327**	**5,553**	**1,388**	**23**	**240**	**1,506**	**0**

Source: (Reference 4, Reference 5)

a) Peak month estimated need of labor categories where need is greater than or equal to 5.

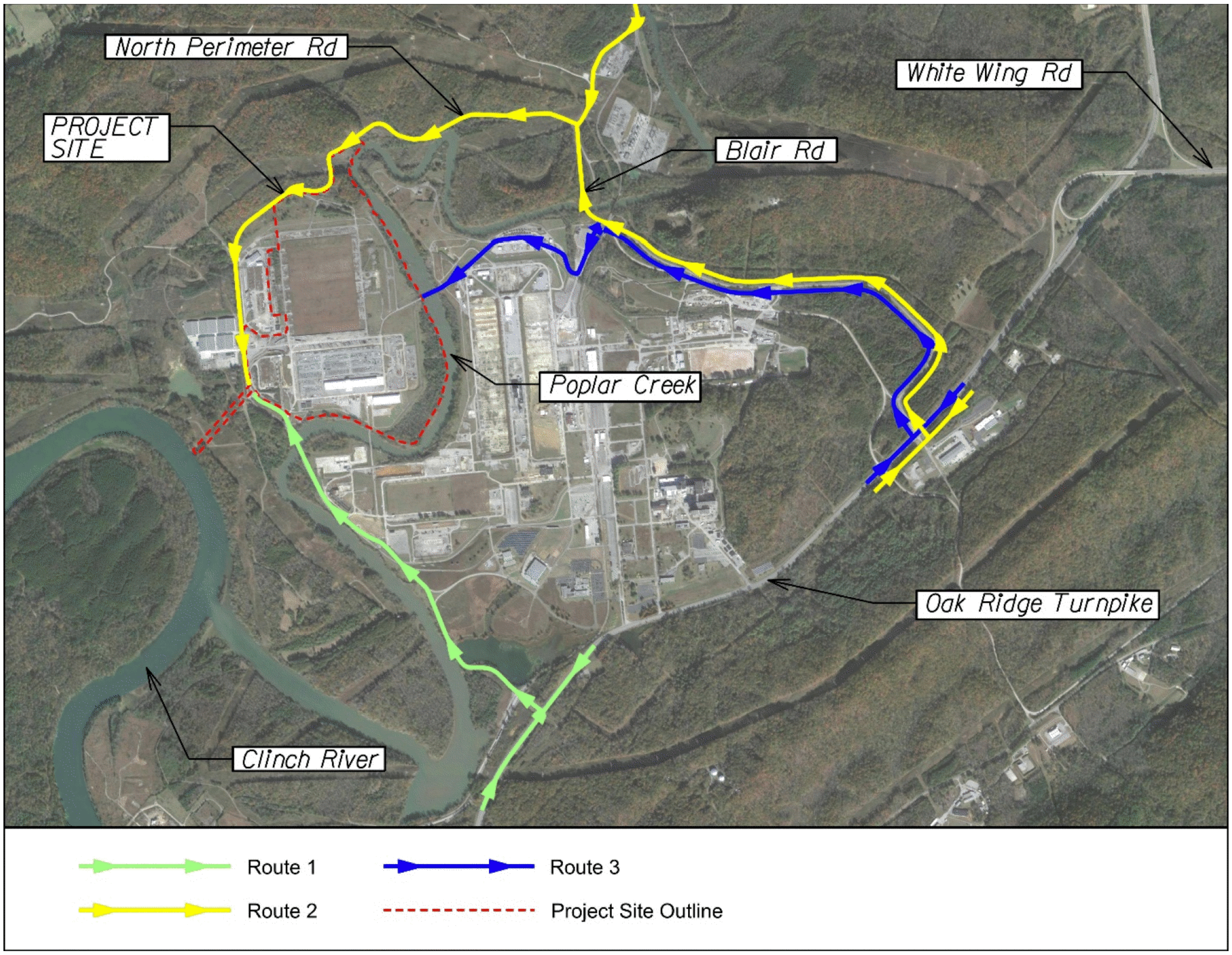
b) ROI labor force estimate from Reference 4.

c) Left column: Estimated available construction and decommissioning labor force based on 20 percent of BLS estimated labor force; Available operational labor force based on 10 percent of BLS estimated labor force. Right column: Total reflects the total estimated labor force available to meet the Peak Need.

d) ROI labor force deficiency determined by subtracting estimated Available Labor Force from Peak Need.

ND = No Data available

Figure 4.7-1. Likely Routes taken to/from the Site



4.8 HUMAN HEALTH

The following subsections discuss the potential nonradiological and the radiological health impacts to the public and to occupational workers from construction, operation, and decommission of the facility. Federal regulations for generating, managing, handling, storing, treating, protecting, and disposing of wastes during construction, operation, and decommissioning are issued and overseen by the NRC and the EPA. These regulations include compliance with provisions of the Clean Air Act, Clean Water Act, Atomic Energy Act, and Resource Conservation and Recovery Act. In Tennessee, construction and operation permits pertaining to the Federal Clean Air Act and the Federal Clean Water Act are required from the TDEC. The Tennessee Code TCA § 68-212-201 protects the public health, safety, and welfare through a coordinated statewide hazardous substance management program.

4.8.1 Nonradiological Impacts

Nonradiological hazards pertaining to the facility include hazards from emissions, discharges, and waste from normal facility processes and from accidental releases. Nonradioactive wastes from construction, operation, and decommissioning activities of the facility include solid waste and liquid waste, and air emissions. Wastes, discharges, and emissions are managed in accordance with applicable federal, state, and local laws and regulations, and in accordance with applicable permit requirements.

4.8.1.1 Nonradioactive Chemical Sources

During construction, nonradioactive chemicals which include fuels, oils, solvents, and other materials necessary for site preparation and construction are expected to be present onsite. During operation, nonradioactive chemicals would be stored onsite in small quantities include lubricating oil for rotating equipment and cleaning materials and consumables used for cleaning and maintenance. A bounding value of approximately 21,555 gallons of diesel fuel for the standby diesel generator would be contained in an onsite storage tank. The bounding inventory of other major chemicals (i.e., those in excess of 1,000 pounds) used during operations at the facility is provided in Table 4.8-1. Additionally, Table 4.8-2 provides information regarding chemical storage by chemical group and maximum inventory. During decommissioning, nonradioactive chemicals expected on site would be similar to the construction materials.

4.8.1.2 Nonradioactive Liquid, Gaseous, and Solid Waste Management and Control Systems

4.8.1.2.1 Nonradioactive Liquid Wastes

The primary source of liquid wastes would be sanitary wastes that would be discharged to the Rarity Ridge wastewater treatment facility. Insignificant volumes of nonradioactive liquid chemical wastes would be generated during construction, operation, or decommissioning. Some lab-scale chemical use would occur outside the Reactor Building. Liquid wastes produced as a result of these activities would be treated to ensure they meet the requirements of the wastewater treatment facility before being discharged to the municipal sewer system.

4.8.1.2.2 Nonradioactive Gaseous Wastes

The facility would generate gaseous effluents resulting from process operations and the ventilation of operating areas. The nonradiological contaminants associated with this discharge are described in Section 4.2.

The gaseous effluent from ventilation of operating areas would include the following control systems:

- The exhaust airstream passes through a high-efficiency particulate air (HEPA) filtration system prior to discharge from the stack

- Additional controls may be implemented as required by local permit conditions.

Gaseous effluents from the main facility building would be vented to the atmosphere through the Reactor Building ventilation stack.

4.8.1.2.3 Nonradioactive Solid Wastes

The following is a representative list of nonradioactive solid wastes that would be generated by the project during construction, operation, and decommissioning:

- Construction and demolition debris
- Spent personal protective equipment
- Maintenance items such as heating, ventilation, and air conditioning filters, pipes, electronics, etc.
- Batteries (alkaline, lithium)
- Expired light bulbs and fixtures
- Office supplies
- Expired ink cartridges
- Cleaning supplies
- Empty plastic containers
- Food wastes

Solid waste management and control measures for the facility would include waste reduction, recycling, and waste minimization practices that would be employed during all project phases (construction, operation, decommissioning).

4.8.1.3 Nonradioactive Effluents Released

A list of chemicals that may be released as air emissions to the onsite and offsite environment during operation is provided in Section 4.2. Some small amounts of maintenance and lab chemicals would be released to the city sewer within federal and local limits. Administrative controls ensure that these effluents meet the requirements of the Rarity Ridge wastewater treatment facility before they are released. Liquid wastes would not be released to surface water bodies or ponds.

4.8.1.4 Chemical Exposure to the Public

4.8.1.4.1 Air Emissions

Air emissions from the facility are estimated to be below 100 tons per year for applicable criteria pollutants (SO_2, NOx, PM_{10}, $PM_{2.5}$, CO, VOCs, lead) during the 2-year construction period and decommissioning phases of the project. Chemical exposures through air emissions would be even lower during operations. The TDEC views emissions not exceeding 100 tpy to be minor and waives requirements for dispersion modeling. As the estimated offsite emissions would be insignificant from all phases of the project, direct and indirect human health impacts beyond the site boundary during construction, operations, and decommissioning would be SMALL.

4.8.1.4.2 Liquid Effluents

As described in Section 4.8.1.3, construction, operation, and decommissioning of the facility would not release nonradioactive liquid chemicals to the environment, as wastewater discharges are sent to Rarity Ridge Wastewater Facility for treatment. Therefore, the direct and indirect impacts from liquid effluents during construction, operation, and decommissioning would be SMALL.

4.8.1.5 Physical Occupational Hazards

Physical occupational hazards would exist during all phases of the project, particularly during the construction and decommissioning phases. Because occupational hazards occur onsite and during construction, operation, and decommissioning of the facility, they are considered direct impacts. No indirect impacts (offsite) are identified. Table 4.8-2 lists the general types of occupational physical hazards (physical, electrical, and chemical) that may be present at the facility during the phases of the project. Occupational physical hazards would be reduced or eliminated through implementation of safety practices, training, and physical control measures. Operations would adhere to the regulations and standards established by the U.S. Occupational Safety and Health Administration and the National Institute of Occupational Safety and Health regulations. Therefore, the impacts from occupational hazards would be SMALL.

4.8.1.6 Chemical Exposure to the Workforce

As planned, the facility would not store or use highly hazardous chemicals in quantities above the Threshold Quantities in Appendix A to 29 CFR 1910.119 during construction. During operation, quantities of Flibe and nitrate salt above the Threshold Quantity would be present onsite and therefore, the requirements of 29 CFR 1910.119 Process Safety Management of Highly Hazardous Chemicals apply to the facility. The majority of process chemicals would be used in liquid form and contained in tanks and pipes, limiting workforce exposure. Because potential chemical exposure to the workforce during operation would occur onsite, they are considered direct impacts. No indirect impacts (offsite) are identified. The facility design and practices would ensure compliance with storage requirements and limit exposures. Therefore, impacts from chemical occupational hazards would be SMALL.

4.8.1.7 Environmental Monitoring Programs

State regulations prescribe nonradiological monitoring requirements and may include those associated with emergency management, environmental health, drinking water, water and sewage, pollution discharge, air pollution, and hazardous waste management. The facility would generate gaseous effluents resulting from operations and the ventilation of operating areas. Specific monitoring requirements in support of required air permits would be determined through the permitting process.

4.8.1.8 Mitigation Measures

Mitigative measures such as administrative procedures and protective measures would be used to ensure protection of human health and the environment. BMPs during construction, operation, and decommissioning will be employed to minimize pollutant releases to onsite and offsite areas, to ensure delivery of wastewater to the Rarity Ridge wastewater treatment facility, and to control air emission, as appropriate. The facility is expected to be designed to have minimal liquid discharge from the Reactor Building. Required permits would be obtained for applicable effluents and emissions. Furthermore, waste reduction practices, including recycling and waste minimization, would be employed.

4.8.2 Radiological Impacts

This section describes the public and the occupational health impacts from the management of radioactive materials at the facility. During the construction phase, radioactive material present on site would be present for construction-related activities such as compaction testing and radiography. These radioactive materials would be present as sealed sources covered by contractor radioactive materials licenses. The impacts from the use of these radioactive materials on both occupational health and public health would be SMALL when the devises containing the radioactive materials are operated according to standard operating procedures. The radiological impacts addressed in the following subsections would result from reactor-related source during the operation and decommission phases of the facility.

4.8.2.1 Layout and Location of Radioactive Material

Figure 2.2-3 depicts the physical layout of the site indicating site features, structures, and designated areas. Radioactive materials would be within the Reactor Building and the Auxiliary Systems Building with the high radiation materials limited to the Reactor Building. The Reactor Building would contain spent fuel storage facilities with a capacity sufficient for 10 years of reactor operation. Access to the Reactor Building and the Auxiliary Systems Building would be strictly controlled and personnel entering these buildings would be participants in the occupational dose monitoring program.

4.8.2.2 Characteristics of Radiation Sources and Expected Radioactive Effluents

4.8.2.2.1 Gaseous Sources of Radiation

Gaseous radioactive effluents would be discharged primarily through the Reactor Building exhaust system. However, as stated in Subsection 2.6.1.3, there is no anticipated need for a gaseous radioactive waste system. Discharges from the Reactor Building exhaust system would pass through a HEPA filter and would be monitored prior to release. Tritium is expected to be the dominant routine gaseous radionuclide. No significant gaseous radioactive effluents are expected to be discharged through the spent fuel cooling system (SFCS), the DHRS, or the PHRS. All releases would be within the limits of 10 CFR 20 with consideration of the guidance provided in Regulatory Guide 4.20; therefore, the impacts from gaseous sources of radiation would be SMALL.

4.8.2.2.2 Liquid Sources of Radiation

The major liquid sources of radiation during operations would include the Flibe reactor coolant and the liquid nitrate salt intermediate coolant. However, when these materials have reached the end of their useful life, they are allowed to cool and solidify. Therefore, they would be managed as solid low-level radioactive waste (LLRW) during operations and decommissioning. Shielding materials, such as thick concrete walls, would be used to shield staff from large radiation exposures. Where necessary, piping used to circulate radioactive liquids would also be shielded to reduce radiation exposure rates. Exposures to these materials would be controlled to limit occupational doses with below regulatory limits provided in 10 CFR 20, Subpart C, *Occupational Dose Limits*. There would be small volumes of liquid wastes containing primarily tritium. These wastes would only be disposed of within the limits of 10 CFR 20 Table 3 (limits for releases to sewers); therefore, the impacts from liquid sources of radiation would be SMALL.

4.8.2.2.3 Fixed Sources of Radiation

During operations, solid sources of radiation that contribute to the direct dose would include fresh, circulating, and spent nuclear fuel, radioactive solid Flibe and nitrate salts, and other LLRWs, such as used moderator pebbles. During decommissioning, sources of radiation would also include the Hermes reactor and activated reactor system components and structural materials surrounding the reactor. These sources would be within the Reactor Building until they are removed for routine waste shipments or as part of facility decommissioning. Shielding materials, such as thick concrete walls, would be used to shield staff from large radiation exposures and control radiation doses to below the occupational limits provided in 10 CFR 20, Subpart C; therefore, the impacts from solid sources of radiation would be SMALL.

4.8.2.3 Baseline Radiation Levels

Background radiation levels and radiation levels in the vicinity of the site is discussed in Section 3.8. The site was once home the DOE’s K-31 and K-33 gaseous diffusion plants and supporting facilities. Prior to transferring the properties for industrial development, the DOE conducted environmental baseline

studies for the properties (Reference 1 and Reference 2). The baseline studies note that remedial actions at the site's cleanup radiological and nonradiological contamination met the conditions for unrestricted industrial use as the areas did not pose an unacceptable cumulative excess lifetime cancer risk of more than 1E-04 or a hazard index of more than 1 (Reference 1 and Reference 3). However, remediation was not conducted with a goal of cleaning up the sites to background levels. Therefore, there could be residual radioactive and nonradioactive contaminants at the site and in the site groundwater that are detectable above background but below the risk-based standards.

Ongoing environmental monitoring is conducted across ORR by DOE. The facility would be in the northwest quadrant of the ORR, so a useful resource and indicator of the baseline radiation levels would be based on DOE's ORR environmental surveillance program. Radiological dose measurements such as measured radiation dose rates, airborne radioactivity concentrations, and waterborne radioactivity concentrations at specified DOE locations on ORR where environmental radiological monitoring data already exist can be extracted from the most recent DOE ORR Annual Site Environmental Report and used as a baseline. DOE has estimated that the maximum radiation dose a hypothetical offsite individual could have received from DOE activities on ORR was estimated to be 0.4 mrem from air pathways, 2 mrem from water pathways, and 0.07 mrem from consumption of wildlife harvested on ORR (Reference 3). Cumulatively, this 3 mrem/yr dose is significantly less than the 310 mrem annual average dose to people in the U.S. from natural or background radiation.

4.8.2.4 Calculated Annual Total Effective Dose Equivalent, Annual Average Airborne Radioactivity Concentration, and Annual Average Waterborne Radioactivity Concentration

This section discusses the calculated annual total effective dose equivalent (TEDE), annual average airborne radioactivity concentration, and annual average waterborne radioactivity concentration at the dose receptor corresponding to the maximally exposed individual (MEI). The MEI is located at the nearest resident where the doses due to normal operations are expected to be maximized. The distance to the nearest resident (0.7 miles, 1,127 meters) has been conservatively modeled for all sectors. Additionally, TEDE, annual average airborne radioactivity concentration, and annual average waterborne radioactivity concentration to the nearest full-time resident is discussed. The doses to the public are summarized in Table 4.8-3 with dose models and assumptions described in the following subsections.

The radiation dose to the public due to transportation of radioactive waste is discussed in Section 4.10. The dose to the public due to the transportation of radioactive waste is considered an indirect effect of facility operation.

4.8.2.4.1 Gaseous Effluents

Sources of radioactive gaseous effluents are discussed in Section 4.8.2.2.1. The effluents, which consist of the noble gases krypton and xenon, in addition to iodine and tritium, would be released to the environment primarily through the Reactor Building ventilation system exhaust. Prior to release to the environment, gaseous effluents from the Reactor Building ventilation system exhaust would be monitored and passed through a HEPA filter. There is no anticipated need for holding time to allow for decay. No significant gaseous radioactive effluents are expected to be discharged through the SFCS, the DHRS, or the PHRS.

The TMS would capture tritium from gas streams in the facility. Molecular sieve desiccants would capture tritium from the intermediate loop cover gas and from the reactor cell atmosphere. A zirconium-alloy metal hydride would capture tritium, separating it from argon in the reactor inert cover gas. Collection and disposition of tritium by the TMS would reduce the quantity of tritium released to the environment.

Long-Term (Routine) Diffusion Estimates

For routine releases to the atmosphere, the concentration of radioactive material in the surrounding region depends on the amount of effluent released, the height of the release, the momentum and buoyancy of the emitted plume, the wind speed and direction, atmospheric stability, airflow patterns around the site, and various effluent removal mechanisms. This subsection describes the development of the long-term diffusion and deposition estimates for the facility.

To facilitate modeling of the long-term gaseous effluent concentrations and their subsequent health impacts, the NRCDose modeling package from the Radiation Protection Computer Code Analysis and Maintenance Program (RAMP) was utilized. As stated on RAMP's website:

> *NRCDose is a user-friendly graphical user interface (GUI) for the LADTAP II, GASPAR II, and XOQDOQ programs which operate under all Microsoft Windows™ platforms. These Fortran codes implement NRC's current requirements for As Low As Reasonably Achievable (ALARA) for radioactive effluents from nuclear power plants.*

The NRCDose package consists of three distinct programs: XOQDOQ, GASPAR II and LADTAP. XOQDOQ is the atmospheric dispersion model addressing Regulatory Guide 1.111. XOQDOQ is designed to calculate the annual relative effluent concentrations (X/Q) and deposition (D/Q) due to routine releases from nuclear power plants. XOQDOQ evaluates the impacts at radial downwind distances as well as at sensitive locations specified by the user. GASPAR II is an air release radiation dose code that models the gaseous effluent pathway using the release model described in Regulatory Guide 1.109. GASPAR II requires input of released source terms (curies per year), atmospheric dispersion from the XOQDOQ model and surrounding demographics. The code was developed to analyze airborne effluents from light-water-cooled reactors during routine operations. GASPAR II considers such pathways as inhalation, plume-immersion, ground-shine, and ingestion of various contaminated media (meat, milk, vegetation, etc.). Dose calculations can be applied to a defined population or an individual who are evaluated for four age groups: infants (0-1 years), children (1-11 years), teens (12-18 years), and adults (over 18 years). Each calculation considers seven organs (bone, G.I. tract, kidney, liver, lung, skin, and thyroid) as well as the whole-body dose. The third model included in NRCDose, LADTAP, addresses radiation doses associated with liquid pathway is not applicable to the facility as the liquid effluents (as discussed in Section 4.8.2.4.2) are expected to be negligible.

Estimates of atmospheric relative concentrations, X/Q, and relative deposition values, D/Q, were calculated for routine releases from the facility for long-term (annual) time intervals. The XOQDOQ modeling uses joint frequency distributions (JFDs) of wind speed, wind direction, and atmospheric stability class, the XOQDOQ program provides annual average X/Q and D/Q values at the required distances and sectors. Radioactive decay and dry deposition are considered, and a straight-line Gaussian trajectory is modeled between the point of release and receptors at distances for which X/Q and D/Q values are calculated.

Calculation Methodology and Assumptions

Site-specific, validated meteorological data covering a 5-year period of record from January 1, 2016 through December 31, 2020 from Tower L was used to quantitatively evaluate routine-releases at the facility. The meteorological data needed for the X/Q and D/Q calculations in XOQDOQ included wind speed, wind direction, and atmospheric stability as JFDs.

Validated data from ORR Tower L, which is located approximately 1 mile south-southeast of the site, was used to prepare JFDs for the XOQDOQ modeling. Wind speed and wind direction data at 30 meters were used. Temperature difference data between the 10- or 15-meter and the 30-meter heights were

used to calculate the atmospheric stability classes based on Table 2.2 in Regulatory Guide 1.23 (Table 4.8-4). The anemometer on Tower L was located at the 10-meter level from January 2016 through October 2017 and was moved in November 2017 to the 15-meter level, where it remained through May 2021. Data was prepared for January 1, 2016 through December 31, 2020. Of the 43,848 hours of possible data, all 43,848 hours had valid data combinations of wind speed, wind direction, and stability class. This data capture was possible due to use of collocated backup data levels available for Tower L. The resulting data recovery was 100 percent, well above the 90 percent data recovery indicated in Regulatory Guide 1.23. Although this regulatory guide is applicable to power reactors, this data recovery guidance is considered reasonable for non-power reactors.

Six wind speed classes were defined and used in the modeling. The first class consists of calm winds. The wind speed classes used are shown in the JFD tables. Tables for each stability class that was present during the 2016-2020 data period are shown in Tables 4.8-5 through 4.8-10. The largest hourly wind speed in the 5-year dataset is 24.4 miles per hour. The percent occurrence of hours for each wind direction is shown in Table 4.8-11, and the percent occurrence of hours for each stability class is shown in Table 4.8-12.

Facility-specific data to be considered in the XOQDOQ model include building minimum cross-sectional area, building height, and meteorological tower height at which wind speed was measured (Table 4.8-13). The building height and cross-sectional area are used in the calculation of building wake effects. Regulatory Guide 1.111 identifies the tallest adjacent building as appropriate for use. Building area is defined as the smallest vertical-plane, cross-sectional area of the affected building, in square meters. Other inputs to the model included a release height (100 feet for the stacks releasing tritium) and a representative wind height (30 meters).

Using the JFDs, XOQDOQ provides the X/Q values as a function of wind direction for various time periods at the exclusion area boundary (EAB), at points of maximum individual exposure, and at points within a radial grid of sixteen 22-1/2 degree sectors extending to a distance of 50 miles. As discussed above, a circular, analytical EAB was defined at a fixed distance from an effluent release boundary (ERB) release zone. Additionally, receptors were set at the low population zone (LPZ) distance at each of the 16 wind direction sectors. Finally, both *X/Q* and *D/Q* estimates were calculated for the nearest residence and the site boundary across each sector.

Consistent with NRC Regulatory Guide 1.111, *Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors*, regarding the radiological impact evaluations, radioactive decay and deposition was calculated. While not directly applicable to non-power reactors, the methods in Regulatory Guide 1.111 were considered reasonable for the smaller-scale Hermes non-power reactor. For conservative estimates of radioactive decay, a half-life of 2.26 days for short-lived noble gases, a half-life of 101 days for long-lived noble gases, and a half-life of 8 days for iodines are acceptable for releases to the atmosphere. At sites where there is not a well-defined rainy season associated with a local grazing season, wet deposition does not have a significant impact. In addition, the dry deposition rate of noble gases, including tritium, is such that depletion is negligible within 50 miles (Regulatory Guide 1.111). Therefore, in this analysis, only the effects of dry deposition of iodines were considered. The calculations considering “dry deposition” and “no deposition” were identified in the output as "depleted" and "undepleted.”

The facility is surrounded by complex terrain, with alternating ridges and valleys oriented along a southwest to northeast axis. Terrain heights were provided for each of the 16 wind directions for 22 annular distances for which XOQDOQ by default calculates impacts. These heights were generated using the EPA terrain pre-processor, AERMAP. The local wind patterns are influenced by the complex terrain, with up-valley (southwest to west southwest) and down-valley flow (northeast to east northeast)

patterns common, and stable conditions with light winds frequently observed, especially during the summer and fall seasons. These terrain features, along with light, variable winds can produce nonlinear flows as the trajectory of a plume changes in speed and direction with distance from its release point. These nonlinear flow patterns can influence the dispersion around the facility.

For complex terrain sites where these nonlinear dispersion effects are apparent, adjustments to a straight-line model (as XOQDOQ) are possibly warranted. Specifically, adjustment factors for terrain confinement and recirculation effects on annual average dispersion concentrations at boundary locations must be considered. In the XOQDOQ model (NUREG/CR-2919), the computed ground-level concentrations can be adjusted to account for nonlinear trajectories (plume recirculation or stagnation). As outlined in NUREG/CR-2919, the adjustments can be accomplished in two ways. First, a standard default correction factor that is a function of distance can be applied to the X/Q and D/Q values for each of the directional sectors. Second, adjustments can be made by a comparison of results with a variable trajectory model. If the variable trajectory model produces higher concentrations than the straight-line model, the concentration ratio, or adjustment factor, is used in the straight-line model to correct for non-linear dispersion effects.

The 2019 Environmental Report conducted for the Clinch River Nuclear (CRN) site Early Site Permit application (Reference 4) examined these complex terrain considerations using the second approach comparing results from the XOQDOQ model with the CALPUFF trajectory model. The CALPUFF Version 6.42 dispersion modeling system is an advanced, non-steady-state, meteorological and air quality modeling system listed by the EPA in its Guideline on Air Quality Models that can be applied in near-field applications involving complex meteorological conditions.

The CRN site is located approximately 3 miles to south-southeast and is situated in similar surrounding terrain as the facility. Given its proximity and similar surroundings, the Clinch River analysis can serve as a sufficiently representative surrogate for the facility. The 2019 CRN site ER (Reference 4) details the setup and subsequent analysis with one key point stating that CALPUFF was run without wet and dry deposition refinement options with the intent of yielding more conservative (i.e., higher) predicted ground concentrations. For Clinch River, comparison of both model results across all wind directions, for both the EAB and LPZ, XOQDOQ produced multi-year concentration averages that were consistently higher by at least an order of magnitude over those produced using CALPUFF. Therefore, it was concluded for Clinch River that the XOQDOQ model provided adequately conservative annual average X/Q values, thus requiring no nonlinear adjustment factors to the XOQDOQ annual average X/Q and D/Q values. For the facility, similar conservative impacts from XOQDOQ are anticipated.

The multiple-year average X/Q values for the undepleted case, the 2-day decay case, and the 8-day decay case at the LPZ and analytical EAB are summarized in Tables 4.8-14 and 4.8-15, respectively. The X/Q values at both distances demonstrated that the highest X/Q values were estimated by the XOQDOQ model for the 16 wind direction sectors.

Estimates of X/Q (undecayed and undepleted; depleted for radioiodines) and D/Q are provided at various distances from a quarter mile to 50 miles from the facility are presented in Table 4.8-16 through Table 4.8-19. Finally, the X/Q and D/Q impacts at the special location receptors of the site boundary and the nearest residence are reported in Table 4.8-20.

Radiation Dose Modeling

This subsection describes the methodology, data, and results of the evaluation of radiation doses to members of the public. GASPAR II is the computer model used to evaluate doses to members of the public from gaseous effluents released from normal operations at the facility. The annual consumption and usage rates for the average individual and the MEI were taken from Regulatory Guide 1.109 Tables

E-4 and E-5, respectively. While not directly applicable to non-power reactors, Regulatory Guide 1.109 provides receptor parameters that would be applicable to non-power reactors. GASPAR II uses the maximum rates in calculating individual doses and the average rates in calculating population doses.

NUREG-1537, Part 1 outlines the following for establishing the radioactive dose:

- Physical layout of the site, describing or showing the location of radioactive materials that are expected to be present.
- Characteristics of radiation sources and expected radioactive effluents (i.e., radioactive liquid, gaseous, and solid wastes).
- Baseline radiation levels at the site. Measured radiation dose rates, airborne radioactivity concentrations, and waterborne radioactivity concentrations at specific current locations where environmental radiological monitoring data exist.
- Calculated radiation dose rates, annual averaged airborne radioactivity concentrations, and annual averaged waterborne radioactivity concentrations at the site boundary, including a description of the methodology and assumptions.
- Calculated annual total effective dose equivalent to a maximally exposed member of the public in the unrestricted area, including a description of the methodology and assumptions.
- Calculated annual dose to the maximally exposed worker, including a description of the methodology and assumption.
- Description of mitigation measures that reduce or minimize public and occupational exposures to radioactive material.

External radiation doses were not estimated using site-specific dose models as measures would be in place to limit occupational dose to below regulatory limits. The distance from the reactor and waste operations will be such that external doses to the public would be very low and likely not detectable above background. However, for estimates of the total dose to the MEI, a 1 mrem/yr external dose was assumed. Additionally, there are not anticipated radioactive liquid effluents from the facility. Therefore, only the inhalation pathway was included in calculating the radiation dose from the routine emissions from the facility. Inputs to the GASPAR II model are presented in Table 4.8-21.

The GASPAR II computer program was used to calculate doses from gaseous pathways to offsite receptors from normal operations at the facility. This program, described in NUREG-4653, GASPAR II – Technical Reference and User Guide, implements the radiological exposure models described in Regulatory Guide 1.109 for radioactivity releases in gaseous effluents. Routine dilution and deposition estimates were calculated using the XOQDOQ modeling program, which is the dispersion model for evaluating routine releases recommended by NRC in NUREG-2919, XOQDOQ: Computer Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations. Site-specific, validated meteorological data for calendar years 2016—2020 were used as input to the model. The site-specific dilution and deposition estimates were used by the GASPAR II computer program to calculate radiation doses.

Impacts to Members of the Public

This subsection summarizes the impacts to individuals from radioactive effluents released in the course of normal operations. Impacts to the public are evaluated by comparing estimated dose to regulatory acceptance criteria.

Calculated doses at the site boundary (maximum dose location) and at the nearest resident (the MEI) from gaseous effluent are shown in Table 4.8-22. In accordance with the guidance provided in Regulatory Guide 4.20, *Constraints on Releases of Airborne Radioactive Materials to the Environment for*

Licensees other than Power Reactors, the total effective dose rates at these points are compared to the 10 mrem/yr constraint on airborne emissions of radioactive material to the environment as described in 10 CFR 20.1101(d). As the estimated dose rate to the MEI of 0.19 mrem/yr is less than 10 mrem/yr, the criterion is met.

As noted previously, the external dose rate to the MEI from reactor operations is assumed to be 1 mrem/yr. Combining the external dose rate with the total estimated dose from gaseous emissions of 0.19 mrem/yr, the total dose would be approximately 1.2 mrem/yr. For comparison, the average background dose in the United States from natural sources is approximately 311 mrem/yr.

Because the doses to members of the public from normal operations are calculated to be within the regulatory limits for protection of the MEI, the radiological impacts to members of the public from normal operations at the facility would be SMALL.

4.8.2.4.2 Liquid Effluents

As described in Section 4.8.2.2.2, the facility is not expected to generate radioactive liquid waste for effluent release. As a result, there are no expected liquid effluent pathways that contribute to waterborne radioactivity concentrations. Because there are no discharges of radioactive liquid effluent at the site, the annual averaged waterborne radioactivity concentration is not expected to be greater than the baseline concentration. Therefore, the public dose impacts from liquid effluents would be SMALL.

4.8.2.4.3 Direct Dose

From Section 4.8.2.2.3, sources of radiation inside the facility include the operating reactor, waste staging/shipping, and spent fuel storage. The areas identified to have fixed sources of radiation would be designed with appropriate shielding to meet the 10 percent of 10 CFR 20.1301 limits at the outer wall of the facility. However, due to current uncertainty in source terms, the direct dose from site-specific sources have not been modeled.

The direct dose to a member of the public at the EAB would be due to gamma radiation penetrating the walls of the facility or radiation reflecting in the air, known as “shine.” While not specifically modeled, due to site shielding design, the direct dose outside of the buildings would be small and the dose would substantially decrease with increasing distance from the sources. Because the nearest site boundary is located at an appreciable distance from the discussed fixed sources, the direct dose is negligible at the site boundary. Therefore, the public dose impacts from direct exposure sources would be SMALL.

4.8.2.5 Annual Dose to Maximally Exposed Worker

Occupational radiation exposures to workers from all sources at the facility would not result in a dose greater than the occupational dose limits provided in 10 CFR Part 20 limits, Subpart C and provided in Table 4.8-27. Therefore, the dose impacts to workers from direct exposure sources would be SMALL.

4.8.2.6 Radiation Exposure Mitigation Measures

Occupational and public exposures due to operations at the site would be maintained ALARA by limiting exposure times, maximizing distances to sources, and/or utilizing shielding when appropriate. This exposure minimization goal is met through both engineered and administrative controls. The following subsections discuss each individually.

4.8.2.6.1 Engineered Controls

The facility is expected to utilize the following engineered controls to minimize radiation exposure to the public and workers:

- Radiation source identification and controls
- Shielding around radiation sources
- Ventilation control
- Access control to radiation areas
- Remote operation
- Physically separated systems that prevent cross-contamination

4.8.2.6.2 Administrative Controls

To minimize radiation exposure to the public and workers, the facility would utilize administrative controls, which consist of written procedures, policies, and employee training in the following subject areas:

- Radiation safety
- Dose monitoring
- Contamination controls
- Radioactive waste minimization
- Responsibilities for radiological environmental stewardship
- Employee recognition for efforts to improve radiological conditions

4.8.3 Radiological Monitoring

Radiological monitoring includes effluent monitoring and environmental monitoring. Impacts to public health from implementing monitoring described in the following sections would be SMALL. The information gained from monitoring helps to control radiological impacts and ensures they also remain SMALL.

4.8.3.1 Radiological Effluent Monitoring

The NRC requires that operators of nuclear plants and fuel-cycle facilities monitor and report on releases of radioactive effluents. For nuclear plants, the monitoring and reporting system is specified in the Radiological Effluent Technical Specifications. Radiological Effluent Technical Specifications requires the licensee to monitor effluent releases at every significant release point at the facility. Effluent monitoring consists of continuous measurements of some effluent streams; periodic measurement of radioactive particles trapped on filters, and measurement of samples from effluents released in batches. Regulatory Guide 4.1, *Radiological Environmental Monitoring for Nuclear Power Plants*, addresses the environmental monitoring program. This regulatory guide discusses principles and concepts important to environmental monitoring at nuclear power plants. The guide addresses the need for preoperational and background characterization of radioactivity. It also addresses offsite monitoring, including those exposure pathways that are important to a site. The guide defines exposure pathways, the program scope of sampling media and sampling frequency, and the methods of comparing environmental measurements to effluent releases in the annual environmental report. Regulatory Guide 4.1 refers to NUREG-1301, “Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors” for additional guidance on the effluent and environmental monitoring. Both Regulatory Guide 4.1 and NUREG-1301 are written for nuclear power plants rather than test reactors.

There are similarities in airborne releases of radioactivity such that the guidance in Regulatory Guide 4.1 and NUREG-1301 are considered generally relevant for developing the operational radiological environmental monitoring program (REMP) for the Hermes reactor with the exception of the need for preoperational monitoring (See PSAR Section 11.1.7) and the location of monitors (See Section 4.8.3.2.2). A REMP would be established to identify and quantify principal radionuclides in effluents

(Regulatory Guide 4.1). This can be used to verify that the facility is performing as expected and within its design parameters, so that doses to individual members of the public remain within the limits established in 10 CFR 20.1301 and dose due to airborne emissions meet the ALARA requirements of 10 CFR 20.1101(d) as indicated in Regulatory Guide 4.20, *Constraint on Releases of Airborne Radioactive Materials to the Environment for Licensees other than Power Reactors*.

Significant release pathways for radioactive material from the facility would be included in the REMP. Gaseous effluent monitoring would be conducted at locations both on site and at locations around the site boundary during operations and final decommissioning and dispositioning of the Hermes reactor. As discussed in PSAR Section 11.1.7, a description of the environmental monitoring program for the facility will be provided with the application for an Operating License consistent with 10 CFR 50.34(b)(3).

4.8.3.1.1 Gaseous Effluent Monitoring

Gaseous effluents released from the facility would be released primarily through the Reactor Building ventilation system exhaust where they would pass through a HEPA filter and monitored prior to release. There would be sampling provisions to routinely collect grab samples and analyze gas, particulate, iodine, and tritium samples from the exhaust in the vent stack in order to identify radionuclides, identify relative concentrations of radionuclides in the airborne effluent, and quantify radionuclide release. The airborne effluent exhaust from the ventilation system exhaust is not expected to contain significant quantities of radioactive noble gases. No significant gaseous radioactive effluents are expected to be discharged through the SFCS, the DHRS, or the PHRS.

The TMS would capture tritium from gas streams in the facility. Molecular sieve desiccants would capture tritium from the intermediate loop cover gas and from the reactor cell atmosphere. Zirconium-alloy metal hydride would capture tritium; separating it from argon in the reactor inert cover gas. Collection and disposition of tritium by the TMS would reduce the amount of tritium released to the environment ensuring it is below the limits established in 10 CFR 20.

4.8.3.1.2 Liquid Effluent Monitoring

The facility would release no radioactive liquid effluent. As such, there are no defined liquid effluent pathways from the facility and no requirement for radiation monitoring of liquid effluent release pathways.

4.8.3.2 Radiological Environmental Monitoring

The requirement to have a radiological environmental monitoring program is documented in 10 CFR 20.1302. As provided in PSAR Section 11.1.7, the Hermes site is located on a former DOE nuclear facility site and the radiological conditions in the area are well characterized and establish a baseline for the site. The baseline would later be used to ensure that the facilities impact on the environment remains minimal. The NRC requires nuclear plants to submit a report each year on the results of their monitoring programs.

The environmental monitoring system is covered under the REMP. The REMP would require sample airs be taken at various locations in the vicinity of the facility to determine if releases are detectable in the environment off site. The environmental monitoring system is covered under the REMP. As provided in NUREG 1301, air monitoring measurements are typically made at five stations: three near the plant boundary in the direction of most likely wind transport; one in the vicinity of a community likely to have the greatest chance of exposure; and one at a control location 9.3 to 18.6 miles in the upwind direction of prevailing winds. Radioiodine is measured weekly and gross beta activity of particulates captured on filters is measured quarterly. Analyses to identify gamma-emitting radionuclides are done on composite samples weekly (Reference 5).

Although Regulatory Guide 4.1 and NUREG 1301 are written for conventional LWR nuclear power plants, due to the similarities between airborne releases of radioactivity from those nuclear power plants and those potentially released from the facility, the guidance provided in Regulatory Guide 4.1 and NUREG 1301 will be considered when developing radiological environmental monitoring specifications for the facility as described in PSAR Chapter 11. Specifically, guidance provided in Figure 1 of Regulatory Guide 4.1 and Table 3.12-1 of NUREG 1301 will be considered when determining which exposure pathways to sample, sample locations, types of samples, and sample frequencies for the facility. Considering this guidance, the following radiation exposure pathways would be considered for monitoring under the facility REMP:

- Direct radiation exposure pathway monitored using passive dosimeters [e.g., thermoluminescent dosimeters (TLDs)]
- Airborne exposure pathway monitored using continuous air samples
- Ingestion exposure pathway (monitored only if triggered)
- Waterborne exposure pathway (if radioactive effluent needs are later identified or if triggered as a result of an unplanned release)

4.8.3.2.1 Waterborne Exposure Pathways

Groundwater

Leaks and spills onto the ground surface can be absorbed into the soil. Once in the soil, some of the material from the leak or spill may, depending on the local soil properties and associated liquid flux of the release, eventually reach the local water table. The dispersion of this material depends on the local subsurface geology and hydrogeologic characteristics. Liquid releases into the subsurface would be transported as a function of groundwater flow processes and conditions (e.g., hydraulic gradients, permeability, porosity, and geochemical processes) and could eventually be released to the unrestricted areas.

Groundwater sampling would follow the recommendations in Table 3.12-1 of NUREG-1301, i.e., quarterly sampling with gamma isotopic and tritium analysis. Groundwater sampling locations would be chosen based on the groundwater gradient. Groundwater has been identified at depths of 6 to 8 feet below the ground surface (ground surface at Elevation 765 NAVD 88). Measured local water table elevations for the site indicate that the groundwater flow is radially across the site toward Poplar Creek. From the area of the Reactor Building, groundwater flow is toward the east.

In support of an earlier hydrological assessment of the site, there are already 371 test wells identified within the ETTP property boundary (see Figure 3.4-4) that were used for monitoring groundwater. A select few of these wells meet the criteria outlined in the guidance provided in Regulatory Guide 4.1 and NUREG-1301 and could be used in support of the facility REMP.

Surface Water

The two major nearby water features are Poplar Creek and the Clinch River arm of the Watts Bar Reservoir which are 0.2 miles and 0.4 miles respectively from the site's center point. There would be no liquid effluent release pathway from the facility and thus surface waters in the vicinity of the plant are not expected to receive detectable levels of radioactivity. Therefore, surface water sampling would not be included in the radiological environmental monitoring plan. Similarly, marine life in the rivers is not expected to accumulate detectable levels of radioactivity and thus sampling of fish or other marine creatures for the ingestion pathway is not included in the radiological environmental monitoring plan.

4.8.3.2.2 Direct Exposure Pathway

Passive environmental dosimeters, such as TLDs, provide indication of direct radiation from contained radiation sources within the facility Reactor Building, from radiation sources contained within the waste storage and shipping area, from radioactivity in the airborne effluent, and from deposition of airborne radioactivity onto the ground. Table 3.12-1 of NUREG-1301 recommends 40 dosimeter locations with an inner ring at the site boundary and an outer ring at 3.7 to 5 miles from the site. Considering the size of the facility and the low power level (and corresponding low releases) of the Hermes reactor, a minimum number of dosimeter locations are specified.

Dosimeters would be positioned to provide annual direct dose information for onsite locations which are expected to have significant occupancy and at property line locations in the north, south, east, and west directions. These property line locations would include the direction of the theoretical MEI.

Direct exposure pathway monitoring dosimeters would include:

<u>Onsite locations</u>:

- Regularly occupied onsite buildings with dosimeters positioned as close to the Reactor Building as possible:
  - Administrative Building
  - Auxiliary Systems Building
  - Maintenance and Storage Building
  - Security Station
- LLRW loading and shipping area.

<u>Site Perimeter Locations:</u>

- On the north, south, east, and west site fence lines with one being in the direction the prevailing wind to represent the location of the MEI and one being at the shortest distance from the Reactor Building.

<u>Off-site Locations:</u>

- One control dosimeter at a distance sufficiently far to represent a background dose and not influenced by current or future operations at ORR, the Energy*Solutions* Bear Creek LLRW processing facility, the proposed CRN site, or radioactive waste transportation corridors.

4.8.3.2.3 Airborne Exposure Pathway

Airborne effluent releases from the facility could contribute to offsite doses. Most of the activity released in airborne effluents consists of fission and activation noble gases, iodine, and tritium. Effluent streams from the facility that have the potential to include radioactive iodine would be treated using silver-impregnated zeolite and/or carbon filters to remove the iodine. Particulates are removed from airborne effluents using HEPA filters. Therefore, the activities of iodine and particulates in releases are typically several orders of magnitude lower than activities from noble gases and tritium.

Environmental airborne sampling would be performed to identify and quantify radioactive particulate and radioiodine in airborne effluents. Regulatory Guide 4.1 indicates that radioiodine, particulates, and tritium discharged to the atmosphere via airborne effluents should be monitored with air sampling for the inhalation exposure pathway and surface soil sampling and food product sampling for the ingestion exposure pathway (see Section 4.3.2.4).

The guidance provided in Table 3.12-1 of NUREG-1301 would be used to establish locations for airborne sample sampling for radioiodine and particulates, sampling frequency, and type of sample analysis. Continuous air sample locations are specified in accordance with guidance provided in Table 3.12-1 of NUREG-1301. The continuous air samplers would include a radioiodine canister for weekly I-131 analysis and a particulate sampler which is analyzed for gross beta radioactivity and for quarterly isotopic analysis.

Three air sample locations would be near the facility site boundary in different sectors with the highest calculated annual average ground level deposition factor (D/Q) values. A fourth air sample location would be in the vicinity of a community having the highest calculated annual average ground level D/Q. A fifth sample location would be at a sufficient distance from the facility to provide background information for airborne activity.

4.8.3.2.4 Ingestion Exposure Pathway

Ingestion exposure can occur via consumption of contaminated food, water, and other liquids. Ingestion can occur in the following ways:

- Deposition of particulate matter onto edible produce (e.g., from atmospheric pollutants)
- Biotic uptake and accumulation from contaminated soil or water (e.g., irrigation water, uptake of contaminants by fish or livestock)

NUREG-1301 suggests sampling of various biological media (biota monitoring) to indirectly assess doses due to particulate and iodine ingestion. This type of monitoring may include sampling of soils, broad-leafed plants, fish, meat, or milk. Nuclear power plants have long monitored this pathway and have seen neither appreciable dose nor upward trending. Considering the size of the facility and the type of facility being a non-power test reactor with maximum thermal power of 35 MWth, in comparison to conventional nuclear power plants, and that particulate and iodine radionuclides are not normally expected to be present in significant quantities within airborne effluent releases from the facility, biota monitoring is limited to monitoring of the milk pathway, as this pathway is most sensitive for detection of iodine releases.

In the event that results of environmental airborne samples indicate iodine or particulates in quantities large enough to result in a calculated dose greater than that predicted for normal releases (e.g., from GENII models used to show compliance with the 10 CFR 20.1101(d) dose constraint), then a supplemental sampling campaign would be undertaken. The supplemental program would include soil and non-milk food product sampling.

Milk is one of the important foods contributing to the radiation dose to people if milk animals are pastured in an area near a facility that releases radioactive materials. Milk samples are generally considered better indicators of radioiodine in the environment compared to vegetation. However, according to the data presented in Table 2.2-2, there is no dairy or goat production within 5 miles of the site. In the event that such production arises during normal operation of the facility, that is within a 5-mile radius, milk sampling would be included in supplemental sampling events.

4.8.4 References

1. U.S. Department of Energy, "Environmental Baseline Survey Report for the Proposed Title Transfer of the Former K-33 Area at the East Tennessee Technology Park, Oak Ridge, Tennessee." DOE/OR/01-2658. September 2015.

2. U.S. Department of Energy, "Environmental Baseline Survey Report for the Proposed Title Transfer of the Former K-31 Area at the East Tennessee Technology Park, Oak Ridge, Tennessee." DOE/OR/01-2677. July 2015.

3. U.S. Department of Energy, “Oak Ridge Reservation Annual Site Environmental Report - 2020.” DOE/CSC-2514. Chapter 7. September 2021.

4. Clinch River Nuclear Site, Early Site Permit Application, Part 3 Environmental Report, Revision 2. Ascension No. ML19030A478 Chapter 2, Section 02.07.06, pp 2.7.6.3 – 2.7.6.5; March 2019

5. Committee on the Analysis of Cancer Risks in Populations near Nuclear Facilities-Phase I; Nuclear and Radiation Studies Board; Division on Earth and Life Studies; National Research Council. Analysis of Cancer Risks in Populations Near Nuclear Facilities: Phase I. Washington (DC): National Academies Press (US); 2012 Mar 29. H, Radiological Environmental Monitoring Program (REMP). Website: https://www.ncbi.nlm.nih.gov/books/NBK202004/, accessed August 24, 2021.

Table 4.8-1: Summary of Major Chemical Inventory and Quantity

Chemical	Approximate Bounding Inventory (pounds)	Chemical Group	Storage Location
Flibe	40,000	Group 9 - Solids	In-process - Reactor Building
Nitrate salts (NaNO3, KNO3)	1,200,000	Group 9 - Solids	In-process - Reactor Building Storage - Auxiliary Systems Building or Maintenance and Storage Building

Table 4.8-2: Potential Occupational Hazards

Construction and Decommissioning		
Physical	**Electrical**	**Chemical**
Heavy construction equipment Working from heights Excavation and trenching Heavy lifts Demolition Slips and falls Hot work	Power connects/disconnects Generators General wiring Power tools Underground wiring	Oil and fuels Decontamination fluids Cleaners Paints/solvents Natural gas
Operations		
Physical	**Electrical**	**Chemical**
Ergonomics Slips and falls Lifting Loading and unloading Cranes and hoists Elevated work surfaces Stairs	General electrical Wiring Electronics	Flibe Nitrate salts Cleaners Oils and fuels

Table 4.8-3: Annual Total Effective Dose Equivalent to the Public at Bounding Dose Receptors

Dose Receptor	Annual TEDE	Annual TEDE Dose Constraint
Gaseous Effluents		
Site Boundary	0.28 mrem	10 mrem[(a)] (0.1 mSv)
MEI/Nearest Full-Time Resident	0.19 mrem	
Total Dose (Combined External Dose and Gaseous Effluent)		
Site Boundary	1.3 mrem	100 mrem[(a)] (1.0 mSv)
MEI/Nearest Full-Time Resident	1.2 mrem	

[(a)] Dose constraint based on 10 CFR 20.1101(d) for airborne emissions
[(b)] Dose constraint based on 10 CFR 20.1301(a)(1) for licensed operations
Note: Table values do not include contributions from tritium

Table 4.8-4: Classification of Atmospheric Stability

Stability Classification	Pasquill Stability Category	Ambient Temperature Change with Height (°C/100m)
Extremely unstable	A	ΔT ≤ -1.9
Moderately unstable	B	-1.9 < ΔT ≤ -1.7
Slightly unstable	C	-1.7 < ΔT ≤ -1.5
Neutral	D	-1.5 < ΔT ≤ -0.5
Slightly stable	E	-0.5 < ΔT ≤ 1.5
Moderately stable	F	1.5 < ΔT ≤ 4.0
Extremely stable	G	ΔT > 4.0

Note: Based on Table 2.2 in Regulatory Guide 1.23.

Table 4.8-5: Joint Frequency Distribution (Hours) of Wind Speed and Direction by Atmospheric Stability Class – Stability Class A

Wind Direction	Wind Speed (Miles Per Hour)						
	CALM (0 - 2.24)	2.24 < WS <= 4.47	4.47 < WS <= 6.71	6.71 < WS <= 8.95	8.95 < WS <= 13.42	WS > 13.42	TOTAL
N	88	77	37	29	30	1	262
NNE	144	100	57	39	27	2	369
NE	146	142	135	90	90	10	613
ENE	122	150	209	126	110	6	723
E	60	92	80	17	1	0	250
ESE	52	80	34	0	0	0	166
SE	49	62	21	1	0	0	133
SSE	88	79	23	3	1	0	194
S	168	156	48	12	17	1	402
SSW	284	334	177	89	100	19	1003
SW	227	396	341	191	160	17	1332
WSW	129	279	228	83	55	5	779
W	75	179	202	76	81	21	634
WNW	70	107	122	159	219	60	737
NW	72	69	45	90	178	61	515
NNW	79	54	22	34	34	6	229
SUBTOTAL	1853	2356	1781	1039	1103	209	8341

Notes:
1. JFDs based on 43,848 total hours of valid wind direction-wind speed-stability observations.
2. Stability based on $\Delta T \leq -1.9$.
3. Stability class is based on ΔT between 10 or 15 meters and 30 meters. Wind speed and direction measured at 30 meters.

Table 4.8-6: Joint Frequency Distribution (Hours) of Wind Speed and Direction by Atmospheric Stability Class – Stability Class C

Wind Direction	Wind Speed (Miles Per Hour)						
	CALM (0 - 2.24)	2.24 < WS <= 4.47	4.47 < WS <= 6.71	6.71 < WS <= 8.95	8.95 < WS <= 13.42	WS > 13.42	TOTAL
N	4	6	5	3	6	1	25
NNE	4	8	5	1	5	0	23
NE	6	12	11	10	9	2	50
ENE	5	15	15	10	17	0	62
E	11	14	9	0	0	0	34
ESE	2	14	1	0	0	0	17
SE	7	16	3	0	0	0	26
SSE	6	8	1	0	0	0	15
S	17	32	6	3	7	1	66
SSW	30	58	37	16	14	3	158
SW	23	85	44	33	12	2	199
WSW	11	41	40	12	8	0	112
W	2	27	21	8	8	3	69
WNW	3	12	10	17	22	1	65
NW	6	8	7	19	21	4	65
NNW	8	8	3	1	5	3	28
SUBTOTAL	145	364	218	133	134	20	1014

Notes:
1. JFDs based on 43,848 total hours of valid wind direction-wind speed-stability observations.
2. Stability based on-1.7 < ΔT ≤ -1.5.
3. Stability class is based on ΔT between 10 or 15 meters and 30 meters. Wind speed and direction measured at 30 meters.

Table 4.8-7: Joint Frequency Distribution (Hours) of Wind Speed and Direction by Atmospheric Stability Class – Stability Class D

Wind Direction	Wind Speed (Miles Per Hour)						
	CALM (0 - 2.24)	2.24 < WS <= 4.47	4.47 < WS <= 6.71	6.71 < WS <= 8.95	8.95 < WS <= 13.42	WS > 13.42	TOTAL
N	168	92	41	20	19	0	340
NNE	273	144	70	27	17	0	531
NE	315	254	156	131	92	8	956
ENE	220	253	282	179	102	4	1040
E	156	128	90	18	6	0	398
ESE	118	85	22	5	3	0	233
SE	127	78	20	3	0	0	228
SSE	128	86	15	6	0	0	235
S	261	167	75	30	31	11	575
SSW	349	360	228	144	174	55	1310
SW	287	453	347	218	221	30	1556
WSW	195	293	245	108	72	15	928
W	133	246	185	95	100	34	793
WNW	133	163	170	167	227	60	920
NW	125	108	94	103	182	59	671
NNW	137	100	51	46	23	0	357
SUBTOTAL	3125	3010	2091	1300	1269	276	11071

Notes:
1. JFDs based on 43,848 total hours of valid wind direction-wind speed-stability observations.
2. Stability based on-1.5 < ΔT ≤ -0.5.
3. Stability class is based on ΔT between 10 or 15 meters and 30 meters. Wind speed and direction measured at 30 meters.

Table 4.8-8: Joint Frequency Distribution (Hours) of Wind Speed and Direction by Atmospheric Stability Class – Stability Class E

Wind Direction	Wind Speed (Miles Per Hour)						
	CALM (0 - 2.24)	2.24 < WS <= 4.47	4.47 < WS <= 6.71	6.71 < WS <= 8.95	8.95 < WS <= 13.42	WS > 13.42	TOTAL
N	353	73	23	9	9	0	467
NNE	505	157	51	22	7	1	743
NE	634	268	144	74	43	11	1174
ENE	472	277	226	129	43	4	1151
E	323	141	46	11	2	0	523
ESE	282	93	27	4	4	0	410
SE	272	77	17	4	4	0	374
SSE	365	90	27	12	5	0	499
S	589	151	67	43	41	24	915
SSW	902	322	195	137	174	64	1794
SW	579	313	285	209	153	34	1573
WSW	320	225	160	96	65	10	876
W	234	140	145	97	111	27	754
WNW	213	120	149	157	212	57	908
NW	192	91	93	110	186	55	727
NNW	234	55	43	54	33	1	420
SUBTOTAL	6469	2593	1698	1168	1092	288	13308

Notes:
1. JFDs based on 43,848 total hours of valid wind direction-wind speed-stability observations.
2. Stability based on-0.5 < ΔT ≤ 1.5.
3. Stability class is based on ΔT between 10 or 15 meters and 30 meters. Wind speed and direction measured at 30 meters.

Table 4.8-9: Joint Frequency Distribution (Hours) of Wind Speed and Direction by Atmospheric **Stability Class – Stability Class F**

Wind Direction	Wind Speed (Miles Per Hour)						
	CALM (0 - 2.24)	2.24 < WS <= 4.47	4.47 < WS <= 6.71	6.71 < WS <= 8.95	8.95 < WS <= 13.42	WS > 13.42	TOTAL
N	202	23	9	7	3	0	244
NNE	339	43	15	8	3	0	408
NE	412	88	56	18	15	0	589
ENE	370	107	49	9	4	0	539
E	266	50	11	1	1	0	329
ESE	223	27	9	0	1	0	260
SE	219	17	5	0	1	0	242
SSE	298	22	9	1	0	0	330
S	390	48	24	16	5	0	483
SSW	535	123	54	13	10	8	743
SW	321	139	49	18	9	3	539
WSW	152	82	38	7	6	2	287
W	109	41	30	8	8	0	196
WNW	95	30	36	31	20	3	215
NW	77	23	28	18	35	7	188
NNW	101	20	17	8	7	0	153
SUBTOTAL	4109	883	439	163	128	23	5745

Notes:
1. JFDs based on 43,848 total hours of valid wind direction-wind speed-stability observations.
2. Stability based on1.5 < $\Delta T \leq 4.0$.
3. Stability class is based on ΔT between 10 or 15 meters and 30 meters. Wind speed and direction measured at 30 meters.

Table 4.8-10: Joint Frequency Distribution (Hours) of Wind Speed and Direction by Atmospheric Stability Class – Stability Class G

Wind Direction	Wind Speed (Miles Per Hour)						
	CALM (0 - 2.24)	2.24 < WS <= 4.47	4.47 < WS <= 6.71	6.71 < WS <= 8.95	8.95 < WS <= 13.42	WS > 13.42	TOTAL
N	157	17	10	5	2	0	191
NNE	232	33	15	4	1	0	285
NE	353	64	37	12	1	0	467
ENE	298	97	35	5	2	0	437
E	268	47	1	1	0	0	317
ESE	203	16	3	0	0	0	222
SE	182	15	0	0	0	0	197
SSE	224	14	2	0	1	0	241
S	353	51	6	2	0	0	412
SSW	362	132	18	3	1	0	516
SW	242	133	35	4	1	0	415
WSW	122	54	15	3	2	0	196
W	95	32	8	5	1	0	141
WNW	66	24	17	8	3	1	119
NW	76	22	11	5	1	0	115
NNW	82	8	3	4	1	0	98
SUBTOTAL	3315	759	216	61	17	1	4369

Notes:
1. JFDs based on 43,848 total hours of valid wind direction-wind speed-stability observations.
2. Stability based on ΔT > 4.0.
3. Stability class is based on ΔT between 10 or 15 meters and 30 meters. Wind speed and direction measured at 30 meters.

Table 4.8-11: Percent Occurrence of Each Wind Direction

Direction	Percent of Hours
E	4.22
ENE	9.01
ESE	2.98
N	3.49
NE	8.78
NNE	5.38
NNW	2.93
NW	5.20
S	6.51
SE	2.74
SSE	3.45
SSW	12.60
SW	12.80
W	5.90
WNW	6.76
WSW	7.25

Table 4.8-12: Percent Occurrence of Each Stability Class

Pasquill Stability Category	Class A	Class B	Class C	Class D	Class E	Class F	Class G
Percent of Hours	19.02	0.00	2.31	25.25	30.35	13.10	9.96
Note: Stability class is based on ΔT between 10 or 15 meters and 30 meters. Wind speed and direction measured at 30 meters.							

Table 4.8-13: List of Inputs Used in the XOQDOQ Modeling

XODOQ Input Variables	Value
Wind Sensor Height (PLEV)	30 m
Conversion Correction Factor (UCOR)	-100 [1]
Lower-T Sensor Height	15 m
Upper-T sensor Height	30 m
Type of Release	Elevated
Vent Average Velocity (EXIT)	70.9 m/s
Vent Inside Diameter (DIAMTR)	0.9 m
Vent Release Height (HSTACK)	30.5 m
Containment Building Height (HBLDG)	27 m
Building Min. Cross Sectional Area (CRSEC)	862 m^2
Wind Height (SLEV)	30 m
Vent Heat Emission Rate (HEATR)[2]	99,999 cal/s

[1] UCOR set to -100 which triggers no correction to wind speed classes

[2] HEATR was calculated from the buoyancy equation solving for net heat release, q_s (cal/s)

$$q_s = \frac{(g\frac{v_s d^2}{4})}{3.7 \times 10^{-5}}\left[\frac{T - T_a}{T}\right]$$

where g is gravity, T stack temperature (323.2 K), v_s exit velocity (70.9 m/s), d stack diameter (0.91 m) and Ta ambient temperature (287.8 K). This resulted in a value 4.29E+05 cal/s. However HEATR was coded to only accept a value with a maximum of 5 integers, hence the use of 99,999 cal/s.

Table 4.8-14: Long-Term Average X/Q Values Estimated from XOQDOQ at the EAB

EAB Sector	Undepleted	2-Day Decay	8-Day Decay	Deposition
S	4.28E-07	4.28E-07	4.27E-07	2.62E-09
SSW	4.97E-07	4.97E-07	4.97E-07	3.29E-09
SW	8.67E-07	8.66E-07	8.65E-07	6.47E-09
WSW	1.23E-06	1.23E-06	1.22E-06	7.67E-09
W	4.13E-07	4.13E-07	4.13E-07	2.00E-09
WNW	2.79E-07	2.79E-07	2.79E-07	1.28E-09
NW	1.95E-07	1.95E-07	1.95E-07	1.11E-09
NNW	2.49E-07	2.49E-07	2.49E-07	1.47E-09
N	4.84E-07	4.83E-07	4.83E-07	3.70E-09
NNE	1.34E-06	1.34E-06	1.34E-06	1.04E-08
NE	2.22E-06	2.22E-06	2.22E-06	1.39E-08
ENE	1.27E-06	1.27E-06	1.27E-06	7.35E-09
E	1.24E-06	1.24E-06	1.24E-06	6.80E-09
ESE	1.26E-06	1.26E-06	1.26E-06	1.06E-08
SE	1.29E-06	1.29E-06	1.28E-06	1.62E-08
SSE	6.47E-07	6.46E-07	6.44E-07	3.92E-09
Note: EAB was set at 0.16 miles (250 meters)				

Table 4.8-15: Long-Term Average X/Q Values Estimated from XOQDOQ at the LPZ

LPZ Sector	Undepleted	2-Day Decay	8-Day Decay	Deposition
S	3.47E-07	3.46E-07	3.44E-07	3.16E-09
SSW	3.79E-07	3.77E-07	3.73E-07	3.99E-09
SW	4.52E-07	4.50E-07	4.46E-07	7.20E-09
WSW	6.63E-07	6.62E-07	6.55E-07	8.45E-09
W	2.40E-07	2.39E-07	2.37E-07	2.79E-09
WNW	1.97E-07	1.96E-07	1.95E-07	1.80E-09
NW	1.57E-07	1.56E-07	1.55E-07	1.55E-09
NNW	2.04E-07	2.03E-07	2.02E-07	2.02E-09
N	4.07E-07	4.06E-07	4.02E-07	4.76E-09
NNE	8.27E-07	8.24E-07	8.16E-07	1.24E-08
NE	1.16E-06	1.16E-06	1.14E-06	1.62E-08
ENE	5.90E-07	5.89E-07	5.82E-07	9.09E-09
E	7.30E-07	7.29E-07	7.19E-07	8.23E-09
ESE	6.41E-07	6.40E-07	6.30E-07	9.75E-09
SE	2.74E-06	2.73E-06	2.73E-06	1.34E-08
SSE	6.71E-06	6.68E-06	6.68E-06	9.04E-09

Table 4.8-16: Annual Average X/Q for No Decay, Undepleted for Specified Distances at Each Sector (Page 1 of 3)

Sector	Distance (miles)										
	0.25	0.5	0.75	1	1.5	2	2.5	3	3.5	4	4.5
S	6.89E-07	3.80E-07	2.38E-07	1.60E-07	1.01E-07	1.20E-07	1.30E-07	1.35E-07	4.39E-07	3.71E-07	3.00E-07
SSW	9.03E-07	4.27E-07	4.33E-07	6.24E-07	1.26E-06	5.45E-07	2.84E-07	1.67E-07	1.84E-07	1.98E-07	2.12E-07
SW	1.23E-06	5.11E-07	3.80E-07	3.00E-07	2.65E-07	2.81E-07	2.85E-07	2.83E-07	3.09E-07	3.34E-07	3.57E-07
WSW	1.48E-06	7.25E-07	1.06E-06	1.54E-06	3.44E-06	1.33E-06	6.13E-07	3.26E-07	3.71E-07	4.14E-07	4.37E-07
W	5.99E-07	2.67E-07	2.45E-07	2.36E-07	2.82E-07	3.30E-07	3.66E-07	3.92E-07	3.82E-07	3.64E-07	3.38E-07
WNW	4.58E-07	2.18E-07	1.73E-07	1.56E-07	1.50E-07	2.38E-07	3.28E-07	4.04E-07	2.30E-07	1.38E-07	8.76E-08
NW	3.64E-07	1.75E-07	1.64E-07	1.94E-07	3.01E-07	1.76E-07	1.12E-07	7.60E-08	7.23E-08	6.85E-08	6.49E-08
NNW	5.29E-07	2.34E-07	1.89E-07	2.18E-07	3.20E-07	2.97E-07	2.64E-07	2.34E-07	1.82E-07	1.46E-07	1.19E-07
N	1.02E-06	4.64E-07	2.96E-07	2.21E-07	1.92E-07	3.08E-07	4.40E-07	5.86E-07	5.58E-07	5.24E-07	4.84E-07
NNE	2.20E-06	9.37E-07	6.53E-07	4.93E-07	4.15E-07	4.59E-07	4.91E-07	5.12E-07	4.44E-07	3.91E-07	3.50E-07
NE	2.86E-06	1.28E-06	1.05E-06	8.16E-07	6.50E-07	4.21E-07	2.95E-07	2.17E-07	1.96E-07	1.79E-07	1.64E-07
ENE	1.69E-06	6.61E-07	6.36E-07	6.08E-07	6.94E-07	4.62E-07	3.32E-07	2.51E-07	2.49E-07	2.45E-07	2.39E-07
E	1.41E-06	7.82E-07	1.41E-06	2.19E-06	2.15E-06	9.18E-07	3.18E-07	1.30E-07	1.10E-07	9.42E-08	8.23E-08
ESE	1.30E-06	6.87E-07	7.06E-07	6.13E-07	5.44E-07	6.32E-07	5.95E-07	4.45E-07	3.16E-07	2.04E-07	1.24E-07
SE	1.98E-06	2.79E-06	2.14E-06	1.41E-06	7.81E-07	6.54E-07	5.16E-07	3.87E-07	2.87E-07	2.24E-07	1.80E-07
SSE	1.47E-06	6.93E-06	2.27E-06	7.93E-07	1.84E-07	4.26E-07	5.45E-07	3.96E-07	2.92E-07	2.23E-07	1.63E-07

Table 4.8-16: Annual Average X/Q for No Decay, Undepleted for Specified Distances at Each Sector (Page 2 of 3)

Sector	Distance (miles)										
	5	**7.5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**
S	2.48E-07	1.29E-07	8.40E-08	4.88E-08	3.34E-08	2.50E-08	1.97E-08	1.61E-08	1.36E-08	1.17E-08	1.02E-08
SSW	2.23E-07	1.36E-07	9.79E-08	7.57E-08	5.18E-08	3.87E-08	3.05E-08	2.50E-08	2.11E-08	1.81E-08	1.58E-08
SW	3.72E-07	1.75E-07	1.03E-07	1.06E-07	7.24E-08	5.42E-08	4.28E-08	3.51E-08	2.96E-08	2.55E-08	2.23E-08
WSW	4.29E-07	2.41E-07	1.59E-07	9.25E-08	6.33E-08	4.75E-08	3.76E-08	3.08E-08	2.58E-08	2.23E-08	1.96E-08
W	3.07E-07	1.37E-07	7.29E-08	6.63E-08	4.53E-08	3.35E-08	2.60E-08	2.22E-08	1.88E-08	1.62E-08	1.41E-08
WNW	5.88E-08	5.69E-08	5.70E-08	2.96E-08	3.28E-08	2.54E-08	2.05E-08	1.72E-08	1.45E-08	1.25E-08	1.10E-08
NW	6.18E-08	6.87E-08	7.07E-08	2.34E-08	3.14E-08	2.22E-08	1.63E-08	1.60E-08	1.35E-08	1.17E-08	1.02E-08
NNW	9.93E-08	1.37E-07	1.05E-07	2.40E-08	3.30E-08	2.42E-08	1.87E-08	2.05E-08	1.73E-08	1.49E-08	1.30E-08
N	4.40E-07	1.78E-07	8.60E-08	6.54E-08	5.48E-08	4.17E-08	3.33E-08	2.58E-08	2.05E-08	2.33E-08	2.04E-08
NNE	3.16E-07	1.49E-07	8.72E-08	6.28E-08	8.93E-08	6.67E-08	5.26E-08	4.28E-08	3.48E-08	2.30E-08	1.41E-08
NE	1.52E-07	8.98E-08	6.18E-08	9.33E-08	5.62E-08	3.26E-08	1.98E-08	1.74E-08	1.55E-08	1.64E-08	1.70E-08
ENE	2.27E-07	1.33E-07	8.72E-08	3.63E-08	3.44E-08	2.56E-08	2.02E-08	1.65E-08	1.27E-08	1.19E-08	1.04E-08
E	7.29E-08	8.36E-08	6.43E-08	3.72E-08	2.54E-08	1.89E-08	1.49E-08	1.22E-08	1.02E-08	8.77E-09	7.65E-09
ESE	7.75E-08	6.41E-08	5.36E-08	3.29E-08	2.23E-08	1.66E-08	1.30E-08	1.06E-08	8.92E-09	7.65E-09	6.64E-09
SE	1.49E-07	7.84E-08	5.10E-08	2.94E-08	2.01E-08	1.49E-08	1.17E-08	9.60E-09	8.07E-09	6.93E-09	6.05E-09
SSE	1.10E-07	7.87E-08	5.12E-08	2.96E-08	2.02E-08	1.50E-08	1.18E-08	9.67E-09	8.13E-09	6.98E-09	6.09E-09

Table 4.8-16: Annual Average X/Q for No Decay, Undepleted for Specified Distances at Each Sector (Page 3 of 3)

Sector	Distance (miles)									
	0.5-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
S	2.35E-07	1.23E-07	1.29E-07	3.26E-07	3.02E-07	1.35E-07	4.98E-08	2.51E-08	1.62E-08	1.17E-08
SSW	5.17E-07	7.99E-07	3.07E-07	1.84E-07	2.12E-07	1.39E-07	7.00E-08	3.89E-08	2.51E-08	1.81E-08
SW	3.73E-07	2.80E-07	2.83E-07	3.11E-07	3.55E-07	1.87E-07	9.02E-08	5.45E-08	3.52E-08	2.55E-08
WSW	1.20E-06	2.08E-06	6.89E-07	3.75E-07	4.27E-07	2.46E-07	9.43E-08	4.77E-08	3.08E-08	2.23E-08
W	2.46E-07	2.93E-07	3.67E-07	3.78E-07	3.34E-07	1.46E-07	5.84E-08	3.37E-08	2.20E-08	1.62E-08
WNW	1.76E-07	1.90E-07	3.34E-07	2.45E-07	9.18E-08	5.74E-08	3.71E-08	2.54E-08	1.72E-08	1.26E-08
NW	1.80E-07	2.22E-07	1.15E-07	7.19E-08	6.48E-08	6.80E-08	3.75E-08	2.23E-08	1.52E-08	1.17E-08
NNW	2.12E-07	2.87E-07	2.61E-07	1.83E-07	1.20E-07	1.14E-07	4.60E-08	2.44E-08	1.88E-08	1.49E-08
N	3.00E-07	2.50E-07	4.63E-07	5.53E-07	4.79E-07	1.95E-07	6.53E-08	4.18E-08	2.59E-08	2.14E-08
NNE	6.45E-07	4.52E-07	4.91E-07	4.44E-07	3.49E-07	1.58E-07	8.00E-08	6.71E-08	4.26E-08	2.32E-08
NE	9.96E-07	5.85E-07	2.97E-07	1.96E-07	1.64E-07	9.12E-08	6.98E-08	3.38E-08	1.74E-08	1.63E-08
ENE	6.29E-07	5.72E-07	3.34E-07	2.48E-07	2.36E-07	1.33E-07	4.68E-08	2.58E-08	1.61E-08	1.16E-08
E	1.61E-06	1.61E-06	4.03E-07	1.09E-07	8.24E-08	7.27E-08	3.80E-08	1.90E-08	1.22E-08	8.78E-09
ESE	6.60E-07	5.98E-07	5.45E-07	3.10E-07	1.31E-07	6.24E-08	3.28E-08	1.67E-08	1.07E-08	7.65E-09
SE	1.96E-06	8.65E-07	5.01E-07	2.92E-07	1.82E-07	8.20E-08	3.01E-08	1.50E-08	9.63E-09	6.94E-09
SSE	2.65E-06	4.27E-07	4.54E-07	2.95E-07	1.61E-07	7.35E-08	3.02E-08	1.51E-08	9.69E-09	6.99E-09

Table 4.8-17: Annual Average X/Q for 2.26 Day Decay, Undepleted for Specified Distances at Each Sector (Page 1 of 3)

Sector	Distance (miles)										
	0.25	**0.5**	**0.75**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**
S	6.88E-07	3.79E-07	2.38E-07	1.60E-07	9.97E-08	1.18E-07	1.27E-07	1.31E-07	4.23E-07	3.56E-07	2.86E-07
SSW	9.01E-07	4.26E-07	4.31E-07	6.19E-07	1.24E-06	5.34E-07	2.77E-07	1.62E-07	1.77E-07	1.91E-07	2.02E-07
SW	1.22E-06	5.10E-07	3.79E-07	2.98E-07	2.62E-07	2.77E-07	2.80E-07	2.76E-07	2.99E-07	3.21E-07	3.41E-07
WSW	1.47E-06	7.24E-07	1.06E-06	1.53E-06	3.40E-06	1.31E-06	6.01E-07	3.18E-07	3.60E-07	3.99E-07	4.19E-07
W	5.98E-07	2.67E-07	2.44E-07	2.35E-07	2.79E-07	3.24E-07	3.57E-07	3.80E-07	3.68E-07	3.49E-07	3.22E-07
WNW	4.57E-07	2.18E-07	1.73E-07	1.55E-07	1.49E-07	2.33E-07	3.20E-07	3.92E-07	2.21E-07	1.32E-07	8.37E-08
NW	3.64E-07	1.75E-07	1.64E-07	1.93E-07	2.96E-07	1.73E-07	1.09E-07	7.38E-08	6.98E-08	6.58E-08	6.20E-08
NNW	5.28E-07	2.33E-07	1.88E-07	2.17E-07	3.16E-07	2.91E-07	2.57E-07	2.27E-07	1.76E-07	1.40E-07	1.14E-07
N	1.01E-06	4.62E-07	2.95E-07	2.20E-07	1.90E-07	3.03E-07	4.30E-07	5.68E-07	5.38E-07	5.02E-07	4.61E-07
NNE	2.19E-06	9.34E-07	6.50E-07	4.91E-07	4.12E-07	4.52E-07	4.81E-07	4.99E-07	4.30E-07	3.77E-07	3.35E-07
NE	2.85E-06	1.27E-06	1.05E-06	8.13E-07	6.45E-07	4.16E-07	2.90E-07	2.13E-07	1.91E-07	1.73E-07	1.59E-07
ENE	1.69E-06	6.59E-07	6.34E-07	6.06E-07	6.87E-07	4.55E-07	3.26E-07	2.46E-07	2.42E-07	2.37E-07	2.30E-07
E	1.41E-06	7.80E-07	1.40E-06	2.17E-06	2.12E-06	9.03E-07	3.12E-07	1.27E-07	1.07E-07	9.15E-08	7.96E-08
ESE	1.30E-06	6.86E-07	7.05E-07	6.11E-07	5.40E-07	6.23E-07	5.83E-07	4.33E-07	3.06E-07	1.98E-07	1.20E-07
SE	1.98E-06	2.79E-06	2.13E-06	1.41E-06	7.73E-07	6.44E-07	5.05E-07	3.77E-07	2.78E-07	2.16E-07	1.73E-07
SSE	1.47E-06	6.90E-06	2.26E-06	7.87E-07	1.82E-07	4.18E-07	5.32E-07	3.84E-07	2.81E-07	2.14E-07	1.55E-07

Table 4.8-17: Annual Average X/Q for 2.26 Day Decay, Undepleted for Specified Distances at Each Sector (Page 2 of 3)

Sector	Distance (miles)										
	5	7.5	10	15	20	25	30	35	40	45	50
S	2.35E-07	1.19E-07	7.54E-08	4.15E-08	2.69E-08	1.91E-08	1.43E-08	1.11E-08	8.85E-09	7.22E-09	5.98E-09
SSW	2.12E-07	1.26E-07	8.81E-08	6.44E-08	4.18E-08	2.96E-08	2.21E-08	1.72E-08	1.38E-08	1.12E-08	9.30E-09
SW	3.54E-07	1.63E-07	9.31E-08	9.05E-08	5.89E-08	4.19E-08	3.15E-08	2.45E-08	1.97E-08	1.61E-08	1.34E-08
WSW	4.09E-07	2.24E-07	1.44E-07	7.98E-08	5.20E-08	3.71E-08	2.80E-08	2.18E-08	1.74E-08	1.44E-08	1.20E-08
W	2.92E-07	1.26E-07	6.57E-08	5.65E-08	3.66E-08	2.57E-08	1.90E-08	1.53E-08	1.23E-08	1.00E-08	8.30E-09
WNW	5.59E-08	5.26E-08	5.13E-08	2.52E-08	2.64E-08	1.94E-08	1.48E-08	1.18E-08	9.42E-09	7.69E-09	6.38E-09
NW	5.87E-08	6.34E-08	6.34E-08	1.99E-08	2.52E-08	1.69E-08	1.18E-08	1.09E-08	8.73E-09	7.12E-09	5.90E-09
NNW	9.42E-08	1.27E-07	9.39E-08	2.05E-08	2.66E-08	1.84E-08	1.35E-08	1.40E-08	1.12E-08	9.09E-09	7.54E-09
N	4.17E-07	1.65E-07	7.75E-08	5.59E-08	4.43E-08	3.20E-08	2.42E-08	1.78E-08	1.34E-08	1.44E-08	1.20E-08
NNE	3.01E-07	1.39E-07	7.93E-08	5.44E-08	7.30E-08	5.18E-08	3.89E-08	3.01E-08	2.33E-08	1.48E-08	8.76E-09
NE	1.46E-07	8.45E-08	5.69E-08	8.12E-08	4.68E-08	2.62E-08	1.53E-08	1.28E-08	1.10E-08	1.10E-08	1.08E-08
ENE	2.17E-07	1.24E-07	7.95E-08	3.18E-08	2.86E-08	2.04E-08	1.53E-08	1.20E-08	8.89E-09	7.91E-09	6.61E-09
E	7.03E-08	7.83E-08	5.86E-08	3.24E-08	2.11E-08	1.50E-08	1.13E-08	8.82E-09	7.09E-09	5.83E-09	4.87E-09
ESE	7.49E-08	6.04E-08	4.92E-08	2.89E-08	1.88E-08	1.34E-08	1.01E-08	7.88E-09	6.34E-09	5.22E-09	4.35E-09
SE	1.43E-07	7.32E-08	4.66E-08	2.57E-08	1.67E-08	1.19E-08	8.94E-09	6.99E-09	5.62E-09	4.62E-09	3.86E-09
SSE	1.05E-07	7.28E-08	4.61E-08	2.53E-08	1.64E-08	1.16E-08	8.67E-09	6.74E-09	5.38E-09	4.39E-09	3.65E-09

Table 4.8-17: Annual Average X/Q for 2.26 Day Decay, Undepleted for Specified Distances at Each Sector (Page 3 of 3)

Sector	Distance (miles)									
	0.5-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
S	2.34E-07	1.21E-07	1.26E-07	3.14E-07	2.88E-07	1.25E-07	4.26E-08	1.92E-08	1.11E-08	7.24E-09
SSW	5.14E-07	7.87E-07	3.00E-07	1.78E-07	2.02E-07	1.28E-07	5.96E-08	2.99E-08	1.73E-08	1.13E-08
SW	3.72E-07	2.77E-07	2.77E-07	3.01E-07	3.40E-07	1.74E-07	7.70E-08	4.23E-08	2.47E-08	1.61E-08
WSW	1.19E-06	2.05E-06	6.75E-07	3.63E-07	4.09E-07	2.29E-07	8.17E-08	3.74E-08	2.19E-08	1.44E-08
W	2.45E-07	2.89E-07	3.58E-07	3.64E-07	3.19E-07	1.36E-07	4.97E-08	2.59E-08	1.52E-08	1.01E-08
WNW	1.75E-07	1.88E-07	3.25E-07	2.36E-07	8.78E-08	5.28E-08	3.15E-08	1.94E-08	1.18E-08	7.72E-09
NW	1.79E-07	2.18E-07	1.12E-07	6.94E-08	6.19E-08	6.23E-08	3.19E-08	1.71E-08	1.03E-08	7.15E-09
NNW	2.11E-07	2.83E-07	2.54E-07	1.77E-07	1.14E-07	1.05E-07	3.95E-08	1.86E-08	1.28E-08	9.13E-09
N	2.99E-07	2.47E-07	4.51E-07	5.33E-07	4.57E-07	1.82E-07	5.55E-08	3.22E-08	1.80E-08	1.32E-08
NNE	6.43E-07	4.47E-07	4.80E-07	4.30E-07	3.35E-07	1.48E-07	6.82E-08	5.23E-08	3.00E-08	1.51E-08
NE	9.93E-07	5.81E-07	2.93E-07	1.91E-07	1.58E-07	8.60E-08	6.05E-08	2.73E-08	1.28E-08	1.09E-08
ENE	6.27E-07	5.66E-07	3.28E-07	2.41E-07	2.27E-07	1.25E-07	4.10E-08	2.05E-08	1.18E-08	7.72E-09
E	1.61E-06	1.59E-06	3.96E-07	1.07E-07	7.97E-08	6.78E-08	3.32E-08	1.51E-08	8.87E-09	5.85E-09
ESE	6.59E-07	5.92E-07	5.34E-07	3.01E-07	1.26E-07	5.86E-08	2.89E-08	1.35E-08	7.92E-09	5.23E-09
SE	1.95E-06	8.56E-07	4.91E-07	2.83E-07	1.75E-07	7.68E-08	2.63E-08	1.20E-08	7.03E-09	4.64E-09
SSE	2.64E-06	4.22E-07	4.42E-07	2.85E-07	1.54E-07	6.81E-08	2.60E-08	1.17E-08	6.77E-09	4.41E-09

Table 4.8-18: Annual Average X/Q for 8 Day Decay, Depleted for Specified Distances at Each Sector (Page 1 of 3)

Sector	Distance (miles)										
	0.25	0.5	0.75	1	1.5	2	2.5	3	3.5	4	4.5
S	6.84E-07	3.76E-07	2.35E-07	1.57E-07	9.84E-08	1.17E-07	1.27E-07	1.32E-07	4.33E-07	3.61E-07	2.88E-07
SSW	8.97E-07	4.22E-07	4.28E-07	6.18E-07	1.27E-06	5.38E-07	2.79E-07	1.63E-07	1.79E-07	1.93E-07	2.06E-07
SW	1.22E-06	5.05E-07	3.74E-07	2.94E-07	2.58E-07	2.74E-07	2.79E-07	2.76E-07	3.01E-07	3.26E-07	3.48E-07
WSW	1.46E-06	7.16E-07	1.06E-06	1.51E-06	3.41E-06	1.31E-06	6.00E-07	3.18E-07	3.62E-07	4.03E-07	4.21E-07
W	5.95E-07	2.64E-07	2.41E-07	2.32E-07	2.78E-07	3.25E-07	3.59E-07	3.85E-07	3.74E-07	3.56E-07	3.28E-07
WNW	4.55E-07	2.16E-07	1.71E-07	1.53E-07	1.48E-07	2.35E-07	3.24E-07	4.20E-07	2.26E-07	1.35E-07	8.53E-08
NW	3.62E-07	1.73E-07	1.62E-07	1.92E-07	2.98E-07	1.73E-07	1.10E-07	7.41E-08	7.04E-08	6.66E-08	6.30E-08
NNW	5.27E-07	2.31E-07	1.86E-07	2.16E-07	3.17E-07	2.93E-07	2.60E-07	2.30E-07	1.79E-07	1.42E-07	1.16E-07
N	1.01E-06	4.58E-07	2.91E-07	2.16E-07	1.87E-07	3.02E-07	4.33E-07	5.77E-07	5.49E-07	5.13E-07	4.71E-07
NNE	2.18E-06	9.25E-07	6.41E-07	4.82E-07	4.05E-07	4.48E-07	4.80E-07	5.01E-07	4.36E-07	3.83E-07	3.40E-07
NE	2.83E-06	1.26E-06	1.04E-06	8.01E-07	6.36E-07	4.09E-07	2.84E-07	2.09E-07	1.88E-07	1.71E-07	1.57E-07
ENE	1.68E-06	6.51E-07	6.27E-07	6.01E-07	6.84E-07	4.52E-07	3.23E-07	2.44E-07	2.42E-07	2.38E-07	2.32E-07
E	1.40E-06	7.69E-07	1.40E-06	2.18E-06	2.12E-06	9.01E-07	3.10E-07	1.25E-07	1.05E-07	9.00E-08	7.85E-08
ESE	1.28E-06	6.75E-07	6.94E-07	6.02E-07	5.35E-07	6.22E-07	5.84E-07	4.30E-07	3.02E-07	1.97E-07	1.20E-07
SE	1.96E-06	2.78E-06	2.11E-06	1.40E-06	7.69E-07	6.43E-07	5.06E-07	3.74E-07	2.75E-07	2.11E-07	1.68E-07
SSE	1.46E-06	6.91E-06	2.21E-06	7.78E-07	1.80E-07	4.19E-07	5.29E-07	3.79E-07	2.74E-07	2.09E-07	1.52E-07

Table 4.8-18: Annual Average X/Q for 8 Day Decay, Depleted for Specified Distances at Each Sector (Page 2 of 3)

Sector	Distance (miles)										
	5	7.5	10	15	20	25	30	35	40	45	50
S	2.35E-07	1.16E-07	7.24E-08	3.91E-08	2.52E-08	1.78E-08	1.34E-08	1.05E-08	8.45E-09	6.98E-09	5.86E-09
SSW	2.21E-07	1.31E-07	9.11E-08	6.55E-08	4.23E-08	3.00E-08	2.26E-08	1.77E-08	1.43E-08	1.19E-08	9.98E-09
SW	3.62E-07	1.65E-07	9.71E-08	8.95E-08	5.78E-08	4.10E-08	3.09E-08	2.43E-08	1.96E-08	1.61E-08	1.36E-08
WSW	4.09E-07	2.20E-07	1.39E-07	7.55E-08	4.81E-08	3.47E-08	2.61E-08	2.05E-08	1.60E-08	1.37E-08	1.15E-08
W	2.97E-07	1.27E-07	6.60E-08	5.46E-08	3.48E-08	2.43E-08	1.74E-08	1.46E-08	1.21E-08	1.00E-08	8.11E-09
WNW	5.70E-08	5.48E-08	5.19E-08	2.76E-08	2.52E-08	1.77E-08	1.34E-08	1.07E-08	8.62E-09	7.11E-09	5.97E-09
NW	5.98E-08	6.65E-08	6.66E-08	2.19E-08	2.40E-08	1.60E-08	1.17E-08	1.02E-08	8.24E-09	6.80E-09	5.72E-09
NNW	9.66E-08	1.32E-07	9.66E-08	2.25E-08	2.64E-08	1.81E-08	1.48E-08	1.44E-08	1.17E-08	9.66E-09	8.14E-09
N	4.03E-07	1.68E-07	8.15E-08	5.81E-08	4.28E-08	3.04E-08	2.28E-08	1.68E-08	1.47E-08	1.19E-08	9.92E-09
NNE	3.07E-07	1.42E-07	8.22E-08	5.83E-08	7.86E-08	5.60E-08	4.23E-08	3.25E-08	2.38E-08	1.86E-08	1.16E-08
NE	1.45E-07	8.46E-08	5.75E-08	7.39E-08	4.75E-08	2.88E-08	1.72E-08	1.49E-08	1.31E-08	1.33E-08	1.07E-08
ENE	2.19E-07	1.23E-07	7.73E-08	3.29E-08	2.65E-08	1.88E-08	1.41E-08	1.11E-08	7.16E-09	7.37E-09	6.21E-09
E	6.94E-08	7.62E-08	5.11E-08	2.71E-08	1.73E-08	1.22E-08	9.11E-09	7.10E-09	5.71E-09	4.70E-09	3.94E-09
ESE	7.40E-08	5.96E-08	4.68E-08	2.51E-08	1.60E-08	1.13E-08	8.46E-09	6.60E-09	5.31E-09	4.38E-09	3.60E-09
SE	1.38E-07	6.85E-08	4.23E-08	2.27E-08	1.45E-08	1.03E-08	7.69E-09	6.01E-09	4.84E-09	3.99E-09	3.35E-09
SSE	1.06E-07	6.75E-08	4.20E-08	2.25E-08	1.44E-08	1.01E-08	7.56E-09	5.89E-09	4.74E-09	3.90E-09	3.27E-09

Table 4.8-18: Annual Average X/Q for 8 Day Decay, Depleted for Specified Distances at Each Sector (Page 3 of 3)

Sector	Distance (miles)									
	0.5-1	**1-2**	**2-3**	**3-4**	**4-5**	**5-10**	**10-20**	**20-30**	**30-40**	**40-50**
S	2.32E-07	1.20E-07	1.26E-07	3.19E-07	2.90E-07	1.23E-07	4.03E-08	1.80E-08	1.05E-08	7.00E-09
SSW	5.11E-07	8.00E-07	3.01E-07	1.80E-07	2.08E-07	1.33E-07	6.09E-08	3.03E-08	1.78E-08	1.19E-08
SW	3.67E-07	2.73E-07	2.77E-07	3.03E-07	3.47E-07	1.79E-07	7.71E-08	4.15E-08	2.44E-08	1.62E-08
WSW	1.18E-06	2.06E-06	6.77E-07	3.65E-07	4.11E-07	2.26E-07	7.75E-08	3.48E-08	2.04E-08	1.36E-08
W	2.42E-07	2.89E-07	3.60E-07	3.70E-07	3.25E-07	1.38E-07	4.83E-08	2.43E-08	1.44E-08	9.92E-09
WNW	1.73E-07	1.88E-07	3.38E-07	2.47E-07	8.95E-08	5.40E-08	3.19E-08	1.80E-08	1.07E-08	7.14E-09
NW	1.78E-07	2.19E-07	1.13E-07	7.00E-08	6.29E-08	6.50E-08	3.28E-08	1.64E-08	9.87E-09	6.83E-09
NNW	2.09E-07	2.84E-07	2.57E-07	1.80E-07	1.17E-07	1.08E-07	4.07E-08	1.90E-08	1.35E-08	9.70E-09
N	2.95E-07	2.45E-07	4.56E-07	5.43E-07	4.58E-07	1.82E-07	5.65E-08	3.07E-08	1.77E-08	1.20E-08
NNE	6.33E-07	4.41E-07	4.80E-07	4.34E-07	3.40E-07	1.52E-07	7.26E-08	5.66E-08	3.20E-08	1.75E-08
NE	9.81E-07	5.72E-07	2.87E-07	1.88E-07	1.57E-07	8.61E-08	5.85E-08	2.92E-08	1.49E-08	1.23E-08
ENE	6.21E-07	5.63E-07	3.26E-07	2.41E-07	2.29E-07	1.24E-07	3.99E-08	1.90E-08	1.04E-08	6.88E-09
E	1.60E-06	1.59E-06	3.93E-07	1.05E-07	7.86E-08	6.36E-08	2.81E-08	1.23E-08	7.15E-09	4.72E-09
ESE	6.49E-07	5.89E-07	5.33E-07	2.98E-07	1.26E-07	5.71E-08	2.59E-08	1.14E-08	6.64E-09	4.37E-09
SE	1.94E-06	8.52E-07	4.90E-07	2.79E-07	1.70E-07	7.23E-08	2.34E-08	1.04E-08	6.04E-09	4.01E-09
SSE	2.62E-06	4.19E-07	4.39E-07	2.79E-07	1.52E-07	6.46E-08	2.32E-08	1.02E-08	5.93E-09	3.91E-09

Table 4.8-19: Annual Average D/Q for Specified Distances at Each Sector (Page 1 of 3)

Sector	Distance (miles)										
	0.25	0.5	0.75	1	1.5	2	2.5	3	3.5	4	4.5
S	4.59E-09	3.14E-09	2.13E-09	1.20E-09	4.99E-10	2.83E-10	1.83E-10	1.30E-10	1.70E-10	2.69E-10	2.15E-10
SSW	5.48E-09	3.97E-09	2.94E-09	1.72E-09	7.81E-10	4.20E-10	2.69E-10	1.87E-10	1.40E-10	1.09E-10	9.14E-11
SW	1.00E-08	7.16E-09	5.07E-09	2.99E-09	1.28E-09	7.29E-10	4.72E-10	3.41E-10	2.54E-10	2.09E-10	1.84E-10
WSW	1.19E-08	8.41E-09	6.47E-09	3.93E-09	3.27E-09	1.01E-09	6.09E-10	3.87E-10	3.01E-10	2.62E-10	2.79E-10
W	3.68E-09	2.78E-09	2.04E-09	1.25E-09	5.29E-10	3.03E-10	2.13E-10	1.51E-10	1.27E-10	1.20E-10	1.25E-10
WNW	2.36E-09	1.79E-09	1.30E-09	7.70E-10	3.23E-10	1.85E-10	1.25E-10	9.83E-11	6.77E-11	5.05E-11	3.79E-11
NW	2.05E-09	1.55E-09	1.15E-09	6.86E-10	2.93E-10	1.69E-10	1.10E-10	7.76E-11	5.75E-11	4.43E-11	3.51E-11
NNW	2.70E-09	2.01E-09	1.46E-09	8.49E-10	3.51E-10	1.99E-10	1.29E-10	9.16E-11	6.82E-11	5.20E-11	4.08E-11
N	6.41E-09	4.74E-09	3.39E-09	1.98E-09	8.29E-10	4.77E-10	3.11E-10	2.30E-10	1.99E-10	2.04E-10	2.01E-10
NNE	1.70E-08	1.24E-08	8.68E-09	4.99E-09	2.06E-09	1.15E-09	7.61E-10	5.31E-10	3.96E-10	3.08E-10	2.59E-10
NE	2.24E-08	1.61E-08	1.12E-08	6.36E-09	2.73E-09	1.45E-09	9.23E-10	6.42E-10	4.72E-10	3.62E-10	2.86E-10
ENE	1.24E-08	9.05E-09	6.34E-09	3.80E-09	1.56E-09	8.68E-10	5.54E-10	3.86E-10	3.07E-10	2.46E-10	2.24E-10
E	1.06E-08	8.19E-09	6.36E-09	4.74E-09	3.90E-09	1.32E-09	4.98E-10	3.11E-10	2.29E-10	1.75E-10	1.39E-10
ESE	1.44E-08	9.70E-09	7.01E-09	4.01E-09	1.64E-09	1.12E-09	1.18E-09	9.60E-10	5.60E-10	3.15E-10	1.99E-10
SE	1.56E-08	1.33E-08	7.49E-09	3.77E-09	1.57E-09	1.25E-09	8.67E-10	6.49E-10	4.62E-10	3.46E-10	2.70E-10
SSE	6.73E-09	8.97E-09	3.14E-09	1.30E-09	5.05E-10	3.05E-10	4.34E-10	3.88E-10	2.71E-10	1.61E-10	9.87E-11

Table 4.8-19: Annual Average D/Q for Specified Distances at Each Sector (Page 2 of 3)

Sector	Distance (miles)										
	5	**7.5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**
S	1.71E-10	7.75E-11	4.93E-11	2.37E-11	1.44E-11	9.77E-12	7.07E-12	5.35E-12	4.19E-12	3.37E-12	2.76E-12
SSW	8.32E-11	4.71E-11	4.02E-11	4.21E-11	2.43E-11	1.65E-11	1.17E-11	9.01E-12	7.05E-12	5.66E-12	4.64E-12
SW	1.89E-10	9.14E-11	5.15E-11	6.25E-11	3.83E-11	2.65E-11	1.92E-11	1.46E-11	1.14E-11	9.28E-12	7.60E-12
WSW	3.06E-10	1.81E-10	1.16E-10	5.88E-11	3.81E-11	2.47E-11	1.84E-11	1.37E-11	1.16E-11	8.73E-12	7.20E-12
W	1.24E-10	7.06E-11	2.55E-11	2.90E-11	2.01E-11	1.43E-11	1.02E-11	7.12E-12	5.34E-12	4.47E-12	3.81E-12
WNW	3.06E-11	1.55E-11	1.53E-11	5.36E-12	1.72E-11	1.13E-11	8.03E-12	4.97E-12	3.88E-12	3.17E-12	2.59E-12
NW	2.84E-11	1.94E-11	3.76E-11	4.53E-12	1.52E-11	1.06E-11	4.03E-12	4.48E-12	3.60E-12	2.88E-12	2.35E-12
NNW	3.30E-11	6.04E-11	4.88E-11	5.24E-12	9.62E-12	4.41E-12	3.38E-12	5.79E-12	4.58E-12	3.70E-12	3.02E-12
N	1.91E-10	7.06E-11	2.83E-11	2.32E-11	2.61E-11	1.78E-11	1.29E-11	6.30E-12	4.68E-12	6.79E-12	5.26E-12
NNE	2.18E-10	9.18E-11	5.43E-11	2.91E-11	5.81E-11	3.97E-11	2.90E-11	2.46E-11	1.94E-11	8.27E-12	5.10E-12
NE	2.31E-10	1.10E-10	6.81E-11	9.61E-11	5.62E-11	2.03E-11	1.36E-11	1.11E-11	9.29E-12	8.98E-12	1.01E-11
ENE	2.42E-10	1.43E-10	9.57E-11	3.39E-11	3.14E-11	2.12E-11	1.53E-11	1.15E-11	8.95E-12	7.22E-12	5.92E-12
E	1.12E-10	9.90E-11	6.83E-11	3.86E-11	2.35E-11	1.58E-11	1.14E-11	8.58E-12	6.68E-12	5.35E-12	4.39E-12
ESE	1.36E-10	9.70E-11	8.21E-11	4.53E-11	2.75E-11	1.85E-11	1.33E-11	1.00E-11	7.83E-12	6.27E-12	5.41E-12
SE	2.17E-10	1.08E-10	6.52E-11	3.40E-11	2.06E-11	1.39E-11	1.00E-11	7.57E-12	5.91E-12	4.74E-12	3.88E-12
SSE	6.35E-11	5.72E-11	3.61E-11	1.96E-11	1.12E-11	7.62E-12	5.52E-12	4.19E-12	3.28E-12	2.64E-12	2.17E-12

Table 4.8-19: Annual Average D/Q for Specified Distances at Each Sector (Page 3 of 3)

Sector	Distance (miles)									
	0.5-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
S	1.94E-09	5.58E-10	1.88E-10	1.96E-10	2.15E-10	8.57E-11	2.53E-11	9.93E-12	5.40E-12	3.39E-12
SSW	2.63E-09	8.29E-10	2.76E-10	1.42E-10	9.37E-11	5.20E-11	3.38E-11	1.67E-11	9.04E-12	5.70E-12
SW	4.61E-09	1.41E-09	4.88E-10	2.62E-10	1.93E-10	9.54E-11	4.93E-11	2.67E-11	1.47E-11	9.28E-12
WSW	5.77E-09	2.41E-09	6.28E-10	3.11E-10	2.84E-10	1.80E-10	6.22E-11	2.57E-11	1.42E-11	9.02E-12
W	1.85E-09	5.88E-10	2.12E-10	1.31E-10	1.23E-10	6.23E-11	2.43E-11	1.42E-11	7.34E-12	4.48E-12
WNW	1.18E-09	3.61E-10	1.30E-10	6.99E-11	3.89E-11	1.88E-11	1.28E-11	1.16E-11	5.43E-12	3.16E-12
NW	1.03E-09	3.25E-10	1.13E-10	5.82E-11	3.53E-11	2.95E-11	1.66E-11	9.18E-12	4.02E-12	2.90E-12
NNW	1.31E-09	3.94E-10	1.33E-10	6.87E-11	4.12E-11	4.92E-11	1.69E-11	5.39E-12	4.64E-12	3.71E-12
N	3.06E-09	9.29E-10	3.23E-10	2.10E-10	1.98E-10	7.85E-11	2.56E-11	1.80E-11	7.56E-12	5.60E-12
NNE	7.86E-09	2.31E-09	7.73E-10	4.01E-10	2.58E-10	1.03E-10	4.76E-11	4.03E-11	2.39E-11	1.04E-11
NE	1.01E-08	2.97E-09	9.50E-10	4.78E-10	2.88E-10	1.18E-10	7.21E-11	2.72E-11	1.11E-11	9.50E-12
ENE	5.81E-09	1.75E-09	5.71E-10	3.06E-10	2.37E-10	1.44E-10	4.65E-11	2.15E-11	1.16E-11	7.25E-12
E	6.04E-09	2.94E-09	6.41E-10	2.32E-10	1.40E-10	8.83E-11	3.85E-11	1.61E-11	8.66E-12	5.39E-12
ESE	6.27E-09	1.94E-09	1.08E-09	5.81E-10	2.10E-10	9.91E-11	4.56E-11	1.88E-11	1.01E-11	6.41E-12
SE	7.12E-09	1.91E-09	8.81E-10	4.71E-10	2.73E-10	1.13E-10	3.50E-11	1.42E-11	7.64E-12	4.77E-12
SSE	3.62E-09	5.94E-10	3.81E-10	2.63E-10	1.04E-10	4.92E-11	1.95E-11	7.75E-12	4.22E-12	2.65E-12

Table 4.8-20: X/Q and D/Q Values for No Decay, Decay, and Undepleted at Each Receptor Location (Page 1 of 2)

Receptor	Sector	Distance (miles)	Distance (meters)	X/Q Values (sec/m^3) No Decay Undepleted	X/Q Values (sec/m^3) 2.26 Decay Undepleted	X/Q Values (sec/m^3) 8 Day Delay Depleted	D/Q (m^{-2})
Site Boundary	S	0.29	466	5.17E-07	5.16E-07	5.15E-07	4.39E-09
	SSW	0.31	495	6.49E-07	6.47E-07	6.44E-07	5.21E-09
	SW	0.34	549	7.38E-07	7.36E-07	7.32E-07	9.09E-09
	WSW	0.33	531	9.22E-07	9.20E-07	9.13E-07	1.09E-08
	W	0.2	315	4.74E-07	4.73E-07	4.71E-07	2.72E-09
	WNW	0.27	428	3.46E-07	3.46E-07	3.44E-07	2.35E-09
	NW	0.31	506	2.53E-07	2.52E-07	2.51E-07	1.96E-09
	NNW	0.38	608	2.95E-07	2.94E-07	2.93E-07	2.39E-09
	N	0.37	596	6.10E-07	6.08E-07	6.05E-07	5.69E-09
	N	0.47	757	4.38E-07	4.37E-07	4.33E-07	4.95E-09
	N	0.5	804	4.04E-07	4.03E-07	3.99E-07	4.74E-09
	NNE	0.25	408	1.70E-06	1.70E-06	1.69E-06	1.69E-08
	NE	0.2	321	2.40E-06	2.39E-06	2.38E-06	1.80E-08
	ENE	0.2	315	1.42E-06	1.42E-06	1.41E-06	9.59E-09
	E	0.22	350	1.21E-06	1.21E-06	1.20E-06	9.27E-09
	ESE	0.28	449	9.42E-07	9.41E-07	9.32E-07	1.39E-08
	SE	0.34	549	2.06E-06	2.06E-06	2.05E-06	1.78E-08
	SSE	0.38	613	2.54E-06	2.53E-06	2.49E-06	7.17E-09

Table 4.8-20: X/Q and D/Q Values for No Decay, Decay, and Undepleted at Each Receptor Location (Page 2 of 2)

				X/Q Values (sec/m³)			
		Distance		No Decay	2.26 Decay	8 Day Delay	D/Q
Receptor	Sector	(miles)	(meters)	Undepleted	Undepleted	Depleted	(m^{-2})
Residence	S	0.7	1127	2.42E-07	2.41E-07	2.39E-07	2.28E-09
	SSW	0.7	1127	3.87E-07	3.85E-07	3.83E-07	3.13E-09
	SW	0.7	1127	3.70E-07	3.68E-07	3.64E-07	5.38E-09
	WSW	0.7	1127	9.41E-07	9.39E-07	9.38E-07	6.94E-09
	W	0.7	1127	2.32E-07	2.31E-07	2.29E-07	2.15E-09
	WNW	0.7	1127	1.67E-07	1.66E-07	1.65E-07	1.38E-09
	NW	0.7	1127	1.52E-07	1.51E-07	1.49E-07	1.21E-09
	NNW	0.7	1127	1.74E-07	1.73E-07	1.72E-07	1.55E-09
	N	0.7	1127	2.92E-07	2.91E-07	2.87E-07	3.60E-09
	NNE	0.7	1127	6.40E-07	6.38E-07	6.29E-07	9.26E-09
	NE	0.7	1127	1.03E-06	1.03E-06	1.02E-06	1.19E-08
	ENE	0.7	1127	5.97E-07	5.96E-07	5.90E-07	6.77E-09
	E	0.7	1127	1.22E-06	1.22E-06	1.21E-06	6.19E-09
	ESE	0.7	1127	6.80E-07	6.79E-07	6.69E-07	6.94E-09
	SE	0.7	1127	2.21E-06	2.20E-06	2.19E-06	8.29E-09
	SSE	0.7	1127	2.73E-06	2.71E-06	2.66E-06	4.16E-09
Note: The nearest resident distance of 0.7 miles was used for all sectors.							

Table 4.8-21: Gaseous Pathway Parameters – GASPAR II Information

Parameter	Values
Release source terms	See Table 4.8-14.
Population	664,124
Meteorology	See Tables 4.8-6 to 4.8-13.

Table 4.8-22: Gaseous Effluent Doses to MEI

Location	Pathway		Dose per Unit (mrem/yr)							
			Total Body	GI-Tract	Bone	Liver	Kidney	Thyroid	Lung	Skin
Maximum Dose Site Boundary Location (0.38 miles, SSE)	External	Plume	7.2E-02	7.2E-02	7.2E-02	7.2E-02	7.2E-02	7.2E-02	7.4E-02	1.7E-01
		Ground	1.9E-01	1.9E-01	1.9E-01	1.9E-01	1.9E-01	1.9E-01	1.9E-01	2.3E-01
		Total	2.6E-01	2.6E-01	2.6E-01	2.6E-01	2.6E-01	2.6E-01	2.6E-01	3.9E-01
	Inhalation	Adult	2.1E-02	2.1E-02	1.4E-02	2.1E-02	2.2E-02	1.6E-01	2.8E-02	1.8E-02
		Teen	2.2E-02	2.2E-02	2.0E-02	2.3E-02	2.3E-02	1.9E-01	3.4E-02	1.8E-02
		Child	2.1E-02	2.1E-02	2.7E-02	2.2E-02	2.2E-02	2.3E-01	3.0E-02	1.6E-02
		Infant	1.3E-02	1.3E-02	1.8E-02	1.4E-02	1.4E-02	2.0E-01	2.0E-02	9.2E-03
	All	Adult	2.8E-01	2.8E-01	2.8E-01	2.8E-01	2.8E-01	4.1E-01	2.9E-01	4.0E-01
		Teen	2.8E-01	2.8E-01	2.8E-01	2.8E-01	2.8E-01	4.5E-01	3.0E-01	4.0E-01
		Child	2.8E-01	2.8E-01	2.9E-01	2.8E-01	2.8E-01	4.8E-01	2.9E-01	4.0E-01
		Infant	2.7E-01	2.7E-01	2.8E-01	2.8E-01	2.8E-01	4.6E-01	2.8E-01	3.9E-01
Residence (0.7 miles, SSE)	External	Plume	7.3E-02	7.3E-02	7.3E-02	7.3E-02	7.3E-02	7.3E-02	7.4E-02	5.5E+00
		Ground	1.3E-01	1.3E-01	1.3E-01	1.3E-01	1.3E-01	1.3E-01	1.3E-01	1.5E-01
		Total	1.7E-01	1.7E-01	1.7E-01	1.7E-01	1.7E-01	1.7E-01	1.7E-01	5.6E+00
	Inhalation	Adult	2.2E-02	2.3E-02	1.5E-02	2.3E-02	2.3E-02	1.6E-01	3.0E-02	1.9E-02
		Teen	2.3E-02	2.4E-02	2.1E-02	2.5E-02	2.5E-02	2.1E-01	3.6E-02	1.9E-02
		Child	2.2E-02	2.2E-02	2.9E-02	2.3E-02	2.4E-02	2.4E-01	3.3E-02	1.7E-02
		Infant	1.4E-02	1.4E-02	2.0E-02	1.5E-02	1.5E-02	2.2E-01	2.1E-02	9.9E-03
MEI	All	Adult	1.9E-01	1.9E-01	1.9E-01	1.9E-01	1.9E-01	3.4E-01	2.0E-01	5.6E+00
		Teen	1.9E-01	2.0E-01	1.9E-01	2.0E-01	2.0E-01	3.8E-01	2.1E-01	5.6E+00
		Child	1.9E-01	1.9E-01	2.0E-01	1.9E-01	1.9E-01	4.1E-01	2.0E-01	5.6E+00
		Infant	1.8E-01	1.8E-01	1.9E-01	1.9E-01	1.9E-01	3.9E-01	1.9E-01	5.6E+00
	Max		1.9E-01	2.0E-01	2.0E-01	2.0E-01	2.0E-01	4.1E-01	2.1E-01	5.6E+00
	Group		Teen	Teen	Child	Teen	Teen	Child	Teen	Teen

Note: In the first four rows for the MEI, MEI doses are obtained by conservatively summing the residence total external dose with the residence inhalation even though they are not all at the same location.

4.9 WASTE MANAGEMENT

4.9.1 Sources and Types of Waste Created

The following sections discuss nonradioactive, nonhazardous hazardous, and radioactive wastes associated with the facility during construction, operation, and decommissioning.

4.9.1.1 Construction

During the construction phase, the majority of waste generated would be construction and demolition (C&D) waste. Local solid waste haulers would be contracted to dispose of C&D waste in permitted local landfills. Such waste would include material produced directly or incidentally by C&D. Examples of which would include scrap lumber, bricks, sandblast grit, glass, wiring, non-asbestos insulation, roofing materials, building siding, scrap metal, concrete with reinforcing steel, nails, wood, electrical wiring, rebar, concrete, excavated dirt, tree stumps, rubble, and similar construction and demolition wastes. Kairos Power would secure the necessary contracts for proper disposal of C&D wastes.

Soils excavated for the purpose of construction would be stockpiled on site and managed to limit water and wind erosion as well as impacts from runoff. Sanitary wastes would be picked up on a routine schedule and transported to a local sanitary waste landfill. Only small amounts of hazardous waste would be generated during construction. These could include waste oils, degreasers, etc. No radioactive waste would be generated during construction. However, as the site was previously the site of a gaseous diffusion plant and it has undergone a radiological remediation and release, there is a potential for encountering radioactive materials that are not related to the construction and operation of the Hermes reactor. As the facility is a relatively small industrial facility, the impacts of waste management from construction activities would be SMALL.

4.9.1.2 Operation

Facility operations would generate municipal solid waste commonly known as “trash” or “garbage” which would consists of food waste, plastic film, paper waste, and food product packaging waste. General office and industrial supplies waste would also be generated at the facility. Solid wastes generated in conjunction with operation of the facility would be managed in accordance with applicable state and federal environmental regulations and disposed in approved and licensed disposal facilities. Solid wastes (e.g., office waste, recyclables) would be collected and stored temporarily onsite and disposed of or recycled locally. The waste would be transported from the site by a local sanitary waste entity without being treated or packaged. These activities would be typical for a general commercial facility within the Oak Ridge area.

While the facility would be registered as a Small Quantity Generator, there would be no significant sources of hazardous waste during facility operations. However, all hazardous wastes, including universal wastes, would be managed in accordance with a written waste management plan that conforms to all State and Federal regulations regarding the storage and disposal of hazardous waste.

Radioactive waste that would be generated by the operation of the facility, include but are not limited to:

- Spent fuel pebbles
- Flibe
- Nitrate salt
- Filters and cold traps
- Routine waste from maintenance activities

Systems designed to support the safe and efficient management of these waste streams are described in Section 2.6. These waste systems would be operated in accordance with written procedures such that the final waste form would be acceptable for transportation in U.S. Department of Transportation (DOT) and/or NRC certified shipping containers. The quantities of radioactive wastes are also discussed in Section 2.6. There would be no on-site disposal of radioactive wastes during operations.

Each Hermes TRISO fuel pebble is estimated at 6 grams of uranium. At 35 MWth and 6 percent fissions per initial (heavy) metal atom (FIMA), an estimated 38,800 pebbles, or approximately 233 kilograms of uranium, will be consumed by the Hermes Reactor each year. Since the life of the Hermes Reactor is estimated to be 10 years, a total of 388,000 pebbles, or approximately 2,330 kilograms of uranium (2.33 metric tons of uranium [MTU] over 10 years), would be consumed (this is a conservative estimate that assumes Hermes operates at full power). In contrast, the amount of spent fuel discharged from a typical light water reactor operating at low burnups is about 20 MTU per year.

Reprocessing is currently unlikely in the U.S., and an open fuel cycle is anticipated. Used TRISO fuel is assumed to be stored onsite until ultimate disposal. Management of used nuclear fuel is addressed in 10 CFR 51.23 and the associated NUREG–2157, Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel (Reference 1). NUREG–2157 concluded that the impact for at-reactor storage for each resource most of the resource areas would be small for short-term, long-term, and indefinite storage. NUREG-2157 did not address non-LWRs; to provide additional guidance to non-LWR license applications, the NRC, through Pacific Northwest National Laboratory, prepared Non-LRW Reactor Fuel Environmental Data (PNNL-29367) (Reference 2). Given degradation rates for storage systems associated with continued storage of TRISO fuel would not be significantly different than those considered for LWR storage systems, the environmental impacts for continued storage of LWRs described in NUREG–2157 are considered to bound any impacts of the Hermes fuel storage. Furthermore, the anticipated low mass of spent fuel generated during Hermes operations, approximately 2.33 MTU over 10 years, would be significantly lower than the 20 MTU per year generated from the power reactor evaluated in NUREG–2157.

Based on the quantities of waste, systems designed to manage radioactive waste streams, and waste management, impacts from all types of waste generated during operations, including impacts on the capacity of waste management facilities, would be SMALL. Impacts from waste transportation are discussed in Section 4.10.

4.9.1.3 Decommissioning

Prior to decommissioning the facility, Kairos Power would provide the NRC with a license termination plan (LTP) as described in NUREG 1757, Consolidated Decommissioning Guidance, Volumes 1 through 4. The LTP is defined in NUREG 1757 as a “detailed description of the activities a reactor licensee intends to use to assess the radiological status of its facility, to remove radioactivity attributable to licensed operations at its facility to levels that permit release of the site in accordance with NRC’s regulations and termination of the license, and to demonstrate that the facility meets NRC’s requirements for release. An LTP consists of several interrelated components including: (1) a site characterization; (2) identification of remaining dismantlement activities; (3) plans for site remediation; (4) detailed plans for the final radiation survey; (5) a description of the end use of the facility, if restricted; (6) an updated site-specific estimate of remaining decommissioning costs; and (7) a supplement to the environmental report, pursuant to 10 CFR 51.33, describing any new information or significant environmental change associated with the licensee’s proposed termination activities (see 10 CFR 50.82).”

There would be no onsite disposal of waste during decommissioning of the facility. Aspects of decommissioning, including waste management, would be described in the LTP which would be submitted to the NRC for review.

The environmental impacts from the decommissioning of nuclear power plants, including the impacts from wastes generated during decommissioning, have been analyzed by the NRC as described in NUREG-0586, *Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities,* Supplement 1, Volume 1. For each impact area affected by waste management, the NRC concluded that the impacts from waste management operations will not result in an impact that will be greater than SMALL, including the commitments of land required for disposal of LLRW. Given the facility would be much smaller than the reactor facilities analyzed in NUREG-0586, the impacts from waste management during decommissioning would be bounded by the conclusion made by the NRC and would also be SMALL. While Supplement 1 of NUREG-0586 excludes test reactors, the original NUREG-0586, dated August 1988, does not exclude test reactors and the conclusions provided in the 1998 version NUREG-0586 for test reactors are consistent with the conclusions provided in Supplement 1 of NUREG-0586.

4.9.2 References

1. U.S. Nuclear Regulatory Commission. “Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel,” NUREG-2157, Vol. 1. September 2014.
2. Pacific Northwest National Laboratory. "Non-LRW Reactor Fuel Environmental Data," PNNL-29367. September 2020.

4.10 TRANSPORTATION

Transportation of nuclear and nonnuclear materials would be required during construction, operation, and decommissioning of the facility. These materials would include construction materials, construction and demolition wastes, new nuclear fuel, nitrate salts and Flibe salts, radioactive waste, and routine nonradioactive waste. The following subsections describe the environmental consequences of transportation of these materials within the context of the requirements of Section 19.4.10, *Transportation*, of the ISG for NUREG-1537. The guidance states that the following should be presented in the ER:

- Transportation mode (i.e., truck, plane, rail, or barge) and projected destinations of the radioactive waste and nonradioactive waste
- Estimated transportation distance from the originating site to the projected destinations of the radioactive waste and nonradioactive waste
- Treatment and packaging for radioactive and nonradioactive wastes
- Calculated radiological dose to members of the public and workers from incident-free transportation scenarios

The NRC has generically evaluated the environmental impacts of the transportation of fuel and radioactive waste in Table S-4 of 10 CFR 51.52 for light water reactor (LWR) fuel that meet certain entry conditions specified in 10 CFR 51.52(a). Section 10 CFR 51.52 discusses LWRs but does not provide direction on evaluating transportation of nuclear fuel and waste to and from non-LWRs in an ER. However, the applicant and the NRC must still evaluate transportation. As such, to provide additional guidance to non-LWR license applications, the NRC, through Pacific Northwest National Laboratory, prepared *Environmental Impacts from Transportation of Fuel and Wastes to and from Non-LWRs* (PNNL-29365) (Reference 1).

While considering the information requested for non-power reactors in Section 19.4.10 of the ISG for NUREG-1537 and the additional guidance provided in PNNL-29365 for non-LWR license applications, transportation impacts are assessed in the following sections broken down by the phase of the reactor's life:

- Construction
  - Nonradioactive material and waste shipments
- Operation
  - Nonradioactive material and waste shipments
  - New unirradiated fuel shipments
  - LLRW shipments
- Decommissioning
  - Nonradioactive waste shipments
  - Spent fuel shipments
  - LLRW shipment

4.10.1 Impacts from Construction

Construction materials are expected to be transported to the facility primarily via truck; however, rail lines are accessible in close proximity to the site. The impacts from the increased traffic from the construction phase of the project on other resources such as air quality, noise, etc. are described in

other sections of this ER and the direct and indirect impacts from the construction-related traffic would be SMALL.

4.10.2 Impacts from Operation

During the operation period, which includes startup activities, the facility would receive shipments of new nuclear fuel and coolant salts. When shipped to the site, the coolant salts would be nonradioactive; however, both the primary salt coolant Flibe and the intermediate (for heat transfer) nitrate salt coolant would become radioactive. There is sufficient storage capacity onsite for storage of the radioactive Flibe wastes, which would be allowed to cool, solidify, and likely held until decommissioning. As such, transportation of Flibe waste is described in Section 4.10.3. If Flibe wastes were shipped prior to decommissioning, impacts would be bound by those described in Section 4.10.2.3. Similarly, there would be sufficient onsite storage capacity for spent TRISO fuel and spent fuel transportation is also discussed in Section 4.10.3.

The following sections describe the impacts from transportation of materials to and from the facility during operations. Collectively, these impacts would be SMALL.

4.10.2.1 Transportation of Unirradiated Fuel

In the United States, low-enriched nuclear fuel for commercial light-water nuclear power plants is manufactured at either one of three facilities located in South Carolina, North Carolina, and Richland, Washington. A decision on the sourcing of fuel has not been made at this time. Fuel may be provided from either existing manufacturers or manufactured by Kairos Power at a nearby facility. For evaluation purposes it is assumed new TRISO fuel would be shipped by truck from Richland, WA. Richland, WA is the location of the furthest nuclear fuel manufacturer in the U.S. from the Kairos site.

Before startup, the facility would receive an initial shipment of fuel and then periodic shipments thereafter of fuel over the reactor's estimated 10-year licensed operating life. The fuel loading for each 4.0 centimeter-diameter fuel pebble is estimated at 6 grams of uranium (6gU/pebble). For Hermes, at 35 MW_{th} and 6 percent fissions per initial (heavy) metal atom (FIMA), 38,800 pebbles will be consumed by the Hermes Reactor each year. Since the life of the Hermes Reactor is estimated to be 10 years, a total of 388,000 pebbles would be consumed.

Fresh fuel would likely be shipped from the manufacturer in appropriately certified containers such as Versa-Pac (VP) containers manufactured by DAHER Group, Transport Logistics International, Inc. (Reference 2). There are two VP sizes available which are certified by the DOT and configured for shipment of uranium oxides, uranium metal, uranyl nitrate crystals, and other uranium compounds such as TRISO fuel, which is specifically mentioned in the certification (Reference 3). The VP-110 is a 110-gallon drum-like package and the VP-55 is a smaller 55-gallon drum-like package. Both packages meet the specifications provided in 49 CFR 173.417 for fissile material package. If the VP-55 is used, each would contain approximately 350 fuel pebbles (Reference 2). The VP-55 has an outer diameter for approximately 23.2 inches and a height of 34.8 inches and has maximum gross weight limit of 750 pounds (Reference 3).

Fuel would be transported to the facility either periodically or once per year given the relatively small quantity involved. Approximately 111 containers of new fuel would be shipped each year consisting of 350 fuel pebbles per VP-55 (Reference 2). A standard highway shipping weight limit of 80,000 pounds gross weight and approximately 40,000 pounds cargo weight for a 40-foot container is maintained. Therefore, at 750 pounds per fuel container containing 350 fuel pebbles, approximately three trucks would be needed to transport a year's supply of fuel when operating at 35 MWth.

Unlike a conventional reactor which places new fuel into its core upon receipt, fuel pebbles would be continually fed into the reactor as spent fuel pebbles are being removed. Therefore, once containers of new fuel are received at the reactor facility, they would be placed into the fresh fuel storage area. There is sufficient on-site storage capacity for new fuel awaiting loading into the reactor at the facility.

Unirradiated fuel would be shipped on exclusive-use vehicles and fuel packages. Conveyances transporting unirradiated fuel packages must satisfy the radiation level restrictions in 49 CFR 173.441. For exclusive use shipments, the dose on contact with the package would not exceed 1 rem per hour (rem/hr) for a closed transport vehicle, 0.2 rem/hr at any point on the outer surface of the vehicle, and 0.01 rem/hr at 2 meters from the outer surface of the vehicle provided the conditions in 49 CFR 173.441(b)(1) are met. However, as evaluated in *Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants*, WASH-1238, external dose rate associated with traditional unirradiated fuel shipments containing between 0.5 and 2.0 curies of uranium in fuel casks would average about 4.0E-04 rem/hr at about 1 meter from the surface of the package and 5.0E-05 rem/hr at about 3 meters, well below the regulatory limits (Reference 4).

Transportation dose modeling of traditional LWR fuel using RADTRAN has demonstrated that the impacts from incident free transportation and transportation accidents is SMALL (Reference 5, Reference 6, Reference 7). The U.S. Department of Defense (DOD), acting through the Strategic Capabilities Office, has analyzed the transportation of high-activity low-enriched uranium TRISO fuels in VP-110 packages from Lynchburg, Virginia to Idaho using RADTRAN and also determined that the radiological risk measured as a risk of latent cancer fatality is less than 1 in 10,000 (Reference 8). Therefore, the impacts from the transportation of TRISO new fuel to the facility would be SMALL. Given uncertainty in the specific shipping modes and routes for transporting TRISO fuel to the facility, the shorter transportation distance than evaluated by DOD, the likely avoidance of major population centers, and the significant amount of past analysis of incident-free transportation of unirradiated nuclear fuel, a case-specific RADTRAN analysis was not performed for this Environmental Report.

4.10.2.2 Transportation of Spent Fuel

Spent fuel pebbles would be stored in long cylindrical storage canisters that are compatible with conventional dry cask storage overpacks. Individual canisters are 12 inches in outer diameter and over 7 feet in height. Each container would hold approximately 1,900 to 2,100 fuel pebbles. Canisters would be stored in a water pool for 30 to 50 days for initial cooling and then transferred to an air-cooled spent fuel storage bay.

Shipments of spent fuel during normal operations are not anticipated. Spent fuel would remain on site in the spent fuel storage facility which would be designed to accommodate all of the spent fuel generated during the expected 10-year licensed life of the reactor. Therefore, transportation of spent fuel is addressed as a decommissioning activity in Section 4.10.3.1 of this Environmental Report.

4.10.2.3 Transportation of Radioactive Waste

Routine LLRW would be transported off-site for disposal via truck. As provided in Table 2.6-1, radioactive waste volumes would be bounded by the estimates in WASH-1238 (Reference 4) and Kairos Power would not ship more than 3,800 ft^3 of Class B solid LLRW, primarily waste generated from tritium removal systems, and less than 400 ft^3 of Class A low-level dry active waste. These volumes would result in approximately 46 truck shipments per year. While some dry active waste may be compacted in waste drums, Kairos Power would not treat any other LLRW on site prior to transportation.

Class B waste would be shipped approximately 1,200 miles to Waste Control Specialists' LLRW disposal site located west of Andrews, Texas. Class A waste would be shipped to Waste Control Specialists or approximately 1,800 miles to Energy*Solutions*' LLRW disposal site located near Clive, Utah.

Prior to shipment, radioactive material would be packaged to meet the DOT and NRC requirements for the transportation of radioactive materials. Class A and Class B waste from routine operations would be packaged and in a solid form. LLRW packaging for transportation would conform with the requirements of 49 CFR 173, Subpart I, *Class 7 (Radioactive) Materials*, and 10 CFR Part 71, *Packaging and Transportation of Radioactive Material*. Class A waste would likely be transported as Low Specific Activity waste and packaged in an industrial package (IP) Type IP-1. IP-1 strong, tight containers would likely include waste boxes (e.g., B-12 or B-25 boxes) and 55-gallon waste drums. Type A and Type B packages would likely be necessary to transport higher activity Class B waste. These packages have been demonstrated to withstand a series of tests, when subjected to normal conditions of transport and hypothetical accident conditions, without releasing the contents.

In accordance with 49 CFR 173.427(a)(1), the external dose rate on a package of Low Specific Activity waste may not exceed an external radiation dose rate of 1 rem/hr at 10 feet from the unshielded material in the package. The dose on contact with the package would not exceed 0.2 rem/hr unless the conveyance is transported by exclusive use shipment. For exclusive use shipments, the dose on contact with the package would not exceed 1 rem/hr provided the conditions in 49 CFR 173.441(b)(1) are met.

LLRW generated from the facility would meet the conditions of 10 CFR 51.52(a)(4) and the number of trucks of radioactive waste would be less than 1 per day (spent fuel is not expected to be shipped during normal operations). Therefore, the environmental impacts under normal conditions of transport, and possible accidents, would not be greater than the impacts set forth in Table S-4 of 10 CFR 51.52. Given that the majority of LLRW shipped from the facility would be in solid form and packaged according to DOT regulations, and the number of radioactive waste shipments and the volumes and activities of the waste is bounded by what is provided in WASH-1238, the impacts from the transportation of LLRW would be SMALL.

4.10.2.4 Transportation of Nonradioactive Materials and Hazardous Waste

General office supplies and industrial supplies supporting the maintenance and day-to-day operations of the facility would be transported to the site. Office waste is generated at the site and transported from the site to a local sanitary waste facility without being treated or packaged. These activities would be typical for a general commercial facility within the Oak Ridge area. The associated incident-free transportation activities do not have an adverse impact on the environment, workers, or the members of the public. There would be no significant shipments of hazardous waste from the facility.

The Flibe reactor coolant and the nitrate salt coolant used to transfer heat from the reactor system to the heat rejection system would be shipped to the facility prior as a solid to startup and during routine operations. Approximately 20 tons of Flibe would be transported via truck in 20 initial 1-ton shipments. Twenty additional 1-ton shipments are expected to be necessary before the end of the first 2 years of operation. Approximately 200 tons of nitrate salt would be needed for reactor startup. This nitrate salt would be transported in 28 shipments, approximately 7 tons each. An additional 200 tons of nitrate salt would be needed annually. The Flibe and nitrate salts are radioactive at the end of their useful life. The Flibe is expected to be stored onsite until decommissioning. Some nitrate salt is expected to be disposed during operations (see Section 2.6.1.1).

The Flibe would be shipped in accordance with DOT regulations for transportation of hazardous materials with the following designations (Reference 9):

- Hazard Class: 6.1, Poison
- Identification Number: UN1566
- Packaging Group: II
- Marine Pollutant

The nitrate salt, a combination of potassium nitrate and sodium nitrate, would be shipped in accordance with DOT regulations for transportation of hazardous materials with the following designations (Reference 10, Reference 11):

- Hazard Class: 5.1, Oxidizer
- Identification Number: UN1486 (potassium nitrate) and UN1498 (sodium nitrate)
- Packaging Group: III

Transportation of the salts to the facility and transportation of nonradioactive materials, nonradioactive waste, and hazardous waste from the facility would be conducted in accordance with applicable Federal and State DOT transportation requirements. As such, the transportation of nonradioactive materials, nonradioactive waste, and hazardous waste associated with the operation of the facility would be SMALL.

4.10.2.5 Incident-Free Radiological Doses

The ISG for NUREG-1537 requests that the applicant assess the radiological impacts of incident-free transportation. The incident-free radiological doses are determined for members of the public and the workers that are involved with the transportation of the radioactive wastes (transportation workers and handling workers). As noted previously, the NRC has determined during its analysis of nuclear power early site permit and construction and operation permit applications that the impacts from transportation accidents involving radioactive waste would be SMALL (Reference 5, Reference 6, Reference 7).

During incident-free transportation of radioactive materials, a radiological dose results from exposure to the external radiation field that surrounds the transportation vehicle. The population dose is a function of the number of people exposed, their proximity to transportation vehicle, their length of time of exposure, and the intensity of the radiation field surrounding the containers. As such, it is independent of the specific radionuclide makeup of the material being transported. For long routes, the average population densities are also similar meaning the primary factor in dose from transportation is distance traveled.

The Tennessee Valley Authority (TVA) recently prepared an ER for the CRN Site Early Site Permit Application. This ER evaluated the dose impacts from incident free transportation for the following 3 transportation scenarios which are considered to be bounding for Hermes reactor project:

- New fuel shipped from Richland, Washington to Oak Ridge, Tennessee
- Spent nuclear fuel shipped from Oak Ridge, Tennessee to Yucca Mountain, Nevada
- LLRW shipped from Oak Ridge, Tennessee to WCS in Texas

Given that dose impacts from incident-free transportation are based on the external dose rate of the conveyance and the distance of the shipment and the TVA shipments were modeled using RADTRAN Version 6.5 at the DOT dose rate limits for exclusive use shipments provided in 49 CFR 173.411(b)(3), the TVA analyses for a single shipment of spent nuclear fuel and LLRW from the CRN site are directly applicable to shipments from the facility and are also assumed to have the same external dose rates. Table 4.10-1 provides the single shipment dose impact from these shipments. Route distances in Table 4.10-1 are approximated from the closest routes provided by Google.com.

Population density along a transportation route is also a factor in determining the population dose along a route. However, for long routes such as Oak Ridge, Tennessee to west Texas, the average population dose along the routes does not vary enough to significantly impact the dose impact per mile. Therefore, the person-rem dose rates for the LLRW shipments analyzed by TVA and presented in Table 4.10-1 were used to estimate the population doses for a LLRW shipment to Energy*Solutions* in Utah. This additional route and dose impact is also provided in Table 4.10-1.

Radiological impacts were determined for two crew members (truck drivers) and the general population that encounter the transport vehicle along the route. The crew receives dose during transportation and during stops for refueling and inspections. The general population is composed of the persons residing within 0.5 mile on either side of the truck route (off-link), persons sharing the road (on-link), and persons at inspection and refueling stops. The radioactive waste shipments were assigned the maximum external dose rate of 10 mrem/hr at 2 meters from the outer lateral surfaces of the vehicle surface of the exclusive use vehicle [49 CFR 173.441(b)(3)]. The TVA RADTRAN model equated this limit to a dose rate of 14 mrem/hr at 1 meter; for new fuel, TVA assumed to be 0.1 mrem/hr at 1 meter (Reference 12).

The incident-free risk from spent fuel shipments would also be bounded by the same dose rate limit. While there is currently no available repository for spent nuclear fuel and the proposed repository at Yucca Mountain in Nevada is not currently moving forward with licensing. The most reasonable off-site storage for spent fuel in the foreseeable future would be regional storage or storage at a DOE facility. It is expected that the incident-free transportation of spent fuel to any future off-site spent fuel storage site would be bounded by shipments to Yucca Mountain.

To calculate the collective dose, a unit risk factor for a single shipment (a per-shipment risk factor) between a given origin and destination was developed to estimate the impact of transporting one shipment of radioactive material over the shipment distances in various population density zones. The unit dose is a function of the distance and exposure time for both the driver and the exposed public. To include the potential of traffic congestion, the analysis assumed that for 10 percent of the time, travel through suburban and urban zones would encounter rush-hour conditions, leading to a lower average speed and higher traffic density.

Table 4.10-2 presents the per-shipment risk factors for the transport of LLRW to Utah and Texas., The risk from new fuel transportation is also considered. Radiological risks are presented in terms of doses and Latent Cancer Fatalities (LCFs) per shipment for each route. The exposed population includes the off-link public (people living along the route), on-link public (pedestrian and car occupants along the route), and public at rest and fuel stops. LCF risk factors were calculated by multiplying the accident dose risks by a health risk conversion factor of 0.0006 LCF per rem or person-rem of exposure (Reference 13).

The annual incident-free radiological doses due to transportation of radioactive materials from the facility are summarized in Table 4.10-2. These doses are calculated on the number of annual shipments provided in the table and discussed in previous sections. The total dose to transportation crews transporting radioactive material to and from the facility during operation is 3.16 person-rem/year. An additional crew dose of 8.40 person-rem/year would be realized shipping spent fuel at decommissioning. The dose to the members of the public due to the transportation of radioactive material to and from the facility during operation is 2.36 person-rem/year. An additional public dose of 4.55 person-rem/year would be recognized shipping spent fuel at decommissioning. Assuming a population in the region of interest (in the five-county area) around the facility is 664,125 people and a 0.31 rem/yr natural background radiation dose, the population dose from background radiation is approximately 2.1E+05 person-rem/year. Compared to the background dose in the vicinity of the facility, the effect of radiation exposure from incident-free transportation is SMALL.

4.10.3 Impacts from Decommissioning

At the time of final reactor shutdown, the facility would initiate decommissioning and transportation of equipment, material, and waste. As noted previously, the facility would not ship spent fuel during the reactor's expected 10-year licensed operating life and would hold all spent fuel shipments until decommissioning. Therefore, the transportation of spent fuel is analyzed below.

4.10.3.1 Transportation of Spent Fuel

While there are currently no available sites to receive spent fuel, such as would be generated from operating the Hermes reactor at the facility, it is assumed that spent fuel shipments would be transported as follows:

- By truck over commercial highways
- To a facility not more than 2,100 miles away, which is the approximate distance from Oak Ridge, Tennessee to Beatty, Nevada (west of Yucca Mountain)
- In a transportation cask that is certified by the NRC and the DOT for transportation of spent TRISO fuel
- Radiation doses to members of the public and workers from incident-free transportation are bounded by the DOT conveyance dose rate limits evaluated in Section 4.10.2.5
- Not more than 60 spent fuel shipments by truck in a single year (bound by the 880 MWe reference reactor in WASH-1238)

Impacts from transportation accidents is not requested in Part 1 of ISG for NUREG-1537. However, NRC has evaluated the risks from spent fuel transport conducted in compliance with 10 CFR Part 71 regulations, *Packaging and Transportation of Radioactive Material*, in NUREG-2125, *Spent Fuel Transportation Risk Assessment*. NUREG-2125 considered radiological and nonradiological risks from routine incident-free transportation and transportation accidents. The findings and conclusions reported by the NRC are that the radiological impacts from spent fuel transportation conducted in compliance with NRC regulations are low.

In NUREG-2125, the NRC provided general insights on expected changes resulting from transporting higher burnup spent LWR fuel. The NRC stated that for incident-free transportation, there would be no effect, as the external dose rates will need to meet the same DOT requirements. The NRC also concluded that impacts to the public will be bounding for accident scenarios even considering changes in the radionuclide inventory and increases in release factors.

Therefore, the impacts from transporting spent fuel from the facility are in compliance with DOT and NRC regulations and would be SMALL.

4.10.3.2 Transportation of Radioactive Waste

The environmental impacts from the decommissioning of nuclear power plants, including the impacts from the transportation of decommissioning waste, have been analyzed by the NRC as described in NUREG-0586, *Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities,* Supplement 1, Volume 1. The NRC made the generic conclusion that for all plants, the potential transportation impacts would be SMALL, with the factor determining the magnitude of transportation impacts of decommissioning including:

- Changes in waste production due to decontamination and dismantlement activities that increase the amount of waste shipped offsite
- Changes in transportation methods (rail, truck, or barge) related either to the increased amount to be shipped offsite or the type of material to be shipped

- Changes in the mix of types of waste categories shipped

Considering the above factors, the facility decommissioning would be considered bounded by the NRC evaluation as the facility's decommissioning approach would not increase the magnitude of the factors evaluated.

- Due to the small size of the facility, its reactor, and support systems, the amount of waste shipped offsite would be less than the amount of waste generated from large PWRs and BWRs evaluated by the NRC.
- It is expected that radioactive waste, with the exception of spent fuel, would be transported by truck from its facility in the eastern United States to a waste disposal site in the western United States consistent with the analysis conducted by the NRC.
- Most decommissioning waste would be consistent with the waste and waste categories evaluated by the NRC. However, the decommissioning of the facility would include the transportation of radioactive Flibe and nitrate salts which were not considered in the NRC analysis. These wastes would be solid at the time of transportation and would be classified as Class C waste or lower with currently available certified waste transportation packaging and an available disposal site.

Due to the small size of the facility, its reactor, and support systems, the facility decommissioning is considered to be bounded by the NRC assessment in NUREG-0586 of large Pressurized Water Reactors and Boiling Water Reactors. The NRC also concluded decommissioning of non-LWRs (i.e., fast breeder reactor and high-temperature gas reactor) would be bounded by their analysis. Therefore, the impacts from the transportation of radioactive waste from decommissioning the facility would be SMALL.

4.10.3.3 Transportation of Nonradioactive Materials and Waste

The NRC conclusion that transportation of decommissioning wastes would be SMALL included additional nonradiological impacts on public health and safety from transportation accidents associated with transportation of uncontaminated material. The NRC also concluded that the number of shipments into the decommissioning facility would be much smaller than the number of shipments from the facility. As such, the overall impact from the transportation of nonradioactive materials and waste would be SMALL.

4.10.4 References

1. Pacific Northwest National Laboratory. "Environmental Impacts from Transportation of Fuel and wastes to and from Non-LWRs," PNNL-29365. September 2020.
2. Oak Ridge National Laboratory. "Advanced Reactor Safeguards: Nuclear Material Control and Accounting for Pebble Bed Reactors." ORNL/SPR=2020/1849. January 2021.
3. U.S. Department of Transportation. Competent Authority Certification for a Type Fissile Radioactive Materials Package Design Certificate USA/9342/AF-96, Revision 5. September 24, 2021.
4. Atomic Energy Commission. "Environmental Survey of Transportation of Radioactive Material to and from Nuclear Power Reactors." WASH-1238. December 1972.
5. U.S. Nuclear Regulatory Commission. "Final Environmental Impact Statement for Combined Licenses for Virgil C. Summer Nuclear Station, Units 2 and 3." NUREG 1939, Volume 1. April 2011.

6. U.S. Nuclear Regulatory Commission. "Final Supplemental Environmental Impact Statement for Combined License (COLs) for Vogtle Electric Generating Plant Unit 3 and 4." NUREG 1947. March 2011.

7. U.S. Nuclear Regulatory Commission. "Environmental Impact Statement for an Early Site Permit (ESP) at the Clinch River Nuclear Site." NUREG-2226, Volume 1. April 2019.

8. U.S. Department of Defense. "Construction and Demonstration of a Prototype Mobile Microreactor, Environmental Impact Statement." Draft. September 2021.

9. Kairos Power LLC, 2021. Flibe Safety Data Sheet. Issued April 2, 2021.

10. SQM, 2014. Sodium Nitrate Safety Data Sheet. Issued January 2014.

11. SQM, 2015. Potassium Nitrate Safety Data Sheet. Issued March 2015

12. Tennessee Valley Authority. "Clinch River Nuclear Site Early Site Permit, Part 3, Environmental Report." Rev. 2. March 16, 2019.

13. U.S. Department of Energy. "Estimating Radiation Risk from Total Effective Dose Equivalent (TEDEs)." ISCORS Technical Report No. 1. August 9, 2002.

Table 4.10-1: Dose and Risk Factors per Shipment of Radioactive Materials

Origin	Material	Destination	Approx. Distance (miles)	Incident-free Radiation Dose Impacts per Shipment			
				Crew Dose (person-rem)	Crew Risk (LCF)	Population Dose (person-rem)	Population Risk (LCF)
Richland, Washington [a]	New fuel	Oak Ridge, Tennessee	2,450	8.29E-04 [b]	4.97E-07	6.03E-04 [a]	3.62E-07
Oak Ridge, Tennessee	LLRW	ES, Utah	1,860	8.20E-02 [c]	4.92E-05	6.14E-02 [a]	3.68E-05
Oak Ridge, Tennessee	LLRW	WCS, Texas	1,200	5.53E-02 [b]	3.32E-05	4.14E-02 [b]	2.48E-05
Oak Ridge, Tennessee	Spent fuel	Yucca Mtn., NV	2,100	1.40E-01 [b]	8.40E-05	7.58E-02 [b]	4.55E-05

ES – Energy*Solutions*, Clive UT
WCS – Waste Control Specialists, Andrews, TX
Yucca Mnt. – Beatty, NV
[a] Assumed for evaluation purposes.
[b] Calculated by TVA for a similar route (Reference 12).
[c] Based on the person-rem per mile dose rate for TVA-calculated shipments (Reference 12).

Table 4.10-2: Annual Dose and Risk Factors for Shipment of Radioactive Waste

Origin	Material	Destination	Shipments)	Annual Incident-free Radiation Dose Impacts			
				Crew Dose (person-rem)	Crew Risk (LCF)	Population Dose (person-rem)	Population Risk (LCF)
Richland, Washington	New fuel	Oak Ridge, Tennessee	3	2.49E-03	1.492E-06	1.81E-03	1.09E-06
Oak Ridge, Tennessee	LLRW	ES, Utah	23 [a]	1.89E+00	1.13E-03	1.41E+00	8.47E-04
Oak Ridge, Tennessee	LLRW	WCS, Texas	23 [a]	1.27E+00	7.63E-04	9.52E-01	5.71E-04
Total (annual operation)			**49**	**3.16E+00**	**1.90E-03**	**2.37E+00**	**1.42E-03**
Oak Ridge, Tennessee	Spent fuel	Yucca Mtn.	60 [c]	8.40E+00	5.04E-03	4.55E+00	2.73E-03

Kairos – Kairos Hermes Reactor Facility, Oak Ridge, TN
ES – Energy*Solutions*, Clive UT
WCS – Waste Control Specialists, Andrews, TX
Yucca Mtn. – Beatty, NV
[a] Assumed for evaluation purposes.
[b] Half of estimated number of LLRW shipments for the reference reactor (Reference 4).
[c] Estimated number of fuel shipments for the reference reactor (Reference 4); all shipped at decommissioning.

4.11 POSTULATED EVENTS

This section describes the postulated events that are within the design basis of the facility and a maximum hypothetical accident (MHA) that bounds the radiological consequences of the postulated events.

4.11.1 Event Categories

The events are grouped according to type and characteristics of the events. The event categories are:

- MHA
- Insertion of Excess Reactivity
- Salt Spills
- Loss of Forced Circulation (includes a loss of normal electric power)
- Mishandling or Malfunction of Pebble Handling and Storage System
- Radioactive Release from a Subsystem or Component
- Primary Heat Exchanger Tube Break
- General Challenges to Normal Operation
- Internal and External Hazard Events

For postulated events, figures of merit for each event category provide surrogate metrics which demonstrate that the resulting dose is bounded by the dose consequences of the MHA analysis as described in KP-TR-018-P, "Transient Methodology Technical Report" (Reference 1). Acceptance criteria for these figures of merit represent design limits that ensure the MHA is bounding. The MHA dose consequences are evaluated in PSAR Section 13.2.

4.11.2 Event Descriptions

4.11.2.1 Maximum Hypothetical Accident

The MHA is a heat up event where hypothesized conditions result in a conservatively analyzed release of radionuclides. The radioactive material that would be at risk for release in the MHA includes radionuclides contained in the fuel, the radionuclides circulating in the Flibe, and the radioactive material at risk for release distributed within the primary system (i.e., steel structures and graphite). Hypothetical temperature histories are applied to the system, along with the non-physical assumptions described in PSAR Section 13.2, to drive radionuclide movement and bound the system response to other postulated events. The MHA analysis is consistent with the fission product release accident analysis required for the 10 CFR 100.11 determination of exclusion area, low population zone, and population center distances. The MHA is a bounding event with conservative radionuclide transport assumptions that challenge the important radioactive retention features of the functional containment.

4.11.2.2 Insertion of Excess Reactivity

The insertion of reactivity event described in PSAR Section 13.1 is initiated by a control system error or an operator error that causes a continuous withdrawal of the highest worth control element at maximum control element drive speed. The reactivity insertion is detected by the Reactor Protection System due to a high flux or a high coolant temperature, initiating control and shutdown elements insertion, fulfilling the reactivity control function. The decay heat removal system limits reactor temperature and fulfills the heat removal function.

The insertion of excess reactivity category consists of other insertion of reactivity events, including:

- Reactivity insertion events caused by fuel loading error (e.g., errors in rate of fresh fuel injection, incorrect order of fuel insertion)

- Reactivity insertion events with concurrent pump trip
- Reactivity insertion events with normal heat rejection available
- Local phenomena leading to ramp insertion of reactivity
- Change in reactivity due to shifting of graphite reflector blocks
- Venting of gas bubbles accumulated in the active core
- Local phenomena leading to step insertion of reactivity
- Local negative reactivity anomaly (e.g., inadvertent single element insertion, cover gas injection)
- Reactivity insertion events during startup
- Increase in heat removal events (e.g., primary salt pump overspeed, intermediate pump overspeed)

The methods to ensure that this event category is bounded by the MHA are provided in Reference 1.

4.11.2.3 Salt Spills

The salt spill postulated event described in PSAR Section 13.1 initiates when a hypothetical double-ended guillotine break in the primary heat transport system piping during normal operation causes a Flibe spill. The salt spill would be detected by the reactor protection system due to low reactor coolant level, which initiates control and shutdown elements insertion, fulfilling the reactivity control function. The decay heat removal system limits reactor temperature and fulfills the heat removal function. The primary salt pump trips to limit the amount of spilled Flibe. The intermediate salt pump would be tripped concurrently to ensure a positive pressure differential between the primary and intermediate loops. Radionuclides from the coolant circulating activity in the broken pipe are released into the facility air when aerosols are generated from the coolant that exits the pipe. The spilled Flibe forms a Flibe pool, and radionuclides would be released through evaporation until the top surface of the Flibe pool is solidified.

The salt spill category consists of other salt spill events, including:

- Spurious draining and smaller leaks from the primary heat transport system
- Leaks from other Flibe containing systems and components (e.g., inventory management system fill/drain tank, inventory management system piping, chemistry control system piping)
- Leaks up to the hypothetical double-ended guillotine primary salt piping break size
- Mechanical impact or collision events involving Flibe containing structures, systems, and components (except the vessel)
- Leaks from the primary heat rejection system that contains a non-Flibe coolant, which may contain non-zero amount of Flibe from heat exchanger leaks

The methods to ensure that this event category is bounded by the MHA are provided in Reference 1.

4.11.2.4 Loss of Forced Circulation

The postulated loss of forced circulation event described in PSAR Section 13.1 initiates with the seizure of the primary salt pump. The reduced flow would be detected by the reactor protection system, which initiates control and shutdown elements insertion, fulfilling the reactivity control function. The decay heat removal limits reactor temperature and fulfills the heat removal function.

The loss of forced circulation category includes other loss of circulation events, including:

- Blockage of flow path external to the reactor vessel in the primary heat transport system
- Spurious pump trip signal
- Shaft fracture
- Bearing failure

- Pump control system errors
- Supply breaker spurious opening
- Loss of net-positive suction head (e.g., pump overspeed, low level)
- Loss of normal electrical power
- Loss of normal heat sink

The methods to ensure that this event category is bounded by the MHA are provided in Reference 1.

4.11.2.5 Mishandling or Malfunction of Pebble Handling and Storage System

The postulated PHSS malfunction described in PSAR Section 13.1 is a break in a transfer line when pebbles are removed from the core, resulting in a spill of pebbles within the transfer line to the room. This condition would be detected by the reactor protection system, which trips the pebble handling and storage system to stop pebble movement. The design of the pebbles, the pebble handling and storage system, and the surrounding room ensure there would be no inadvertent criticalities, structural damage to pebbles, or overheating. The heat-up of the pebbles in the pebble handling and storage system mobilizes the Flibe accumulated on the piping.

The pebble handling and storage malfunction category consists of other pebble handling and storage malfunctions, including:

- Transfer line break when pebbles are inserted into empty core
- Transfer line break when pebbles are inserted into the core at power
- Transfer line break when pebbles are transferred to storage canisters
- Mishandling of fuel outside the reactor (e.g., containment box, at the material balance areas and key measure points)

The methods to ensure that this event category is bounded by the MHA are provided in Reference 1.

4.11.2.6 Radioactive Release from a Subsystem or Component

A radioactive release from a subsystem or component could result from the failure of a system or component containing radioactive material. However, the limiting event for this category is assumed to be a seismic event that results in the failure of systems containing radioactive material that are not qualified to maintain structural integrity in a safe shutdown earthquake. The only figure of merit for this event is the amount of radioactive material contained in subsystems and components. To ensure that this event group is bounded by the MHA, there is a design requirement on the amount of radioactive material at risk for release in subsystems and components to remain below the amount of radioactive material at risk for release assumed in the MHA. The systems expected to accumulate radionuclides as a function of operation include:

- Tritium management system
- Inert gas system
- Chemistry control system (including filters)
- Inventory management system
- Primary heat rejection system

4.11.2.7 Primary Heat Exchanger Tube Break

The complete break of a primary heat exchanger tube event is described in PSAR Section 13.1. The positive pressure difference maintained between the primary loop and intermediate loop forces the primary Flibe coolant into the intermediate coolant loop and mixes with the secondary nitrate coolant. The tube break would be detected by the reactor protection system due to a drop in the

reactor coolant level, which initiates control and shutdown elements insertion, fulfilling the reactivity control function. The reactor protection system also initiates an intermediate salt pump trip and a primary salt pump trip to limit nitrate ingress into the reactor vessel. The reactor decay heat removal system performs its function to limit reactor temperature and fulfill the heat removal function. This event category also includes a smaller leak in a primary heat exchanger tube.

The methods to ensure that this event category is bounded by the MHA are provided in Reference 1.

4.11.2.8 Internal and External Hazards

The portions of the design relied upon to perform safety functions are protected from the internal and external hazard levels defined in PSAR Chapter 2. Events in this category are bounded by or considered as initiators in other event categories. The internal hazard events in the design basis include:

- Internal fire
- Internal water flood

The external hazard events in the design basis include:

- Seismic event
- High wind event
- Toxic release
- Mechanical impact or collision with structures, systems, and components (SSCs)
- External flood

Engineered safety features contained within areas protected from or able to withstand the intensity of the hazard loading, for hazard events initiated outside those areas (e.g., fire) maintain their capability to bring the plant to a safe state following a postulated event. The SSCs within those areas would be designed to withstand an upper bound hazard loading intensity associated with the area (e.g., SSCs can withstand an upper bound heat load and the associated area is equipped with fire detection and suppression systems to limit the heat load).

For SSCs not protected with such an area, the effects are considered in the event category described in Section 4.11.2.6.

4.11.2.9 General Challenges to Normal Operation

This category of events includes challenges to normal operation not covered by another event category that result in an automatic or manual shutdown of the plant. Disturbances, including an inadvertent operator action, are detected directly or indirectly by the reactor protection system, which initiates control and shutdown elements insertion, fulfilling the reactivity control function. The decay heat removal system would perform its function to limit reactor temperature and fulfill the heat removal function.

Grouped events include spurious trips due to control system anomalies, operator errors, and equipment failures. This event group also includes scenarios where operators choose to manually shut down the plant. Also included are faults in the reactivity control and shutdown system, electrical system, primary heat rejection system, and other plant systems that would challenge normal operations.

This group also contains inert gas system disturbances, and instrumentation and control system faults. This event group relies upon the reactor protection system and is bounded by the loss of forced circulation postulated event.

4.11.3 Consequence Analysis of Maximum Hypothetical Accident

The calculation of the dose consequences of the MHA uses the source term methods for design basis accidents presented in Reference 2. PSAR Section 13.2 describes the MHA analysis, including the application of the non-physical conditions described in Section 4.11.2.1.

The evaluation of the MHA dose consequences first identifies and accounts for the sources of radioactive material at risk for release and the barriers to release. Each barrier is then evaluated for a release fraction to provide dose consequences at the exclusion area and low population zone boundaries.

The four sources of radioactive material at risk for release and the associated barriers to release evaluated in the MHA are:

- TRISO fuel in the reactor core
    - Barriers: TRISO layers, Flibe, and gas space
- Circulating activity
    - Barriers: Flibe and gas space
- Structural MAR: Tritium retained by graphite and in Flibe
    - Barriers: Graphite grains (for non-Flibe tritium) and gas space
- Structural MAR: Argon-41 retained in closed graphite pores
    - Barriers: Graphite pores and gas space

The dose consequences of the MHA are provided in Table 4.11-1. The dose consequence results meet the site dose limits in 10 CFR 100.11(a)(1-2) at the exclusion area boundary and low population zone with significant margin.

4.11.4 References

1. Kairos Power LLC, “Postulated Event Methodology Technical Report,” KP-TR-018-P, Revision 0.

2. Kairos Power LLC, “KP-FHR Mechanistic Source Term Methodology Topical Report,” KP-TR-012-P, Revision 1.

Table 4.11-1: Dose Consequence from the MHA

Location and Duration	Whole Body Dose (rem)		Thyroid Dose (rem)	
	10 CFR 100 Limit	MHA Result	10 CFR 100 Limit	MHA Result
Exclusion Area Boundary (First 2 hours at 250m)	25	0.201	300	0.161
Low Population Zone (30 days at 800m)	25	0.056	300	0.083

4.12 ENVIRONMENTAL JUSTICE

This section describes the potential impacts to environmental justice communities from construction, operation and decommissioning of the facility.

4.12.1 Assessment of Human Health and Environmental Impacts

4.12.1.1 Minority and Low Income Populations

According to the CEQ, adverse health effects to be evaluated within the context of environmental justice impacts may include bodily impairment, infirmity, illness, or death. Environmental effects may include ecological, cultural, human health, economic, or social impacts. Disproportionately high and adverse human health or environmental effects occur when the risk or rate of exposure to an environmental hazard or an impact or risk of an impact on the natural or physical environment for a minority or low-income population is high and appreciably exceeds the impact level for the general population or for another appropriate comparison group (Reference 1).

In accordance with Section 19.4.12 of the ISG for NUREG-1537, and consistent with the Commission's Policy Statement (69 FR 52040) and Environmental Impact Statements for the SHINE and Northwest Medical Isotopes Radioisotope Production Facility construction permits, affected populations are defined as minority and low-income populations who reside within a 5-mi (8-km) radius of the proposed facility site (Reference 2, Reference 3). No environmental justice communities have been identified within the area analyzed; therefore, disproportionate impacts on low-income or minority populations from other actions are not expected. The above sections evaluated the impacts of the proposed project on the human health and the environment. It was determined that activities associated with the construction, operations and decommissioning of the proposed project would be SMALL or non-adverse to the general population. As described in Section 4.2.1.1, plant construction and decommissioning may result in construction related noise, exposure to fugitive dust, increased commuter and other vehicular traffic, exhaust emissions, vibrations, and generation of construction-related wastes. However, these would be short term and primarily limited to onsite activities. Similarly, operations of the site would be expected to have SMALL or non-adverse impacts to the general population. As discussed in Section 3.9, no minority or low-income populations were identified within a 5-mile radius. Therefore, there would be no disproportionate effects to environmental justice communities in association with the Proposed Action, and human health and environmental impacts on minority and low-income populations would be SMALL.

4.12.2 Mitigation Measures

Mitigation measures include implementing best management practices for controlling fugitive dust and proper maintenance of construction equipment for controlling emissions; recycling of construction waste, to the extent possible; and minimizing land disturbance, removing construction debris in a timely manner, and adding landscape enhancements. Additionally, noise levels attenuate to acceptable levels near the site boundary (see Section 4.2). Mitigation measures to reduce or minimize adverse impacts on Environmental Justice (EJ) populations would not be required; any measures as described in Sections 4.12.1 and 4.12.2 would be used to minimize potentially adverse impacts of construction affecting the general population, which would be SMALL.

4.12.3 References

1. Council on Environmental Quality. Environmental Justice: Guidance Under the National Environmental Policy Act. December 10, 1997.

2. NUREG-2183, “Environmental Impact Statement for the Construction Permit for the SHINE Medical Radioisotope Production Facility,” October 2015.

3. NUREG-2209, "Environmental Impact Statement for the Construction Permit for the Northwest Medical Isotopes Radioisotope Production Facility," May 2017.

4.13 CUMULATIVE EFFECTS

This section contains a summary of potential cumulative environmental impacts associated with construction and operation activities for the site in combination with other past, present, and reasonably foreseeable actions or projects in the area. The term *cumulative impact,* which was previously defined in the regulations of the CEQ implementing NEPA, has been repealed. However, in the revised 2020 NEPA regulations, the definition of *effects* or *impacts* (40 CFR 1508.1(g)) includes evaluation of collective actions, and is defined as follows:

> "Effects or impacts means changes to the human environment from the proposed action or alternatives that are reasonably foreseeable and have a reasonably close causal relationship to the proposed action or alternatives, including those effects that occur at the same time and place as the proposed action or alternatives and may include effects that are later in time or farther removed in distance from the proposed action or alternatives."

For the purposes of this evaluation, reasonably foreseeable actions are projects that are clearly indicated in an available long-term master plan or comparable document and/or have received funding and/or have applied for a permit associated with construction or operation. Per NUREG-1537, this section includes "related and non-related federal and non-Federal actions that could contribute to cumulative impacts, such as:

- Information about current or planned local economic development programs or projects (e.g., commercial, industrial, and/or residential); and
- Information about current or planned infrastructure improvements (e.g., transportation, electric and water utility)."

A summary of past, present, and reasonably foreseeable projects that could have a cumulative effect within the geographic area of interest are listed in Table 4.13-1. The cumulative impact assessment for each geographic area of interest that may be affected by the project is presented below. The resources assessed include land use and visual resources; air quality and noise; geologic environment; water resources (hydrology, water use, water quality); ecological resources (terrestrial and aquatic communities); historic and cultural resources; socioeconomics; human health; waste management; and environmental justice. According to the CEQ's Considering Cumulative Effects Under NEPA (Reference 1), the establishment of an appropriate geographic area of analysis is an important step in performing the cumulative effects analysis. The analysis of cumulative environmental impacts is resource specific. The geographic area of analysis of the considered past, present, and reasonably foreseeable actions from the site are the same as those used for each resource discussed above and are based on the environmental effects that may occur to each of the affected resources under consideration. An appropriate context of analysis was selected for each of the resources described below.

4.13.1 Land Use and Visual Resources

The description of the affected environment in Section 3.1 serves as a baseline for the land use and visual resources cumulative impact assessment. The geographic area of analysis for evaluation of cumulative effects on land use and visual resources is the same as that used in Section 4.1 and includes 185 acres within the site boundary and the 5-mile region surrounding the site. As discussed in Section 4.1.1, construction and operation impacts from the facility on land use would be SMALL.

Table 4.13-1 identifies recent past, present, and reasonably foreseeable future actions within the geographic extent of analysis that can be assessed to determine cumulative effects on land use and visual resources. Relevant "other actions" that are considered in this cumulative effects analysis are limited to proposed and/or in progress developments which could alter current land use status and the

visual character of the area. Specifically, as noted in Table 4.13-1, the ETTP, the Proposed CRN site, The Sludge Processing Mock Test Facility, the Roane Regional Business and Technology Park, Kairos Power Fuel Fabrication Facility, Coqui Pharma, the Tellico West Industrial Park, the Horizon Center Industrial Park, the Heritage Center Industrial Park, the Future Oak Ridge Airport, the Preserve at Clinch River, Kingston Point, and the Roane County High School.

4.13.1.1 Land Use Resources

The site consists of a 185-acre parcel located within the DOE ETTP in Oak Ridge, Tennessee. The site is located in Roane County, adjacent to the Clinch River arm of the Watts Bar Reservoir, approximately 13 miles west of downtown Oak Ridge. The site is classified as "public use" on the Tennessee Comptroller of the Treasury Existing Land Use map for Oak Ridge (Reference 2) . As discussed in Section 4.1.1, impacts to land use as a result of the construction, operation, and decommissioning of the Hermes reactor would be SMALL.

The "region" of the site is defined as the area within a 5-mile radius of the site centerpoint (Figure 3.11). Major land use/land cover within the region is listed in Table 3.1-1 and depicted in Figure 3.1-2. The dominant land use in the region is herbaceous grassland (39.3 percent) (Reference 3).

As noted in Table 4.13-1 and Section 4.13.1, endeavors which may contribute to cumulative impacts include proposed and in-progress construction projects. The Preserve at Clinch River and Kingston Point are residential developments which are either in progress or proposed, these projects would alter land use in the vicinity of the site in a minor way, as both sites and the surrounding areas are already developed (residential and golf course). The proposed Roane County High School could potentially alter land use from undeveloped to developed, due to its proposed location near Roane State Community College; however, as the site for the new high school has not yet been chosen, and due to its location adjacent to another educational facility, potential cumulative effects to land use would be minor. The majority of the projects which could cause cumulative impacts to land use are proposed and in-progress industrial facilities. The noted projects would be in areas already zoned for industrial use, most of which would be constructed on land that was historically industrial. Therefore, although technically land use at these project sites may change from undeveloped/brownfield to industrial, it would occur in areas that already have industrial sites in the near vicinity to them, in areas that are slated to become industrial, and at sites which had former industrial uses, making cumulative impacts to land use SMALL and the incremental contribution to cumulative impacts from the Proposed Action would also be SMALL.

4.13.1.2 Visual Resources

Similar to land use, impacts to visual resources would occur due to the proposed or in-progress construction projects noted above. The majority of these projects would not be visible from the site. Kairos Power anticipates the construction of a fuel fabrication facility which would be near the site and would alter the visual resources in the vicinity. Details on the appearance of this facility have not yet been finalized, but it is anticipated to be smaller than the Hermes reactor. However, this site is (and was in the past) already highly industrial with respect to visual resources; therefore, cumulative impacts would be minor. Industrial development at the ETTP may alter the appearance of the area near the site, however, the ETTP site is already industrial, and the addition of structures to the area would be a beneficial impact as the site is currently abandoned and the majority of the ETTP site consists of concrete pads and roadways where the former Manhattan Project buildings stood. The proposed Oak Ridge Airport may be visible from the site vicinity; however, as with the ETTP, this area is already industrial in nature. Visual impacts from airplanes landing and taking off may occur, but these would be incidental and temporary. If these projects were to be constructed at the same time as the Proposed Action, visual impacts could occur due to multiple construction sites in the same vicinity with very large

equipment. These impacts would be temporary, however, and would cease once construction was complete. Overall, due to the already industrial appearance of the vicinity, cumulative impacts to visual resources would be SMALL and the incremental contribution to cumulative impacts from the Proposed Action would also be SMALL.

4.13.2 Air Quality and Noise

4.13.2.1 Air Quality

The description of the affected environment in Section 3.2 serves as a baseline for the air quality cumulative impact assessment. Table 4.13-1 identifies recent past, present, and reasonably foreseeable future actions within the geographic extent of analysis that can be considered contributors to cumulative impacts to air quality.

As described in Section 4.2.1.1, air emission impacts from construction would be SMALL as emissions would be controlled at the source where practicable; maintained within established regulatory limits designed to minimize impacts; and located a significant distance from the public. Operation of the facility would also have a SMALL impact on air quality, as discussed in Section 4.2.1.2.

Criteria Pollutants

Air emission impacts as a result of concurrent construction activities are expected at both the facility and some of the projects listed in Table 4.13-1. These proposed and in-progress projects may overlap with the proposed construction schedule for the Hermes reactor, which is anticipated to begin in 2026. Implementation of mitigation measures described in Section 4.2.1.1 would minimize impacts to local ambient air quality and the nuisance impacts to the public in proximity to the project. Impacts to air quality from construction activities are expected to be minor, localized, and short-term; therefore, overlapping construction schedules are not expected to contribute significantly to cumulative effects.

As shown in Table 4.13-1, projects which could impact air quality during potential construction include the ETTP, the Proposed Clinch River Nuclear Site, the Sludge Processing Mock Test Facility, the Uranium Processing Facility, the Outfall 200 Mercury Treatment Facility, the Environmental Management/Waste Management Facility on ORR, the Kairos Power Fuel Fabrication Facility, Coqui Pharma, the Tellico West Industrial Park, the Horizon Center Industrial Park, the Heritage Center Industrial Park, and the Future Oak Ridge Airport. Existing permitted emissions facilities are considered part of the baseline air quality.) Given their proximity to the site, it is notable that the proposed and in-progress construction projects may contribute to cumulative impacts to air quality. The multiple projects would all be governed by new construction air permits processed through TDEC. Presumably, the permit process would mitigate to ensure that counties potentially impacted would continue to be in attainment. Additionally, all large construction projects would be required to mitigate air quality impacts as listed in Section 4.2.1.1. Permitting reviews performed by the TDEC are conducted to ensure that new permits do not result in regional air quality degradation. Therefore, the cumulative impacts of construction related criteria pollutants to air quality are SMALL and the incremental contribution to cumulative impacts from the Proposed Action would also be SMALL.

The majority of the facilities listed in Table 4.13-1 may contribute to cumulative impacts to regional and local air quality during operations. As stated in Section 4.2.1.2, the criteria pollutant operational emissions from the site are estimated to be well below 100 tpy for all criteria pollutants. Also, the HAPs are estimated to be below 10 tpy for any single pollutant and below 25 tpy for all HAPs combined. As a result, the project is subject to non-Title V requirements. No air quality modeling is required for non-Title V permitting. Tennessee has established the Tennessee Ambient Air Quality Standards. Primary standards set limits to protect public health and secondary standards set limits to protect public welfare

such as decreased visibility, and damage to animals, crops, vegetation, and buildings. The principal (criteria) pollutants for which NAAQS have been set are CO, NO_2, lead, SO_2, PM_{10}, $PM_{2.5}$, and O_3. One or more averaging times are associated with each pollutant for which the standard must be attained. Therefore, as with construction-related air permits, TDEC would also review the operational facilities permits for air emissions, ensuring that air quality in the region remains in attainment.

Greenhouse Gas Emissions

The cumulative impacts of a single or combination of GHG emission sources must be placed in geographic context, considering the following factors:

- The environmental impact should be assessed on a global rather than local or regional basis.
- The effect is not sensitive to the location of the emission release point.
- The magnitudes of individual GHG sources related to human activity, no matter how large compared to other sources, are small when compared to the total mass of GHGs in the atmosphere.
- The total number and variety of GHG sources is extremely large and the sources are ubiquitous.

GHG emissions associated with building, operating, and decommissioning the new facility are discussed in Section 4.2.1.2.3. As noted in Section 3.2.5, a comprehensive program to avoid and control GHG emissions associated with the facility will be developed.

Evaluation of cumulative impacts of GHG emissions requires the use of a global climate model. A synthesis of the results of numerous climate modeling studies are presented in the report from Karl, et al. (Reference 4). The cumulative impacts of global GHG emissions, as presented in the report, are the appropriate basis for evaluation of cumulative impacts with regard to the facility. The report concludes that climate changes are underway in the United States as part of the global climate and that these changes are projected to grow. While noticeable, none of the changes would result in a destabilization of the global climate. In 2010, the EPA issued the CO_2 Tailoring Rule (75 Federal Register 31514), which stated that GHG emissions would be factors in Prevention of Significant Deterioration (PSD) and Title V permitting and reporting. This revised permitting criterion indicates the need to regulate CO_2 and other GHGs from major emission sources. GHG emissions from individual stationary sources and, cumulatively, from multiple sources, can contribute to national and global climate change. The multiple projects and facilities that may contribute to air quality impacts as shown in Table 4.13-1 and discussed above may also contribute to GHG emissions. However, these projects and facilities would be governed by the EPA and TDEC rules. Although the global cumulative impacts from GHGs continue to rise and could be considered LARGE, given the relatively low emissions from the facility and the potential and existing projects and facilities in the region, in comparison to total global emissions, the incremental contribution of the Proposed Action to global cumulative impacts would be SMALL.

4.13.2.2 Noise

The description of the affected environment in Section 3.2.6 serves as a baseline for the noise cumulative impact assessment. The geographic area of analysis for evaluation of cumulative effects from noise emissions includes the 185 acres within the site boundary and the 1-mile area surrounding the site. Noise impacts resulting from construction and operation of the facility are discussed in Sections 4.2.2.1 and 4.2.2.2 and are SMALL.

Table 4.13-1 identifies recent past, present, and reasonably foreseeable future actions within the geographic extent of analysis that can be assessed to determine cumulative effects on noise. Relevant "other actions" that are considered in this cumulative effects analysis are limited to facilities and projects within one mile of the site including the ETTP, the Kairos Fuel Fabrication Facility, Coqui Pharma, the Heritage Center industrial Park, and the future Oak Ridge Airport.

During the construction periods for the site and the potential and in-progress facilities above, additional impacts to noise are expected in the immediate area around each site, if construction happens at the same time. Noise levels from construction equipment are expected to attenuate rapidly with distance, and therefore, do not significantly impact nearby sensitive noise receptors (all one mile or farther away). Additionally, there are few noise receptors in the 1-mile area other than employees at industrial facilities. Noise levels are also impacted by increases in traffic volume during both construction and operation; however, they are not expected to be significantly higher than current traffic levels. External noise emission from the facility and other potential and in-progress facilities in Table 4.13-1 during operation are primarily limited by the walls and other physical barriers of the facilities themselves. Additionally, the area surrounding the one-mile radius of the site is heavily wooded and hilly, further attenuating noise prior to reaching any receptors. Noise impacts from the operation of the future airport would likely dominate future cumulative noise levels.

Therefore, cumulative impacts to noise in the region are SMALL and the incremental contribution to cumulative impacts from the Proposed Action would also be SMALL.

4.13.3 Geologic Environment

The description of the affected environment in Section 3.3 serves as a baseline for the geologic environment cumulative impact assessment. The geographic area of analysis for evaluation of cumulative effects on geologic resources is the same as that used in Section 4.3 and includes the 185 acres within the site boundary and the 5-mile region surrounding the site. As discussed in Section 4.3, construction and operation impacts from the site on the geologic environment are SMALL.

Table 4.13-1 identifies recent past, present, and reasonably foreseeable future actions within the geographic extent of analysis that can be assessed to determine cumulative effects on the geologic environment. Relevant “other actions” that are considered in this cumulative effects analysis are limited to those within five miles. Of these projects, none were considered likely to contribute to cumulative impacts to geological resources.

Other potential projects in the vicinity of the site would result in impacts to the same geologic resources as those affected by the facility. However, there are no sensitive geologic resources in the region surrounding the site. Additionally, as noted in Section 3.3, the probability of regional-scale impacts due to geologic factors would be low. Impacts from those projects identified within five miles are expected to be localized and minor. As discussed in Section 4.3.2, impacts to soils from the facility would be SMALL as minimal amounts of grading and excavation would occur. Additionally, fill material would be stockpiled and used on-site. Due to the sizes of the acreages of the proposed and in-progress facilities within five miles, it is likely that these same measures would occur at these other facilities for cost reduction purposes. Therefore, cumulative impacts to geological resources would be SMALL and the incremental contribution to cumulative impacts from the Proposed Action would also be SMALL.

4.13.4 Water Resources

The description of the affected environment in Section 3.4 serves as a baseline for the water resources cumulative impact assessment. The geographic area of analysis for evaluation of cumulative effects on water resources is the same as that used in Section 4.4 and includes the 185 acres within the site boundary and the 5-mile region surrounding the site. As discussed in Section 4.4.1, construction impacts to water resources are SMALL. Impacts from operation of the facility are discussed in Section 4.4.2 and would be SMALL.

Table 4.13-1 identifies recent past, present, and reasonably foreseeable future actions within the geographic extent of analysis that can be assessed to determine cumulative effects on water resources.

Relevant "other actions" that are considered in this cumulative effects analysis are limited to the utility line extensions planned in support of the facility including the ETTP, the proposed CRN site, the Sludge Processing Mock Test Facility, the Uranium Processing Facility at Y-12, the Outfall 200 Mercury Treatment Facility at Y-12, the New Y-12 Steam Plant, the Roane Regional Business and Technology Park, operations at ORNL and ORR, the White Oak Dam, the Kairos Fuel Fabrication Facility, Coqui Pharma, Energy Solutions, LLC Bear Creek Facility, Horizon Center Industrial Park, Heritage Center Industrial Park, the Future Oak Ridge Airport, the City of Oak Ridge Water Treatment Plant, and the Preserve at Clinch River. Potential cumulative impacts are discussed in the sections below.

4.13.4.1 Hydrology

There are no surface water resources located on the site; therefore, there are no direct impacts as a result of alteration of streams or water bodies. The nearest water bodies are the nearby Poplar Creek, which is a tributary of the Clinch River, and the Clinch River arm of the Tennessee River. Construction at the facility location represents potential sources of pollution associated with runoff from construction sites. It is anticipated that at the potential new construction sites listed in Table 4.13-1, BMPs would also be used in accordance with TDEC and federal rules to prevent sediment runoff and subsequent siltation in receiving streams during construction.

During operations, potential impacts associated with hydrology are also related to stormwater management. Currently drainage patterns on the site are complex due to the areas underlying geology, past cut and fill operations, transient interactions with bounding surface water bodies, and numerous anthropogenic features, including building sumps, leaking subsurface drains and utilities, and extensive areas covered by impermeable paved surfaces and roofed buildings. Drainage patterns would change as a result of the construction at the facility. One project which would impact hydrology is the proposed CRN site, as the proposed facility would use surface water withdrawn from the Clinch River arm of the Watts Bar Reservoir for cooling purposes. The White Oak Dam is an impoundment which acts as a settling pond to reduce radioactive waste runoff into the Clinch River arm of the Watts Bar Reservoir. This dam may be removed as part of site remediation, which would also impact surface water flow in the future. The other projects noted in Section 4.13-4 may also contribute to changes in hydrology in the immediate vicinity, however, these are also expected to be limited to stormwater management changes. The projects would be regulated by TDEC as part of the NPDES permit program which would reduce potential impacts to surface water due to stormwater runoff in general. The removal of White Oak Dam would constitute a beneficial impact by returning the local hydrology to conditions that were present prior to the Manhattan Project. Due to the minimal impacts to hydrology presented by each potential project in the vicinity of the site, cumulative hydrologic impacts would be SMALL and the incremental contribution to cumulative impacts from the Proposed Action would also be SMALL.

4.13.4.2 Water Use

As discussed in section 4.4.2, impacts to surface water and groundwater use due to the site during construction, operation, and decommissioning would be SMALL. Table 4.13-1 shows the proposed and in-progress projects and facilities which could contribute to cumulative impacts to water use. Section 4.13.4 identifies those projects specifically, all of which do, or may in the future, receive water from Oak Ridge Public Works and release wastewater to either the Rarity Ridge Wastewater Treatment Plant (WWTP) or the main Oak Ridge WWTP. As noted in Section 3.4.2.1, a new water treatment plant expected to be complete by 2025, which would service the ETTP, is expected to produce 16 MGD and may be expanded to 20 MGD. The existing plant, which is now maintained by the City of Oak Ridge, regularly supplies 4.15 MGD to Oak Ridge citizens and has a generating capacity of 12 MGD with the ability to provide 16 MGD on an infrequent basis.

Additionally, wastewater treatment capacity at the two WWTPs is 30.6 MGD and they are currently only treating 5.6 MGD. Groundwater use in the vicinity of the site is almost negligible, representing 0.9 percent of total water use. As stated in Section 4.4.2, the site water use is estimated at 0.07 MGD and wastewater generation is estimated at 0.02 MGD. It is currently unknown what amount of water would be used and how much wastewater would be generated by the operating and proposed/in-progress projects which would share these same water sources and discharge to the two Oak Ridge WWTPs, however, due to the relatively small impacts to water and wastewater systems during construction and operation of the Hermes reactor, and the present operating capacities of the water systems, cumulative impacts from water use would be SMALL and the incremental contribution to cumulative impacts from the Proposed Action would also be SMALL.

4.13.4.3 Water Quality

As stated in Section 3.4.3.1.1, historical activities in and around the ETTP from the Manhattan project and other nuclear activities have impaired surface and groundwater quality in the vicinity of the site. The main pollutants are mercury in soils (both terrestrial and submerged) and surface water, and VOCs and PCBs in groundwater. Additionally, both Poplar Creek and the Clinch River arm of Watts Bar Reservoir are considered impaired based on the EPA 303d impaired waters list. Poplar Creek is impaired for high levels of PCBs and mercury, while the Clinch River arm of the Watts Bar Reservoir is listed for PCBs, mercury, and pesticides for the year 2020 (Reference 5). Restoration of the ORR is one of the largest environmental cleanup sites in the United States. Cleanup efforts at the ETTP began in the early 2000s under the authority of the TDEC Division of Remediation, the DOE, Oak Ridge Office of Environmental Management, and the contractor UCOR at a cost of $4.5 billion for the 2,200 acre site (Reference 6). Section 4.4.3.1 indicates that impacts from the construction and operation of the Hermes reactor to water quality would be SMALL.

Table 4.13-1 and Section 4.13.4 describe projects in the vicinity of the site which may contribute to impacts to water quality. Only the proposed CRN Site would withdraw and discharge surface water and thus is the only project which may directly impact water quality. The remainder of the projects would likely receive water from the City of Oak Ridge system and discharge to the City's WWTPs or to surface waters through the TDEC NPDES permitting system. The existing information regarding water quality in the area, the efforts to remediate previous impacts, and the highly regulated nature of water use in the vicinity by both State and Federal agencies indicate that it is unlikely that any of the operational or proposed projects would contribute to cumulative impacts to water quality. Additionally, due to the use of surface water for human consumption from the local reservoirs operated by TVA, it is expected that water quality is highly monitored. Groundwater is not able to be used due to previous contamination. Therefore, due to the lack of groundwater use, the extensive regulatory knowledge of existing water quality conditions, the multiple municipal water systems, and NPDES regulations, cumulative impacts to water quality would be SMALL and the incremental contribution to cumulative impacts from the Proposed Action would also be SMALL.

4.13.5 Ecological Resources

The description of the affected environment in Section 3.5 serves as a baseline for the ecological resources cumulative impact assessment. The geographic area of analysis for evaluation of cumulative effects on ecological resources is the same as that used in Section 4.5 and includes the 185 acres within the site boundary and the 5-mile region surrounding the site. As discussed in Section 4.5.1, impacts from construction on terrestrial and aquatic ecosystems, including protected species, are SMALL. Section 4.5.2 demonstrates that the potential impacts from operation of the facility on terrestrial and aquatic ecosystems, including protected species, would be SMALL.

Table 4.13-1 identifies recent past, present, and reasonably foreseeable future actions within the geographic extent of analysis that can be assessed to determine cumulative effects on ecological resources. Relevant "other actions" that should be considered in this cumulative effects analysis with respect to terrestrial ecological resources were not identified, as the major operational, proposed, or in-progress projects are located on similar habitats to the facility (previously developed with industrial structures, heavily disturbed, or artificially vegetated herbaceous habitats). The smaller projects in the vicinity (residential development) are also on already developed or disturbed land. Therefore, cumulative impacts to terrestrial ecological resources would be SMALL and the incremental contribution to cumulative impacts from the Proposed Action would also be SMALL.

Aquatic community resources that could be affected by the proposed facility include the Clinch River arm of the Watts Bar Reservoir, which may be impacted by the proposed CRN site. However, this facility would be specifically permitted and highly regulated to minimize negative impacts to aquatic communities. The potential removal of the White Oak Dam would impact aquatic communities, but as this would restore the local hydrology to its former natural state, this would be a beneficial impact. Additionally, because of the implementation of BMPs onsite during construction at the various proposed and in-progress facilities, cumulative impacts to aquatic resources would be SMALL and the incremental contribution to cumulative impacts from the Proposed Action would also be SMALL.

4.13.6 Historical and Cultural Resources

The description of the affected environment in Section 3.6 serves as a baseline for the historical and cultural resources cumulative impact assessment. The geographic area of analysis for evaluation of cumulative effects on historical and cultural resources is the same as that used in Section 4.6 and includes the 185 acres within the site boundary and the 10-mile region surrounding the site. As discussed in Section 4.6.1, impacts from construction and operation of the facility would be SMALL.

Table 4.13-1 identifies recent past, present, and reasonably foreseeable future actions within the geographic extent of analysis that can be assessed to determine cumulative effects on historical and cultural resources. Relevant "other actions" that should be considered in this cumulative effects analysis were not identified, as the majority of operational, proposed, or in-progress projects are on already developed land, with no historic structures remaining. Although the Manhattan Project was historically significant, the majority of the historic structures formerly at the ETTP have already been demolished. Additionally, no historic properties would be impacted by the site, therefore, no additional cumulative impacts to historic and cultural resources would occur. Consequently, potential cumulative impacts of the site would be SMALL and the incremental contribution to cumulative impacts from the Proposed Action would also be SMALL.

4.13.7 Socioeconomic Environment

The description of the affected environment in Section 3.7 serves as a baseline for the socioeconomic cumulative impact assessment. The geographic area of analysis for evaluation of cumulative effects on socioeconomic resources is the same as that used in Section 4.7 and includes the 185 acres within the site boundary and the five-county ROI (Anderson, Knox, Loudon, Morgan, and Roane). As discussed in Section 4.7.1, impacts from construction and operation of the facility have a SMALL impact on socioeconomic conditions. Impacts to transportation in the ROI associated with the development of the site are discussed in Section 4.7.2 and would be SMALL.

Table 4.13-1 identifies recent past, present, and reasonably foreseeable future actions within the geographic extent of analysis that can be assessed to determine cumulative effects on the socioeconomic environment. Relevant "other actions" that are considered in this cumulative impacts analysis are limited to the ETTP, the proposed CRN site, the Y-12 Shipping and Receiving facility, the K-

1251 Barge Facility, the Roane Regional Business and Technology Park, the Environmental Management Waste Management Facility on ORR, the Kairos Power Fuel Fabrication Facility, Coqui Pharma, the Tellico West Industrial Park, the Horizon Center Industrial Park, the Heritage Center Industrial Park, the TDOT projects, the future Oak Ridge Airport, the Preserve, Clinch River, Kingston Point, and Roane County High School. The Y-12 Shipping and Receiving Facility and the K-1251 Barge Facility are operational and were included for potential impacts to transportation. The two housing projects were included for potential impacts to housing availability. The remainder of the projects are proposed or planned.

4.13.7.1 Population

As described in Section 4.7.1.1, impacts to population due to the construction and operation of the facility would be SMALL. Potential cumulative impacts to population could occur if the multiple proposed and planned construction project would occur at the same time. This could cause a sudden influx of construction workers. Additionally, the multiple business and industrial parks could sell more parcels and cause a need for additional construction workers. During operations of the multiple proposed facilities and potential new facilities at the business and industrial parks, additional persons may move into the area due to an abundance of well-paying jobs. However, this situation is unlikely, and due to the minor impacts to population from the construction and operation of the facility, cumulative impacts would be SMALL and the incremental contribution to cumulative impacts from the Proposed Action would also be SMALL.

4.13.7.2 Housing

The current housing available in the ROI is discussed in Section 3.7.2.2, and the impacts are discussed in Section 4.7.1.2, and are considered SMALL. Potential cumulative impacts to housing could occur if the multiple proposed construction projects are in-progress at the same time, causing a high housing demand. Additionally, if the multiple projects cause an abundance of well-paying jobs during operations, an influx of persons could occur, raising housing demand. Neither of these situations is likely to occur, and present, proposed, and future housing developments would be able to construct housing for additional population in the ROI. Additionally, there is ample workforce available in the ROI and jobs would likely go to people already living in the ROI prior to any influx. Therefore, due to the ample housing available, the multiple residential developments in progress and planned, and lack of a significant influx of workers to the area, cumulative impacts to housing would be SMALL and the incremental contribution to cumulative impacts from the Proposed Action would also be SMALL.

4.13.7.3 Public Services

Public services currently in the ROI are discussed in Section 3.7.2.5 and include public water supplies and wastewater treatment systems. Impacts to public services are discussed in Section 4.7.1.3 and are estimated to be SMALL due to the construction and operation of the facility. As discussed in Section 4.13.4, cumulative impacts to water resources (including both water use and wastewater generation) are expected to be SMALL. As a large influx of population is not likely, and due to the current situation where water availability is far larger than water use, cumulative impacts to public services would be SMALL and the incremental contribution to cumulative impacts from the Proposed Action would also be SMALL.

4.13.7.4 Public Education

Public education is described in Section 3.7.2.5 and includes local schools. Section 4.7.1.4 discusses impacts to public education in the ROI and estimates that the impacts due to the construction and operation of the facility would be SMALL. One proposed project in the ROI concerns the consolidation of

five public high schools in Roane County. This would cause impacts to public education in Roane County only, and would constitute a beneficial impact, modernizing buildings and obtaining new technology for the students. The other proposed and planned projects within the ROI would not significantly impact public education due to a lack of immigration of families to the area. Additionally, the school aged cohort in the ROI represents 0.99 percent of the overall population, and this ratio is unlikely to change. The student-to-teacher ratio in the ROI is low, so additional students would be easily absorbed by existing educational facilities. Therefore, due to a lack of significant influx to the area due to the facility and the other planned facilities, the amount of spaces for school children in the public education system, cumulative impacts to public education would be SMALL and the incremental contribution to cumulative impacts from the Proposed Action would also be SMALL.

4.13.7.5 Tax Base

Section 3.7.2.4 describes the tax payment situation in the ROI, including sales tax and property tax. As discussed in Section 4.7.1.5, tax revenue impacts due to the construction and operation of the facility would be SMALL and beneficial. The multiple proposed and in-progress facilities within the ROI are listed in Table 4.13-1, and tax revenue impacts would likely also be beneficial. Due to the similarities in taxes associated with all of the facilities due to the majority of them being at the ETTP or ORNL, changes due to the other projects would likely be similar. As discussed in Section 4.7.1.9, the overall tax revenue from the site is positive, and relatively small in comparison to the established tax bases. Therefore, in combination with the other projects, cumulative effects to the tax bases would be SMALL and the incremental contribution to cumulative impacts from the Proposed Action would also be SMALL.

4.13.7.6 Transportation

As described in Section 4.7.2, no modifications to the local traffic infrastructure are necessary as a result of construction-related traffic at the site and no mitigation measures would be required. If other concurrent projects were to cause impacts, it is expected that these projects would have mitigation measures to reduce them. Therefore, cumulative effects to transportation infrastructure and traffic patterns would be SMALL and the incremental contribution to cumulative impacts from the Proposed Action would also be SMALL.

4.13.7.7 Public Recreational Facilities

Public Recreational Facilities within the ROI are described in Section 3.7.2.5.2. As stated in Section 4.7.3, impacts due to the construction and operation of the facility are expected to be SMALL. The majority of the larger proposed projects in the ROI would be similar to the facility with respect to traffic and visual impairments, as most of them are located at the ETTP, ORNL, or in similar industrial areas. Noise and indirect impacts to traffic patterns are possible at all proposed and in-progress project sites. However, none of these are near major recreational facilities, other than the Manhattan Project National Park, therefore, cumulative impacts to public recreational facilities would be SMALL and the incremental contribution to cumulative impacts from the Proposed Action would also be SMALL.

4.13.7.8 Summary of Socioeconomic Cumulative Impacts

In summary, cumulative impacts from other actions identified in Table 4.13-1 on aspects of socioeconomics, including water/wastewater systems, population growth, local tax base, the labor force, transportation, public education, and recreational facilities would be SMALL and the incremental contribution to cumulative impacts from the Proposed Action would also be SMALL.

4.13.8 Human Health

The geographic area of analysis for evaluation of cumulative effects on human health is the same as that used in Section 4.8 and includes the 185 acres within the site boundary and the 5-mile region surrounding the site. As discussed in Sections 4.8.1 and 4.8.2, impacts from operation of the facility would have a SMALL impact on human health.

Table 4.13-1 identifies recent past, present, and reasonably foreseeable future actions within the geographic extent of analysis that can be assessed to determine cumulative effects on human health. Relevant "other actions" that are considered in this cumulative impacts analysis are limited to the ORR actions including operations and/or new construction of the Environmental Management Waste Management Facility, the Sludge Processing Mock Facility, Uranium Processing Facility, Mercury Treatment Facility, the Spallation Neutron Source, and the High Flux Isotope Reactor; and future construction and operation at the CRN site, the Coqui Pharma site, and the Kairos Power Nuclear Fuel Fabrication Facility.

4.13.8.1 Nonradiological Impacts

Construction of any facility includes potential hazards to workers typical of any construction site. Normal construction safety practices would be employed to promote worker safety and reduce the likelihood of worker injury during construction. Therefore, because controls are in place to limit injuries and illnesses and occupational impacts rarely reach beyond the construction site, cumulative occupational hazards from construction would be SMALL.

Potential nonradiological public health hazards pertaining to the construction and operation of facilities the 5-mile region surrounding the site are associated with routine emissions and discharges as well as accidental spills/releases.

To minimize potential exposure to the public, control systems are in place to limit emissions in accordance with federal, state, and local requirements. These controls include conveyance of wastewater to appropriate approved wastewater treatment facilities, discharges to Waters of the United States in accordance with NPDES permits, implementation of Spill Prevention Control and Countermeasure Plans, and air emission controls Although, environmental contamination contributions to water resource and air from past operations at ORR contribute to a MODERATE cumulative impact to human health; however, the incremental contribution to cumulative impacts from the Proposed Action would be SMALL

4.13.8.2 Radiological Impacts

As described in Section 4.8.2, the radiological impacts from construction and operation of the Hermes reactor would be SMALL. Specifically, the estimated total body dose to the hypothetical MEI from gaseous effluents and direct radiation during operation would be 1.2 mrem/yr. For analysis of cumulative impacts, the geographic area of interest considered was 5 miles beyond the site boundary. Table 4.13-1 summarizes past, present, and future projects and actions that could contribute to cumulative effects. Those listed that have a potential to contribute to cumulative radiation exposures include the past operations at ORR, the existing and proposed ORR facilities (Y-12, ORNL, and disposal sites); the existing Energy*Solutions* Bear Creek Facility, and proposed operations at the CRN site, the Coqui Pharma site, and the Kairos Power Nuclear Fuel Fabrication Facility.

As noted in Section 3.8.4, operations on the ORR release small quantities of radionuclides to the environment. In the 2020 ORR Annual Site Environmental Report, detailed analysis of the effective dose received by the MEI from air pathways was determined to be 0.4 mrem/yr. The effective dose to the MEI from water, including drinking, bathing, irrigating, recreating, and fish consumption, was

determined to be 2 mrem/yr. The effective dose from consumption of wildlife harvested on the ORR, including turkeys, geese, and deer, was determined to be 0.07 mrem/yr. Combined, the annual dose to the hypothetical MEI from normal operations at ORR is 3 mrem/yr (Reference 44). This is approximately 1 percent of the average background radiation dose in the United States.

There are several non-DOE facilities on or near the ORR that could also contribute to radiation doses to the public. In 2017, DOE requested information from these facilities regarding their potential radiation doses to members of the public, and fifteen facilities responded with information about their dose contributions (Reference 45). Ten facilities had no radiological emissions. Three facilities reported annual doses from airborne releases with annual doses of 0.4 mrem, 0.21 mrem, and < 10 mrem. Doses from direct radiation ranged from none to 2 mrem based measurements at the facility and immediate surrounding. Therefore, DOE estimated that annual doses to members of the public from air and water emissions and external radiation from both non-DOE and DOE sources on and near the ORR were less than 100 mrem/yr. It is assumed Energy*Solutions* Bear Creek Facility was one of the responding facilities and its contribution to the cumulative dose would be a fraction of the less than 100 mrem estimated by DOE.

The proposed nuclear power generation at the CRN site and the radiopharmaceutical production would contribute additional radiation to the surrounding area. The CRN site ER estimates that the MEI receiving dose from up to four operating small modular reactors at the site would be 11 mrem/yr (Reference 46). The annual dose to the MEI from the SHINE Medical Technologies medical isotopes production facility located in Wisconsin, considered a reasonable surrogate for the proposed Coqui Pharma medical isotopes production facility, was estimated at 9 mrem/yr (Reference 47). Even if it is conservatively assumed that an individual could be exposed to a total dose based on adding the ORR's total dose estimate of 3 mrem/yr, the CRN site estimate of 11 mrem/yr, the anticipated Coqui Pharma dose of 9 mrem/yr, and the other non-DOE sources evaluated by the DOE, the cumulative would be less than 100 mrem/yr. Accordingly, cumulative radiological impacts to members of the public during operation would be SMALL and the incremental contribution to cumulative impacts from the Proposed Action would also be SMALL.

4.13.9 Waste Management

All regional construction, operation, and decommissioning projects will have an impact on cumulative waste management and the region of influence is dependent on the type of waste and the available disposal locations. Due to its relatively small size and operating staff, the contribution of the Hermes reactor project on the local (multi-county) nonradioactive and nonhazardous C&D waste and general sanitary waste (i.e., "garbage") management resources and disposal capacity would be SMALL and the percentage of the contributed when considering other current and proposed projects would also be SMALL. With respect to hazardous waste, construction, operation, and decommissioning of the Hermes reactor will have a negligible effect on the cumulative impact on regional (multi-state) hazardous waste management and disposal resources from regional projects. For radioactive waste generated during operation and decommission, such disposals are only available at a few existing facilities that are located well outside the local region. Given the volumes of LLRW received at these facilities from industries such as the nuclear power industry (93 operating commercial reactors in 2021), medical industry, research and development, the operation and future decommissioning of a single non-power reactor will not contribute significantly to LLRW management and disposal resources. Likewise, each of the other proposed projects and existing non-DOE facilities that generate LLRW within 5 miles of the site will have only a small effect on the nation-wide LLRW management and disposal infrastructure. Most hazardous and radioactive waste generated at ORR is managed at ORR treatment and disposal facilities and does

not contribute to the cumulative waste impacts. Therefore, the cumulative impact of the proposed project on all waste management resources would be SMALL.

4.13.10 Transportation

Section 4.10 describes the radiological impacts of incident-free transportation assuming all shipments of radioactive materials and waste to and from the Hermes reactor facility are by truck. Shipments include irradiated (spent) fuel, unirradiated fuel, and radioactive waste. Probable transportation routes were bounded by shipping unirradiated fuel more than 2,000 miles from Washington, shipping irradiated fuel more than 2,000 miles to Nevada, and shipping radioactive waste approximately 1,200 miles to Texas. An estimated 3 shipments of new fuel to the facility would occur each year with approximately 46 shipments of LLRW each year to Texas. All spent fuel would be shipped after reactor shutdown. As shown in Section 4.10, impacts from incident-free transportation associated with the transport of fuel and waste for the proposed project would be SMALL.

This cumulative analysis considers radiological impacts from incident-free transportation associated with the transportation of fuel and waste for the proposed project along with impacts from past, present, and reasonably foreseeable actions that may contribute to cumulative impacts within the geographic area of interest. The geographic area of interest for radiological impacts of transportation is nationwide. Geographically, the Kairos Power site is near two main transportation corridors, the East-West I-40 and the North-South I-75, which historically channel most of the transport in the region. Although the potential cumulative impact along major traffic routes is SMALL, local roads in the immediate vicinity of the site would experience an increase in radioactive material shipments. Radiological cumulative impacts associated with transportation of radioactive materials and waste to and from the site includes impacts from radioactive material shipments to and from ORR facilities, the Energy*Solutions* Bear Creek facility, the proposed Coqui Pharma facility, proposed nuclear power reactors at the CRN site, and the proposed Kairos Power fuel fabrication facility. For example, the future Y-12 Uranium Processing Facility will receive shipments of uranium from other DOE facilities and the U.S. Navy and distribute uranium to other locations. Outside the 5-mile area around the site, the Watts Bar and Sequoyah nuclear power plants ship LLRW along I-75 and I-40. Like the shipments associated with the Kairos site, the impacts from each individual shipment would be minimal and, when combined with the impacts associated with the site, the total impact would also be minimal. While the region would have a significant number of radioactive material and radioactive waste shipments when compared to other regions of the country, the dose impact from each shipment is very small when compared to natural background radiation. Therefore, the cumulative radiological impacts of incident-free transportation of unirradiated fuel to, along with irradiated fuel and radioactive waste would be SMALL and the incremental contribution to cumulative impacts from the Proposed Action would also be SMALL.

4.13.11 Environmental Justice

The geographic area of analysis for evaluation of cumulative effects on environmental justice includes the 185 acres within the site boundary and the 5-mile region surrounding the site. No environmental justice communities have been identified within area analyzed; therefore, disproportionate impacts on low-income or minority populations from other actions are not expected. Disturbance to nearby residents related to temporary and minor traffic, air quality and noise impacts during construction, operations and decommissioning would affect the general population, and are not expected to disproportionately other populations.

Table 4.13-1 identifies recent past, present, and reasonably foreseeable future actions within the geographic extent of analysis that can be assessed to determine cumulative effects on environmental justice. No present or on-going actions were identified that are relevant to this analysis. Thus, the

cumulative impacts on environmental justice are SMALL and the incremental contribution to cumulative impacts from the Proposed Action would also be SMALL.

4.13.12 Conclusion

Table 4.13-2 summarizes the cumulative impacts in all resource areas. In conclusion, there are no significant cumulative adverse environmental impacts from the construction and operation of the site when considered together with other past, present, and reasonably foreseeable future projects in the area.

4.13.13 References

1. Council on Environmental Quality. Environmental Justice: Guidance Under the National Environmental Policy Act. December 10, 1997.
2. Tennessee Comptroller of the Treasury, Existing Land Use, Oak Ridge, Tennessee, 2021.
3. U.S. Geological Survey, National Land Cover Database, Retrieved from: https://www.mrlc.gov/national-land-cover-database-nlcd-2016
4. Karl, T.R. and P.J. Young, "The 1986 Southeast Drought in Historical Perspective," Bulletin of American Meteorological Society, Vol. 68:773-778.
5. Jones, V., "Former Tennessee uranium enrichment complex marks cleanup milestone," Washington Examiner, October 14, 2020. Retrieved from https://www.msn.com/en-us/news/us/former-tennessee-uranium-enrichment-complex-marks-cleanup-milestone/ar-BB1a1sXB
6. Tennessee Department of Environment and Conservation, Wellhead Protection Program, Website: https://www.tn.gov/environment/program-areas/wr-water-resources/water-quality/wellhead-protection-program.html, accessed August 11, 2021.
7. Tennessee Valley Authority, Clinch River Nuclear Site Early Site Permit Application, Part 2, Site Safety Analysis Report, Revision 2, Section 2.2, March 8, 2019.
8. U.S. Department of Energy. East Tennessee Technology Park. Website: https://www.energy.gov/orem/cleanup-sites/east-tennessee-technology-park, accessed August 30, 2021.
9. U.S. Department of Energy. Oak Ridge Constructing Test Facility for Sludge Processing, Website: https://www.energy.gov/em/articles/oak-ridge-constructing-test-facility-sludge-processing, accessed May 21, 2021.
10. Y-12 National Security Complex. Uranium Processing Facility. Website: https://www.y12.doe.gov/upf, accessed May 21, 2021.
11. Bechtel. Uranium Processing Facility, Oak Ridge, Tennessee. Website: https://www.bechtel.com/projects/uranium-processing-facility/, accessed May 21, 2021.
12. U.S. Department of Energy. Y-12 National Security Complex. Website: https://www.energy.gov/orem/cleanup-sites/y-12-national-security-complex, accessed May 21, 2021.
13. Huotari, J. “DOE awards $91 million contract for Mercury Treatment Facility at Y-12”, Oak Ridge Today, December 5, 2018. Retrieved from: https://oakridgetoday.com/2018/12/05/doe-awards-91-million-contract-mercury-treatment-facility-y-12/.

14. U.S. Department of Energy. Strategic Plan for Mercury Remediation at the Y-12 National Security Complex Oak Ridge, Tennessee. Revision 1. DOE/OR/2605&D2/RI. September 2017.

15. Bechtel. A 'Greener' Steam Plant Brought On Line At Y-12. Website: https://www.bechtel.com/newsroom/releases/2010/06/greener-steam-plant-brought-on-line-y12/, accessed May 21, 2021.

16. Roane Regional Business & Technology Park, Roane ECD, Website: https://www.roaneecd.com/sites/roane-regional-business-tech-park/, accessed May 21, 2021.

17. Oak Ridge National Laboratory, User Facilities, Website: https://www.ornl.gov/content/user-facilities, accessed June 27, 2021.

18. Oak Ridge National Laboratory. Spallation Neutron Source. Website: https://neutrons.ornl.gov/sns, accessed May 21, 2021

19. Oak Ridge National Laboratory. High Flux Isotope Reactor. Website: https://neutrons.ornl.gov/hfir, accessed October 17, 2021

20. Munger, F., "What to do With White Oak Lake," Cleanup, EPA, Oak Ridge EM, ORNL, TDEC. July 09, 2015. Retrieved from http://knoxblogs.com/atomiccity/2015/07/09/what-to-do-with-white-oak-lake/.

21. Oak Ridge Office of Environmental Management. "Ongoing Efforts to Assure waste Disposal Capacity for the Oak Ridge Reservation," November 14, 2018.

22. Krause, C., "Medical Isotope Firm CEO tells of plans for OR facility," The Oak Ridger. March 19, 2020. Retrieved from https://www.oakridger.com/story/news/technology/2020/03/19/medical-isotope-firm-ceo--tells-of-plans-for-or-facility/112376002/.

23. Not Used

24. Tennessee Valley Authority, "Economic Development Grant Proposal for Tellico West Industrial Park Environmental Assessment, Monroe County, Tennessee," April 2020.

25. Energy Solutions, Bear Creek Processing Facility. 2016. Retrieved from https://www.energysolutions.com/waste-processing/bear-creek-processing-facility/.

26. City of Oak Ridge, Tennessee, Horizon Center Industrial Park, Website: http://oridb.net/horizon-center-park/, accessed 06/27/2021.

27. Heritage Center. A Premier Address for Today's Innovative Industries, Website: http://heritagectr.com/, accessed October 18, 2021.

28. Pounds, B., Oak Ridge Airport, Oak Ridger. March 16, 2021. Retrieved from https://www.aviationpros.com/airports/news/21214654/more-steps-taken-toward-creation-of-new-oak-ridge-airport.

29. Pounds, B., "UT-Battelle Gives City $500K for Airport," Oak Ridger, Aviation Pros. March 24, 2021. Retrieved from https://www.aviationpros.com/airports/news/21215666/utbattelle-gives-city-500k-for-airport.

30. U.S. Environmental Protection Agency. EPA Announces Nearly $21 Million Water infrastructure Loan to the City of Oak Ridge. Published 18 October 2019. Website: https://www.epa.gov/newsreleases/epa-announces-nearly-21-million-water-infrastructure-loan-city-oak-ridge, accessed May 21, 2021.

31. U.S. Environmental Protection Agency. Water Treatment Plant Design and Construction. City of Oak Ridge. WIFIA Program. Website: https://www.epa.gov/sites/production/files/2019-10/documents/cityof_oakridgewifiaprojectfactsheet_loanclose.pdf, accessed May 21, 2021.

32. U.S. Environmental Protection Agency. Oak Ridge Water Treatment Plant Design and Construction. Website: https://www.epa.gov/wifia/oak-ridge-water-treatment-plant-design-and-construction, accessed May 21, 2021.

33. Houtari, John. 2021. Construction of new water plant could start in May, be complete next year. Oak Ridge Today. Published 7 February 2021. Website: https://oakridgetoday.com/2021/02/07/construction-of-new-water-plant-could-start-in-may-be-complete-next-year/, accessed May 21, 2021.

34. Oak Ridge Municipal Planning Commission, Virtual Regular Business Meeting. March 18, 2021. Retrieved from http://oakridgetn.gov/images/uploads/Documents/Boards&Commissions/Planning%20Commission/Agenda/PC_Packet_03_18_2021.pdf.

35. Tennessee Valley Authority. Sequoyah Nuclear Plant. Website: https://www.tva.com/energy/our-power-system/nuclear/sequoyah-nuclear-plant, accessed May 21, 2021.

36. Tennessee Valley Authority. Watts Bar Nuclear Plant. Website: https://www.tva.com/energy/our-power-system/nuclear/watts-bar-nuclear-plant, accessed May 21, 2021.

37. Tennessee Valley Authority. Bull Run Fossil Plant. Website: https://www.tva.com/energy/our-power-system/coal/bull-run-fossil-plant, accessed May 21, 2021.

38. Tennessee Valley Authority. Kingston Fossil Plant. Website: https://www.tva.com/energy/our-power-system/coal/kingston-fossil-plant, accessed May 21, 2021.

39. Van Winkle, J.E., "Baseline Environmental Analysis Report for the K-1251 Barge Facility at the East Tennessee Technology Park," Oak Ridge, Tennessee. 2007. Retrieved from https://www.osti.gov/biblio/964674-EpJWXe/.

40. 1075news.com. 2021. TDOT Planning To Replace I-40 Bridge Over Clinch River In Kingston. Website: http://1057news.com/2021/07/14/14/58/19/tdot-planning-to-replace-i-40-bridge-over-clinch-river-in-kingston/, accessed October 5, 2021.

41. Tennessee Department of Transportation. Interactive Tennessee Road Improvement Program. Website: https://www.arcgis.com/apps/dashboards/e14888bce2954050a10df5e949a1bc1d, accessed October 5, 2021.

42. Willett, Hugh. 2020. Kingston Point, Residential And Commercial Project, Proposed. Website: https://www.roanecounty.com/content/kingston-point-residential-and-commercial-project-proposed, accessed October 5, 2021.

43. Lewis Group Architects. 2018. Roane County Board of Education Work Session. Website: https://1.cdn.edl.io/VksNUxvCgC6zJLTjMqPxgeexYYTclg3AUye1fcVCrKt8TyEu.pdf, accessed October 5, 2021

44. U.S. Department of Energy, "Oak Ridge Reservation Annual Site Environmental Report - 2020." DOE/CSC-2514. Chapter 7, Dose. September 2021.

45. U.S. Department of Energy, “Oak Ridge Reservation Annual Site Environmental Report - 2017.” DOE/CSC-2514. Chapter 7, Dose. September 2018.

46. Tennessee Valley Authority, “Clinch River Nuclear Site Early Site Permit Application, Part 3, Environmental Report.” Section 5.11, Cumulative Impacts Related to Operations. March 26, 2019.

47. SHINE Medical Technologies. “Preliminary Safety Analysis Report.” Section 19.4, Impacts of Proposed Construction, Operations, and Decommissioning. October 13. 2015.

Table 4.13-1: Past, Present, and Reasonably Foreseeable Projects and Other Actions Considered in the Cumulative Effects Analysis (Page 1 of 2)

Project Name	Summary of Project	Location (from Reactor building)	Status	Potentially Affected Resource(s)	Retained for Cumulative Effects Analysis	Basis
Federal Facilities						
Proposed Clinch River Nuclear Site (Reference 7)	Two or more small modular reactors to be built by TVA	3.5 miles South-southeast	Proposed NRC issued ESP-006 on December 19, 2019	Land use and visual resources, air quality and noise, water resources, ecological resources, transportation, socioeconomics	Y	Potential for overlapping construction timeline
East Tennessee Technology Park (Reference 8)	Clean up and redevelopment of the former Manhattan Project Site	Adjacent across Poplar Creek	In progress	Land use and visual resources, air quality, transportation, socioeconomics, noise, water resources, human health	Y	On-going industrial developments
Sludge Processing Mock Test Facility (Reference 9)	Construction of a TRU sludge waste processing facility	Approximately 5.3 miles east	Construction underway; expected completion 2022	Water resources, air quality, land use, waste management	Y	Construction underway
Uranium Processing Facility at Y-12 (Reference 10, Reference 11)	New building in Y-12 complex	Approximately 8.4 miles northeast	Construction began 2018; expected to continue through 2025	Water resources, air quality and noise, waste management, human health,	Y	Construction underway
Outfall 200 Mercury Treatment Facility at Y-12 (Reference 12, Reference 13, Reference 14)	Construction of two mercury treatment facilities in separate areas connected by a pipeline	Approximately 9 miles northeast	Construction began 2017 and scheduled to begin operations in mid-2020's	Water quality, air quality and noise, human health, waste management	Y	Construction underway
New Y-12 Steam Plant (Reference 15)	Natural gas power generation for Y-12 operations.	Approximately 9 miles northeast	Operational since 2010	Air quality	Y	Operational
Y-12 Shipping and Receiving (On-site verification)	Non-hazardous shipping and receiving facility	West and adjacent <1000 feet	Operational	Transportation	Y	Operational
K-1251 Barge Facility (Reference 39)	Barge docking facility approximately 1-acre in size.	2 miles Southeast	Operational	Transportation	Y	Operational
Roane Regional Business and Technology Park (Reference 16)	Business and industrial park with sites for development	Approximately 5 miles southeast	Operational since 2001	Land use and visual resources, water resources, air quality, socioeconomics, transportation	Y	Operational, although future development timeline unknown
ORNL *(Reference 17)*	DOE Nuclear and High-Tech Research Facility	Approximately 5 miles east	Operational since 1943	Water resources, air quality	Y	Operational
ORNL - Spallation Neutron Source (Reference 18)	Accelerator-based neutron pulse for research and development (R&D). Includes upgrades and second target station construction completion 2025.	Approximately 5.8 miles east	Operational since 2006	Air quality, water resources, human health, waste management	Y	Operational
ORNL - High Flux Isotope Reactor (Reference 19)	Critical reaction providing a stable beam of neutrons for R&D.	Approximately 5.75 miles east	Operational since 1965. Decommission anticipated after 2060.	Air quality, water resources, human health, waste management	Y	Operational
White Oak Dam (Reference 20)	Manhattan Project impoundment on White Oak Creek with 25 ac settling pond. Formed to reduce radioactive waste runoff into Clinch River, must be remediated by 2036.	Approximately 5 miles southeast	Operational since 1943	Water resources, human health	Y	Operational
Environmental Management Waste Management Facility on ORR (Reference 21)	Proposed new landfill for disposal of radioactive, hazardous, and toxic wastes in Oak Ridge because current landfill will soon reach max capacity	Approximately 5.3 miles northeast (current location is 6.8 miles northeast)	Proposed	Water resources, air quality, socioeconomics, human health, waste management	Y	Additional capacity needed
Industries and Manufacturing Facilities						
Kairos Power Fuel Fabrication Facility	Fabrication of tri-structural isotropic (TRISO) coated uranium oxycarbide (UCO) kernels in a graphite matrix	Near or on K-31 Site	Potential	Land use and visual resources, air quality and noise, water resources, socioeconomics, transportation, human health, waste management	Y	Interdependent with the facility construction and future development timeline unknown.
Coquí Pharma (Reference 22)	Planned Medical Isotope Production Facility	Duct Island; Approximately 0.75 miles south	Proposed	Land use and visual resources, air quality and noise, water resources, socioeconomics, human health	Y	Close proximity and potential for overlapping construction timelin e
Tellico West Industrial Park (Reference 24)	Development of industrial site for Tellico Reservoir Development Agency	25.4 miles southeast	Proposed	Air quality, socioeconomics	Y	Timeframe uncertain
Energy*Solutions*, LLC Bear Creek Facility *(Reference 25)*	Processing and packaging of radioactive material for permanent disposal	Approximately 2.1 miles southeast	Operational	Air quality, water resources, human health, waste management	Y	Operational

Table 4.13-2: Past, Present, and Reasonably Foreseeable Projects and Other Actions Considered in the Cumulative Effects Analysis (Page 2 of 2)

Project Name	Summary of Project	Location (from Reactor building)	Status	Potentially Affected Resource(s)	Retained for Cumulative Effects Analysis	Basis
Horizon Center Industrial Park (Reference 26)	Industrial park available for development	Approximately 2.3 miles northeast	Various lots sold and available	Land use and visual resources, air quality, water resources, socioeconomics, transportation, noise	Y	Potential ongoing construction
Heritage Center Industrial Park (Reference 27)	Industrial park available for development; includes Hermes site and Coquí Pharma project site on Duct Island	On site and extending south and east	Various sites pending sale, leased, sold, or fully serviced	Land use and visual resources, air quality and noise, water resources, socioeconomics, transportation, noise	Y	Potential ongoing construction
Transportation Projects						
TDOT Projects (Reference 40)	Bridge Replacement, I-40 over Clinch River in Kingston	Approximately 7.5 miles southwest	Pre-planning, no data	Transportation, socioeconomics	Y	web news report only, time frame uncertain
TDOT Projects with proposed letting dates (Reference 41)	Total projects in 5-county ROI: 108, includes bridge repair/replacement, resurfacing, maintenance and repair	Various within the ROI	Planned or in progress	Transportation, socioeconomics	Y	Projects have been slated for the contract phase.
Construction of a General Aviation Airport Future Oak Ridge Airport (Reference 28, Reference 29)	Development of a general aviation airport	Approximately 1.1 miles east	Have not broken ground yet; construction could start in 2021.	Land use and visual resources, air quality and noise, water resources, , socioeconomics, transportation	Y	Close proximity and potential for overlapping construction timeline
Utility Projects						
City of Oak Ridge Water Treatment Plant (Reference 30, Reference 31, Reference 32, Reference 33)	Upgrade aging drinking water treatment plant/ infrastructure (Water Infrastructure Finance and Innovation Act (WIFIA) grant)	Approximately 9.6 miles northeast	Construction to begin upon award of WIFIA grant	Air quality, water resources, socioeconomics	Y	Potential for overlapping construction
New Construction						
The Preserve at Clinch River (Reference 34)	New home construction, subarea G	Approximately 2 miles south	Operational since 2002	Land use and visual resources, water resources, air quality, socioeconomic	Y	Ongoing construction of homes
Kingston Point (Reference 42)	New residential, recreational and commercial development	Approximately 9 miles southwest	proposed	Land use and visual resources, socioeconomics	Y	Proposed 110 acre development on former golf course.
Energy Projects						
Nuclear						
Sequoyah Nuclear Plant, Units 1 and 2 (Reference 35)	Power Generation	Approximately 62.5 miles southwest	Operational since 1981 and 1982, respectively	Air quality, human health	Y	Operational
Watts Bar Nuclear Plant, Units 1 and 2 (Reference 36)	Power Generation	Approximately 31.75 miles southwest	Operational since 1996 and 2016, respectively	Air quality, human health	Y	Operational
Coal-Fired						
Bull Run Fossil Plant (Reference 37)	Net capability 870 MWe	Bull Run Creek; approximately 15 miles northeast	Operational since 1967; will be retired in Dec 2023 with decommissioning taking 5-6 years	Air quality, human health	Y	Operational
Kingston Fossil Plant (Reference 38)	Net capability 1379 MWe	Watts Bar Reservoir; approximately 7 miles west	Operational since 1955	Air quality, human health	Y	Operational
Oher Actions/Projects						
Roane County High School (Reference 43)	Combine Harriman, Rockwood, and Roane County High Schools into a new combined high school to be located adjacent to Roane State Community College.	Approximately 12 miles southwest	Planning	Land use and visual resources, transportation, socioeconomics	Y	Will combine 5 high schools from the surrounding area Including Oliver Springs

Table 4.13-3: Cumulative Impacts on Environmental Resources, Including the Impacts of the Proposed Project

Resource Category	Level of Cumulative Impacts
Land Use and Visual Resources	
Land Use	SMALL
Visual Resources	SMALL
Air Quality and Noise	
Air Quality	SMALL
Noise	SMALL
Geologic Environment	SMALL
Water Resources	
Hydrology	SMALL
Water Use	SMALL
Water Quality	SMALL
Ecological Resources	
Terrestrial Ecosystems	SMALL
Aquatic Ecosystems	SMALL
Historic and Cultural Resources	SMALL
Socioeconomics	SMALL
Human Health	
Nonradiological Health	SMALL
Radiological Health	SMALL
Transportation	SMALL
Environmental Justice	SMALL

Kairos Power

Chapter 5

Alternatives

Hermes Non-Power Reactor

Environmental Report

Revision 0

October 2021

TABLE OF CONTENTS

List of Tables

List of Figures

CHAPTER 5 ALTERNATIVES

5.1 NO-ACTION ALTERNATIVE

The proposed federal action is issuance of a Construction Permit (CP) and subsequent Operating License (OL) for a non-power test reactor facility (Hermes) to test and demonstrate the key technologies, design features, and safety functions of the Kairos Power Fluoride Salt-Cooled High Temperature Reactor (KP-FHR) technology. The facility would also provide data that may be used for the validation of safety analysis tools and computational methodologies used for the design and licensing of a KP-FHR commercial power reactor. Under the No-Action Alternative, the NRC would not issue the CP or OL and there would be no subsequent construction or operation. Consistent with the guidance in the Final Interim Staff Guidance (ISG) Augmenting NUREG- 1537, Chapter 19, the environmental consequences of the No-Action Alternative are assumed to be the status quo.

If the test reactor were not constructed and operated, the adverse environmental consequences discussed in Chapter 4 would be avoided. However, as discussed in Chapter 4, the adverse impacts of construction and operation of the test reactor were concluded to be SMALL. Therefore, the benefit of avoiding those impacts would not be significant. Construction and operation of the test reactor does provide socioeconomic benefits as described in Section 4.7, including increases in tax revenues to local jurisdictions, which would not be realized if the test reactor were not constructed and operated. Furthermore, as discussed in Chapter 1, the government has expressed interest in the development and demonstration of advanced reactor technologies; therefore, if the test reactor is not constructed and operated, the benefits of this initiative would not be realized.

As discussed in Section 1.1, construction and operation of the test reactor provides a means to test the key KP-FHR technologies, design features, and safety functions at a reduced scale relative to the anticipated commercial power reactor. These programmatic benefits would also not be realized under the No-Action Alternative. The programmatic benefits support deployment of advanced nuclear technologies that result in less reliance on carbon fuel-based forms of energy production.

5.2 ALTERNATIVE ELIMINATED FROM FURTHER DISCUSSION

As discussed in Chapter 2 the site would have an average water intake of 0.7 million gallons per day (MGD) with a maximum of 1.1 MGD and discharge of 0.02 MGD. Per conversations with the Oak Ridge Utility Services Department, the water plant regularly supplies 6 to 8 MGD. The current plant has the capacity to regularly produce 12 MGD with the ability to occasionally produce 16 MGD. In addition, the City is planning a new modular treatment water plant that would be designed for 16 MGD with the ability to expand to 20 MGD. This new plant is anticipated to be tested and fully operational by 2025. The projected average daily demand from the city for 2025 is 8.3 MGD and a peak day demand of 12.4 MGD.

Since the municipal water plant has sufficient capacity to service the needs of the site, the municipal water supply system has been selected as the proposed water source for the facility. Water intake from the Clinch River was considered as a potential alternative, but was eliminated from further consideration due to the following:

- An existing intake structure exists on the Clinch River from previous activities on the former K-33 site; however, it was decommissioned and all operating features other than the structure itself were removed and the area has not been maintained for operation since.

- The environmental impacts associated with in-water retrofit activities, potential dredging requirements, and impingement and entrainment would be greater than using the existing municipal system.
- The site has an expected limited licensed operational life of 10 years and does not support the costs associated with retrofitting the existing structure.

Per conversations with the Oak Ridge Utility Services Department, the wastewater plant receiving the flows from the industrial parks on the west end of the city is currently rated for 0.6 MGD with an average flow between 0.05 and 0.07 MGD; however, peak flows have occasionally exceeded the 0.6 MGD plant capacity. The city is currently working towards reducing inflow and infiltration coming to the plant. The city is evaluating an expansion to this plant which would double the capacity; however, no specific plans are currently in place.

Since the municipal waste system currently has sufficient capacity to service the needs of the site (0.07 MGD), it has been selected as the proposed wastewater discharge option. Wastewater discharge to Poplar Creek was considered as a potential alternative, but was eliminated from further consideration due to the following:

- Existing oil water separators and discharge structures currently exist near the proposed site. However, additional upgrades may be required to include additional permitting, water treatment, and monitoring.
- The environmental impacts associated with in-water retrofit activities and added discharges to the environment would be greater than utilizing the existing municipal system.
- The facility's operational life of 10 years does not support the costs associated with retrofitting existing structures.

5.3 REASONABLE ALTERNATIVES

This section describes how the site was developed, and potential alternatives to the proposed project, based on the guidance in Section 19.5 of the Final ISG Augmenting NUREG-1537, Part 1 and Section 19.5 of the Final ISG Augmenting NUREG-1537, Part 2. Based on the guidance in these ISG documents, this section:

- Describes the process used to develop, identify, and evaluate reasonable alternatives
- Describes reasonable alternatives considered
- Identifies the alternatives that were eliminated from further evaluation
- Considers whether alternatives may avoid or reduce adverse effects

According to the two ISG documents, reasonable alternatives may include, but are not limited to, alternative sites, alternative siting within a proposed site, modification of existing facilities, alternative technologies, and/or alternative transportation methods. The proposed project involves the demonstration and testing of new technology. Therefore, alternative technologies are not considered, and modification of an existing facility to house the proposed project is not feasible. With respect to alternative transportation methods, the proposed location of the site on a specific site within the East Tennessee Technology Park (ETTP) limits transportation options to vehicle transport using the existing road network, or rail transport using the existing onsite rail network. Based on the scope/size of components, extensive use of rail transport is not expected to be necessary, but the existing rail infrastructure would be expected to be sufficient without significant modification. Alternative routes, types of vehicles, carpooling of workers, or other transportation-related features may be considered as mitigation measures, but do not merit full analysis as alternatives. Similarly, the proposed project has been specifically sited within the former K-33 site on the ETTP to minimize potential impacts. The

specific location within that former building site is selected based on geologic conditions and minimization of potential impacts. Therefore, there are no other potential locations within the site that would reduce or avoid adverse effects.

Because none of these potential types of alternatives are feasible or would reduce or avoid adverse effects, this subsection is limited to identification and analysis of potential alternative locations and alternative process water intake and discharge options. This approach meets the requirement of the ISG documents, which state that, if new construction is proposed, then the alternatives should include at least one alternative location. Similarly, the level of analysis of the alternative site(s) in this subsection is commensurate with the context, degree, and intensity of the potential impacts, as indicated in the ISG documents.

5.3.1 Alternative Sites

Kairos Power is submitting a Construction Permit Application (CPA) for the Hermes non-power reactor at the former K-33 site on the ETTP in Oak Ridge, Tennessee. Part of the process for developing the CPA is selection of a site that would provide the geographic setting for the facility, as well as identification of potential alternative sites that may be considered if they meet Kairos Power's objectives and could result in a reduction in environmental impacts. This section provides a description of the bases, assumptions, and processes applied to the identification of the candidate sites for detailed analysis, and the selection of the proposed site and potential alternative sites.

The objective of the siting process is to identify a site that meets Kairos Power's business objectives for the project, satisfies applicable NRC site suitability requirements, and is compliant with NRC's implementation guidance for the National Environmental Policy Act (NEPA) analysis requirements for non-power reactors, with respect to the consideration of alternative sites. Kairos Power's mission is to enable the world's transition to clean energy, with the ultimate goal of dramatically improving people's quality of life, while protecting the environment. In furtherance of this mission, Kairos Power implements an iterative approach to technology development and deployment, which includes the deployment of the Hermes reactor, the primary objective of which is to demonstrate the ability to produce low-cost nuclear heat.

In the absence of specific guidance for identifying and evaluating alternative non-power reactor sites, Kairos Power has considered a process similar to that outlined in *Advanced Nuclear Technology: Site Selection and Evaluation Criteria for New Nuclear Power Generation Facilities* (EPRI Siting Guide), June 2015, Report 3002005435 (Reference 1). The process used by Kairos Power included defining a region of influence (ROI), identifying candidate areas, identifying potential sites within candidate sites, evaluating and scoring candidate sites, and determining which candidate site(s) would be included in the analysis of alternatives.

The Hermes reactor is developed and sited under a set of objectives to support its role as a demonstration and testing platform for the KP-FHR technology. These objectives, with regard to site selection, include the following:

- Facilitating rapid deployment of a non-power reactor in support of Kairos Power's iterative development approach
- Selecting a site that is, or can be, supported by sufficient high-quality existing site data for licensing and design
- Supporting both near-term and future testing capabilities; this objective results in a strong preference for close proximity to a U.S. Department of Energy (DOE) national laboratory site capable of supporting testing requirements

- Supporting opportunities for future development; this objective equates to identifying a nexus to either a future Kairos Power commercial reactor market or potential for future expansion for Kairos Power production, fabrication, or commercial reactor deployment

Additional objectives further inform the selection of potential and candidate sites. These objectives include availability of the potential/candidate site, the expected ability to apply existing and/or regional site data, the ability to acquire timely site data where needed, and other considerations, including, if applicable, the existence of a current or recently issued NRC license or permit that could be used or adapted to the Hermes reactor.

The site selection study was conducted under strict confidentiality and potential sites are not explicitly identified within this report. Investigations conducted as part of the site selection process were executed using existing reconnaissance-level data, available in the public domain or with limited consultation with various stakeholders.

5.3.2 Identification of Reasonable Alternatives

The continental United States was identified as the project ROI. While Hermes is not a commercial reactor, Kairos Power's business objectives for Hermes include a strong preference for deployment of the non-power reactor in a geographic area with a nexus to future domestic deployment for market opportunities or expansion. Accordingly, siting Hermes outside the continental United States was not considered. Within the continental United States, Kairos Power does not have a service area, as is typical for power reactor licensees. Therefore, the ROI was not limited to a specific area within the continental United States.

Within the ROI, high-level business objectives were used to narrow down the continental United States to a number of sub-regions, based on the likely ability to identify candidate areas. For most sub-regions, this selection was based on proximity to national laboratory sites. In selected cases, sites with existing or near-term prospective NRC licenses were included, because they may have advantages related to site suitability, availability of site data, and/or length of time required to obtain a CP.

Sub-regions that were initially considered included:

- Eastern Tennessee Pacific Northwest
- Eastern Idaho
- Piketon, Ohio
- Southeast United States
- Proximity to other national laboratories: Los Alamos, Sandia, Livermore, Argonne, and Brookhaven

These sub-regions were screened using exclusionary criteria based on business objectives to eliminate those areas that are either unsuitable or are significantly less suitable than other potential siting areas, resulting in the identification of five candidate areas. The regional screening process includes the ability to be supported by sufficient high-quality site data for licensing and design; proximity to a national laboratory site capable of supporting Hermes test plans; a nexus to future Kairos Power commercial reactor market or future expansion of Kairos Power operations; and (as a special consideration) the existence of a current or prospective NRC licensed site. Owing to the business need for a site being made available in a short time period, these screening evaluations also considered the likely availability of one or more sites within each sub-region.

Five sub-regions that were determined to remain eligible based on the screening process were identified as candidate areas. These candidate areas were reviewed to verify that each remaining candidate area provided at least one potential site capable of satisfying Kairos Power's business objectives for the

project. National laboratory sites included within the "Other National Laboratory Sites" sub-region were eliminated from further consideration because they did not meet one or more exclusionary screening criteria (e.g., lack of readily available site-specific data). Following identification of the candidate areas, individual potential sites were identified within each of the candidate areas. The process for identifying potential sites was based on identification of sites that were potentially available for use and, where applicable, contiguous to a national laboratory site. In addition, the identification included an assessment of individual sites against similar criteria used to evaluate sub-regions but applied at the site level.

As a result of the potential site identification processes described above, 11 potential sites were identified for further consideration. Potential sites were then evaluated to identify candidate sites. The criteria used to identify the candidate sites were as follows:

- Availability of the site for access/characterization and use within the Hermes schedule (i.e., site characterization immediately, support a construction start in 2023)
- Ability to acquire timely site-specific data
- Availability of high quality and sufficient site data for licensing and design

An additional criterion, the expected ability to apply existing regional data to the analysis, was also considered, but was ultimately eliminated as it did not prove to be a discriminator between sites.

Based on the application of these high-level criteria to the potential sites, six potential sites were eliminated from further consideration/analysis as shown in Table 5.3-1. Two sites were identified and retained for consideration and analysis as candidate sites. In addition, three more sites were deferred from further consideration, but were carried forward for further analysis to confirm the conclusion that they are not clearly superior in terms of Kairos Power business needs. Had one or more of these three additional candidate sites turned out to be clearly superior with respect to Kairos Power's business needs, then they would have been reexamined to determine if the exclusionary criterion(a) should be revisited; at the conclusion of the evaluation, this was concluded not to be the case, and these sites were then eliminated.

The candidate sites were further evaluated using weighted scores associated with the Kairos Power business needs, with the goal of identifying a proposed site, as well as establishing at least one alternative site, as indicated by the ISG to NUREG-1537, to compare to the proposed site for a detailed comparative environmental impact analysis. The business criteria and their associated weights (0 for no importance, to 10 for critical importance) were established based on Kairos Power business priorities for how the Hermes project fits into the overall Kairos Power development and deployment strategy. The scores for each site were established through team review of the extent to which each site met the applicable criterion, on a scale of 0 (not at all) to 5 (substantial). The scoring criteria, weights, and application to each candidate site are described in Table 5.3-2.

The basis for the weights and scores in Table 5.3-2 are described below, along with key observations of certain scores.

<u>Nexus to future Kairos Power commercial reactor market or future expansion</u>

This criterion is similar or identical to one previously applied at the region or sub-region level; in this case it is applied at the discrete site level for the purpose of scoring. This criterion has a weight of 7 because it is of above average importance that Hermes be sited reasonably near future Kairos Power interests, for logistical efficiency.

Candidate sites 1.1 and 1.2 score as substantially or fully conforming, with 1.3 only slightly lower (largely conforms). Candidate sites 3.1 and 3.2 score lower (moderate) because of limited proximity to likely future Kairos Power operations.

Access to construction resources (e.g., concrete, labor, etc.)

This criterion is above average in importance, but with a weight of 6 is slightly lower than that discussed above because construction resources can be imported if necessary.

Candidate sites 1.1, 1.2 f, and 1.3 all score reasonably high (largely conforms), while candidate site 3.1 scores lower (moderate) and candidate site 3.2 scores even lower (small), owing to their relatively remote locations.

Can be acquired (timely) or owner agreement to build

This criterion is similar or identical to one previously applied at the region or sub-region level; in this case it is applied at the discrete site level for the purpose of scoring. This criterion is weighted at 10 because it is critical to achieving Kairos Power's business objectives.

Candidate site 1.1 is not available on the Kairos Power timeline and scores accordingly low (none). Candidate site 1.2 scores high (substantially conforms) owing to its immediate availability. Candidate sites 1.3 and 3.1 score as moderate because of the likely complexity of granting durable access or ownership to Kairos Power. Candidate site 3.2 scores higher (largely conforms) because of the presumption of being able to acquire the property as a private sale.

Local development infrastructure (road, rail, power, potable water)

This criterion is of above average importance (weighted at 8) because of the schedule implications of having to develop infrastructure.

Candidate site 1.1 conforms to a large extent but would require some onsite infrastructure development. Candidate site 1.2 scores highest (substantially conforms) owing to available, existing infrastructure. Candidate sites 1.3 and 3.2 are effectively greenfield sites and score moderate as a result. Candidate site 3.1 has slightly more infrastructure and scores higher (largely conforms).

Strong local community support

This criterion was established with a weight of 5 because it is of average importance.

Candidate sites 1.1, 1.2, 1.3, and 3.2 all scored reasonably high (largely conforms) based on historical positive community experience and support for nuclear, while candidate site 3.1 Idaho National Laboratory (INL) scored slightly higher (substantially conforms) owing to community support for the lab itself.

Water availability (operations phase)

This criterion was weighted at 8 because of the importance of water availability to preserve design options.

Candidate sites 1.1, 1.2, and 1.3 all scored highest (substantially or fully conforming) while candidate sites 3.1 and 3.2 both scored low (small) owing to competition for limited water supply.

Minimize conflict with other major projects

This criterion was weighted at 4, slightly below average, reflecting that potentially competing nearby projects can have an impact but can be managed.

Candidate site 1.1 has less than the highest score (i.e., largely conforms) owing to the expectation of other reactor development projects on the site. Candidate sites 1.2, and 3.2 higher (substantially or fully conforming) because of minimal expected disruption. Candidate sites 1.3 and 3.1 scored lower (moderate) because of feedback and expectations regarding future planned projects on those sites.

Location supports (or does not preclude) nuclear utility support

This criterion was weighted slightly below average at 4. It is important to engender utility support during Hermes development and operation, but remote support can suffice.

Candidate sites 1.1, 1.2, and 1.3 scored highest (substantially or fully conforming) owing to direct proximity to utility support. Candidate sites 3.1 INL and 3.2 Eagle Rock scored lower (moderate) owing to remote support options.

Minimize reliance on DOE as "landlord"

This criterion is weighted relatively low at 3, reflecting that the challenges associated with siting on a DOE reservation can be overcome with adequate planning.

Candidate sites 1.1, 1.2, and 3.2 all scored highest (substantially or fully conforming) based on being non-DOE owned. Candidate sites 1.3 and 3.1 scored lowest (none).

Avoidance of significant environmental impact (e.g., wetlands)

This criterion was weighted very high at 9, reflecting the preference not to constitute significant environmental impact.

Candidate sites 1.1, 3.1, and 3.2 scored relatively high (largely conforms) because of the expected ability to avoid significant impacts, particularly to wetlands. Candidate site 1.3 scored slightly lower (moderate) because of its status as effectively greenfield with access to water. Candidate site 1.2 scored highest (substantially or fully conforming) based on its brownfield status with previous water use infrastructure. Even though the existing infrastructure may need to be modified, this modification is not expected to result in as significant an impact as if developed the infrastructure needed to be developed from scratch.

Site-specific existing test/research nexus

This criterion is similar or identical to one previously applied at the region or sub-region level; in this case it is applied at the discrete site level for the purpose of scoring. This criterion was weighted slightly below average in support of the possible inclusion of Hermes in a future test/research mission beyond its intended Kairos Power mission.

Candidate sites 1.1 and 3.2 score high (largely conforms) but not highest, owing to location/logistics of the sites relative to national laboratory reservations. Candidate sites 1.2, 1.3, and 3.1 score highest (substantially or fully conforming) because they are either within or effectively contiguous to laboratory property.

Conclusion

Candidate sites 1.1 and 1.3 were initially eliminated from consideration but were scored further to confirm that neither was superior from a business perspective. Comparison of both sites' scoring, even accounting for exclusion of 1.1 for reasons of availability, do not indicate that either is superior. Accordingly, they were eliminated from further consideration as the proposed site or as an alternative site.

Similarly, candidate site 3.1 was initially eliminated from consideration, but was scored further in the event that it emerged as superior from a business perspective. Comparison of its score with that of candidate site 3.2 indicates they are virtually identical regarding these criteria, indicating that neither would reduce or avoid adverse effects more than the other. Therefore, candidate site 3.1 was eliminated from further consideration as the proposed site or as an alternative site.

Based on application of the business criteria above, two candidate sites are selected for inclusion in comparative environmental impact analyses: site 1.2 and site 3.2. Of these, candidate site 1.2 former K-33 site was selected by Kairos Power as their proposed site, and candidate site 3.2 is proposed as an alternative site for detailed environmental impact analysis.

5.3.3 References

1. EPRI. Advanced Nuclear Technology: Site Selection and Evaluation Criteria for New Nuclear Power Generation Facilities (Siting Guide). June 9, 2015. Available at: https://www.epri.com/research/products/1006878.

Table 5.3-1: Results of Potential Site Evaluation

Potential Site ID	Potential Site Evaluation Status
Candidate Area 1 – Eastern Tennessee	
1.1	Deferred from consideration by Kairos Power, but identified as candidate site for further evaluation to confirm not superior from business perspective
1.2	Identified as Candidate Site
1.3	Deferred from consideration by Kairos Power, but identified as candidate site for further evaluation to confirm not superior from business perspective
Candidate Area 2 – Pacific Northwest	
2.1	Eliminated from further evaluation
2.2	Eliminated from further evaluation
Candidate Area 3 – Eastern Idaho	
3.1	Deferred from consideration by Kairos Power, but identified as candidate site for further evaluation to confirm not superior from business perspective
3.2	Identified as Candidate Site
Candidate Area 4 – Piketon, Ohio	
4.1	Eliminated from further evaluation
Candidate Area 5 – Southeast United States	
5.1	Eliminated from further evaluation
5.2	Eliminated from further evaluation
5.3	Eliminated from further evaluation

Table 5.3-2: Weighted Scoring of Candidate Sites

Candidate Site Scoring Criterion	Weight	Candidate Sites				
		1.1	1.2	1.3	3.1	3.2
Nexus to future Kairos Power commercial reactor market or future expansion[(a)]	7	4	4	3	2	2
Access to construction resources (e.g., concrete, labor, etc.)	6	3	3	3	2	1
Can be acquired (timely) or owner agreement to build[(a)]	10	0	4	2	2	3
Local development infrastructure (road, rail, power, potable water)	8	3	4	2	3	2
Strong local community support (or lack of opposition)	5	3	3	3	4	3
Water availability (operations phase)	8	4	4	4	1	1
Minimize conflict with other major projects	4	3	4	2	2	4
Location supports (or does not preclude) nuclear utility support	4	4	4	4	2	2
Minimize reliance on DOE as "landlord"	3	4	4	0	0	2
Avoidance of significant environmental impact (e.g., wetlands)	9	3	4	2	3	3
Site-specific existing test/research nexus[(a)]	4	3	4	4	4	3
Total		**196**	**261**	**178**	**149**	**150**

Scoring key:
0 – Does not conform to criterion at all
1 – Conforms to a small extent
2 – Conforms to a moderate extent
3 – Conforms to a large extent
4 – Substantially or fully conforms

(a) - These criteria are similar or identical to previously applied criteria at the region or sub-region level; these are applied at the discrete site level for the purpose of scoring.

5.4 EVALUATION OF REASONABLE ALTERNATIVE SITES DISCUSSION

The evaluation of potential and candidate sites is described in Section 5.3. This evaluation resulted in the identification of candidate site 3.2 (Eagle Rock) as the proposed alternative site. This section provides the alternative site evaluation for the Eagle Rock site.

5.4.1 Eagle Rock

The Eagle Rock site is located within Bonneville County, Idaho and is surrounded by Bingham, Bonneville, and Butte counties, which are also located in Idaho. This site is situated on approximately 4,200 acres approximately 20 miles west of Idaho Falls, Idaho (Figure 5.4-1). The INL is located approximately 1-mile west of the site.

5.4.1.1 Land Use and Visual Resources Impacts

This section describes the land use and visual resources on and near the Eagle Rock site, which includes the area that would be directly affected by construction and operation of the Hermes reactor on the Eagle Rock site.

5.4.1.1.1 Land Use

The Eagle Rock site is located in Bonneville County. Cultivated crops and undeveloped sagebrush or woodlands are the predominant land uses for Bonneville County. Less than 3 percent of the land in the county is developed. The Eagle Rock site is bordered on the west by state-owned land and to the south and east by lands managed by the Bureau of Land Management (BLM). Private lands lie to the northeast and south, the INL is located to the north and west, and Hell’s Half Acre National Natural Landmark (NNL) and Wilderness Study Area (WSA) lies south of the Eagle Rock site. Agricultural lands are northeast and southeast of the Eagle Rock site (Reference 1).

Land use within the Eagle Rock site is primarily cultivated cropland and sagebrush, with additional land use being pasture/hay, open space, and upland grasslands. Near the south end of the Eagle Rock site, a few agricultural buildings are located along US 20. The Federal Government previously held uranium land patents on two 16-acre parcels near the Eagle Rock site, but the uranium leases have now been relinquished (42 U.S.C. 2098 Sec. 68b). Some of the land located within the Eagle Rock site has been designated as prime farmland by the Natural Resources Conservation Service (NRCS) (Reference 1).

There are several special land use areas near the Eagle Rock site (Figure 5.4-2). Hell’s Half Acre WSA, just south of US 20, is the closest at approximately 1 mile from the site. The northern portion of the Hell’s Half Acre WSA was named a NNL in 1973. North Menan Butte NNL, 20 miles to the northeast; Big Southern Butte NNL, 32 miles to the southwest; and Great Rift NNL, 45 miles to the southwest; are three additional NNLs in the region, and The Craters of the Moon National Monument and Preserve is 50 miles west of the Eagle Rock site. Challis National Forest (30 miles northwest) and Targhee National Forest (30 miles north northwest) are two national forests located northwest of the INL property. The Idaho Department of Fish and Game manages for hunting both the Mud Lake wildlife management area (WMA), located 22 miles north of the Eagle Rock site, and Market Lake WMA, located 20 miles northeast. The U.S. Fish and Wildlife Service (USFWS) manages the Camas National Wildlife Refuge, 27 miles north of the Eagle Rock site. Fort Hall Indian Reservation, the property of the Shoshone-Bannock Tribes, is 37 miles south of the Eagle Rock site (Reference 1).

For the purposes of this analysis, the Eagle Rock site would likely be approximately 95 acres with permanent impacts to approximately 30 acres of cultivated cropland, sagebrush, pasture, open space, upland grasslands, and prime farmland. The loss of agricultural/cultivated crops to industrial facilities is

minor when compared to the agricultural land remaining within the project area and the impacts to land use from construction and operations would be SMALL.

5.4.1.1.2 Visual Resources

Gently rolling, sagebrush semi-desert, with some high points characterizes the Eagle Rock site area. Sagebrush, standing approximately 3 feet tall, is the tallest vegetation on the property. Kettle Butte, located 0.75 miles east of the Eagle Rock site, is the highest point in the vicinity, although larger buttes are visible in the distance. The eastern portion of the Eagle Rock site is used for agriculture, and single-story agricultural storage structures can be seen adjacent to US 20 in the vicinity of the Eagle Rock site (Reference 1).

Lands immediately surrounding the Eagle Rock site to the north, east, and west are primarily sagebrush semi-desert. BLM manages the lands to the north and west and has designated them for grazing and multi-purpose use. South of US 20 is a combination of private and BLM-managed lands, a large portion of which is Hell's Half Acre WSA. Another visually sensitive resource near the Eagle Rock site is the Wasden Complex, a significant group of archaeological sites located about 1 mile from the Eagle Rock site (Reference 1).

The Eagle Rock site is located within 2 miles of US 20, an area where visual intrusions are very obvious, as opposed to distant background areas where they are less noticeable. Visual intrusions are highly visible from key observation points in this area, causing the greatest apparent contrast.

The Eagle Rock site is in a relatively undeveloped setting. Sensitivity, which addresses the expectation for pristine environments, would be expected to be low to changes in the visual landscape for farmers and workers using the area and moderate to high for those using the Hell's Half Acre WSA (Reference 1).

The scenery in adjacent areas is similar to that of the Eagle Rock site and has little influence on visual quality. Although the Eagle Rock site is adjacent to unique geologic features associated with Hell's Half Acre WSA, the Eagle Rock site itself is not unique. Very few cultural modifications, consisting of storage sheds, agricultural crops, and US 20, are in the area.

Construction at the Eagle Rock site would impact the visual resources at the site. The appearance of large heavy equipment against the highly natural background would change the view considerably. Additionally, traffic and delivered materials coming to and from the construction site would alter views along US 20. The site would not be highly visible from the visually sensitive areas due to distance. However, due to the flat nature of the surrounding landscape, taller equipment may be visible from longer distances. Views from Kettle Butte may be significantly negatively impacted. However, there are almost no observers in the area for great lengths of time, and impacts would be temporary; therefore, impacts during construction would be MODERATE. Impacts during operation would be similar, but smaller than those during construction because staging areas would have been returned to their current state. However, overall impacts to visual resources would be MODERATE.

5.4.1.2 Air Quality and Noise

5.4.1.2.1 Air Quality

Under the Clean Air Act, U.S. Environmental Protection Agency (EPA)'s National Ambient Air Quality Standards (NAAQS) set maximum levels of air pollutants in ambient air which are considered to be protective of public human health and welfare. An area where these standards are not met is designated as a nonattainment area, but once air quality in this area meets the ambient air quality standards, the area is re-designated as a maintenance area. Maintenance areas are designated by

pollutant, and criteria pollutants include ozone (O_3), particulate matter, carbon monoxide (CO), nitrogen oxides (NO_x), sulfur dioxide (SO_2), and lead.

The Eagle Rock site is located within Bonneville County, Idaho and is surrounded by Bingham, Bonneville, and Butte counties, which are also located in Idaho. All four counties are in attainment for all criteria pollutants (Reference 2).

Fort Hall Indian Reservation, in Bannock and Power Counties, is the closest nonattainment area to the Eagle Rock site and is designated as nonattainment for particulate matter with an aerodynamic diameter of 10 microns or less (PM_{10}) (Reference 2).

Total allowable increases in ambient pollutant levels above established baseline levels are placed on PM_{10}, sulfur dioxide, and nitrogen dioxide by the Prevention of Significant Deterioration Program (40 CFR 52.21), where pollutant levels are below the ambient air quality standards. Under these regulations, the allowable increases are smallest in areas where the air quality value of visibility must be preserved (e.g., national parks and wilderness areas). These areas are designated as Class I areas (Reference 2).

Class I areas in and around the Eagle Rock site include Craters of the Moon National Monument and Preserve (47 miles to the west); Grand Teton National Park (65 miles to the east); and Yellowstone National Park (65 miles to the northeast) (Reference 3). Small air quality increments apply in these areas, and sources that impact them may need to consider visibility impacts and air quality-related values (Reference 1). However, the Federal Land Manager guidance (Reference 4) for modeling these impacts indicates that if the distance to the nearest Class I area in kilometers times 10 exceeds the project emissions (in tpy) of sulfur dioxide plus oxides of nitrogen plus particulate matter plus sulfuric acid mist, then the project screens out of modeling requirements. Since this total emission rate is not expected to exceed 250 tpy (leading to a distance threshold of 16 miles for modeling requirements), this project can screen out of Class I area modeling.

Air emissions during construction and operations would be similar to those described for the proposed action and would include emissions of criteria pollutants such as SO_2, NOx, CO, PM_{10}, and $PM_{2.5}$ and fugitive dust from onsite and offsite vehicle use; nonradiological gaseous criteria pollutants and hazardous air pollutants (HAPs) from fossil-fuel-powered emergency generators and equipment; and radiological air emissions from the primary heat rejection stack, Reactor Building ventilation stack, and spent fuel cooling stack. However, as with the Eagle Rock site, mitigation measures would be implemented and the impacts to air quality would be SMALL.

5.4.1.2.2 Noise

Noise is unwanted or unwelcome sound usually caused by human activity that is added to the natural acoustic setting of a locale. Noise is further defined as sound that disrupts normal activities and diminishes the quality of the environment. The most common measurement of sound and environmental noise is the dBA, a logarithmic scale that ranges from 0 dBA to about 140 dBA.

The Eagle Rock site consists of sagebrush steppe, which transitions to non-irrigated pasture in the northeastern corner of the property, and to irrigated cropland in the southern portions of the property. The predominant community, non-irrigated pasture, is the result of historical mechanical modification of sagebrush steppe by removing shrubs and planting grasses such as crested wheatgrass (*Agropyron cristatum*) to improve grazing. Barley, wheat, and potatoes are grown on the irrigated cropland and similar crops are grown on areas surrounding the Eagle Rock site. The entire land surface of natural areas of the Eagle Rock site, with the exception of small rock outcroppings, is covered with a natural or vegetative covering throughout the growing season. Land cover typically results in the attenuation of sound, and the ground surface of the Eagle Rock site should be relatively sound-absorptive. Sound

pressure level attenuations would be expected to average 6 dBA, with every doubling distance between source and receptor, which is common throughout much of the continental United States (Reference 1).

Noise sources on and near the site include seasonally used machinery and equipment to prepare fields and plant and harvest crops; trucks used to transport harvested crops; and an irrigation pump in the site’s center, which is the only identified significant anthropogenic point source. Highway US 20, located along the Eagle Rock site’s southern border, is a major transportation corridor in the immediate vicinity of the site and the only identified anthropogenic noise source of note within the property’s vicinity. It is used for commerce and by many employees of INL, located immediately west of the property, to commute between their homes and the lab.

Farm workers, who periodically work in agricultural fields on or near the property; hikers, who frequent a trail leading into Hell’s Half Acre Wilderness Study Area and located about 0.3 miles southwest of the property; and residents, the nearest of which is estimated to be 4.8 miles east of the site; are the human receptors closest to the site. None of these are considered to be sensitive human receptors. Idaho Falls, approximately 20 miles east of the Eagle Rock site, is the nearest community.

Noise during construction and operations would be similar to that described for the proposed action and would include temporary increases and fluctuations in ambient noise levels around the site during construction, traffic associated with the workforce, and outdoor equipment (i.e., heat exchange fans and several exhaust and ventilation stacks) during operations. With the nearest resident over 4 miles from the site, the increase in noise from construction and operation would unlikely be perceptible and the impacts to the noise environment would be SMALL.

5.4.1.3 Geology, Soils, and Seismology

The Eagle Rock site is located within the axial volcanic zone of the Eastern Snake River Plain (ESRP) physiographic province, a 62-mile wide topographic depression extending 373 miles from Twin Falls to Ashton, Idaho. The Eagle Rock site is relatively flat, with a mildly sloping surface; areas of basaltic rock outcrop and small ridges occur across the site, especially in the northwestern and southern parts. As suggested by area geologic mapping, the volcanic vent at Kettle Butte produced the basalt flows at the Eagle Rock site. Eagle Rock site elevations range from approximately 5,100 feet to 5,250 feet, and depths to the basalt bedrock range from 0 to 21.5 feet (Reference 1).

Volcanic landforms are the predominant physiographic features of the ESRP province. North-to-northwest trending mountains, with peaks reaching 12,000 feet, bound the ESRP on the north and south. These mountains are separated by basins containing sediments and volcanic rocks. Throughout the Pleistocene and Holocene, the two most recent geological epochs, widespread basaltic volcanic activity occurred on the ESRP, the most recent occurring about 2000 years ago west of the site. The ESRP is underlain by basaltic lava interbedded with poorly consolidated sedimentary materials. Streams, lakes, and wind have deposited sediment materials consisting of clays, silts, sands, and gravels, that accumulated to thicknesses approaching 200 feet. These interbedded sequences are underlain by a thick sequence of silica-rich volcanic rocks (Reference 1, Reference 5, Reference 6, Reference 7).

Glacial outburst flooding, wind erosion and deposition, and range fires significantly modified the appearance of the ESRP landscape during the late Pleistocene to late Holocene, and some of these processes continue modifying the landscape today. Widespread deposition from winds has formed thick deposits of loess across the ESRP and areas to its southeast (Reference 1).

Early large volcanic eruptions were rich in silica while later ones predominantly contained basalt (Reference 1). The most recent and closest volcanic eruption to the ESRP occurred about 2000 years ago at Craters of the Moon National Monument, 27 miles southwest of the site (Reference 8).

A soil map of the Eagle Rock site is shown as Figure 5.4-3. Pleistocene age loess deposits, consisting of silt and sandy silt, make up most of the unconsolidated surficial material. Basalt gravel, in small angular to subrounded pieces, is also sparsely found. Most of the soils at the Eagle Rock site are characterized by the U.S. Department of Agriculture (USDA) soil survey for Bonneville County as Pancheri silt loam. Other soils on the site include the Pancheri- and Polatis-rock outcrop complexes, well-drained, moderately deep, silt loams, are found on the steeper slopes of basalt outcrops, which occur as erosional surfaces within intermittent stream drainages and as low irregular ridges of debris. The NRCS classifies Pacheri silt loam soils, if irrigated, as prime farmland. These soils cover about 63 percent of the Eagle Rock site (Reference 1).

Surface soil samples were previously collected from ten locations across the site and analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticides, herbicides, metals, phosphorous, and fluoride, and tested for percent moisture content. The results of the analyses for metals, fluoride, and moisture content in soils are summarized in Table 5.4-1. Mercury was not detected, and all other metals fall within the range of INL-reported background concentrations in surface soils. Moisture content ranged from 9.1 to 16.5 percent. Table 5.4-2 shows results for VOCs, SVOCs, and pesticides (herbicides were not detected). Three VOCs, 1,3,5-trimethylbenzene, 1,3-dichlorobenzene, and tetrachloroethene, were detected in one of the ten samples. Three SVOCs, benzo(a)pyrene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene, were detected in four soil samples, and the pesticide chlorpropham was detected in three samples. Detected concentrations of these organics do not exceed EPA's regional screening levels for industrial soils (Reference 9). Radionuclides, including uranium, thorium, their daughter products, potassium-40, and cesium-137, were also analyzed in the ten surface soil samples; the results are shown in Table 5.4-3. These radionuclides are naturally occurring, with the exception of cesium-137, which is produced by weapons testing and is widely found in the environment (Reference 1).

The Eagle Rock site is situated on a volcanic ridge that extends across the middle of the site from northeast to southwest (Figure 5.4-4). Although low level seismic activity is common at the site, most earthquakes with the potential to affect the Eagle Rock site occur in the Basin and Range province north of the site (Figure 5.4-4). Earthquakes in this province could produce the feel of moderate to strong ground shaking at the Eagle Rock site (Reference 1, Reference 7, Reference 10).

The major volcanic hazard at the Eagle Rock site is the inundation and burning of structures by lava flows. Other potential common hazards from volcanic activity include ground deformation, volcanic earthquakes, gas release, and volcanic ash. A volcanic eruption that could impact the Eagle Rock site has a mean annual probability of 3.7×10^{-6} (Reference 1).

Potential impacts to geologic and soil resources during the construction and operations of the Eagle Rock site include regional-scale hazards and local hazards. The regional-scale hazards include earthquakes, volcanic activity, landslides, subsidence, and erosional processes.

Local hazards are associated with site-specific properties of the soil and bedrock and include soil disturbance due to excavation, exposure of contaminated soil, blasting of bedrock (if required for construction), the volume of material excavated or used during construction, impacts to rare or unique geologic resources, and impacts to economic rock, mineral, or energy resources. With implementation of best management practices (BMPs), potential hazards during construction and operation of the Eagle Rock site would be SMALL.

5.4.1.4 Water Resources

5.4.1.4.1 Surface Water Features

The Eagle Rock site is located in southeast Idaho on the easternmost edge of the Snake River Plain. The Snake River, generally flowing from the northeast to the southwest, lies about 20 miles to the east of the Eagle Rock site. American Falls Reservoir and Lake Wolcott, on the Snake River, are about 49 miles and 79 miles southwest of the Eagle Rock site, respectively, and are the largest surface water bodies downgradient of the property. No rivers, lakes, or streams lie within the Eagle Rock site, although a few small drainage features occur within irrigated crop circles, in the property's northeastern corner, and along the southern portion of the property, draining water from irrigated agricultural areas (Reference 1).

The Eagle Rock site contains no wetlands. The closest wetland to the property is the Market Lake WMA, near Roberts, about 20 miles to the northeast. The Eagle Rock site is not located within any 100-year or 500-year floodplains. The Snake River, located 20 miles to the east, is the closest river to the Eagle Rock site; no levees, reservoirs, or surface waters exist that could cause flooding of the Eagle Rock site (Reference 1).

Similar to the proposed action, construction and operation activities would comply with the National Pollutant Discharge Elimination System (NPDES) Permit requirements and stormwater runoff would be diverted to a stormwater pond. There would be no direct discharges of stormwater or wastewater to surface water. A Stormwater Pollution Prevention Plan (SWPPP) would be developed to identify control measures to minimize disturbed areas and protect natural site features and erodible soil. Compliance with the requirements of the NPDES permit requirements and SWPPP would minimize impacts to surface water quality such that the resultant impacts would be SMALL.

5.4.1.4.2 Groundwater Resources

The ESRP aquifer underlies the Snake River Plain in the vicinity of the Eagle Rock site and is the source of its potable and process water supply. The ESRP aquifer underlies an area of 10,040 mi^2 and reaches a thickness of slightly over 1,300 feet, with the upper 300 to 500 feet being the most productive. The ESRP is largely unconfined, with groundwater flow southwestwardly from recharge areas on the Yellowstone Plateau and from areas on the Snake River Plain where surface water irrigation and precipitation occur (Reference 1).

Most of the basalt bedrock below the Eagle Rock site is fractured to some degree; however, there are massive zones with few or no fractures present. Typically, narrow vertical fractures are within flow interiors. Large vertical and horizontal fractures are within flow tops and bottoms, which are also marked by the presence of cinder, scoria, increased vesicles, and red oxidation. The aquifer is unconfined or semi-confined, based on field tests (Reference 1).

The majority of the ESRP aquifer recharge comes from irrigation water, with small aquifers in valleys along the plain's edge, infiltration from rivers and canals, and precipitation (rain and snow) also contributing to recharge (Reference 11).

Groundwater flowing through the Snake River Plain aquifers eventually discharges to the Snake River or is withdrawn for irrigation, drinking water, and commercial and livestock use. Over 90 percent of groundwater withdrawn is used for irrigation of crops, and about four percent is used for the public and domestic water supply (Reference 12).

In 1991, the ESRP aquifer was designated a sole source aquifer. By definition, a sole source aquifer supplies at least 50 percent of the drinking water in the petitioned area, and no reasonably available

alternative drinking water source exists to supply those depending on the aquifer (Reference 13). The ESRP aquifer is one of the most productive aquifers in the United States (Reference 14). The aquifer consists of a thick sequence of basalts and sedimentary interbeds filling a large, arcuate, structural basin in southeastern Idaho. Recharge to the ESRP aquifer is primarily from infiltration of applied irrigation water, infiltration of streamflow, groundwater inflow from adjoining mountain drainage basins, and infiltration of precipitation. Populations in southeast and south-central Idaho currently depend on the ESRP as their sole source of drinking water.

The upper portion of the ESRP aquifer is of high quality when compared with drinking water standards. Two agricultural wells and five monitoring wells sampled in 2008 were analyzed for metals (dissolved and total), total organic carbon, VOCs, SVOCs, polychlorinated biphenyls (PCBs), total petroleum hydrocarbons, pesticides, and herbicides (Reference 15). Aluminum and iron concentrations, likely resulting from the presence of suspended particles, were the only metals detected above EPA maximum contaminant levels. No VOCs, SVOCs, PCBs, pesticides, or herbicides were detected in groundwater samples, with the following exceptions: trace amounts of chloroform and low levels of bis(2-ethylhexyl)phthalate and diethylphthalate were detected, likely resulting from sample handling, and low levels of lubricating oil were detected, likely resulting from drilling activities (Reference 1).

During construction and operations, the water supply at the Eagle Rock site would be obtained from onsite wells completed in the ESRP aquifer. No surface water resources would be used. Because the annual maximum usage rates during construction and normal operations would be well below the annual water right appropriation (Reference 14), impacts on the groundwater supply would be SMALL.

5.4.1.5 Ecological Resources

The Eagle Rock site is located in an ecological region known as the Snake River Plain and is associated with three sub-regions within this plain: East Snake River Basalt Plain, Upper Snake River Plain, and Lava Fields, with approximate sizes of 6,400, 1,500, and 1,100 square miles, respectively. The Snake River Plain is referred to as the Sagebrush Steppe, and large expanses of sagebrush, a variety of native grasses, and saltbush and shadscale found in the saltier soils characterize both the East Snake River Basalt Plain and the Upper Snake River Plain. On the Upper Snake River Plain, soils are typically deeper, and where irrigation is available, pastures and small grains are produced, which differentiate it from the East Snake River Basalt Plain. The Lava Fields sub-region includes the Craters of the Moon National Monument and Preserve (Reference 1).

5.4.1.5.1 Vegetation

The western part of the Eagle Rock site is sagebrush steppe (1,060 acres), which then transitions to non-irrigated pasture in the northeastern corner of the property (2,180 acres) and to irrigated cropland in the southern portions of the property (962 acres). The predominant community, non-irrigated pasture, is the result of historical mechanical modification of sagebrush steppe by removing shrubs and planting grasses to improve grazing. The land immediately east of the Eagle Rock site is intensively managed for agriculture, while sagebrush steppe and shrubland lie to the west and north of the property (Reference 1). The vegetation types of the Eagle Rock site are shown on Figure 5.4-5.

Dominant plant species in the sagebrush steppe include Wyoming big sagebrush (*Artemisia tridentata wyomingensis*), dwarf goldenbush (*Ericameria nana*), and Sandberg bluegrass (*Poa secunda*). Non-irrigated pasture was planted in grasses in portions of the sagebrush steppe where shrubs were removed. As a result, crested wheatgrass (*Agropyron cristatum*) and cheatgrass (*Bromus tectorum*), both non-native species, are the dominant plant species in the non-irrigated pastureland. Some shrubs remain in the pastureland, primarily in rock outcrops. Barley, wheat, and potatoes are grown on the irrigated cropland (Reference 1).

Plant communities would be affected primarily during construction. Direct impacts would result from land clearing and grading, underground utility installation, and road construction. All vegetation would be cleared from the proposed facility footprint as well as from construction laydown areas and equipment assembly and staging areas (approximately 95 acres). Sagebrush steppe is the predominant plant community type in the region and provides valuable habitat for numerous native species. However, following construction, approximately 65 acres would be allowed to return to its native state and the surrounding area has ample acreage of the same habitat type. Therefore, the impacts on vegetation would be SMALL.

5.4.1.5.2 Wildlife

Wildlife surveys of the Eagle Rock site were conducted in May, June, and October 2008, in January and April 2009, and in April 2010. These surveys identified 27 wildlife species in the sagebrush steppe community. Pronghorn antelope (*Antilocapra americana*), greater sage-grouse (*Centrocercus urophasianus*), sage thrasher (*Oreoscoptes montanus*), sage sparrow (*Amphispiza belli*), and Brewer's sparrow (*Spizella breweri*), which are sagebrush obligate species, are known to occur on the Eagle Rock site (Reference 1).

Eagle Rock site wildlife surveys identified 15 wildlife species in the non-irrigated pasture habitat and ten species in the irrigated cropland. Small mammal trapping was not conducted on the Eagle Rock site, but small mammals common in similar habitats at INL include the mountain cottontail (*Sylvilagus nuttallii*), pygmy rabbit (*Brachylagus idahoensis*), black-tailed jack rabbit (*Lepus californicus*), least chipmunk (*Tamias minimus*), Townsend's ground squirrel (*Spermophilus townsendii*), Great Basin pocket mouse (*Perognathus parvus*), Ord's kangaroo rat (*Dipodomys ordii*), deer mouse (*Peromyscus maniculatus*), western harvest mouse (*Reithrodontomys megalotis*), montane vole (*Microtus montanus*), and bushy-tailed woodrat (*Neotoma cinerea*) (Reference 1).

Large mammals that have been observed on the Eagle Rock site include the pronghorn, white-tailed deer (*Odocoileus virginianus*), coyote (*Canis latrans*), and badger (*Taxidea taxus*); pronghorns use the property throughout the year, and the property is located within important winter-spring pronghorn habitat (Reference 1). Mule deer (*Odocoileus hemionus*) and elk (*Cervus canadensis*) occur in the region during summer and winter and migrate through the INL area between summer and winter use areas (Reference 16). There are no indications that mule deer, elk, or pronghorn populations are declining in the region; elk and pronghorn populations may be slightly increasing (Reference 1).

A query of the USFWS's Information for Planning and Consultation (IPaC) online database (Reference 56) for the Eagle Rock site location identified no species with a federal listing status that are likely to occur on or in the vicinity of the property. Species that have been observed on the Eagle Rock site and have a NatureServe state ranking indicating potential concern are the grasshopper sparrow (*Ammodramus savannarum,* rare or uncommon breeding population) and long-billed curlew (*Numenius americanus,* imperiled breeding population) (Reference 17).

Vegetation removal and site grading could result in direct impacts on wildlife present on the site and could result in mortality of less mobile species, such as reptiles, small mammals, and nesting or burrowing species. However, species with greater mobility would likely relocate to nearby suitable habitat. Some wildlife species are totally dependent on the sagebrush steppe and are classified as sagebrush obligates. Depending on the species and specific habitat requirements, the loss of sagebrush habitat could have greater impact during specific life stages, such as breeding, nesting, brood rearing, or wintering. Mitigation measures such as scheduling construction outside of the nesting season would be implemented to reduce impacts. Impacts to wildlife during construction could be MODERATE and impacts during operation would be SMALL.

5.4.1.5.3 Wetlands

Wetlands are not present on or adjacent to the Eagle Rock site. The property and adjacent areas also lack aquatic habitats such as lakes, ponds, rivers, and streams. Surface water features consist of drainages that, due to infiltration and evaporation, generally contain water only during wet periods (intermittent) or during or immediately after precipitation events (ephemeral) (Reference 1). Therefore, the impacts to wetlands would be SMALL.

5.4.1.6 Historic and Cultural Resources

In the area surrounding the Eagle Rock site, there are significant archaeological sites. The Wasden Complex, a series of lava blister caves containing evidence of human use dating back to at least 10,000 B.C., is located approximately 1 mile from the Eagle Rock site and is one of the most important sites found in the region. Three distinct sites, containing evidence of continuous use up to the Historic Period, make up the complex. Evidence of people hunting mammoth, and a type of now extinct bison, is found at the complex. A complex of this age containing direct evidence of humans hunting extinct animals is extremely rare (Reference 1).

A National Historic Preservation Act of 1966 Section 106 review of a previously proposed Eagle Rock project was conducted on the Area of Potential Effect (APE), defined by the NRC as the 592-acre portion of the Eagle Rock site that would be directly affected by construction activities. An archaeological contractor surveyed 941 acres of the Eagle Rock site, within which the 592-acre APE was included, for historic and cultural resources (Reference 18). In 2009, an additional 64 acres was surveyed. 13 archaeological sites and 24 isolated finds were identified within the APE by the surveys. Isolated finds are not considered archaeological sites but are isolated occurrences of cultural resource material. The 24 isolated finds and nine of the archaeological sites are not considered eligible for listing on the National Register of Historic Places (NRHP). The John Leopard Homestead archaeological site, consisting of several structural remains, is recommended eligible for listing on the NRHP (Reference 1). The archaeological contractor performed additional research for three other archaeological sites, and determined they lacked sufficient information to be considered significant (Reference 18).

An NRC file search on the 4,200-acre parcel of land on which the previously proposed Eagle Rock facility was to be built revealed that this property had not been previously surveyed for the presence of historic and cultural resources, prior to AREVA Enrichment Services' 2008 license application. Seven previously recorded archaeological sites within 1 mile of the Eagle Rock site were identified by the NRC file search. Four of the sites, three of which are associated with the Wasden complex, are eligible for listing on the NRHP. No information was available for the remaining three sites (Reference 1).

Due to the presence of four archeological sites previously identified within the proposed Eagle Rock site and the potential for additional sites, impacts to historic and archeological resources would be MODERATE. To minimize impacts, an Archaeological Monitoring and Discovery Plan would be developed to specify procedures for addressing and handling the unexpected discovery of human remains or archaeological material during construction. During operation, impacts would be SMALL, as these resources would have already been addressed during construction.

5.4.1.7 Socioeconomics

This section characterizes the current socioeconomic conditions within the ROI surrounding the Eagle Rock site and provides a basis for assessing potential socioeconomic impacts as a result of construction and operation. The socioeconomic characterization addresses demographics (resident and transient population growth rates, race and ethnicity), community characteristics (the economy, housing

availability, public services, local transportation), and tax payment information. Population data was gathered using 2015-2019 American Community Survey 5-Year Estimates.

Data is analyzed at various geographic levels for the purpose of comparison. The nature and extent of socioeconomic characterization is consistent with the Final ISG Augmenting NUREG-1537, Part 1, Section 3.7.

5.4.1.7.1 Demography

Resident Population

Resident Population of Communities in Region of Influence

The socioeconomic ROI is identified as the three-county region nearest the Eagle Rock site (Bingham, Bonneville, and Jefferson counties) as illustrated in Figure 5.4-6 (Reference 19). The ROI is defined by the areas where construction and operations workers and their families are most likely to reside, and spend their wages, salary, and benefits on goods and services, which impact the socioeconomic environment in the region.

Table 5.4-4 shows the historic resident population from 1990-2019 for counties in the ROI and the State (Reference 20, Reference 21, Reference 22, Reference 23). Between 1990 and 2019, population in the ROI increased 49.4 percent overall, from 126,333 to 188,765. Rates of growth were 22.0 percent in Bingham County, 58.4 percent in Bonneville County, and 72.5 percent in Jefferson County (Reference 20, Reference 21, Reference 22, Reference 23). The closest metropolitan area is Idaho Falls, located 20 miles east of the site, located in Bonneville County. In 2019, the population of the city of Idaho Falls was 145,507 (Reference 23). ROI counties are part of the Idaho Falls-Rexburg-Blackfoot, ID Combined Statistical Area (Reference 24).

Region of Influence Resident Population Growth Projection

Table 5.4-5 shows projected population for the state of Idaho. Population is projected to increase 12.4 percent (from 1,778,684 to 1,931,075) between 2019 and 2026 in the State. Between 2026 and 2029, population is projected to increase 3.1 percent (from 1,931,075 to 1,990,232) (Reference 25). Population projections were not available for ROI counties.

Transient Population within 5 Miles

Transient populations are temporary or seasonal populations residing in the area, such as in lodging accommodations, dormitories or classrooms on a college campus. According to the results of the desktop research, there are no schools or lodging facilities within 5 miles of the site. Thus, there are no transient populations in the area.

Race and Ethnicity of the Resident Population in the Region of Influence

As shown in Table 5.4-6, in 2019 the minority population in the ROI was 18.7 percent, similar to the State (18.0 percent) and less than the nation (39.3 percent). Bingham County had the most minority population (26.3 percent); Jefferson County had the least (13.3 percent). Minority population in Bonneville County was 17.0 percent. The predominant minority group within the ROI were Hispanic/Latino (13.9 percent) (Reference 26).

Community Characteristics

Community characteristics refer to socioeconomic attributes of the local economy, local housing statistics, public services, infrastructure including major transportation, facilities, and tax payment information. The data presented below reflect community characteristics in the ROI. Data was gathered using 2015-2019 American Community Survey 5-Year Estimates and the Bureau of Economic Analysis.

Economy

The economy of the ROI is evaluated by examining per capita and household income, division of the labor force, unemployment rates, and poverty rates.

Income (Population and Household)

As shown in Table 5.4-7, per capita income for 2019 within the ROI ranged from $23,059 (Bingham County) to $28,671 (Bonneville County). During the same period, the State's per capita income ($27,970) was within the range of the ROI values. The nation's per capita income was greater than the ROI and the State ($34,103) (Reference 27).

In 2019, median household income for the ROI ranged from $55,472 (Bingham County) to $63,048 (Jefferson County). The United States had higher median household income ($62,843) than the ROI, while the value for Idaho ($55,785) fell within the ROI range (Reference 27).

Labor Force and Unemployment

Table 5.4-8 shows unemployment rates and the number of individuals in the labor force. The unemployment rate for Bingham (4.8 percent) and Jefferson (4.5 percent) Counties were higher than the State (4.3 percent) while Bonneville (3.4 percent) County's rate was lower. The nation's unemployment rate was 5.3 percent (Reference 27). Table 5.4-9 displays the total number of people employed as well as the types of employment. In Idaho health care/social assistance (22.4 percent) and government (14.5 percent) categories comprised the highest percentage of jobs. This is also reflected in the United States data. Within ROI counties, the health care/social assistance category also represented the highest percentage of jobs, followed by government jobs (Reference 28).

Poverty Rates

The analysis for low-income populations in the ROI followed the Council on Environmental Quality (CEQ) guidance for identifying low-income populations. Table 5.4-10 presents the results of the low-income population analysis within the ROI. In 2019, the percentage of the individuals with income below the poverty level ranged from 6.9 percent (Jefferson County) to 11.2 percent (Bingham County) within the ROI, while the State and nation rates were higher at 13.1 percent and 13.4 percent respectively. The percentage of families with income below the poverty level in the ROI ranged from 5.0 percent (Jefferson County) to 8.3 percent (Bingham County) while the State and nation rates were higher at 9.1 percent and 9.5 percent respectively (Reference 27).

Housing

Table 5.4-11 shows the total number of housing units 69,039 in the ROI in 2019. The number of occupied and vacant units was 63,548 and 5,491 respectively (Reference 23). The rental vacancy rate for the ROI was 8.0 percent, lower than Idaho (12.9 percent) and the nation (12.1 percent). The median home value for the ROI ranged from $160,100 (Bingham County) to $203,700 (Jefferson County) while the median home value of the State and nation was $167,200 and $217,500 respectively (Reference 23).

Impacts to socioeconomics in the ROI would be based on the size of the workforce constructing the facility, the availability of required labor in the ROI and adjacent areas, the expenditures needed to support the construction program, and the tax payments made to political jurisdictions. An influx of workers and families relocating to the area to fill temporary and permanent construction and operation-related jobs may increase demand for housing. However, as shown in Table 5.4-11, there were over 5,000 housing units available in the ROI in 2019. Therefore, ample housing in the ROI would be available for any potential relocating families. Due to the large number of existing construction and manufacturing jobs in the ROI (see Table 5.4-9) it is likely that the majority of the workforce for the

project would come from the local area. Therefore, as a relatively small number of people and their families would migrate to the ROI, impacts to socioeconomics would be SMALL.

Transportation

This section describes the existing transportation infrastructure at and in the region of the Eagle Rock site. The Eagle Rock site is served directly and exclusively by road. There are no plans for rail access to the site. Nearby rail and air transportation routes also serve the region, but there are no viable water transportation routes. Figure 5.4-2 shows transportation routes near the Eagle Rock site.

Roads

The major routes serving the area are US 20, US 26, and I-15. US 20 is an east-west principal arterial with a speed limit ranging from 45 mph near Idaho Falls, 55 mph just beyond the city limits of Idaho Falls, and finally to 70 mph in the area of the Eagle Rock site. US 26 is a principal arterial roadway which intersects US 20 west of the Eagle Rock site. I-15 is a north-south interstate which intersects with US 20 in Idaho Falls.

A traffic study of the roads in the vicinity of the Eagle Rock site was conducted. The annual average daily traffic (AADT) count near the Eagle Rock site is 2,800 on US 20 (Table 5.4-12). The current traffic volume on I-15 in the vicinity of Idaho Falls (and the junction with US 20) is approximately 18,000 vehicles per day with the highest daily counts at 28,000 AADT at US 20 east of I-15 and 26,000 AADT at I-15 south of Idaho Falls (Table 5.4-12).

All AADT counts were found to be below level of service (LOS) C levels for their type and would continue to be so using the assumption of 2 percent growth for 2025 indicating that all roads in the vicinity would be below capacity during construction and operation (Table 5.4-13). Design capacities for highways are not typically calculated, as capacities are considered high by default. Based on the expected number of trips generated by the project, no capacity issues have been identified on the existing roadway network surrounding the Eagle Rock site. As shown in the projected 2025 volume to capacity (v/c) ratios, the roadways in the vicinity are all under capacity (below 1.0); therefore, this location is not expected to be significantly impacted by the additional site traffic generated by the proposed action. Traffic congestion on I-15 near US 20 is considered a problem with several construction options being considered to reduce congestion on US 15 and US 20 near Idaho Falls, with work beginning in the next 6-9 years (Reference 29).

US 20 between Idaho Falls and the proposed Eagle Rock site is subject to chronic weather-related closure, primarily in winter months because of unfavorable road conditions, snow drifts, and low visibility. The section of US 20 subject to closure extends from approximately 5 miles west of Idaho Falls to the junction of US 20 and US 26 near INL (mileposts 264 to 301), encompassing the proposed Eagle Rock site. Road closures typically last from 6 hours to 1 day, with the maximum closure occurring only once or twice in the last 5 years. About five closures of US 20 are anticipated in a typical snow year. The Idaho Transportation Department would likely work with the proposed Eagle Rock site management to facilitate shift changes that occur during road closures. Fire-related closures of US 20 are possible but are less frequent and shorter in duration than weather-related closures.

Load limits on US 20 (between Idaho Falls and the Eagle Rock site) and I-15 are controlled by Idaho Transportation Department. The three-axle gross vehicle weight limits are 29,257 kg (64,500 pounds) on US 20 and 31,979 kg (70,500 pounds) on I-15 (Reference 30).

Based on the expected number of trips generated by the Hermes site, no capacity issues have been identified on the existing roadway network surrounding the Eagle Rock site. As shown in the projected

2025 v/c ratios, the roadways in the vicinity are all under capacity (below 1.0); therefore, impacts to traffic would be SMALL during construction and operation.

Rail

There is no direct rail access to the Eagle Rock site. Union Pacific provides three branches of freight rail service through Idaho Falls (Montana Main, Yellowstone, and Aberdeen), with the nearest access being approximately 20 miles to the east (Reference 31). In addition, a DOE-owned spur that connects at the Scoville Siding provides active freight service to the nearby INL, approximately 25 miles to the west of the Eagle Rock site. A regional short line carrier, Eastern Idaho Railroad, connects areas north and east of Idaho Falls to Union Pacific lines (Reference 31, Reference 32).

There may be some deliveries transported by rail for this project which would then be unloaded at a freight yard and shipped by tractor trailer to the site. There are no expected disruptions to rail service in or around the project area due to construction, and operation. The expected impacts to rail service would be SMALL.

Air

Two airports serve the region of the Eagle Rock site. The Idaho Falls Regional Airport, approximately 20 miles east of the Eagle Rock site, is operated by the City of Idaho Falls. It provides regularly scheduled regional passenger service to Denver, Salt Lake City, Boise, Seattle, and Las Vegas. The airport has two runways that are different sizes to accommodate commercial and private aviation (Reference 33). Approximately 20 miles to the west of the Eagle Rock site is Midway Airport in Atomic City. This airport is used exclusively by private planes.

There is likely to be a minor increase in air travel due to workers coming to and departing from the site during various stages of construction. These increases would be minimal and temporary. No expected increases in air travel would be expected during plant operation. The impact to air travel would be SMALL.

Water

Although the Snake River flows through Idaho Falls east of the Eagle Rock site, there are no ports or viable water transportation routes that serve the region; therefore, the impact to water travel would be SMALL.

Public Services

Public services include water supply and wastewater treatment facilities and police, fire, and social services. Irrigation and domestic water withdrawals are from the Snake River and the American Falls Reservoir, with 97 percent of the surface and groundwater withdrawn in the state being used for agriculture (Reference 34). The East Idaho Wastewater Treatment Plant has a capacity of 2 MGD servicing approximately 21,000 people (Reference 35) while the Idaho Falls Wastewater Treatment Plant has an average capacity of 17 MGD, with a maximum capacity of 34.4 MGD (Reference 36). Water is supplied exclusively through groundwater wells, with a system wide capacity of 88.1 MGD (Reference 37). With a daily water usage rate of 0.08 MGD, the facility would have a SMALL impact on water and wastewater treatment in the area.

There are 80 police officers in the Bingham County police force as well as 168 officers in Bonneville County with a level of service ranging from 1.2 to 2.5 officers per 1000 residents (Table 5.4-14) (Reference 38, Reference 39). Bingham County employs 39 full time and 112 part time paid firefighters, while Bonneville County has 97 full time and 32 part time paid firefighters (Reference 40, Reference 41).

With an average of 212 onsite workers during construction and 68 workers during operations, the impact to public safety would be SMALL during the proposed project period.

Bingham County has 33 public schools with 10,496 students and one private school with 23 students (Reference 42). Bonneville County has 52 public schools with 25,918 students and 7 Private Schools with a total of 1,090 students (Reference 43). Table 5.4-15 provides summary statistics for the school districts in the ROI, including enrollment and educational staffing. Two indices of educational quality are student-teacher ratios and levels of service (number of teachers per 1000 population). The student-teacher ratio in Bonneville County schools is slightly higher (20.6) than the ratio for schools in Bingham County (18.0). Eight colleges and adult learning centers are located within 50 miles of the proposed Eagle Rock site, with a combined enrollment of 58,486. The closest schools to the Eagle Rock site are about 20 miles east, in Idaho Falls. With an average of 212 onsite workers during construction and 68 workers during operations, the impact to the educational system would be SMALL during the project lifetime.

Tax revenue in Idaho comes from primarily personal and corporate income taxes, sales and use taxes, and property taxes. Personal income taxes range from 1.12 percent on the first $1,541 of taxable income to 6.92 percent of taxable income above $11,554 for single filers and $23,108 for married couples filing jointly (Reference 44). A 6 percent sales tax is applied to the sale, rental, or lease of tangible personal property, while rates on some services, including food, hotel, motel, and campground accommodations are 8 percent (Reference 5 Reference 46). A use tax is applied to stored goods if sales taxes have not already been paid (Reference 45). Property taxes are collected by the county in which the Eagle Rock site is located. The property tax rates for Bonneville County were 0.79 percent on average, while Bingham County had a median effective property tax rate of 0.72 percent (Reference 47, Reference 48). Construction and operation would constitute less than 1 percent of the total two-county ROI employment; the economic impact of the Eagle Rock site would be SMALL.

5.4.1.8 Human Health

5.4.1.8.1 Nonradiological Impacts

No unusual existing sources of nonradioactive chemical exposure or effluents have been identified in the vicinity of the Eagle Rock site. Other than INL, no operating industrial facilities with environmental monitoring programs have been identified in the site vicinity. Industrial operations at INL are similar to those at the Oak Ridge National Laboratory (ORNL) located near the proposed preferred site. A KP-FHR facility at the Eagle Rock site would be essentially the same as the facility described for the Oak Ridge, Tennessee site in Section 4.8.1 with regard to the following factors:

- Nonradioactive chemical sources (location, type, strength)
- Nonradioactive liquid, gaseous, and solid waste management and effluent control systems
- Nonradioactive effluents released
- Chemical exposure to the public and onsite workforce
- Physical occupational hazards
- Environmental monitoring programs

Nonradiological chemical sources, wastes, effluents, and occupational hazards associated with the facility would be strictly controlled to ensure compliance with applicable environmental and occupational regulations and standards as discussed in Section 4.8.1. Therefore, the nonradiological human health impacts associated with construction and operation of the facility at the Eagle Rock site would be SMALL.

5.4.1.8.2 Radiological Impacts

No unusual existing sources of radiation have been identified in the vicinity of the Eagle Rock site. Due to the elevation of the site at more than 5,000 feet above sea level, cosmic radiation, a major source of background radiation exposure would be 10 times higher at the Eagle Rock site than at the Oak Ridge site. Cosmic radiation makes up about 5 percent of the average background radiation dose of 620 millirem per year (mrem/yr) from natural and manmade sources. The NRC estimates the annual dose from cosmic radiation at an elevation below 1,000 feet as 2 mrem/yr. At an elevation between 5,000 and 6,000 feet, the estimated dose is 29 mrem/yr.

The physical layout of any alternative site would be similar to that of the Oak Ridge site with radioactive materials primarily located in the central part of the Reactor Building. A facility at the Eagle Rock site would be essentially the same as the facility described for the Oak Ridge site in Section 4.8.2 with regard to the following factors:

- Characteristics of radiation sources and expected radioactive effluents
- Compliance with 10 CFR 20.1301, including calculated radiation dose rates at the site boundary
- Annual radiation dose to the maximally exposed worker
- Mitigation measures to minimize public and occupational exposures to radioactive material

Radiation sources and radioactive effluents would be strictly controlled to ensure compliance with applicable regulations and standards as discussed in Section 4.8.2. Therefore, the radiological human health impacts associated with construction and operation of the facility at the Eagle Rock site would be SMALL.

5.4.1.8.3 Waste Management Impacts

No conditions have been identified for the Eagle Rock site that would significantly affect waste management impacts. A KP-FHR facility at the Eagle Rock site would be essentially the same as the facility described for the Oak Ridge site in Section 4.9 with regard to the following factors:

- Sources, types, and approximate quantities of solid, hazardous, radioactive, and mixed wastes
- Proposed waste management systems designed to collect, store, and process the waste
- Anticipated waste disposal or waste management plans
- Anticipated waste-minimization plans to minimize the generation of waste

Wastes would be handled, processed, stored, and disposed as discussed in Section 4.9. Therefore, the waste management impacts associated with construction and operation of the facility at the Eagle Rock site would be SMALL.

5.4.1.8.4 Transportation Impacts

The Eagle Rock site and the Oak Ridge site are located approximately 1,900 miles apart. As a result, transportation distances for nuclear materials and radioactive waste would be significantly different. These distances are summarized in Table 5.4-16. While the radiation dose impact from transportation of radioactive materials has an approximate linear impact from increases in distances when large distances are considered, the dose impact on the public from incident-free transportation is still well below the average background radiation dose of 620 mrem/yr.

No other conditions have been identified for the Eagle Rock site that would significantly affect the impacts of transporting nuclear and non-nuclear materials and waste. A KP-FHR facility at the Eagle Rock site would be essentially the same as the facility described for the Oak Ridge site in Section 4.10 with regard to the following factors:

- Transportation modes
- Treatment and packaging for radioactive and nonradioactive wastes

While the radiation dose to the public from the transportation of radioactive materials increases with distance, the overall transportation impacts associated with construction and operation of the KP-FHR facility at the Eagle Rock site would be SMALL.

5.4.1.9 Postulated Accidents

No conditions have been identified for the Eagle Rock site that would significantly affect the radiological and nonradiological impacts from postulated accidents. The KP-FHR facility at the Eagle Rock site would be essentially the same as that described for the Oak Ridge site with regard to the following factors:

- Credible accidents having a potential for releases into the environment
- Radiological and nonradiological consequences from the postulated accidents

The KP-FHR facility would be designed, constructed, and operated to ensure that the consequences of postulated accidents would comply with applicable regulations and standards as discussed for the Oak Ridge site. Therefore, the postulated accident impacts associated with construction and operation of the KP-FHR facility at the Eagle Rock site would be SMALL.

5.4.1.10 Environmental Justice

On February 11, 1994, President Clinton signed Executive Order 12898 *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*. Executive Order 12898 directs federal executive agencies to consider environmental justice under the National Environmental Policy Act of 1969 (NEPA). This Executive Order ensures that minority and/or low-income populations do not bear a disproportionate share of adverse health or environmental consequences of the building of the facility.

Guidance for addressing environmental justice is provided by the CEQ's *Environmental Justice Guidance under the National Environmental Policy Act;* NRC *Policy Statement on the Treatment of Environmental Justice Matters in NRC Licensing Actions;* and NRC Office Instruction No. LIC 203, Revision 3, *Procedural Guidance for Preparing Categorical Exclusions, Environmental Assessments and Considering Environmental Issues* (Reference 49, Reference 50, Reference 51).

In identifying minority and low-income populations, the following CEQ definitions of minority individuals and populations and low-income populations were used:

- Minority individuals - Individuals who identify themselves as members of the following population groups: American Indian or Alaskan Native, Asian, Native Hawaiian or Other Pacific Islander, Black, Hispanic, or two or more races.
- Minority populations - Minority populations are identified where (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. For the purposes of this analysis, "meaningfully greater" is defined as greater than 20 percent of the minority population percentage in the county in which the affected population is located. The thresholds for each county used in the analysis are located in Table 5.4-17.
- Low-income populations - Low-income populations in an affected area are identified with the annual statistical poverty thresholds from the U.S. Census Bureau's (USCB) Current Population Reports, Series P-60, on Income and Poverty. In this analysis, low-income populations are identified where: (1) the population of an affected area exceeds 50 percent low-income based on the Census data, or

(2) the percentage of low-income population in the affected area is "meaningfully greater", defined as greater than 20 percent of the low-income population percentage in the county in which the affected population is located. The thresholds for each county used in the analysis are located in Table 5.4-17.

According to CEQ guidance, USCB data are typically used to determine minority and low-income population percentages in the affected area of a project in order to conduct a quantitative assessment of potential environmental justice impacts. The geographic unit used in the analysis to identify any environmental justice communities of concern is the census block group. For the purposes of this analysis, a census block group constitutes an environmental justice community if one of the two criteria described above for either minority or low-income populations are met (Reference 49).

As the location for the proposed project, Bonneville County would experience the majority of environmental impacts as compared to other ROI counties. Block Group 1, Census Tract 9715, located in Bonneville County encompasses the Eagle Rock site. A total of 4 census block groups located within a 5-mile radius of the site were evaluated for potential environmental justice impacts. The 5-mile radius is consistent with Section 19.4.12 of the ISG for NUREG-1537, the Commission's Policy Statement (69 FR 52040), and Environmental Impact Statements for the SHINE and Northwest Medical Isotopes production facility construction permits (Reference 52, Reference 53). These block groups traversed parts of Bonneville, Bingham and Jefferson Counties. Table 5.4-17 identifies thresholds for each county for the identification of minority and low-income communities within the 5-mile radius. The thresholds were derived by adding 20 percent to the aggregate minority percentage and low-income percentage in Bonneville, Bingham and Jefferson Counties as applicable (Reference 54, Reference 55).

Methodology

The geographic area of analysis is the 5-mile area around the site. The analysis followed the CEQ guidance for identifying minority and low-income populations in the ROI as defined above and used the "block group" method recommended by the NRC to identify the locations of minority and low-income populations of the geographic area of analysis. The block group is the smallest geographical unit for which the USCB tabulates data required for environmental justice analysis (USNRC 2004). Data from 2015-2019 American Community Survey 5-Year Estimates, along with geographic information system (GIS) software, were used to determine the minority and low-income characteristics of resident populations by block group. If any part of a block group was located within 5 miles of the site, the entire block group was included in the analysis. A total of 4 block groups met these criteria and were evaluated as part of this analysis.

Minority Populations

Table 5.4-18 shows the percentage of minority populations in each block group within the 5-mile radius of the Eagle Rock site, and the county in which the block group is located (Reference 54). Overall, the aggregate minority population of block groups in the 5-mile study area was 23.6 percent, more than the 5 county ROI (18.7 percent) and the State (18.0 percent) as shown in Table 5.4-6 (Reference 26).

None of the 4 block groups met the "greater than 50 percent" minority population threshold indicating potential environmental justice populations. None of the minority percentages in any of the block groups within the 5-mile radius exceeded the "20 percent greater" thresholds (46.3 percent in Bingham County, 37.0 percent in Bonneville County, and 33.3 percent in Jefferson County) as shown in Table 5.4-17 (Reference 26).

Therefore, there are no minority populations subject to consideration as potential environmental justice communities of concern in a 5-mile radius of the Eagle Rock site. As such, the impacts from construction and operation of the Eagle Rock site on minority populations would be SMALL.

Low-Income Populations

Low-income populations are those that fall below the poverty level identified by the USCB, including variations by family size and composition. If the total income for a family or unrelated individual falls below the relevant poverty threshold, then the family or unrelated individual is classified as being "below the poverty level."

Table 5.4-19 shows the percentage of low-income populations in each block group within the 5-mile radius, and the county in which the block group is located. Overall, the aggregate low-income population of block groups in the 5-mile study area was 5.2 percent (Reference 55). As shown in Table 5.4-10, this is less than the State (13.1 percent). None of the 4 block groups met the "greater than 50 percent" low-income population threshold indicating potential environmental justice populations. None of the block groups exceeded the "20 percent greater" thresholds (31.2 percent in Bingham County, 30.5 percent in Bonneville County, and 26.9 percent in Jefferson County) as shown in Table 5.4-17 (Reference 27).

Therefore, there are no low-income populations subject to consideration as potential environmental justice communities of concern in a 5-mile radius of the Eagle Rock site. As such, the impacts from construction and operation of the Eagle Rock site on low-income populations would be SMALL.

5.4.1.11 Cumulative Impacts

This section contains a summary of potential cumulative environmental impacts associated with construction and operation activities for the Eagle Rock site in combination with other past, present, and reasonably foreseeable actions or projects in the area. The term *cumulative impact,* which was previously defined in the regulations of the CEQ implementing the NEPA, has been repealed. However, in the revised 2020 NEPA regulations, the definition of *effects* or *impacts* (40 CFR 1508.1(g)) includes evaluation of collective actions, and is defined as follows:

"Effects or impacts means changes to the human environment from the proposed action or alternatives that are reasonably foreseeable and have a reasonably close causal relationship to the proposed action or alternatives, including those effects that occur at the same time and place as the proposed action or alternatives and may include effects that are later in time or farther removed in distance from the proposed action or alternatives."

For the purposes of this evaluation, reasonably foreseeable actions are projects that are clearly indicated in an available long-term master plan or comparable document and/or have received funding and/or have applied for a permit associated with construction or operation. Per NUREG-1537, this section includes "related and non-related" federal and non-Federal actions that could contribute to cumulative impacts, such as:

- Information about current or planned local economic development programs or projects (e.g., commercial, industrial, and/or residential)
- Information about current or planned infrastructure improvements (e.g., transportation, electric and water utility)

A summary of past, present, and reasonably foreseeable projects that could have a cumulative effect within the geographic area of interest are listed in Table 5.4-20. These projects include two nearby proposed transmission line projects, and the Carbon Free Power Project, a proposed small modular

reactor project. The cumulative impact assessment for each geographic area of interest that may be affected by the project is presented below. The resources assessed include land use and visual resources; air quality and noise; geologic environment; water resources (hydrology, water use, water quality); ecological resources (terrestrial and aquatic communities); historic and cultural resources; socioeconomics; human health; waste management; and environmental justice. According to the CEQ's Considering Cumulative Effects Under NEPA (Reference 49), the establishment of an appropriate geographic area of analysis is an important step in performing the cumulative effects analysis. The analysis of cumulative environmental impacts is resource specific. The geographic area of analysis of the considered past, present, and reasonably foreseeable actions from the Eagle Rock site are the same as those used for each resource discussed in Section 5.4.1 and are based on the environmental effects that may occur to each of the affected resources under consideration. Past impacts have resulted primarily from the development of agriculture in the region and the development of the INL near the Eagle Rock site. The main INL facilities lie outside the 5-mile ROI, but within the three-county ROI for socioeconomics. An appropriate context of analysis was selected for each of the resources described below (Reference 1).

5.4.1.11.1 Land Use and Visual Resources

The two transmission line projects in Table 5.4-20 would not create adverse cumulative impacts to land use and visual resources, as the Rocky Mountain Power line would use existing ROWs and the new substation would be at the Eagle Rock site. The Mountain States Transmission Intertie is on hold and would be at least 10 miles from the Eagle Rock site. Depending on the location chosen for the Carbon Free Power Project, cumulative impacts to land use and visual resources could occur. The amount of land changed from rangeland to industrial use would likely be doubled and the appearance of two large nuclear facilities in the midst of a natural landscape would alter views significantly. Therefore, the overall cumulative impacts to land use and visual resources would be MODERATE. However, the project's incremental contribution would be SMALL for land use and MODERATE for visual resources.

5.4.1.11.2 Air Quality and Noise

The two transmission line projects in Table 5.4-20 would not contribute significantly to cumulative impacts to air quality noise. The Carbon Free Power Project could contribute to cumulative impacts if both projects were constructed simultaneously and located close together. However, as this project is further along the permitting process, they are unlikely to be constructed at the same time. The construction and operation of both the Carbon Free Power Project and Eagle Rock site would be regulated by federal, state, and local laws with respect to air emissions and, as such, would not impact general air quality in the region. Noise both during construction and operation would attenuate rapidly and there are no sensitive receptors or residents near the Eagle Falls site. Therefore, cumulative impacts to noise would be SMALL and the project's incremental contribution would also be SMALL.

5.4.1.11.3 Geologic Environment

Cumulative impacts to the geologic environment would consist of soil disturbance and erosion. As all of the possible projects in the vicinity would be required to secure permits for both the construction and operational phases, these impacts would be SMALL, due to the fact that BMPs, SWPPPs, and NPDES permits would reduce the likelihood of adverse impacts. Likewise, the project's incremental contribution would also be SMALL.

5.4.1.11.4 Water resources

Cumulative impacts to water resources are not anticipated with respect to the two transmission line projects in Table 5.4-20. It is assumed that the two nuclear facilities would share the same water source,

i.e., onsite groundwater wells, cumulative impacts are possible. Additionally, it is also assumed that the two facilities would share the same sanitary wastewater discharge systems and discharge stormwater to surface waters. However, due to the relatively small amount of water consumed and released by the facility, the incremental contribution to the cumulative impacts would be SMALL.

5.4.1.11.5 Ecological Resources

The two transmission line projects are not expected to contribute significantly to cumulative ecological impacts. The Mountain States Transmission Intertie would be located 10 miles east of the Eagle Rock site, and construction presently is on hold. A portion of the Rocky Mountain Power transmission would be constructed onsite along an existing right-of-way to provide power to the Eagle Rock site. There could be loss of native vegetation providing habitat for wildlife within the transmission ling right-of-way. This would result in additional habitat loss and habitat fragmentation on the Eagle Rock site. However, the impacts from development of the Eagle Rock site would be SMALL, and the incremental contribution to cumulative impacts is expected to be SMALL. The Carbon Free Power Project is under review by NRC and a location has not been selected. There would be no potential for cumulative impact unless this project was constructed close to the Eagle Rock site.

5.4.1.11.6 Historical and Cultural Resources

The two transmission line projects are not anticipated to contribute significantly to cumulative impacts to historic and cultural resources. Due to the presence of four archeological sites previously identified within the proposed Eagle Rock site and the potential for additional sites at the final location of the Carbon Free Power Project, impacts to historic and archeological resources would be MODERATE because of the additional ground disturbance. This could be mitigated with plans to specify procedures for addressing the unexpected discover of archeological resources and selecting locations which are less likely to have historic and cultural resources. However, as the exact location of both nuclear facilities has not yet been decided, cumulative impacts to historic and cultural resources remain MODERATE and the facilities incremental contribution to cumulative impacts would be SMALL.

5.4.1.11.7 Socioeconomic Environment

Cumulative socioeconomic impacts are not anticipated with respect to the two transmission line projects. The construction and operation of two nuclear facilities in the ROI may have cumulative impacts if they occur simultaneously. However, as the Carbon Free Power Project is further along in the permitting process this is not likely. Impacts could consist of transportation issues, housing shortages, larger class size in schools, and increased tax revenue. The cumulative impacts to socioeconomics due to the construction and operation of the facility and the Carbon Free Power Project are expected to be similar and SMALL, and the facility’s incremental contribution to cumulative impacts would also be SMALL.

5.4.1.11.8 Human Health

Cumulative impacts to human health due to the two transmission projects are not anticipated. The Eagle Rock facility would not store or use highly hazardous chemicals in quantities above the Threshold Quantities in Appendix A to 29 CFR 1910.119 during construction. The Eagle Rock facility would be designed, and practices would be applied, to keep air contaminants below the limits in 29 CFR 1910.1000. In summary, occupational hazards are managed and minimized by compliance with Occupational Safety and Health Administration (OSHA) regulations and therefore impacts from chemical occupational hazards would be SMALL. It is assumed that similar practices and constraints would operate during the construction and operation of the Carbon Free Power Project, therefore cumulative

impacts to human health would be SMALL and the incremental contribution from the Eagle Rock facility would also be SMALL.

5.4.1.11.9 Waste Management

Cumulative impacts to waste with respect to the two transmission lines are not anticipated. Although waste would be generated it would be small amounts of construction materials and packaging. It is anticipated that wastes generated by the two nuclear facilities construction and operation would be similar in type and quantity. Materials would include construction materials, small amounts of hazardous wastes, and radioactive waste. As the incremental impacts to waste management due to the construction and operation of the Eagle Rock facility would be SMALL, and waste would be governed by the same regulations at the Carbon Free Power Project, overall cumulative impacts to waste management would also be SMALL.

5.4.1.11.10 Environmental Justice

Cumulative impacts to environmental justice are not anticipated because there are no potential environmental justice communities of concern within a 5-mile radius of the Eagle Rock site. As such, cumulative impacts with respect to environmental justice would be SMALL and the incremental contribution from the Eagle Rock facility would also be SMALL.

5.4.2 References

1. U.S. Nuclear Regulatory Commission. 2011. Environmental Impact Statement for the Proposed Eagle Rock Enrichment Facility in Bonneville County, Idaho. Final Report.

2. U.S. Environmental Protection Agency. 2021. Nonattainment Areas for Criteria Pollutants (Green Book). Website: https://www.epa.gov/green-book.

3. National Park Service. 2021. National Park Service. NPS Class I Areas. Accessed July 7, 2021 at https://www.nps.gov/subjects/air/npsclass1.htm#R.

4. Federal Land Managers. 2010. Federal Land Managers’ Air Quality Related Values Work Group (FLAG): phase 1 report—revised (2010). Natural Resource Report. NPS/NRPC/NRR—2010/232. Natural Resource Program Center. Denver, Colorado. Website: https://irma.nps.gov/DataStore/Reference/Profile/2125044.

5. Ackerman, D.J., G.W. Rattray, J.P. Rousseau, L.C. Davis, and B.R. Orr. “A Conceptual Model of Ground-Water Flow in the Eastern Snake River Plain Aquifer at the Idaho National Laboratory and Vicinity with Implications for Contaminant Transport.” U.S. Geological Survey Scientific Investigations Report 2006-5122. DOE/ID-22198. Prepared in cooperation with the U.S. Department of Energy.

6. U.S. Department of Energy. “Draft Environmental Impact Statement for the Proposed Consolidation of Nuclear Operations Related to Production of Radioisotope Power Systems.” DOE/EIS-0373D. Office of Nuclear Energy, Science, and Technology, Washington, D.C. June 2005.

7. Hughes, S.S., R.P. Smith, W.R. Hackett, and S.R. Anderson. “Mafic Volcanism and Environmental Geology of the Eastern Snake River Plain, Idaho.” In: *Guidebook to the Geology of Eastern Idaho, Idaho Museum of Natural History*, pp. 143–168. (S.S. Hughes and G.D. Thackray, eds).

8. Payne, S.J. “Modeling of the Sedimentary Interbedded Basalt Stratigraphy for the Idaho National Laboratory Probabilistic Seismic Hazard Analysis.” Report INL/EST-05-01047. Idaho National Laboratory. April 2006.

9. U.S. Environmental Protection Agency. Regional Screening Levels Table. May 2021. Accessed online at https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables.

10. U.S. Department of Energy. "Site-Specific Probabilistic Seismic Hazard Analyses for the Idaho National Engineering Laboratory, Volume 1 – Final Report." INEL-95/0536. Prepared by Woodward-Clyde Federal Services and Pacific Engineering and Analysis for the U.S. Department of Energy. May 1996.

11. Idaho Water Resource Board. Eastern Snake Plain Aquifer (ESPA) – Comprehensive Aquifer Management Plan. January 2009.

12. Idaho Department of Environmental Quality. State of Idaho Oversight Monitor: Idaho's Treasure; the Eastern Snake River Plain Aquifer. Idaho INL Oversight Program. Boise, Idaho. May 2005.

13. U.S. Environmental Protection Agency. Sole Source Aquifers for Drinking Water: What is a sole source aquifer? Accessed online on July 8, 2021 at https://www.epa.gov/dwssa/overview-drinking-water-sole-source-aquifer-program#What_Is_SSA.

14. U.S. Geological Survey. An Update of Hydrologic Conditions and Distribution of Selected Constituents in Water, Eastern Snake River Plain Aquifer and Perched Groundwater Zones, Idaho National Laboratory, Idaho, Emphasis 2016–18. Scientific Investigations Report 2019-5149. DOE/ID-22251. 2020.

15. AREVA Enrichment Services, LLC. Eagle Rock Enrichment Facility Environmental Report, Rev. 3. Bethesda, Maryland. May 2011.

16. U.S. Bureau of Land Management and U.S. Department of Energy. Bureau of Land Management and United States Department of Energy. Final Management Plan, INEEL Sagebrush Steppe Ecosystem Reserve. EA ID-074-02-067. May 2004.

17. Idaho Fish and Game. Species Conservation Status. Accessed online on July 2, 2021 at https://idfg.idaho.gov/species/taxa/list.

18. Ringhoff, M., E.J. Stoner, C.C. Chambellan, and S. Mehls. "A Class III Cultural Resource Inventory of the Proposed Eagle Rock Enrichment Facility, Bonneville County, Idaho." Prepared by Western Cultural Resource Management, Inc. for AREVA Enrichment Services, LLC. November 21, 2008.

19. U.S. Census Bureau Geographic Division, 2020. Website: https://www.census.gov/cgi-bin/geo/shapefiles/index.php?year=2020&layergroup=Block+Groups, accessed October 2021.

20. National Bureau of Economic Research, 1900 Census U.S. Decennial County Population Data, 1900-1990, Website: https://www.nber.org/research/data/census-us-decennial-county-population-data-1900-1990, accessed September 2021.

21. U.S. Census Bureau, 2000 Total Population - 2000 Decennial Census. Table: P001, Website: https://data.census.gov/cedsci/table?q=P001&t=Counts,%20Estimates,%20and%20Projections%3APopulations%20and%20People&g=0100000US_0400000US16_0500000US16011,16019,16051&y=2000&tid=DECENNIALSF12000.P001&hidePreview=true&tp=true, accessed September 2021.

22. U.S. Census Bureau, 2010 Census - Table Results, Website: https://data.census.gov/cedsci/table?q=dp05&g=0100000US_0400000US16_0500000US16011,16019,16051&tid=ACSDP5Y2010.DP05&hidePreview=true&tp=true, accessed September 2021.

23. U.S. Census Bureau, ACS Demographic and Housing Estimates - 2019 American Community Survey 5 Year Census - Table Results, Website: https://data.census.gov/cedsci/table?q=median%20home%20value&g=0100000US_0400000US01,16_0500000US01033,01077,01079,01083,01089,01103,16011,16019,16051&tid=ACSDP5Y2019.DP04&hidePreview=true&moe=false, accessed September 2021.

24. U.S. Census Bureau, IDAHO - Core Based Statistical Areas (CBSAs) and Counties, 2013. Website: https://www2.census.gov/geo/maps/metroarea/stcbsa_pg/Feb2013/cbsa2013_ID.pdf

25. Idaho Department of Labor. 2021. IDAHO -State Projections. Website: https://lmi.idaho.gov/population-projections, accessed October 7, 2021.

26. U.S. Census Bureau, Hispanic or Latino Origin by Race Table B03002, Website: https://data.census.gov/cedsci/table?q=B03002&g=0100000US_0400000US16_0500000US16011,16019,16051&tid=ACSDT5Y2019.B03002&hidePreview=true&moe=false, accessed September 2021.

27. U.S. Census Bureau, Poverty Status - Table DP03, Website: https://data.census.gov/cedsci/table?text=B17021&g=0400000US01,16,47_0500000US16011,16019,16051&tp=false&layer=VT_2018_040_00_PY_D1&cid=B17021_001E&tid=ACSDT5Y2019.B17021&hidePreview=true&vintage=2018&moe=false, accessed September 2021.

28. U.S. Census Bureau, Selected Economic Characteristics - Table DP03, Website: https://data.census.gov/cedsci/table?g=0400000US16,47_0500000US16011,16019,16051,47001,47093,47105,47129,47145_1600000US4755120&y=2019&tid=ACSDP5Y2019.DP03&hidePreview=true&moe=false, accessed September 2021.

29. Nelson, Rett and EastIdahoNews.com. 2021. “Governor Proposes Bill Allocating $80 Million for Statewide Road Improvement Projects.” *East Idaho News* (blog). April 1, 2021. https://www.eastidahonews.com/2021/03/governor-proposes-bill-allocating-80-million-for-statewide-road-improvement-projects/.

30. Idaho Transportation Department, B. 2019. “Idaho Route Capacity Map,” 1.

31. Idaho State Rail. Idaho State Rail Plan.” https://apps.itd.idaho.gov/apps/freight/Idaho-Statewide-Rail-Plan.pdf

32. American Rails. 2021. “Idaho Railroads: Map, History, Abandoned Lines.” American-Rails.Com. 2021. https://www.american-rails.com/id.html.

33. Air Miles Calculator. 2021. “Idaho Falls Regional Airport (IDA), Idaho Falls, ID.” Air Miles Calculator. 2021. https://www.airmilescalculator.com/airport/ida/.

34. Sean Ellis. 2021. “Idaho Ranks No. 2 in Total Irrigation Withdrawals.” Post Register. 2021. https://www.postregister.com/farmandranch/water_and_irrigation/idaho-ranks-no-2-in-total-irrigation-withdrawals/article_863ffc38-9204-5699-879e-d14160455de7.html.

35. U.S. Environmental Protection Agency. Oxbowwater Treatment NPDES Factsheet 2014. Accessed October 5, 2021. https://www.epa.gov/sites/default/files/2017-12/documents/r10-npdes-eastern-idaho-oxbow-id0020133-fact-sheet-2014.pdf.

36. Murray, Smith &Associates, Inc. 2015. “Water Facility Plan for the City of Idaho Falls.” https://id-idahofalls.civicplus.com/DocumentCenter/View/975/Water-Facility-Plan-PDF?bidId=.

37. Murray, Smith &Associates, Inc. and Pharmer Engineering LLC. 2010. “Wastewater Treatment Plant Facilities Plan: Idaho Falls.”

https://www.idahofallsidaho.gov/DocumentCenter/View/7753/Wastewater-Treatment-Plant-Facilities-Plan?bidId=.

38. Federal Bureau of Investigation. “FBI Crime Data Reporter: Bonneville County Sherriff’s Office.” 2020. https://crime-data-explorer.app.cloud.gov/pages/le/pe.

39. Federal Bureau of Investigation. “FBI Crime Data Reporter: Idaho Falls Police Department.” 2020. https://crime-data-explorer.app.cloud.gov/pages/le/pe.

40. Risk Mitigation Group LLC. “Bingham County, ID Fire Departments.” 2021. https://www.firedepartment.net/directory/idaho/bingham-county.

41. Risk Mitigation Group LLC. “Bonneville County, ID Fire Departments.” 2021. https://www.firedepartment.net/directory/idaho/bonneville-county.

42. National Center for Education Statistics. “Bingham Idaho Public Schools Statistics.” 2021. https://nces.ed.gov/ccd/districtsearch/district_list.asp?Search=1&details=1&InstName=&DistrictID=&Address=&City=&State=16&Zip=&Miles=&County=Bingham&PhoneAreaCode=&Phone=&DistrictType=1&DistrictType=2&DistrictType=3&DistrictType=4&DistrictType=5&DistrictType=6&DistrictType=7&DistrictType=8&NumOfStudents=&NumOfStudentsRange=more&NumOfSchools=&NumOfSchoolsRange=more.

43. National Center for Education Statistics. “Bonneville County Public School Districts.” 2021. https://nces.ed.gov/ccd/districtsearch/district_list.asp?Search=1&details=1&InstName=&DistrictID=&Address=&City=&State=16&Zip=&Miles=&County=Bonneville&PhoneAreaCode=&Phone=&DistrictType=1&DistrictType=2&DistrictType=3&DistrictType=4&DistrictType=5&DistrictType=6&DistrictType=7&DistrictType=8&NumOfStudents=&NumOfStudentsRange=more&NumOfSchools=&NumOfSchoolsRange=more.

44. Tax Rates.org. “Bingham County, Idaho - Property Tax Rates.” 2021. https://www.propertytax101.org/idaho/binghamcounty.

45. Idaho State Tax Commission. “Sales/Use Tax - Idaho State Tax Commission.” 2021. https://tax.idaho.gov/i-1023.cfm.

46. Idaho State Tax Commission. “Travel & Convention Tax - Idaho State Tax Commission.” 2021. https://tax.idaho.gov/i-1096.cfm.

47. Tax Rates.org. “Bingham County, Idaho - Property Tax Rates.” 2021. https://www.propertytax101.org/idaho/binghamcounty.

48. Tax Rates.org. “Bonneville County Idaho Property Taxes - 2021.” https://www.tax-rates.org/idaho/bonneville_county_property_tax.

49. Council of Environmental Quality. 1997. Environmental Justice: Guidance Under the National Environmental Policy Act. December 10, 1997.

50. U.S. Nuclear Regulatory Commission. Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions (69 FR 52040), August 24, 2004.

51. U.S. Nuclear Regulatory Commission. Office Instruction No. LIC 203, Revision 3, Procedural Guidance for Preparing Environmental Assessments and Considering Environmental Issues, July 1, 2013.

52. NUREG-2183, “Environmental Impact Statement for the Construction Permit for the SHINE Medical Radioisotope Production Facility,” October 2015.

53. NUREG-2209, "Environmental Impact Statement for the Construction Permit for the Northwest Medical Isotopes Radioisotope Production Facility," May 2017.

54. U.S. Census Bureau. 2019 Hispanic Or Latino Origin By Race. Table B03002. Website: https://data.census.gov/cedsci/table?q=B03002&g=0100000US_0400000US16_0500000US16011,16019,16051_1500000US160119503001,160199715001,160199715002,160519601003&tid=ACSDT5Y2019.B03002&hidePreview=true&moe=false, accessed October 2021.

55. U.S. Census Bureau. 2019 Poverty Status Of Individuals In The Past 12 Months By Living Arrangement. Table B17021. Website: https://data.census.gov/cedsci/table?q= B03002&g=0100000US_0400000US16_0500000US16011,16019,16051_1500000US160119503001,160199715001,160199715002,160519601003&tid=ACSDT5Y2019.B03002&hidePreview=true&moe=false, accessed October 2021.

56. U.S. Fish and Wildlife Service. IPaC Information for Planning and Consultation. Website: https://ecos.fws.gov/ipac/location/RCXTRBKF4JCYJHYP2CKSV6SYIA/resources, accessed on July 2, 2021.

57. Transmission Hub. 2018. Mountain States Transmission Service. Website: https://www.transmissionhub.com/articles/transprojects/mountain-states-transmission-intertie, accessed on October 15, 2021.

58. NuScale. 2021. Carbon Free Power Project. Website: https://www.nuscalepower.com/projects/carbon-free-power-project, accessed on October 15, 2021.

59. Idaho National Laboratory. “What is the Carbon Free Power Project.” Website: https://inl.gov/article/frequently-asked-questions/, accessed on October 15, 2021.

Table 5.4-1: Metals, Soluble Fluoride, and Percent Moisture in Surface Soil at the Eagle Rock Site

Analyte	Soil Concentrations (mg/kg)										Detection Limit (mg/kg)	Background (mg/kg)
	SS1	SS2	SS3	SS4	SS5	SS6	SS7	SS8	SS9	SS10		
Arsenic	5.5	7.7	5.5	7.1	6.6	7.3	6.7	7.1	6.9	6.2	1.3-1.8	3.7-24.4
Barium	160	180	180	200	170	170	200	170	170	190	0.50	87-255
Cadmium	0.56	0.61	ND	0.69	0.59	0.58	0.74	0.57	0.6	0.55	0.50	1.3-2.8
Chromium (III)	21	20	20	25	23	21	23	21	22	25	0.50	14-27
Lead	15	16	14	18	16	16	17	16	16	18	0.60-0.81	9-28
Selenium	0.26	0.19	0.15	0.17	0.42	0.2	0.15	0.16	0.16	0.13	0.05	0.3-16.7
Silver	ND	ND	ND	0.7	ND	ND	ND	0.7	ND	ND	0.5-0.8	2.7-2.8
Total mercury	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.05	0.05-0.06
Soluble fluoride	12	ND	ND	ND	10	ND	10	ND	ND	ND	5	-
Percent moisture	15.9	12.2	9.1	12.2	15.7	11.1	15.7	11.8	16.5	10.5	0.1	-
Source: (Reference 1)												

Table 5.4-2: VOCs, SVOCs, and Pesticides Detected in the Surface Soil at the Eagle Rock Site

Analyte	Soil Concentrations (mg/kg)										Regional Screening Level (mg/kg)[a]
	SS1	SS2	SS3	SS4	SS5	SS6	SS7	SS8	SS9	SS10	
VOCs											
1,3,5-Trimethylbenzene	0.0067	ND[b]	ND	ND	ND	ND	ND	ND	ND	ND	200
1,3-Dichlorobenzene	0.0082	ND	ND	ND	ND	ND	ND	ND	ND	ND	10,000[c]
Tetrachloroethene	0.0086	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.7
SVOCs											
Benzo(a)pyrene	ND	0.014	ND	0.035	ND	ND	ND	ND	0.059	0.014	0.21
Dibenzo(a,h)anthracene	ND	0.012	ND	0.024	ND	ND	ND	ND	0.038	0.0099	0.21
Ideno(1,2,3-cd)pyrene	ND	0.025	ND	0.081	ND	ND	ND	ND	0.146	0.024	2.1
Pesticide											
Chlorpropham	ND	ND	ND	0.0074	ND	0.0055	ND	0.0110	ND	ND	120,000

[a] Regional screening levels (RSLs) based on carcinogenic target risk for industrial soils, except for 1,3,5-trimethylbenzene and chlorpropham which are based on a noncancerous hazard index.
[b] ND = not detected.
[c] RSL not available for 1,3-dichlorobenzene; value provided is for 1,2-dichlorobenzene.
Source: (Reference 1)

Table 5.4-3: Radiochemical Analyses of Surface Soil at the Eagle Rock Site

Radionuclides	Measured Concentrations [a]		Representative Soil Concentrations [b]	
	Bq/kg	pCi/kg	Bq/kg	pCi/kg
Actinium-228 Thorium-228	38 ± 3.2	1020 ± 87.8	-[c]	-
Cesium-137	10 ± 4.4	288 ± 118	252[d]	6,800[d]
Potassium-40	660 ± 57	17,900 ± 1540	400	10,800
Thorium-228	47 ± 4.8	1,270 ± 131	-	-
Thorium-230	46 ± 5.0	1,250 ± 136	-	-
Thorium-232	44 ± 3.5	1,190 ± 92.0	37	999
Uranium-234	29 ± 2.5	784 ± 68.3	-	-
Uranium-235	3.3 ± 1.8	90.1 ± 48.9	-	-
Uranium-238	30 ± 2.7	805 ± 73.0	66	1,782

[a] Concentrations noted as mean ± standard deviation; n=10 for all radionuclides but cesium-137 for which n=9.
[b] Representative soil concentrations are taken from Table 4.3 of the National Council on Radiation Protection Report No. 94.
[c] A dash indicates value is not available from the National Council on Radiation Protection Report No. 94.
[d] Value from the IDEQ INL Oversight Program
Source: (Reference 1)

Table 5.4-4: Historic Population and Growth Rates of ROI Counties

County	1990	2000	2010	2019	Percent Change 1990 - 2019
Bingham	37,583	41,735	44,496	45,839	22.0%
Bonneville	72,207	82,522	100,213	114,392	58.4%
Jefferson	16,543	19,155	24,523	28,534	72.5%
Total ROI	126,333	143,412	169,232	188,765	49.4%
Idaho	1,006,749	1,293,953	1,526,797	1,717,750	70.6%

Sources: (Reference 20, Reference 21, Reference 22, Reference 23)

Table 5.4-5: Projected Population and Growth Rates of ROI Counties

County	2019	Projected 2026	Projected 2029	Percent Change 2019 - 2026	Percent Change 2026 - 2029
Bingham	45,839	-	-	-	-
Bonneville	114,392	-	-	-	-
Jefferson	28,534	-	-	-	-
Idaho	1,778,684	1,931,075	1,990,232	12.4%	3.1%

Sources: (Reference 23, Reference 25)
Note: Projections were not available at the county level

Table 5.4-6: Demographic (Race and Ethnicity) Characteristics of ROI Counties

Racial/Ethnic Composition	Bingham		Bonneville		Jefferson		ROI		Idaho		United States	
	Total	Percent	Total	Percent	Total	Percent	Total	Percent	Total	Percent	Total	Percent
Total Population	45,839		114,392		28,534		188,765		1,717,750		324,697,795	
White	33,799	73.7	94,977	83.0	24,750	86.7	153,526	81.3	1,407,883	82.0	197,100,373	60.7
Aggregate Minority	12,040	26.3	19,415	17.0	3,784	13.3	35,239	18.7	309,867	18.0	127,597,422	39.3
Black or African American	130	0.3	508	0.4	0	0.0	638	0.3	11,316	0.7	399,77,554	12.3
American Indian and Alaska Native	2,350	5.1	411	0.4	346	1.2	3,107	1.6	19,027	1.1	2,160,378	0.7
Asian	263	0.6	1,040	0.9	127	0.4	1,430	0.8	23,061	1.3	17,708,954	5.5
Native Hawaiian and Other Pacific Islander	24	0.1	127	0.1	14	0.0	165	0.1	2,341	0.1	540,511	0.2
Other Race	45	0.1	58	0.1	0	0.0	103	0.1	1,419	0.1	789,047	0.2
Two or More Races	981	2.1	2,355	2.1	293	1.0	3,629	1.9	37,227	2.2	7,941,608	2.4
Hispanic or Latino	8,247	18.0	14,916	13.0	3,004	10.5	26,167	13.9	215,476	12.5	58,479,370	18.0
Source: (Reference 26)												

Table 5.4-7: Median Household and Per Capita Income Levels in ROI Counties

	Bingham	Bonneville	Jefferson	Idaho	United States
Median Household Income (dollars)	55,472	60,615	63,048	55,785	62,843
Per Capita Income (dollars)	23,059	28,671	24,677	27,970	34,103
Source: Reference 27					

Table 5.4-8: Civilian Labor Force and Unemployment Rates

	Bingham	Bonneville	Jefferson	ROI	Idaho	United States
Civilian Labor Force	20,729	53,039	13,525	87,293	828,116	163,555,585
Unemployment Rate	4.8%	3.4%	4.5%	NA	4.3%	5.3%
Source: (Reference 28) NA = Not applicable, as only rates reported by official sources are reported.						

Table 5.4-9: Employment by Industry

	Bingham, ID		Bonneville, ID		Jefferson, ID		Idaho		United States	
	Total	**Percent**	**Total**	**Percent**	**Total**	**Percent**	**Total**	**percent**	**Total**	**Percent**
Total employment (number of jobs)	19,732	-	51,226	-	12,917		792,237		154,842,185	-
Farm employment	1,700	8.6	1,534	3	1,239	5.3	39,590	5.0	2,743,687	1.8
Construction	1,497	7.6	3,880	7.6	1,234	7.9	61,463	7.8	10,207,602	6.6
Manufacturing	1,921	9.7	4,356	8.5	1,105	8.8	76,960	9.7	15,651,460	10.1
Retail trade	2,215	11.2	6,212	12.1	1,568	11.9	95,988	12.1	17,267,009	11.2
Health care and social assistance	4,408	22.3	12,313	24	2,350	22.7	177,544	22.4	35,840,954	23.1
Accommodation and food services	1,386	7	4,960	9.7	942	8.7	73,964	9.3	14,962,299	9.7
Other services (non-government)	844	4.3	2,128	4.2	527	4.2	35,889	4.5	7,522,777	4.9
Government and government enterprises	3,728	18.9	8,224	16.1	2,300	17.0	115,250	14.5	21,250,767	13.7
Source: (Reference 28)										

Table 5.4-10: Percent of Individuals and Families Living Below the Census Poverty Threshold in ROI Counties

	Bingham	Bonneville	Jefferson	Idaho	United States
Percentage of Individuals whose Income in the Past 12 Months is below Poverty Level	11.2%	10.5%	6.9%	13.1%	13.4%
Percentage of Families whose Income in the Past 12 Months is below Poverty Level	8.3%	7.6%	5.0%	9.1%	9.5%
Source: (Reference 27)					

Table 5.4-11: Housing

	Bingham County, Idaho	Bonneville County, Idaho	Jefferson County, Idaho	ROI	United States	Idaho
Total housing units	16,745	42,925	9,369	69,039	137,428,986	723,594
Occupied housing units	14,989	39,768	8,791	63,548	120,756,048	630,008
Vacant housing units	1,756	3,157	578	5,491	16,672,938	93,586
Vacancy Rate	10.5%	7.4%	6.2%	8.0%	12.1%	12.9%
Median Home Value	$160,100	$181,200	$203,700	NA	$217,500	$212,300
Source: (Reference 23) NA: Not applicable, as only rates reported by official sources are reported.						

Table 5.4-12: Traffic Data Summary for Roads near Eagle Rock Facility

Road	Direction	Roadway Type	Area Type	Location	2009 AADT	2019 AADT	Projected 2025 AADT	Projected 2025 Volume / Capacity Ratio*
US 20	E-W	2 Lane Undivided	Rural	At US 26 near Atomic City	1,900	2,800	3,153	0.367
US 20	E-W	2 Lane Undivided	Rural	Near Eagle Rock site	2,210	2,800	3,153	0.367
US 20	E-W	4 Lane Divided	Areas over 5,000 population not in Urbanized areas	Idaho Falls west city limit	9,900	10,500	11,825	0.237
US 20	E-W	4 Lane Divided	Areas over 5,000 population not in Urbanized areas	Immediately east of I-15	29,733	28,000	31,533	0.632
US 20	N-S	4 Lane Divided	Areas over 5,000 population not in Urbanized areas	Idaho Falls north city limit	16,000	21,000	23,649	0.474
I-15	N-S	4 Lane Divided	Urbanized areas	North of Idaho Falls	5,400	6,400	7,207	0.144
I-15	N-S	4 Lane Divided	Urbanized areas	At US 20	18,000	21,500	24,212	0.485
I-15	N-S	4 Lane Divided	Urbanized areas	South of Idaho Falls (65th Street)	20,000	26,000	29,280	0.587
US 26	E-W	2 Lane Undivided	Rural	Atomic City	1,100	1,200	1,351	0.157
*A volume to capacity (v/c) ratio of 1.0 indicates a roadway that is at capacity.								

Table 5.4-13: Planning LOS Daily Traffic Volume Thresholds

Roadway Type	Area Type	LOS B	LOS C	LOS D	LOS E
2 Lane Undivided	Rural	4,600	8,600	14,000	28,500
4 Lane Divided	Areas over 5,000 population not in Urbanized areas	34,600	49,900	63,000	71,700
4 Lane Divided	Urbanized areas	47,600	66,400	83,200	87,300

Table 5.4-14: Public Safety Employment in the two-county ROI for 2020

Location	Number of Police Officers	Level of Service (per 1000)	Number of Firefighters
Bingham County			
County	35	1.2	Full time: 16 Part time: 5
Aberdeen	5	2.5	Full time: 0 Part time31
Blackfoot	27	2.2	Full time: 23 Part time: 20
Shelley	8	1.8	Full time: 0 Part time: 56
Bonneville County			
County	79	1.4	Full time: 3 Part time: 32
Idaho Falls	89	1.4	Full time: 94 Part time: 0
ROI	243	1.50	Full time: 138 Part time: 144

Table 5.4-15: School district data for Bingham and Bonneville Counties

Location	Number of students	Number of Teachers (FTE)	Student-Teacher Ratio
Bingham County Public Schools	10,496	590.33	18.0
Bonneville County Public Schools	25,918	1259.56	20.6

Table 5.4-16: Transportation Route Distances for Nuclear Materials and Radioactive Waste

Origin	Destination	Material Transported	Distance (miles)
Lynchburg, VA	Oak Ridge, TN	New TRISO fuel	350
Lynchburg, VA	Eagle Rock, ID	New TRISO fuel	2,200
Oak Ridge, TN	Energy*Solutions*, UT	Class A LLRW	1,860
Oak Ridge, TN	Waste Control Specialists, TX	Class B & C LLRW	1,200
Oak Ridge, TN	Yucca Mountain, NV	Spent fuel	2,100
Eagle Rock, ID	Energy*Solutions*, UT	Class A LLRW	300
Eagle Rock, ID	Waste Control Specialists, TX	Class B & C LLRW	1,200
Eagle Rock, ID	Yucca Mountain, NV	Spent fuel	690

Table 5.4-17. 2019 Thresholds for Identification of Minority and Low-income Environmental Justice Communities in ROI Counties

County	Minority Threshold (Rate + 20%)	Low-income Threshold (Rate + 20%)
Bingham	46.30%	31.20%
Bonneville	37.00%	30.50%
Jefferson	33.30%	26.90%
Source: (Reference 26, Reference 27)		

Table 5.4-18: Block Group Minority Populations within 5-mile radius

Location	Total Population	Minority Population	Percent Minority
Block Group 1, Census Tract 9503, Bingham County, Idaho	1382	259	18.7%
Block Group 1, Census Tract 9715, Bonneville County, Idaho	642	198	30.8%
Block Group 2, Census Tract 9715, Bonneville County, Idaho	1045	258	24.7%
Block Group 3, Census Tract 9601, Jefferson County, Idaho	861	214	24.9%
Total Block Groups in 5-Mile Radius	3,930	929	23.6%
Bingham County, Idaho	45,839	12,040	26.3%
Bonneville County, Idaho	114,392	19,415	17.0%
Jefferson County, Idaho	28,534	3,784	13.3%
Source: (Reference 54)			

Table 5.4-19: Block Group Low Income Populations within 5-Mile Radius

Location	Total Population	Low Income Population	Percent Low Income Individual
Block Group 1, Census Tract 9503, Bingham County, Idaho	1,382	69	5.0%
Block Group 1, Census Tract 9715, Bonneville County, Idaho	642	48	7.5%
Block Group 2, Census Tract 9715, Bonneville County, Idaho	1,045	51	4.9%
Block Group 3, Census Tract 9601, Jefferson County, Idaho	861	38	4.4%
Total Block Groups in 5-Mile Radius	3,930	206	5.2%
Bingham County, Idaho	45,080	5,039	11.2%
Bonneville County, Idaho	113,110	11,856	10.5%
Jefferson County, Idaho	28,495	1,953	6.9%
Source: (Reference 55)			

Table 5.4-20: Potentially Significant Projects Identified Within a 10-Mile Radius of the Eagle Rock Site

Project/Company Name	Summary of Project	Location	Distance from Site	Status	Reference
Rocky Mountain Power (RMP)	Proposed 161-kilovolt 15 (kV) electrical transmission line and associated substation installation and upgrades to provide electrical power for the operation of the proposed Eagle Rock site	From the existing Bonneville Substation 13.7 miles to an existing Kettle substation then to the proposed Twin Buttes Substation at the Eagle Rock site.	On-site and along an existing right of way to Idaho Falls.	Would be constructed to provide power to the Eagle Rock site.	Reference 1
Mountain States Transmission Intertie	Proposed 500-kV transmission 38 line running between western Montana and southeastern Idaho	One alternative route 10 miles east of the Eagle Rock site.	10 miles east of the Eagle Rock site.	On hold	Reference 1, Reference 57
Carbon Free Power Project	The first NuScale small modular reactor power plant will begin operation in the United States in Idaho Falls, Idaho	Idaho National Laboratory	Location not selected yet.	Under NRC review	Reference 58 Reference 59

Figure 5.4-1: Location of the Eagle Rock Site

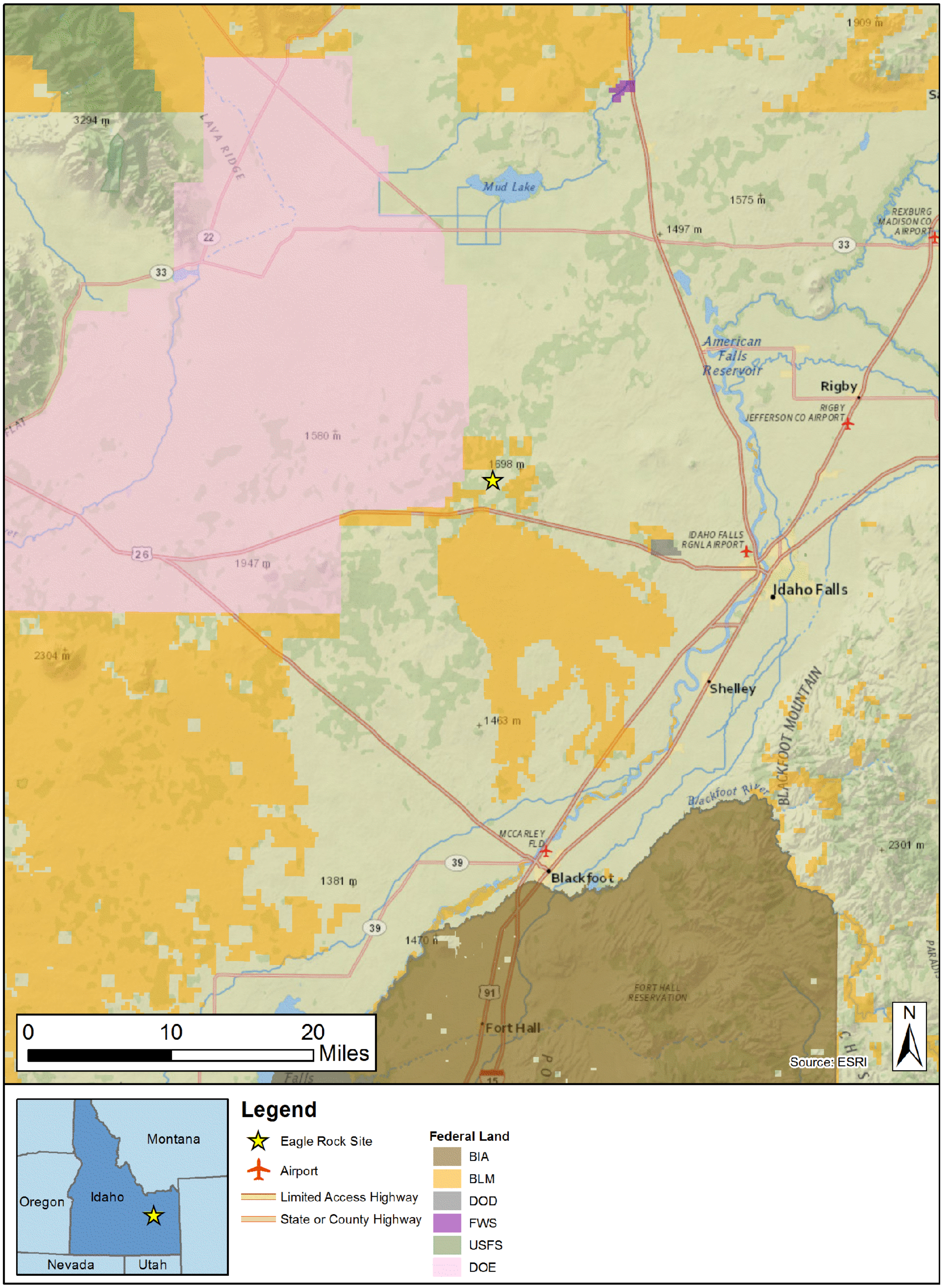
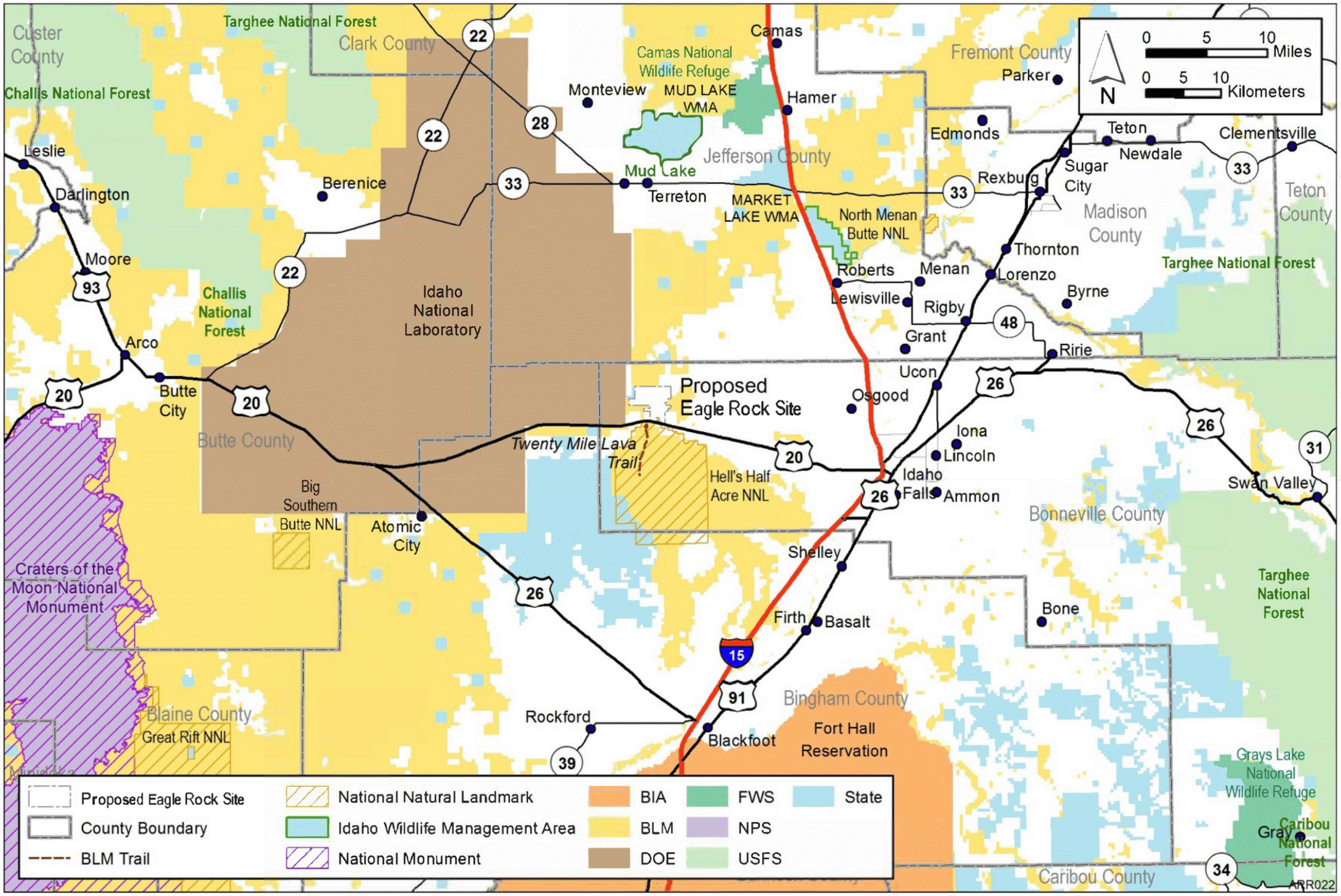
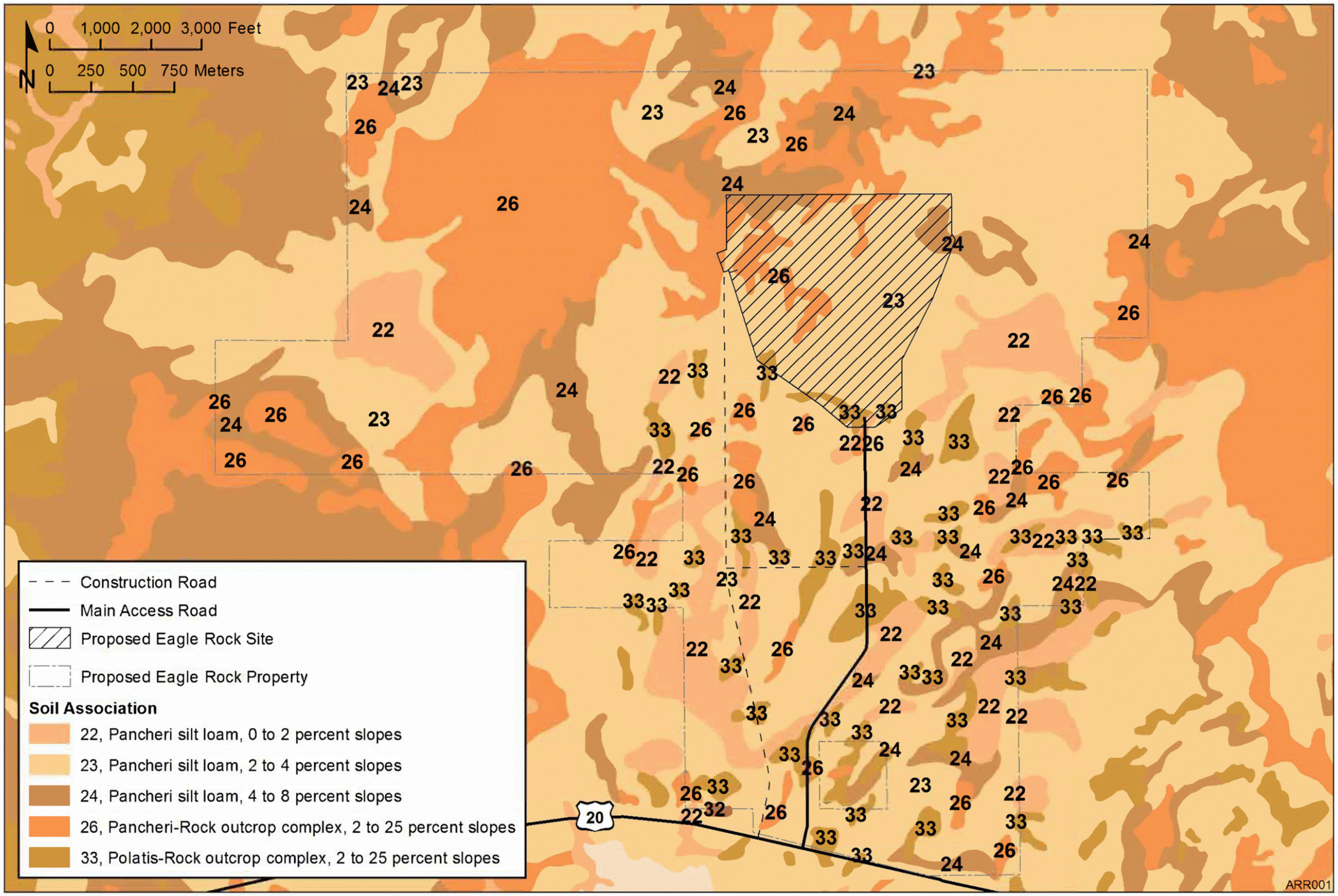


Figure 5.4-2: Special Land Use Classification Areas



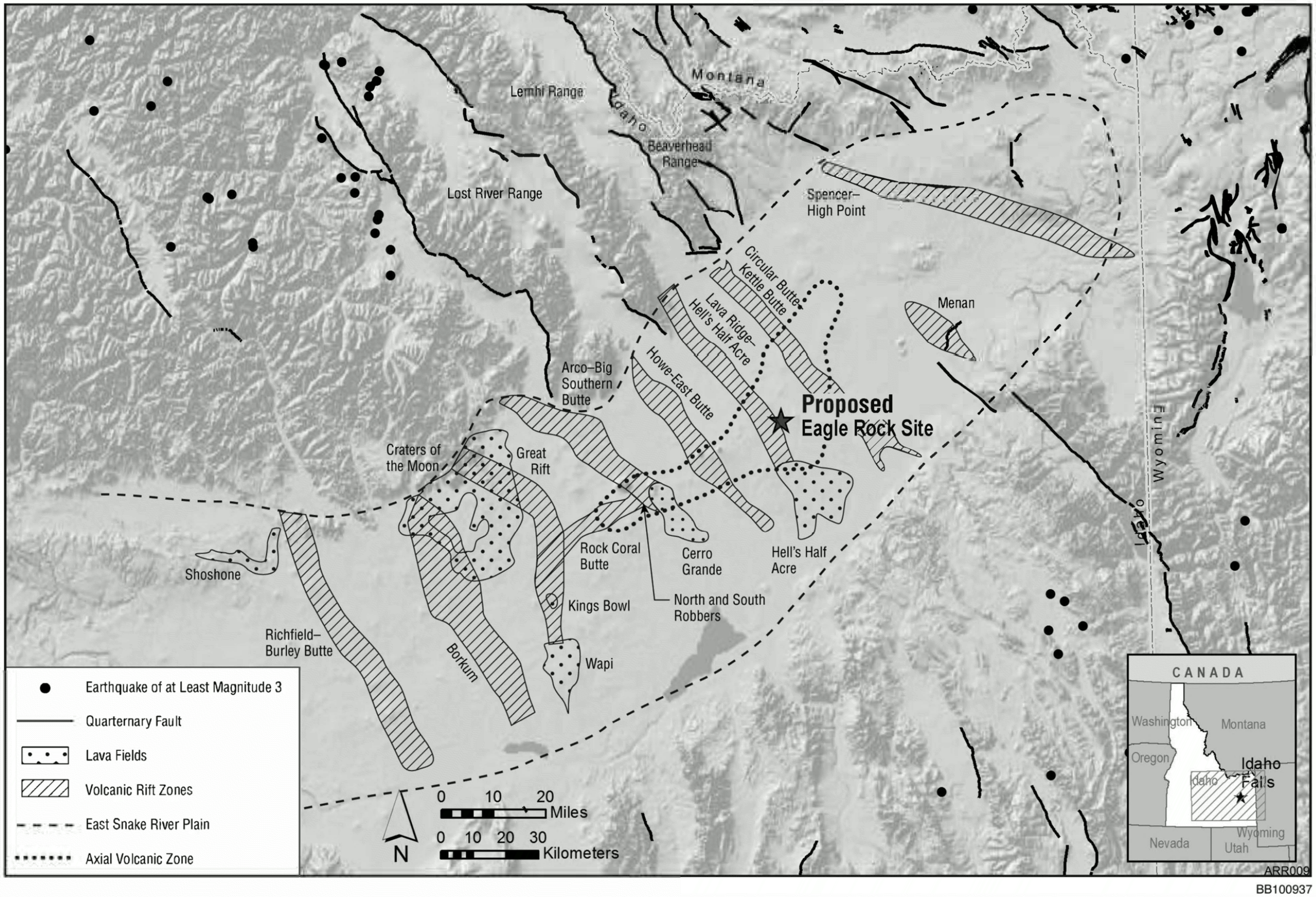
Source: (Reference 1)

Figure 5.4-3: Soil Map of the Eagle Rock Site and Surrounding Area



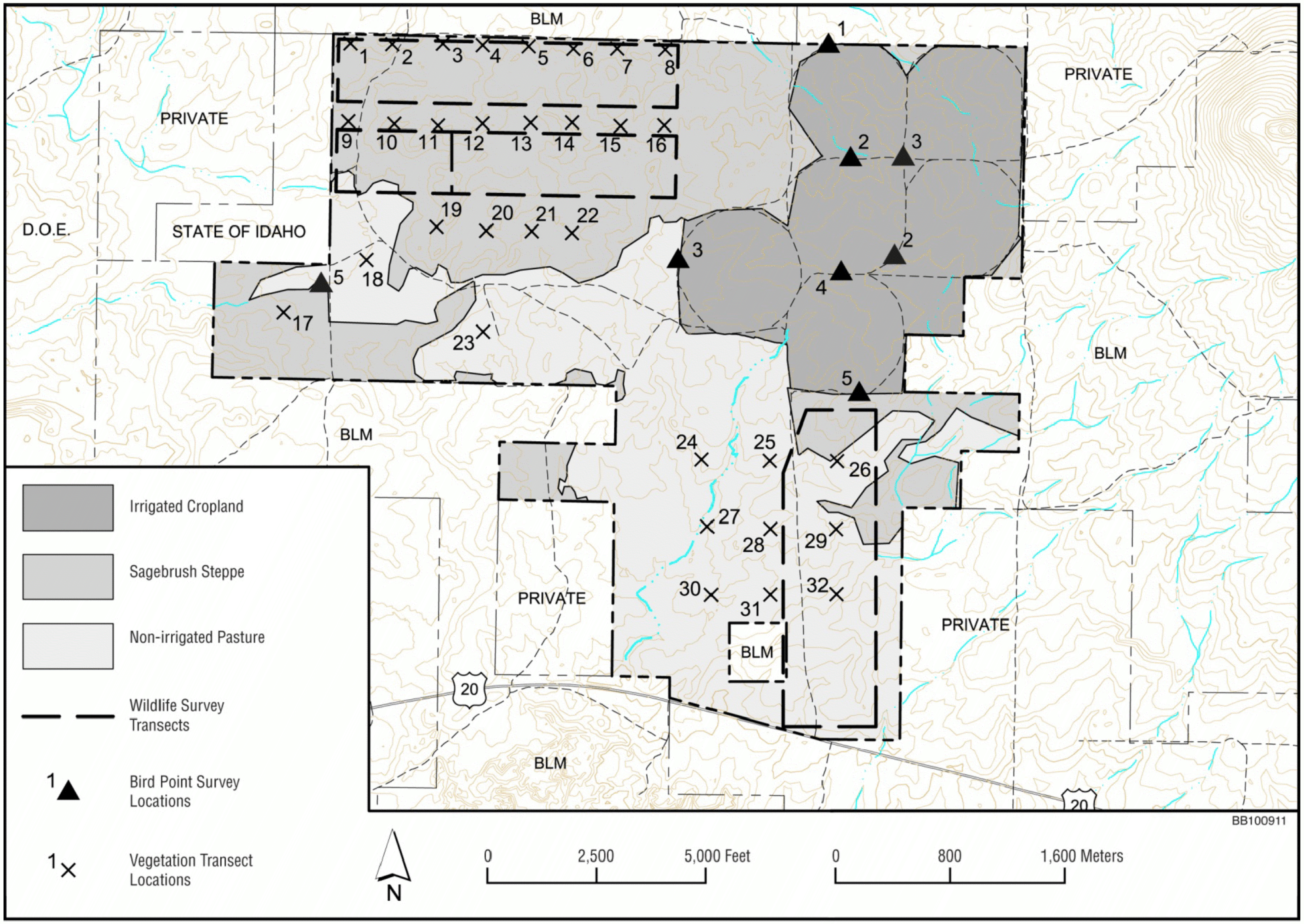
Source: (Reference 1)

Figure 5.4-4: Lava Fields and Volcanic Rift Zones of the ESRP



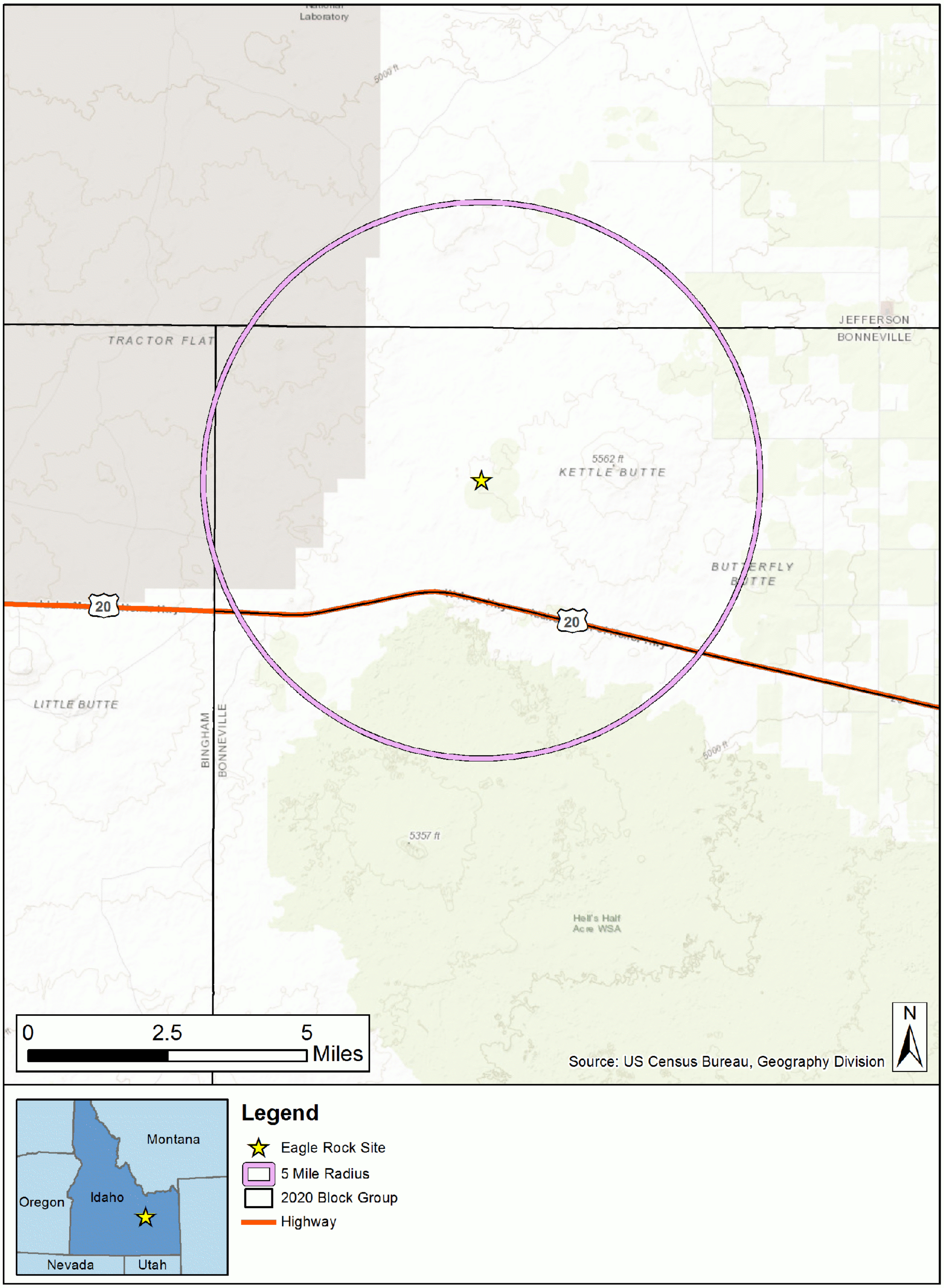
Source: (Reference 1)

Figure 5.4-5. Vegetation Types of the Proposed Eagle Rock Site



Source: (Reference 1)

Figure 5.4-6: Location of Eagle Rock



5.5 COST-BENEFIT OF THE ALTERNATIVES

This section discusses the costs and benefits of each reasonable alternative and the proposed action, including a qualitative discussion of environmental impacts. Assumptions and uncertainties included in the evaluations are also provided. As discussed in Sections 5.1 and 5.2, alternative technologies and alternative water intake and discharge options were not considered as viable alternatives. Therefore, the cost benefit analysis is associated with the proposed site and the alternative site. For this evaluation, the test reactor facility design, described in Chapter 2, and the construction and operation practices, described in Chapter 4, are assumed to be the same for each site. This assumption allows for a comprehensive and consistent comparison of costs and benefits.

5.5.1 Eagle Rock

5.5.1.1 Environmental Degradation

The environmental impacts expected to result from construction and operation of the facility at the Eagle Rock site are summarized below.

5.5.1.1.1 Land Use and Visual Resources Impacts

- Facility construction would result in the permanent conversion of approximately 30 acres of agricultural fallow and lands to industrial land use, and the temporary conversion of approximately 95 acres of agricultural lands to industrial land use.
- Almost all of the land permanently or temporarily converted to industrial land use would be classified as Prime Farmland or Farmland of Statewide Importance.
- Facility construction and operation would alter appearance of a highly natural site to an industrial site, changing the view considerably.

5.5.1.1.2 Air Quality and Noise

- Facility construction and operation would include minor emissions of criteria pollutants such as SO_2, NO_x, CO, PM_{10}, and $PM_{2.5}$ and fugitive dust from on-site and offsite vehicle use; nonradiological gaseous criteria pollutants and HAPs from fossil-fuel-powered emergency generators and equipment; and radiological air emissions from the primary heat rejection stack, Reactor Building ventilation stack, and spent fuel cooling stack.
- Facility construction and operation would include temporary and minor increases and fluctuations in ambient noise levels around the site during construction; traffic associated with the workforce; and outdoor equipment (i.e., heat exchange fans and several exhaust and ventilation stacks) during operations.

5.5.1.1.3 Water Resources

- Facility construction and operation would result in minor pollutant loads and increased runoff from roadways, parking areas, industrial activities, and landscaping.
- Groundwater extracted due to dewatering activities would be managed properly to minimize environmental degradation.

5.5.1.1.4 Ecological Resources

- Facility construction would result in the loss of undisturbed habitats and agricultural land due to site preparation and conversion to industrial land use. There would be both temporary and permanent displacement of terrestrial wildlife to adjacent undisturbed habitats. Some temporarily displaced wildlife species would return after construction activities are completed.

- Noise from construction and operational activities, including lighting, would result in some temporary and some permanent displacement of wildlife. Some temporarily displaced wildlife species would return to any remaining suitable habitat.
- During operation, there would be the potential for birds to collide with buildings and stacks. However, collisions are unlikely, and the impact is expected to be minor.

5.5.1.1.5 Historical and Cultural Resources

- Facility construction has the potential to impact archeological sites previously identified at the site. An Archaeological Monitoring and Discovery Plan would be developed to minimize these impacts.

5.5.1.1.6 Socioeconomics

- Facility construction would result in a temporary increase in demand for housing, public education resources, police, fire, medical and social services, and parks and recreation facilities.
- Facility operation would result in a minor increase in demand for housing, public education resources, police, fire, medical and social services, parks and recreation facilities, and other public services.
- Facility construction would result in a temporary increase in local traffic due to construction workforce traffic in early morning and late afternoon and periodic construction vehicle traffic throughout the workday.
- Facility operation would result in minor increase in local traffic due to vehicle movements associated with employees and deliveries/shipments of supplies and products.

5.5.1.1.7 Environmental Justice

- No environmental justice impacts would be anticipated.

5.5.1.1.8 Human Health

- During facility operation, the public would be exposed to minor doses of radiation due to transportation of radioactive materials to and from the site, as well as direct radiation and releases of gaseous effluents from the project. Radioactive materials would be strictly controlled, and all radiological doses would comply with regulatory limits.

5.5.1.2 Other Costs

- No other environmental costs, such as lost tax revenues or decreased recreational values, have been identified.

5.5.1.3 Environmental Benefits

- The construction phase of this project is expected to create approximately 212 onsite workers (425 at peak times) and 68 full-time positions during the 10-year operating period. Another 168 positions are expected during decommissioning. The wages earned and money spent by these workers would also stimulate the local economy.

5.5.1.3.1 Increase in Tax Payments

- The tax basis of unimproved land is determined by land value alone. Once buildings or other improvements are made, those improvements would be assessed, and both the land and the improvements would be taxed. The taxes for the site would increase substantially after project construction, benefitting Bonneville County.

5.5.1.3.2 Creation and Improvement of Infrastructure

- No creation or improvement of infrastructure is expected to result directly from the project.

5.5.1.3.3 Other Benefits

- The construction and operation of this project would advance commercial development and deployment of advanced nuclear reactor technology. This benefit would also support DOE's goal of designing and developing safe and affordable reactor technologies that can be licensed and deployed over the next 10 to 14 years.

5.6 COMPARISON OF THE POTENTIAL ENVIRONMENTAL IMPACTS

This section compares the environmental impacts, costs, and benefits discussed in Sections 5.2 and 5.3 for the alternative sites with the impacts, costs, and benefits expected at the site, and evaluates whether any of the alternatives would reduce or avoid adverse effects. The results are provided in Table 5.6-1.

Table 5.6-1 Comparison of Construction Impacts for the Kairos Power Site and Alternative Sites

Category	Kairos Power (Oak Ridge)	Eagle Rock	No-Action
Land Use Impacts	SMALL	SMALL	SMALL
Visual Resources Impacts	SMALL	MODERATE	SMALL
Air Quality Impacts	SMALL	SMALL	SMALL
Noise Impacts	SMALL	SMALL	SMALL
Geology, Soils, and Seismology Impacts	SMALL	SMALL	SMALL
Water Resources Impacts			
Surface Water Impacts	SMALL	SMALL	SMALL
Ground Water Impacts	SMALL	SMALL	SMALL
Ecological Resources Impacts			
Vegetation	SMALL	SMALL	SMALL
Wildlife	SMALL	MODERATE	SMALL
Wetlands	SMALL	SMALL	SMALL
Historical and Cultural Resources Impacts	SMALL	MODERATE	SMALL
Socioeconomic Impacts			
Housing	SMALL	SMALL	SMALL
Public Services	SMALL	SMALL	SMALL
Public Education	SMALL	SMALL	SMALL
Taxes	SMALL	SMALL	SMALL
Transportation	SMALL	SMALL	SMALL
Human Health Impacts			
Nonradiological Impacts	SMALL	SMALL	SMALL
Radiological Impacts	SMALL	SMALL	SMALL
Waste Management Impacts	SMALL	SMALL	SMALL
Transportation Impacts	SMALL	SMALL	SMALL
Postulated Accident Impacts	SMALL	SMALL	SMALL
Environmental Justice Impacts	SMALL	SMALL	SMALL

Table 5.6-2 Comparison of Operation Impacts for the Kairos Power Site and Alternative Sites

Category	Kairos Power (Oak Ridge)	Eagle Rock	No-Action
Land Use Impacts	SMALL	SMALL	SMALL
Visual Resources Impacts	SMALL	MODERATE	SMALL
Air Quality Impacts	SMALL	SMALL	SMALL
Noise Impacts	SMALL	SMALL	SMALL
Geology, Soils, and Seismology Impacts	SMALL	SMALL	SMALL
Water Resources Impacts			
Surface Water Impacts	SMALL	SMALL	SMALL
Ground Water Impacts	SMALL	SMALL	SMALL
Ecological Resources Impacts			
Vegetation	SMALL	SMALL	SMALL
Wildlife	SMALL	SMALL	SMALL
Wetlands	SMALL	SMALL	SMALL
Historical and Cultural Resources Impacts	SMALL	SMALL	SMALL
Socioeconomic Impacts			
Housing	SMALL	SMALL	SMALL
Public Services	SMALL	SMALL	SMALL
Public Education	SMALL	SMALL	SMALL
Taxes	SMALL	SMALL	SMALL
Transportation	SMALL	SMALL	SMALL
Human Health Impacts			
Nonradiological Impacts	SMALL	SMALL	SMALL
Radiological Impacts	SMALL	SMALL	SMALL
Waste Management Impacts	SMALL	SMALL	SMALL
Transportation Impacts	SMALL	SMALL	SMALL
Postulated Accident Impacts	SMALL	SMALL	SMALL
Environmental Justice Impacts	SMALL	SMALL	SMALL

Kairos Power

Chapter 6

Conclusions

Hermes Non-Power Reactor

Environmental Report

Revision 0

October 2021

TABLE OF CONTENTS

List of Tables

List of Figures

None

CHAPTER 6 CONCLUSIONS

This chapter evaluates (1) any adverse effects that cannot be avoided, (2) the relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity, and (3) any irreversible and irretrievable commitments of resources that would be involved in the proposed action.

6.1 UNAVOIDABLE ADVERSE ENVIRONMENTAL IMPACTS

This section describes principal unavoidable adverse environmental impacts for which mitigation measures are either considered impractical, do not exist, or cannot entirely eliminate the impact. Chapter 4 describes the impacts of constructing and operating the facility. The unavoidable adverse impacts identified in Chapter 4 are discussed in this section.

6.1.1 Unavoidable Adverse Environmental Impacts of Construction

Construction impacts and measures and controls used to reduce or eliminate such impacts are discussed in Chapter 4 and are briefly summarized in Table 6.1-1. All of the impacts described in Table 6.1-1 would be SMALL because they either would not be detectable or would be minor compared to the availability of the affected resources. Exceptions include land use and visual resources, as 30 acres of a previously disturbed brownfield site would be impacted during facility operations and decommissioning and blocking the view of the construction site from the surrounding area is impracticable. No construction-related activities would result in disproportionately high and adverse environmental or health effects on minority or low-income populations.

Table 6.1-1 summarizes impacts related to construction activities that would result in a measurable loss or permanent change in resources, the mitigation and control measures available to reduce those impacts, and the unavoidable adverse impacts that would remain after mitigation measures and control measures are applied. Many of the mitigation measures for reducing construction-related impacts are also referred to as best management practices (BMPs). BMPs would be implemented through permitting requirements and plans and procedures developed for constructing or operating the facility.

As indicated in Table 6.1-1, most of the adverse impacts are either avoidable or negligible after mitigation and control measures are considered.

Unavoidable adverse impacts from construction of the facility would include:

- Construction activities would affect 138 acres of previously disturbed land, of which approximately 30 acres would be permanently disturbed for operation of the facility. Temporarily impacted areas used for parking and staging would be restored with either native plants or landscaping.
- Visual resources are unavoidably impacted during construction because of activities which cannot be screened from view.
- Unavoidable water use impacts are minimal due to the large amounts of water available in the City of Oak Ridge municipal system.
- Impacts to social services and traffic patterns due to a potential influx of population would be minor.
- Construction activities result in unavoidable localized increases in air emissions and noise. Activities associated with the use of construction equipment and construction workforce traveling to and from the project site may result in varying amounts of dust, air emissions, noise, and vibration that may potentially impact both onsite workers and other workers in the area. Emissions from construction activities and equipment are minimized through implementation of mitigation measures, including proper maintenance of construction equipment and vehicles. Posted speed limits, traffic control and administrative measures, such as staggered shift hours, would reduce

traffic noise during the weekday business hours. By implementation of mitigation measures, emissions and noise impacts associated with construction activities are temporary and localized at and near the site. Noise levels would return to ambient levels within 1 mile of the construction site.

6.1.2 Unavoidable Adverse Environmental Impacts of Operations

Impacts due to the operation of the facility are discussed in detail in Chapter 4. Table 6.1-2 summarizes operational impacts and identifies measures and controls available to reduce or eliminate such impacts. This subsection describes unavoidable adverse impacts that would result from operation of the facility. Operations-related impacts would be SMALL, because they would either not be detectable or would be minor compared to the availability or status of the affected resource as described in Table 6.1-2. Table 6.1-2 summarizes operations-related impacts that would result in a measurable loss or permanent change in resources, the mitigation and control measures available to reduce these impacts, and the adverse impacts that would remain after mitigation and controls measures are applied. As indicated in Table 6.1-2, all of the adverse impacts are either avoidable or negligible after mitigation and control measures are considered.

As discussed in Subsection 4.5.1, continued commitment of land over the operational life of the facility includes approximately 30 acres of the site. It is expected that operational activities at the site would have SMALL impacts on land use within the Site Boundary and in its vicinity.

Unavoidable adverse impacts from operation of the facility include:

- Approximately 30 acres of previously disturbed brownfield site would continue to be impacted during operations.
- Visual resources would be impacted by the continued presence of the facility. This could be mitigated with landscaping around the perimeter, if needed.
- Impacts to surface water quality would be mitigated by the use of BMPs, a stormwater pollution prevention plan (SWPPP), and a national pollutant discharge elimination system (NPDES) permit.
- Impacts to social services and traffic patterns due to a potential influx of population would be minor and could be mitigated using adjustments to traffic signals as necessary.
- Impacts to terrestrial ecology would consist of infrequent bird impacts with structures.
- Air quality impacts would be mitigated by engineering of the facility. The criteria pollutant operational emissions are estimated to be well below 100 tpy for individual criteria pollutants and no HAPs are estimated to exceed 10 tpy for any single pollutant, and all HAPs combined are expected to be less than 25 tpy.

6.1.3 Summary of Adverse Environmental Impacts from Construction, Operations, and Decommissioning

The adverse environmental impacts associated with the construction and operation of the facility would be SMALL and would be further reduced through the application of mitigation and control measures described in Tables 6.1-1 and 6.1-2.

Most of the impacts from construction and operation would be SMALL due to design features that result in lower levels of impacts, BMPs that control and mitigate emissions and discharges to air and water, use of lands that were previously altered or disturbed, and applicable federal and state permitting requirements designed to protect humans and biota. These SMALL impacts generally have no detectable adverse impacts or only minor adverse impacts.

Prior to decommissioning, Kairos Power would submit a License Termination Plan to the NRC and request a license amendment. The NRC has evaluated the environmental impacts from

decommissioning nuclear power reactors in NUREG-0586, “Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities,” Supplement 1, Volume 1 (Reference 1). For each impact area, the NRC concluded that decommissioning would not result in an impact that would be greater than SMALL. Given that this alternative action would be a non-power reactor and the facility would be much smaller than the reactor facilities analyzed in NUREG-0586, the impacts from decommissioning would be bounded by the conclusion of the NRC and would also be SMALL.

Table 6.1-1: Construction-Related Unavoidable Adverse Environmental Impacts (Page 1 of 3)

Resource Area	Adverse Impact	Mitigation Measure	Unavoidable Adverse Environmental Impacts
Land Use and Visual Resources	Construction of the facility would impact 30 acres of a previously disturbed brownfield site during facility operation and decommissioning.	Construction activities would comply with all relevant federal, state, and local regulatory requirements, including BMPs and stormwater management plans to control erosion and runoff.	A total of 30 acres of brownfield would be lost during facility operation and decommissioning. The site was previously disturbed as part of the Manhattan Project, land use is already industrial, 30 acres are a small portion of the 185-acre site, technically land use will not change; therefore, unavoidable adverse impacts are minimal.
	Partial obstruction of views of the existing landscape.	Visual impacts would be minimized by, installing fencing (visual screen), retention of trees on the perimeter of the site, and installation of landscaping after construction is complete.	Visual impacts due to construction activities are unavoidable, but temporary.
	Temporary impact to 138 acres of previously disturbed brownfield for parking and staging.	Temporary impacted areas would be restored to their previous condition or improved with landscaping and native plants.	Some localized short-term impacts to temporary impact areas are expected but should be eliminated once construction is complete. Therefore, unavoidable adverse environmental impacts are not anticipated.
Air Quality and Noise	Activities associated with the use of construction equipment (grading and engine air emissions), painting resulting in volatile organic contaminates (VOCs), and increased traffic may impact air quality onsite and offsite.	BMPs and dust control measures would reduce particulate emissions. Painting contractors would adhere to federal and state regulations to minimize VOC impacts. The area is in attainment and an increase in traffic due to construction should not cause non-attainment.	Unavoidable adverse environmental impacts are not anticipated.
	Potential impacts due to increase in noise levels from construction equipment and construction workforce traveling to and from the site.	Noise levels are anticipated to decrease to ambient levels within one mile of the site, no sensitive receptors are located within this radius. Onsite noise exposure would be controlled through general industry practices. Traffic noise would be limited to shift changes and occur during normal business hours.	Temporary impacts to noise levels onsite are possible; however, these increases would be minor and limited to within one mile of the site. Therefore, unavoidable adverse environmental impacts are not anticipated.

Table 6.1-1: Construction-Related Unavoidable Adverse Environmental Impacts (Page 2 of 3)

Resource Area	Adverse Impact	Mitigation Measure	Unavoidable Adverse Environmental Impacts
Geologic Environment	Potential local adverse impacts due to excavation and other construction related activities	Geologic resources at the site are the same throughout the region and do not include any unique or rare geological resources. No mitigation measures beyond compliance with local building codes would be anticipated as no significant impacts due to large scale or local hazards have been identified.	Unavoidable adverse environmental impacts would not be anticipated.
Water Resources and Water Quality	All public water supplies in the site vicinity are sourced from surface water. Additional needs during construction are identified and would be satisfied by existing system capacities.	Water would be supplied by the City of Oak Ridge Public Works, which has ample capacity for construction needs. Portable toilets with offsite treatment would be supplied for workers until permanent facilities are completed.	Unavoidable adverse environmental impacts would be the physical use of surface water during construction. As municipal capacity and available surface water are ample in supply, this impact would be minimal.
	Potential impacts are limited to offsite areas and are associated with runoff and siltation into adjacent waterbodies.	Construction activities would comply with all relevant federal, state, and local regulatory requirements, including BMPs and stormwater management plans to control erosion and runoff. Any groundwater produced during construction and decommissioning from dewatering would be properly managed as discussed in Subsection 4.4.1.1.	Unavoidable adverse impacts may occur if contaminated groundwater or construction runoff were to enter surface water. Groundwater extracted due to dewatering will be properly managed. BMPs would be implemented to minimize this risk. Therefore, unavoidable adverse environmental impacts would not be anticipated.
Ecological Resources	Wildlife potentially affected by construction includes bird, mammal, and/or herpetofauna species.	The site is previously disturbed and a brownfield site; there is minimal habitat for wildlife onsite and utilization of the site is low.	Unavoidable adverse environmental impacts would be not anticipated.
	Potential impacts are limited to offsite areas associated with runoff and siltation into Poplar Creek and the Clinch River.	BMPs would be used in accordance with the SWPPP as required by the Tennessee Department of Environment and Conservation (TDEC) to prevent sediment runoff and subsequent siltation in receiving streams during construction.	Unavoidable adverse environmental impacts would not be anticipated.

Table 6.1-1: Construction-Related Unavoidable Adverse Environmental Impacts (Page 3 of 3)

Resource Area	Adverse Impact	Mitigation Measure	Unavoidable Adverse Environmental Impacts
Historic and Cultural Resources	No adverse impacts on cultural or historic resources have been identified	No mitigation measures required.	Unavoidable adverse environmental impacts would not be anticipated.
Socioeconomics	There is a potential minor increase in the local population and associated increased demand for local public services, schooling, housing, and land.	Potential increases in population should not cause impacts due to the number of potential immigrants in comparison with the existing population.	Unavoidable adverse environmental impacts would not be anticipated.
	Potential impacts in traffic infrastructure and patterns due to increased traffic from construction-related vehicles	Potential traffic increases should not impact level of service due to the existing lack of issues.	Unavoidable adverse environmental impacts would not be anticipated.
Human Health	Potential impacts to the general public and construction workforce include dust and other air emissions during construction, and potential injuries due to construction accidents.	BMPs including dust control plans would be implemented during construction to minimize fugitive dust. Site specific safety training would minimize the potential for injuries.	Unavoidable adverse impacts would include slight increases in air emissions at the construction site.
Waste Management	Potential impacts to the capacity of waste disposal facilities managing construction waste.	Waste generation rates would be reduced through aggressive recycling and reuse programs.	Unavoidable adverse impacts would not be anticipated due to aggressive recycling and reuse programs
Transportation	No adverse impacts associated with the transportation of nuclear and nonnuclear materials	No mitigation measures required	Unavoidable adverse environmental impacts would not be anticipated
Environmental Justice	Potential impacts due to increase in noise and dust and commuter traffic during construction is not expected to disproportionately affect minority and low-income populations.	See the discussions above on mitigation measures for human health and environmental effects, such as noise, traffic, and air quality.	Unavoidable adverse environmental impacts would not be anticipated.

Table 6.1-2: Operations-Related Unavoidable Adverse Environmental Impacts (Page 1 of 3)

Element	Adverse Impact	Mitigation Measure	Unavoidable Adverse Environmental Impacts
Land Use and Visual Resources	Visual impacts as a result of the main building and exhaust vent stack.	The majority of the structures would be less than 100 feet high and will be contained within an 8-acre area. Landscaping may be installed around the perimeter of the facility and/or parking lots.	Minor impacts to visual resources would occur; however, the area is already industrial so these would be small.
Air Quality and Noise	Potential impacts from air emissions from the facility and increased vehicle traffic from the workforce.	Emissions from the facility would be controlled through engineering and permitting. Traffic emissions would not be considered large enough to impact regional air quality.	Estimated criteria pollutant operational emissions would be well below 100 tpy for individual criteria pollutants and estimated HAP emissions would not exceed 10 tpy for any single pollutant, and all estimated HAP emissions combined would to be less than 25 tpy. With such low emissions and due to the area being in compliance with all ambient air quality standards, TDEC would treat this project as a minor source and conclude that the project would not cause or contribute to a violation of the National Ambient Air Quality Standards; therefore, unavoidable adverse environmental impacts would not be anticipated.
	Potential noise impacts from operations and increased vehicular traffic.	Noise from operations is estimated to be contained within the facility footprint. Noise from increased traffic would not be considered above current conditions.	Unavoidable adverse environmental impacts would not be anticipated.
Geologic Environment	Potential impacts from soil erosion.	Soils at the site were determined to be medium firm to very hard and should not erode. Mitigation would not be required.	Unavoidable adverse environmental impacts would not be anticipated.

Table 6.1-2: Operations-Related Unavoidable Adverse Environmental Impacts (Page 2 of 3)

Element	Adverse Impact	Mitigation Measure	Unavoidable Adverse Environmental Impacts
Water Resources and Water Quality	Potential impact to water supply and sanitary treatment systems.	Demineralized water is expected to be trucked to the facility; the City of Oak Ridge Public Works Department has ample capacity to provide the balance of water required for the facility. The City of Oak Ridge Public Works Department has ample capacity to treat the volume of wastewater required for operations. Mitigation would not be required.	Unavoidable adverse environmental impacts are not anticipated.
	Potential impacts from stormwater runoff to adjacent waterbodies.	Stormwater would be managed with BMPs, a SWPPP, and an NPDES permit. Groundwater in the area where dewatering would be required for construction would be contained and sampled to determine whether offsite treatment and disposal of dewatered groundwater would be required or whether it could be pumped to the stormwater pond prior to or discharge in accordance with permit requirements.	Unavoidable adverse environmental impacts would not be anticipated.
Ecological Resources	Possible herbicide exposure and bird collisions.	BMPs would be used as part of an herbicide management plan. Bird collisions would likely only be at the various stacks, which are a relatively small portion of the overall facility.	Unavoidable adverse environmental impacts would not be anticipated due to herbicide use. Bird collisions would be unlikely and minimal over the operation of the facility.
	Possible impacts due to stormwater runoff to Poplar Creek and the Clinch River.	Stormwater would be managed with BMPs, a SWPPP, and an NPDES permit, eliminating potential impacts.	Unavoidable adverse environmental impacts would not be anticipated.
Historic and Cultural Resources	No adverse impacts on cultural or historic resources have been identified	No mitigation measures required.	Unavoidable adverse environmental impacts would not be anticipated.
Socioeconomics	Potential impacts to social services due to a small increase in population.	Adequate social services including housing, educational facilities, transportation, and water treatment capacities are present in the region of interest (ROI) to absorb any population influx. Mitigation could include adjustments to traffic signals in the areas as necessary.	Unavoidable adverse environmental impacts would not be anticipated.

Table 6.1-2: Operations-Related Unavoidable Adverse Environmental Impacts (Page 3 of 3)

Element	Adverse Impact	Mitigation Measure	Unavoidable Adverse Environmental Impacts
Human Health	Potential impacts due to exposure to physical, electrical, and chemicals hazards at the facility.	Occupational Safety and Health Administration (OSHA) compliance would minimize the potential for exposure to the workforce.	Unavoidable adverse environmental impacts would not be anticipated.
	Potential impacts to the general public and operations workforce from radiation sources and airborne radioactive effluents.	The design of the facility would minimize the potential for exposure to the public with emissions controls, radiation shielding, and environmental monitoring.	Unavoidable adverse environmental impacts would not be anticipated.
Waste Management	Potential impacts to the capacity of waste disposal facilities managing sanitary and low-level radioactive waste; there is no current disposal pathway for spent nuclear fuel.	Waste generation rates would be reduced through waste minimization programs; volumes would be reduced with onsite waste compaction.	Unavoidable adverse impacts would not be anticipated due to waste minimization programs.
Transportation	Transportation of radioactive materials results in low levels of radiation dose to the drivers and the public.	Radioactive materials and wastes would be shipped as exclusive use shipments in shielded containers when necessary and in accordance with Department of Transportation (DOT) and NRC regulations.	Unavoidable adverse environmental impacts are not anticipated.
Environmental Justice	Potential impacts due to increase in noise and dust and commuter traffic during operations is not expected to disproportionately affect minority and low-income populations.	See the discussions above on mitigation measures for human health and environmental effects, such as noise, traffic, and air quality.	Unavoidable adverse environmental impacts would not be anticipated.

6.2 RELATIONSHIP BETWEEN SHORT-TERM USES AND LONG-TERM PRODUCTIVITY OF THE ENVIRONMENT

This Environmental Report focuses on the analyses and resulting conclusions associated with the environmental impacts from activities during the new plant construction and operation at the site. These activities are considered short-term uses for purposes of this section. In this section, the long-term is considered to be initiated with the conclusion of proposed facility decommissioning at the site. This section includes an evaluation of the extent that the short-term uses preclude any options for future long-term use of the site.

6.2.1 Construction of the Facility and Long-Term Productivity

Section 6.1.1 summarizes the potential unavoidable adverse environmental impacts of construction and the measures proposed to reduce those impacts. Some small adverse environmental impacts could remain after all practical measures to avoid or mitigate them are taken. However, none of these impacts represent long-term effects that preclude any options for future use of the site.

The acreage disturbed during construction of the facility is larger than that required for the actual structures and ancillary facilities because of the need for construction parking areas, and construction material staging and laydown areas. Preparation of these onsite areas coupled with noise from construction activities may displace some wildlife and alter existing vegetation. Once the new facility is completed, the areas not needed for operations will be returned to grasses or native vegetation.

Construction of the facility would include the installation of water and sewer lines that connect the facility to the City of Oak Ridge water supply system. This additional infrastructure would be available and beneficial to any future use of the site after decommissioning.

Noise emitted by some construction activities would increase the ambient noise levels onsite and in adjacent offsite areas. During construction, the workforce would be protected from excessive noise levels by adherence to the OSHA requirements within high noise environments. Wildlife would be temporarily displaced to suitable offsite habitats. There would be no effects on the long-term productivity of the site as a result of these noise impacts.

Construction traffic would increase the volume of traffic on local roads but would not have an adverse impact on the level of service (LOS). Consequently, no modifications to the physical traffic infrastructure would be necessary and there would be no effects on long-term productivity.

Facility construction would have beneficial socioeconomic effects on the local area such as new construction-related jobs, local spending by the construction workforce, and payment of taxes within the area and region. The in-migration of the construction workforce supports the expansion of existing small businesses or locations for new small businesses that might serve Kairos Power and its employees. The beneficial impacts from the in-migration of the construction workforce and indirect economic output and employment resulting from construction expenditures to the communities within the ROI would decease once construction is completed. However, the changes that are the result of increased tax revenues would continue throughout the operational life of the facility.

Construction of any facility comes with inherent hazards that can have significant impacts including fatalities. However, adhering to applicable safety standards would greatly reduce the risks of accidents and exposures to hazardous environments.

Construction of the facility would have no disproportionate impacts on populations identified as minority and low-income as such populations were not identified within the region around the site.

Therefore, there would be no effects on the long-term productivity of the region as a result of impacts on environmental justice.

6.2.2 Operation of the Facility and Long-Term Productivity

Section 6.1.2 summarizes the potential unavoidable adverse environmental impacts of operation and the measures proposed to reduce or eliminate those impacts. Some small adverse environmental impacts could remain after all practical measures to avoid or mitigate them are taken. However, none of these impacts represent long-term effects that preclude any options for future use of the site.

The site is located in an area that has previously been industrial. Therefore, operation of the new facility represents a continuation of the planned land use. Once the facility is decommissioned to NRC standards, the land could be available for other industrial uses.

During operation, noise levels would be expected to return to ambient levels as facility-generated noise is limited by the walls and other physical barriers of the facility itself. Operation of the new facility would slightly increase air emissions from the primary heat rejections stack, the Reactor Building ventilation stacks, and the spent fuel cooling stack. The equipment would be operated in accordance with applicable federal, state, and local regulations, and would not be expected to result in any long-term decrease in regional air quality.

During operation, exposures to and management of radioactive and hazardous materials and waste would be unavoidable. However, adherence to exposure and dose limits established by regulatory agencies and implementation of a robust facility health and safety program would limit impacts to workers and the public. Exposures to radioactive materials during transportation is also unavoidable; however, the dose impacts to the exposed populations are only a small fraction of background dose.

Operation of the facility would have a comparable impact on all populations in the region around the site. No disproportionate impacts would be expected to either minority or low-income populations as such populations were not identified within the region around the site. Therefore, there would be no long-term effects to environmental justice that preclude any options for future use of the site.

6.2.3 Summary of the Relationship Between Short-Term Use and Long-Term Productivity

The impacts resulting from the facility construction and operation would result in both adverse and beneficial short-term impacts. The principal short-term adverse impacts would be SMALL residual impacts (after implementing mitigation measures) to land use, visual resources, terrestrial ecology, local traffic, noise, and air quality. There would be no long-term impacts to the environment. The principal short-term benefits would be the creation of additional jobs, additional tax revenues, and improvements to local infrastructure. The principal long-term benefit is the continued availability of the improved infrastructure and potential benefits from increased tax revenues after facility decommissioning. The short-term impacts and benefits and long-term benefits do not affect long-term productive use of the site.

6.3 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

This section describes the anticipated irreversible and irretrievable commitments of environmental resources that would be used in the construction and operation of the facility. The term 'irreversible commitments of resources' describes environmental resources that would be potentially changed by the new facility construction or operation and that could not be restored at some later time to the resource's state prior to construction or operation. Irretrievable commitments of resources would be materials used for the proposed facility in such a way that they could not, by practical means, be recycled or restored for other uses.

6.3.1 Irreversible Environmental Commitments

Irreversible environmental resource commitments resulting from the new facility include:

- Degradation of air and water resources
- Land disposal of wastes, including hazardous and low-level radioactive waste
- Commitment of underground geological resources for disposal of high-level radioactive waste and spent fuel

6.3.2 Land Use

The land used for the facility is not irreversibly committed because once the Hermes reactor ceases operations and the facility is decommissioned in accordance with NRC requirements, the land supporting the facilities could be returned to other industrial uses. There would be no permanent storage or disposal of radioactive or nonradioactive wastes at the site. However, as there is currently no disposal or offsite storage pathway for spent nuclear fuel in the United States, the spent reactor fuel may need to remain on site until a suitable pathway is available.

During construction, operation, and decommissioning, the commitment of land resources needed for disposal of wastes would be irreversible. These wastes include nonradioactive and nonhazardous construction and demolition waste, routine sanitary waste and trash, hazardous wastes, and low-level radioactive wastes. However, due to the relatively small scale of the project compared to other non-radiological industrial projects and the operations and decommissioning of large commercial nuclear power reactors, the volumes of waste would have a SMALL impact on the irretrievable commitment of land resources for disposal facilities.

6.3.3 Hydrologic Resources

The proposed facility would require water from the City of Oak Ridge for construction, potable water, fire protection, and facility heating and cooling. The City of Oak Ridge provides water supply for both public drinking and fire protection through treatment of surface water. The average estimated water usage by the facility during operations is 0.07 MGD. According to the city of Oak Ridge, the total treating capacity is approximately 12 MGD. Additionally, a new treatment plant is planned near the Y-12 facility which will have a 16 MGD capacity. Average water usage in the City of Oak Ridge is about 7 MGD. Accordingly, the excess capacity of the Oak Ridge water supply system would be approximately 5 MGD. Once the new Y-12 facility is constructed, excess capacity would be even larger. Because there would be excess capacity within the Oak Ridge water supply system, there would be no indirect effects associated with the demand from the facility. There would be no direct impacts to water quality or hydrology from the facility; therefore, there will be no irreversible impacts.

6.3.4 Ecological Resources

Long-term irreversible losses of terrestrial biota are not anticipated. Subsequent to the completion of construction, floral and faunal resources would be expected to recover in areas that would not be

affected by ongoing operations. Floral resources at the site are limited to vegetated areas which were formerly developed with industrial structures. Losses of fauna due to operations would be primarily attributable to bird collisions with stacks at the facility as wildlife occurrence on the site is low and relatively infrequent.

Water for the facility would be provided by the City of Oak Ridge and demineralized water would be trucked to the facility; therefore, water supply intake or cooling water intake structures would be not needed. Thus, there would be no operational impacts associated with impingement or entrainment of aquatic biota. Furthermore, the facility would not discharge process water directly into Poplar Creek or any other nearby water body, avoiding any impacts associated with pollutant or thermal discharges to aquatic resources. There would be no irreversible impacts to aquatic flora or fauna.

6.3.5 Socioeconomic Resources

No irreversible commitments will be made to socioeconomic resources because they would be reallocated for other purposes once the facility is decommissioned.

6.3.6 Historic and Cultural Resources

No known historic or cultural resources would be irreversibly altered due to the facility.

6.3.7 Air Quality

Construction and decommissioning activities would create dust and other emissions, such as vehicle exhaust. Implementation of controls and limits at the source of emissions on the construction site would result in reduction of impacts offsite. The dust control program would reduce dust due to construction activities and minimize dust reaching site boundaries. Specific mitigation measures are discussed in Subsection 4.2.1.1. Contractors, vendors, and subcontractors would be required to adhere to appropriate federal and state occupational health and safety regulations to protect workers from adverse conditions, including air emissions.

During operations, emissions would be a product of vehicle exhaust, ventilation system exhaust, and fuel combustion resulting in very low levels of gaseous pollutants and particulates released from the facility into the air. Emissions during operations would be in compliance with applicable Federal and State regulations, minimizing their impact on public health and the environment. No irreversible impacts to air quality are anticipated.

6.3.8 Irretrievable Commitments of Resources

Irretrievable commitments of resources during new plant construction would be similar to that of any small-scale industrial facility construction project. Unlike previous industrial construction, asbestos and other materials considered hazardous would not be used or would be used sparingly and in accordance with safety regulations and practices. Materials consumed during the construction phase are shown in Table 2.1-1. These materials would be irretrievable unless they are recycled at decommissioning. Additionally, approximately 31,800 gallons of diesel fuel (as a bounding assumption all fuel is assumed to be diesel) is expected to be used on an average monthly basis during construction (Section 2.1). Use of construction materials in the quantities associated with the facility would have a SMALL impact with respect to the commitment of such resources.

During operations, the main resources that would be irretrievably committed are the nuclear fuel, Flibe liquid salt primary coolant, and the intermediate nitrite salt coolant. The spent nuclear fuel would not be recycled, and the coolant salts would be disposed as low-level radioactive waste. Materials used in the construction of the reactor, spent fuel canisters, and other waste containers and metals and concrete activated as result of reactor operations would also be irretrievable and disposed as radioactive waste.

The inventories, production volumes, or quantities of minerals sold or used in construction, as tabulated by the United States Geological Survey (USGS) for 2014 through 2020 are shown in Table 6.3-1. Aluminum supplies have dropped since 2014 from 2,470,000 metric tons to 1,725,000 metric tons in 2020 but remained reasonably stable from 2015 to 2020. The supply of most other minerals has remained reasonably stable since 2014 with only minor fluctuations in availability during 2014 to 2015. The reasonably stable supply of minerals suggests that they will continue to be available for the foreseeable future in response to demand.

While a given quantity of material consumed during new facility construction and operation at the site is irretrievable, the impact on their availability is SMALL.

6.3.9 References

1. NUREG-0586, “Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities,” Supplement 1, Volume 1, November 2002.

2. U.S. Geological Survey. Minerals Yearbook - Metals and Minerals. Website: https://www.usgs.gov/centers/nmic/minerals-yearbook-metals-and-minerals, accessed on October 13 and 14, 2021

Table 6.3-1. United States Inventories for Minerals Used in Construction

Minerals	Year						
	2014	2015	2016	2017	2018	2019	2020
	Inventory in 1000 Metric Tons by Year [b]						
Aluminum	2,470	1,857	1,762	1,724	1,756	1,720	1,725
Copper	190,000	209,000	223,000	265,000	244,000	-	-
Lead	56,400	60,100	60,300	64,400	66,500	-	-
Titanium [a]	200,000	300,000	100,000	100,000	100,000	100,000	-
Zinc	95,250	93,950	86,750	121,250	126,250	123,250	-
	Inventory in Million Metric Tons by Year						
Iron Ore	3,630	4,760	2,990	3,930	3,100	3,470	-
Cement and clinker	10,670	12,070	12,850	13,200	13,920	12,970	-
Construction Sand and Gravel [c]	829,000	880,000	885,000	888,000	912,000	-	-

[a] Titanium data is United States mineral concentrate production, not inventory.
[b] Reported stock of private companies and United States government stockpiles.
[c] Quantities sold or used, not inventory.
Source: (Reference 2)