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NUREG-2263

Environmental Impact Statement for the Construction Permit for the Kairos Hermes Test Reactor

Draft Report for Comment

Office of Nuclear Material Safety and Safeguards

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Manuscript Completed: September 2022
Date Published: September 2022

Office of Nuclear Material Safety and Safeguards

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Responsible Agency: U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards

Title: *Environmental Impact Statement for the Construction Permit for the Kairos Hermes Test Reactor, Draft Report for Comment*

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ABSTRACT

The U.S Nuclear Regulatory Commission (NRC) has prepared this draft environmental impact statement (EIS) in response to an application submitted by Kairos Power, LLC (Kairos) for a construction permit (CP) for a non-power test reactor termed Hermes at a site in Oak Ridge, Tennessee. Kairos plans to build and operate Hermes to demonstrate key elements of the Kairos Power Fluoride Salt-Cooled, High Temperature Reactor technology for possible future commercial deployment. This draft EIS includes the analysis that evaluates the environmental impacts of the proposed action and considers the following two alternatives to the proposed action: (1) the no-action alternative (i.e., the CP is denied) and (2) building the proposed Hermes non-power test reactor at a site near Idaho Falls, Idaho.

After weighing the environmental, economic, technical, and other benefits against environmental and other costs, and considering reasonable alternatives, the NRC staff recommends, unless safety issues mandate otherwise, that the NRC issue the CP to Kairos. The NRC staff based its recommendation on the following factors:

- the NRC staff's review of Kairos' environmental report (included as part of the CP application) and associated responses from Kairos to requests from the NRC staff for clarifying information;
- the NRC staff's review of comments received as part of the scoping process;
- the NRC staff's communications with, and scoping comments received from, Federal, State, and local agencies, as well as Tribal officials; and
- the NRC staff's independent environmental review.

The NRC's staff's recommendation in this draft EIS is tentative. Before identifying a final recommendation in the final EIS, the NRC staff will also consider comments received on the draft EIS from Federal, State, local, and Tribal officials, and members of the public.

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EXECUTIVE SUMMARY

BACKGROUND

By letter dated September 29, 2021, Kairos Power, LLC (Kairos) submitted an application to the U.S. Nuclear Regulatory Commission (NRC) for a construction permit (CP) pursuant to Title 10 of the *Code of Federal Regulations* Part 50 (10 CFR Part 50, TN249) that would allow construction of a non-power test reactor termed Hermes on a 185-ac site in Oak Ridge, Tennessee (Kairos 2021-TN7879). The Atomic Energy Act of 1954 (42 U.S.C. 2011 *et seq*. TN663) authorizes the NRC to issue CPs for nuclear testing facilities. To issue a CP, the NRC is required to consider the environmental impacts of the proposed action under the National Environmental Policy Act of 1969 (42 U.S.C. 4321 *et seq*., herein referred to as NEPA, TN661). The NRC's environmental protection regulations that implement NEPA in 10 CFR Part 51 (TN250) describe several types of actions that require an environmental impact statement (EIS). Issuing a CP for a nuclear testing facility is identified in 10 CFR 51.20 (TN250) as one type of action that requires an EIS.

Upon acceptance of the application, the NRC staff began the environmental review process described in 10 CFR Part 51 (TN250) by publishing a Notice of Intent in the *Federal Register* (87 FR 9394-TN7885) to prepare an EIS and to conduct scoping activities. In preparation of this draft EIS, the NRC staff performed the following:

- conducted a virtual public outreach and EIS scoping meeting on March 23, 2022;
- conducted a virtual site audit in March 2022 addressing proposed and alternative sites;
- reviewed Kairos's environmental report submitted as part of the application;
- contacted Federal, State, and local agencies, as well as Tribal officials;
- conducted a review using guidance in Final Interim Staff Guidance Augmenting NUREG-1537, Part 1, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Format and Content," for Licensing Radioisotope Production Facilities and Aqueous Homogeneous Reactors; and Part 2, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Standard Review Plan and Acceptance Criteria"; and
- considered public comments received during the EIS scoping process.

PROPOSED ACTION

The proposed Federal action is for the NRC to decide whether to issue a CP to Kairos under 10 CFR Part 50 (TN249) that would allow construction of the Hermes non-power test reactor. If the NRC were to issue a CP, Kairos could build the proposed reactor on a 185-acre site in the Heritage Center Industrial Park of the East Tennessee Technology Park in the City of Oak Ridge, Tennessee. The East Tennessee Technology Park is an industrial park established by the City of Oak Ridge on land formerly owned by the U.S. Department of Energy (DOE). The site was formerly occupied by DOE Buildings K-31 and K-33, which were both part of the former Oak Ridge Gaseous Diffusion Plant. DOE ceased operation of the Oak Ridge Gaseous Diffusion Plant in 1986. Both DOE buildings were since razed, and DOE has remediated the land environmentally and released it for industrial reuse.

Issuance of a CP is a separate licensing action from issuance of an operating license (OL), which allows operation of facilities built pursuant to a CP. If the NRC issues a CP, then Kairos would still have to obtain an OL before being able to operate the Hermes reactor. To obtain an OL, Kairos would have to submit a separate application pursuant to NRC requirements and receive the license before operating the reactor. To conduct a complete and effective environmental review, this EIS addresses the potential environmental impacts from the full life cycle of the Hermes reactor, including its construction, operation, and decommissioning. If, however, Kairos were to apply for an OL, the NRC staff would still have to prepare a supplement to this EIS in accordance with 10 CFR 51.95(b) (TN250).

PURPOSE AND NEED FOR ACTION

The purpose and need of this proposed Federal action is to allow Kairos to build and operate a non-power test reactor to demonstrate key elements of the Kairos Power Fluoride Salt-Cooled, High Temperature Reactor technology for possible future commercial deployment. Operation of the Hermes reactor would not generate any power for sale or distribution. The technology 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. The Hermes reactor would support Kairos' reactor development program, which relies on learning and risk reduction by narrowing the design space through progressive test cycles. Construction and operation of the Hermes reactor would also provide validation and qualification data to support potential future commercial reactors using the Kairos Power Fluoride Salt-Cooled, High Temperature Reactor technology.

The determination of need and the decision to build a test reactor such as Hermes are at the discretion of applicants such as Kairos. This definition of purpose and need reflects the NRC's recognition that, unless there are findings in the safety review required by the Atomic Energy Act of 1954 (TN663), as amended, or findings in the environmental analysis under NEPA that would lead the NRC to reject a CP application, the agency does not have a role in the planning decisions as to whether a particular test reactor should be constructed and operated.

ENVIRONMENTAL IMPACTS OF CONSTRUCTION, OPERATIONS, AND DECOMMISSIONING

The EIS evaluates the potential environmental impacts of the proposed action. The environmental impacts from the proposed action are designated as SMALL, MODERATE, and LARGE, as presented in the final interim staff guidance to NUREG-1537:

SMALL: Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource. In assessing radiological impacts, the NRC has concluded that those impacts that do not exceed permissible levels in the agency's regulations are considered SMALL.

MODERATE: Environmental effects are sufficient to alter noticeably, but not to destabilize, important attributes of the resource.

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

Table ES-1 summarizes the NRC's staff's findings on the level of direct, indirect, and cumulative impacts on environmental resources from the construction, operation, and decommissioning of the proposed Hermes project.

ALTERNATIVES

The NRC staff considered the environmental impacts associated with the following alternatives to constructing the Hermes non-power test reactor project at the proposed site in Oak Ridge:

- the no-action alternative; and
- construction, operation, and decommissioning of the Hermes non-power test reactor at an alternative site, termed the Eagle Rock alternative site, near Idaho Falls, Idaho.

The NRC staff considered possible alternative sites, alternative layouts of proposed facilities within a site, modification of existing facilities instead of building new facilities, alternative technologies, and alternative transportation methods. The NRC staff determined that there were no other reasonable alternatives that warranted detailed consideration in the EIS.

The NRC staff evaluated each alternative using the same resource areas that were used in evaluating impacts from the proposed action. The NRC staff determined that the no-action alternative would result in SMALL impacts to all resource areas. However, the no-action alternative does not fulfill the action's purpose and need. The NRC staff determined that construction, operation, and decommissioning of the Hermes non-power test reactor project at the Eagle Rock alternative site would result in only SMALL impacts for most affected resources, but that it would result in MODERATE impacts to land use and visual resources, ecological resources, and historic and cultural resources. The proposed action, which would also meet the purpose and need but result in only SMALL environmental impacts to all affected resources, would therefore be the environmentally preferrable action. The proposed site in Oak Ridge allows for siting the Hermes non-power test reactor project while disturbing only previously disturbed soils with a history of past industrial development, while avoiding natural vegetation, wetlands, surface water features, agricultural land, and shallow subsurface cultural resources.

RECOMMENDATION

After weighing the environmental, economic, technical, and other benefits against environmental and other costs, and considering reasonable alternatives, the NRC staff recommends, unless safety issues mandate otherwise, that the NRC issue the CP to Kairos. The NRC staff based its recommendation on the following factors:

- the NRC staff's review of Kairos' environmental report (included as part of the CP application) and associated responses from Kairos to requests from the NRC staff for clarifying information;
- the NRC staff's review of comments received as part of the scoping process;
- the NRC staff's communications with, and scoping comments received from, Federal, State, and local agencies, as well as Tribal officials; and
- the NRC staff's independent environmental review.

The NRC's staff's recommendation in this draft EIS is tentative. Before identifying a final recommendation in the final EIS, the NRC staff will also consider comments received on the draft EIS from Federal, State, local, and Tribal officials, and members of the public.

Table ES-1 Summary of Environmental Impacts from Construction, Operation, and Decommissioning of Proposed Hermes Facilities

Resource Area	Summary of Impact	Impact Level
Land use and visual resources	Temporary disturbance of 138 ac of land previously occupied by industrial DOE buildings. Permanent occupation of 30 ac of the same land. Limited land use options for the entire 185-ac Hermes site, which would be designated as an exclusion area throughout operations. Site is within established industrial park. Setting is already industrial and of low scenic quality. Facilities would have an industrial appearance compatible with an existing industrial park. Hermes project is compatible with existing City of Oak Ridge zoning.	SMALL
Air quality and noise	Air emissions of criteria pollutants would be below 100 tons per year (TPY), and hazardous air pollutants would be below 10 TPY individually and 25 TPY combined. Emissions would comply with non-*Title V* permitting requirements. Standard control measures would be used to mitigate fugitive dust releases.	SMALL
Hydrogeology and water resources	No disturbance of geological features of economic or natural value. Disturbances limited to previously disturbed soils. Best management practices (BMPs) would be employed for soil erosion and sediment control. Water demands would be met through municipal or commercial suppliers. No use of groundwater and no direct use of surface water. No cooling towers, ponds, or reservoirs. Wastewater discharged for treatment to municipal wastewater treatment facilities. Limited, temporary dewatering of building excavations for construction. Dewatering water would be dispositioned in accordance with DOE requirements per the quit claim deed for the site. Stormwater would be managed using BMPs.	SMALL
Ecological resources	Ground disturbance would be limited to areas of previously disturbed soils that are unvegetated or support only ruderal early successional vegetation. No disturbances to forest cover or other natural vegetation growing on natural soils, wetlands, surface waters, shorelines, or riparian lands. No Section 404 permit required. BMPs to control stormwater runoff that might reach wetlands or aquatic habitats. Localized, minor increases in noise may affect wildlife, but area wildlife already experiences industrial noise. Limited potential for wildlife to collide with new structures or be injured by vehicles. The Federally endangered gray bat (*Myotis grisescens*) and Indiana bat (*M. sodalis*) and Federally threatened northern long-eared bat (*M. septentrionalis*) are known to occur in the Oak Ridge area and may forage transiently on the site, but no potential roosting or breeding habitat would be disturbed and foraging individuals can be expected to avoid areas of human activity.	SMALL

Resource Area	Summary of Impact	Impact Level
Historic and cultural resources	No effect to historic properties as none are located in direct effects area of potential effects. Ground disturbance limited to areas of extensive past soil disturbance with little potential for remaining archaeological resources. Kairos would also develop an Archaeological Monitoring and Discovery Plan establishing stop work and notification procedures to address unexpected discovery of human remains or archaeological material in compliance with deed requirements and Tennessee State law. The National Register of Historic Places eligible Manhattan Project National Historical Park is located in the indirect effects area of potential effects but will not be adversely affected, because the setting of the proposed Kairos project is in keeping with the current setting of the Manhattan Project National Historical Park.	SMALL
Socioeconomics and environmental justice (EJ)	Construction of Hermes would involve an average of 212 site workers per year over a two-year period, with an estimated peak of 425 workers. Staffing during the four-year operation would average 38 workers per weekday (68 full time positions). Decommissioning would involve an estimated peak employment level of 340 workers. These small numbers of workers would not substantially affect employment levels in the surrounding area, but the demand for some skilled labor might compete with other planned technology projects. The small size of the Hermes project and the distance of the site from the closest census blocks with populations meeting EJ criteria (over 8 mi away) indicate little potential for EJ effects.	SMALL
Human health	Site was formerly occupied by buildings part of the DOE Oak Ridge Gaseous Diffusion Plant used to enrich uranium, but DOE has already razed the buildings and remediated the site for unrestricted industrial reuse. DOE retains responsibility for remediation following any unanticipated discovery of legacy wastes. Based on information in the CP application, the NRC staff expects that radiological releases, doses to the public, and occupational doses would be less than the limits established for protection of human health and the environment in 10 CFR Part 20 (TN283). Applicant would implement normal safety practices contained in Occupational Safety and Health Administration regulations in 29 CFR Part 1910 (TN654) to protect occupational health. Emissions would comply with the Resource Conservation and Recovery Act (TN1281), Clean Air Act (TN1141), and other environmental regulations.	SMALL
Nonradiological waste management	Kairos would develop and implement a plan to manage wastes generated by the Hermes facilities. Management of solid waste, including construction and demolition waste, would involve waste reduction efforts, recycling, and BMPs. Liquid wastes would be discharged for municipal treatment at a wastewater treatment plant or trucked offsite for proper disposal. Gaseous emissions would comply with Tennessee Department of Environment and Conservation regulations.	SMALL

Resource Area	Summary of Impact	Impact Level
Uranium fuel cycle and radiological waste management	Low quantity of uranium used during the four-year operational period. TRISO fuel processes (including enrichment and fuel fabrication) are bounded by Table S-3, developed by NRC to protect human health and the environment. Environmental impacts from storage of spent TRISO fuel from Hermes is bounded by the analysis in the Continued Storage Generic EIS. Estimated volume of low-level radioactive waste (LLRW) is less than or comparable to that from a light water reactor, and the NRC staff determined that there is adequate capacity at LLRW disposal sites and that LLWR sites would accept the LLRW from Hermes. Onsite storage of spent TRISO fuel would have to meet the same regulatory requirements as currently licensed light water reactors.	SMALL
Transportation	Transportation of radioactive fuels and wastes to and from Hermes would be performed in compliance with U.S. Department of Transportation and NRC regulations and constitute only a small percentage of the total materials of these types shipped each year.	SMALL
Accidents	NRC staff is conducting an independent review of the consequences of accidents and will document it in its Safety Evaluation Report. To receive a CP, the Hermes test reactor would have to meet the NRC requirements for postulated accidents, where potential doses at the exclusion area boundary and in the low population zone are below the dose reference values of 10 CFR Part 100 (TN282) for test reactor siting. Additionally, as another indication of the low-level of environmental impacts, the nearest resident dose from accidents is also below the radiation dose limits for individual members of the public in 10 CFR 20.1301(a) (TN283).	SMALL
Climate change	Climate change is a global phenomenon that the construction, operation, and decommissioning of the proposed Hermes test reactor would not appreciably alter. None of the impact conclusions in this draft EIS for the Hermes facilities would change as a result of climate change.	SMALL

ABBREVIATIONS AND ACRONYMS

°F	degree(s) Fahrenheit
%	percent
ac	acre(s)
ARDP	Advanced Reactor Demonstration Program
AECOM	AECOM Technical Services, Inc.
ADAMS	Agencywide Document Access and Management Systems
ACS	American Community Survey
APE	Area of potential effects
Atlas facility	Kairos Atlas Fuel Fabrication Facility
dBA	A-weighted sound levels
BMP	best management practice
BA	biological assessment
C	pyrolytic carbon
CO_2	carbon dioxide
CO_2eq	carbon dioxide equivalent
CO_2eq/kWh	carbon equivalent per kilowatt hour
CFPP	Carbon Free Power Project
CO	carbon monoxide
CBG	Census Block Group
cm	centimeter(s)
CAA	Clean Air Act
CH_4	methane
CRN	Clinch River Nuclear
CFR	*Code of Federal Regulations*
CP	construction permit
CEQ	Council on Environmental Quality
ft^3	cubic foot
ft^3/yr	cubic foot per year
m^3	cubic meter(s)
cy or yd^3	cubic yard(s)
Ci/m^3	curie(s) per meter cubed
Ci/yr	curie(s) per year
DHRS	Decay Heat Removal System
dB	decibel(s)
DOE	U.S. Department of Energy
DBA	design basis accidents
EA	environmental assessment
EAB	exclusion area boundary
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ER	environmental report

ESA	Endangered Species Act
ETTP	East Tennessee Technology Park
FR	*Federal Register*
ft	foot/feet
FWS	U.S. Fish & Wildlife Service
gal	gallon(s)
gpd	gallon(s) per day
gpm	gallon(s) per minute
GWd/MTU	gigawatt-day(s) per metric ton of uranium
GWP	global warming potential
g	gram(s)
g/MT-km	gram per metric ton-kilometer
g/T-mi	gram per ton-mile
GCRP	U.S. Global Change Research Program
GHGs	greenhouse gases
HAP	hazardous air pollutant
Heritage Center	Heritage Center Industrial Park
HALEU	High-Assay Low Enriched Uranium
Horizon Center	Horizon Center Industrial Park
hr/yr	hour(s) per year
in	inch(s)
IpaC	Information for Planning and Consultation
ISFSI	Independent Spent Fuel Storage Installations
Kairos	Kairos Power, LLC
km	kilometer(s)
km/L	kilometer(s) per liter
Pb	lead
LOS	Level of Service
LR	License Renewal
LWR	Light water reactors
LPZ	Low Population Zone
LLRW	low-level radioactive waste
MEI	maximally exposed individual
MHA	maximum hypothetical accident
Mwe	megawatt(s) electric
MWt	megawatt(s) thermal
MWd/MT	megawatt(s)-day per metric ton
MWh	megawatt-hour
MOA	Memorandum of Agreement
m	meter(s)
MT	metric ton(s)
MT CO_2eq	metric ton(s) of carbon dioxide equivalent
MTU	metric ton(s) of uranium
MTU/yr	metric ton(s) of uranium per year

μCi/mL	micro-curie(s) per milliliter
μm	micrometer(s)
mi	mile(s)
mi/gal	mile(s) per gallon
mph	mile(s) per hour
mg	million gallon
mgd	million gallon(s) per day
mrem	millirem (s)
mrem/yr	millirem (s) per year
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act of 1969
NHPA	National Historic Preservation Act
NHP	National Historical Park
NIOSH	National Institute of Occupational Safety and Health
NPS	National Park Service
NPDES	National Pollutant Discharge Elimination System
NRHP	National Register of Historic Places
NO_2	nitrogen dioxide
NPP	nuclear power plant
NRC	U.S. Nuclear Regulatory Commission
O_3	ozone
ORGDP	Oak Ridge Gaseous Diffusion Plant
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
OL	operating license
OSHA	U.S. Occupational Safety and Health Administration
PM	particulate matter
PHSS	pebble handling and storage system
PCB	polychlorinated biphenyl
lb	pound(s)
lb/MWh	pound(s) per megawatt-hour
PSAR	preliminary safety analysis report
PSD	Prevention of Significant Deterioration
RRY	reference reactor-year
ROI	region of interest
SAFSTOR	SAFe STORage
SER	safety evaluation report
Sequoyah	Sequoyah Nuclear Plant
SiC	silicon carbide
mi^2	square miles
State Route	SR
scf	standard cubic feet
SWPP	Storm Water Pollution Prevention Plan
SO_2	sulfur dioxide

SF_6	sulfur hexafluoride
TDEC	Tennessee Department of Environment and Conservation
THC	Tennessee Historical Commission
TVA	Tennessee Valley Authority
TPY	ton(s) per year
TEDE	total effective dose equivalent
TRISO	TRI-structural ISOtropic
TMS	tritium management system
uranium-235	U-235
UC	uranium carbide
UC_2	uranium dicarbide
UO_2	uranium dioxide
UF_6	uranium hexafluoride
VP	Versa-Pac
VOC	volatile organic compounds
WCS	Waste Control Specialists, LLC
WWTP	Wastewater Treatment Plant
Watts Bar	Watts Bar Nuclear Plant

1.0 INTRODUCTION

By letter dated September 29, 2021, Kairos Power, LLC (Kairos) submitted Part 1 of a two-part application to the U.S. Nuclear Regulatory Commission (NRC) for a construction permit (CP) pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50 (TN249), that would allow construction of a non-power test reactor termed Hermes on a 185 acre (ac) site located in Oak Ridge, Tennessee (Kairos 2021-TN7879). Section 104 of the Atomic Energy Act of 1954, as amended, (42 U.S.C. 2011 *et seq*. TN663) and its implementing regulations authorize the NRC to issue CPs for testing facilities. To issue a CP, the NRC is required to consider the environmental impacts of the proposed action under the National Environmental Policy Act of 1969 (NEPA; 42 U.S.C. 4321 *et seq*. TN661, herein referred to as NEPA). The NRC's environmental protection regulations that implement NEPA in 10 CFR Part 51 (TN250) describe several types of actions that would require an environmental impact statement (EIS). CPs and operating licenses (OLs) for test facilities are identified in 10 CFR 51.20 (TN250) as actions that require an EIS.

Applicants for NRC licenses are required under 10 CFR 51.45 (TN250) to submit an ER containing a description of the proposed project, a statement of its purposes, a description of the affected environment, and specific information needed for by the NRC staff to evaluate the potential environmental impacts. After initially submitting Part 1 of the Kairos Hermes application (consisting of its preliminary safety analysis report [PSAR]), on October 31, 2021, Kairos submitted an environmental report (ER) with information needed to assess potential environmental impacts from the CP licensing action (Kairos 2021-TN7880). By letters dated February 10, February 18, and March 1, 2022, Kairos provided supplemental information regarding its CP application, including the ER (Kairos 2022-TN7881, Kairos 2022-TN7882, Kairos 2022-TN7883). References to the Kairos ER in this draft EIS include these revisions.

The NRC staff also made frequent use of the final EIS recently completed as part of the environmental review for an application submitted by the Tennessee Valley Authority for an early site permit for a small modular reactor project (the Clinch River Nuclear [CRN] project) on a site also located within the City of Oak Ridge, situated approximately 2 miles (mi) south of where Hermes would be built (NRC 2019-TN6136). The CRN and Hermes projects are separate and unrelated actions, but because of the proximity of the CRN site to the Hermes site and the recency of the CRN EIS, the staff determined that the CRN EIS contains useful information about the environmental resources in the Oak Ridge region. The CRN project is also considered among the other projects proposed in the Oak Ridge region that might contribute to the cumulative impacts of the Hermes project on environmental resources in the region. Cumulative impacts are addressed in Section 3.0 of this draft EIS in separate sections addressing each environmental resource considered.

1.1 The Proposed Federal Action

The proposed action is for the NRC to issue a CP to Kairos authorizing construction of the Hermes reactor. The site is situated in the Heritage Center Industrial Park of the East Tennessee Technology Park, an industrial park established by the City of Oak Ridge, on land formerly owned by the U.S. Department of Energy (DOE) for the Oak Ridge Gaseous Diffusion Plant (ORGDP). The site was formerly occupied by DOE Buildings K-31 and K-33, which were both part of the ORGDP (Figure 1-1). DOE ceased operation of the ORGDP in 1986. Both DOE buildings were since razed, and the land has been environmentally remediated and released for industrial reuse.

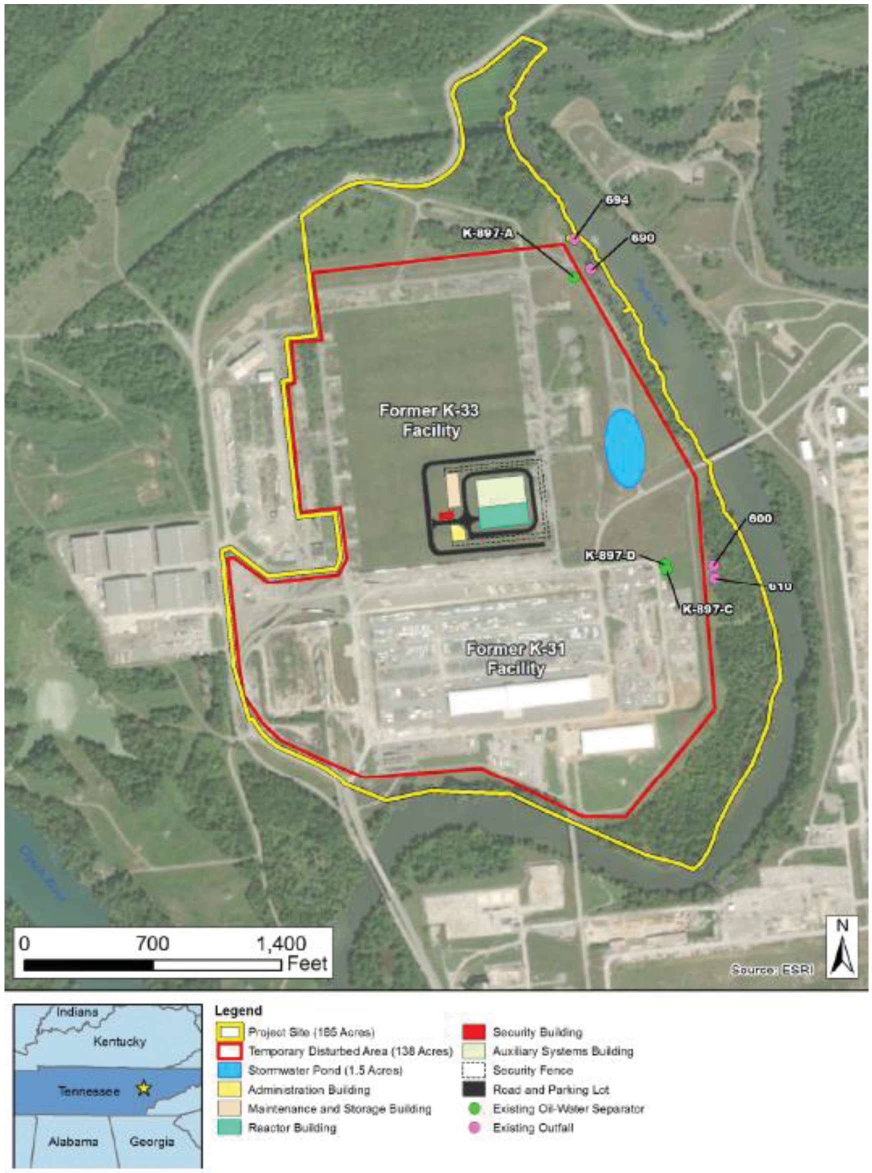

Figure 1-1 Hermes Reactor Site. Source: Kairos 2021-TN7880.

This draft EIS constitutes the NRC staff's review of potential environmental impacts from the proposed action of issuing a CP, as required under 10 CFR 51.70 *et seq*. (TN250). Section 2.0 provides more information about the proposed Hermes project. The issuance of a CP is a separate licensing action from the issuance of an OL. If the NRC issues a CP and Kairos were to seek NRC approval to operate the reactor, then Kairos would have to submit a separate application for an OL pursuant to the NRC's requirements and Kairos would have to obtain NRC approval before it can operate the Hermes testing facility. To conduct a complete environmental review, this draft EIS covers the potential impacts from the construction, operation, and decommissioning life-cycle phases of the Hermes project. The NRC staff recognizes that new and significant information regarding operation and decommissioning may become available subsequent to issuance of the CP. The NRC staff would therefore review any application for an OL for the Hermes project for new and significant information that might alter the staff's conclusions made for this CP application. If Kairos were to apply for an OL, the NRC staff would prepare a supplement to this EIS in accordance with 10 CFR 51.95(b) (TN250).

1.2 Purpose and Need

Kairos proposes to build and operate the Hermes project to demonstrate key elements of the Kairos Power Fluoride Salt-Cooled, High Temperature Reactor (KP-FHR) technology for possible future commercial deployment (Kairos 2021-TN7880 │ Sec 1.3). Operation of the Hermes reactor would not generate any power for sale or distribution. The technology 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. The Hermes reactor would support Kairos' reactor development program, which relies on learning and risk reduction by narrowing the design space through progressive test cycles (Kairos 2021-TN7880 │ Sec 1.3). Kairos states that construction and operation of Hermes would also provide validation and qualification data to support potential future commercial reactors using the KP-FHR technology (Kairos 2021-TN7880 │ Sec 1.3).

Kairos participates in DOE's Advanced Reactor Demonstration Program (ARDP), which assists private industries in the United States in demonstrating advanced nuclear reactors, with the goal of designing and developing safe and affordable reactor technologies that can be licensed and deployed over the next 10 to 14 years. Kairos states that the need for the project is tied to DOE's objectives under the ARDP (Kairos 2021-TN7880 │ Sec 1.3).

1.3 The NRC Application Review

The NRC process to review applications for CPs consists of two separate, parallel reviews. The safety review evaluates the applicant's ability to meet the NRC regulatory safety requirements. The NRC staff documents the findings of the safety review in a Safety Evaluation Report. The environmental review, governed by NEPA and the requirements in 10 CFR Part 51 (TN250), evaluates the environmental impacts of, and alternatives to, the proposed action. This draft EIS presents the results of this evaluation. The NRC considers the findings in both the EIS and the Safety Evaluation Report in its decision to grant or deny the issuance of a CP.

To guide its assessment of environmental impacts, the NRC staff uses three levels of significance for potential impacts: SMALL, MODERATE, and LARGE, as defined below:

- **SMALL** – Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource.
- **MODERATE** – Environmental effects are sufficient to alter noticeably, but not to destabilize, important attributes of the resource.
- **LARGE** – Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

To conduct its environmental review, the NRC staff used guidance contained in the Final Interim Staff Guidance Augmenting NUREG–1537, Part 1, *Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Format and Content, for Licensing Radioisotope Production Facilities and Aqueous Homogeneous Reactors;* (NRC 2012-TN5527) and Part 2, *Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Standard Review Plan and Acceptance Criteria," for Licensing Radioisotope Production Facilities and Aqueous Homogeneous Reactors* (NRC 2012-TN5528). Because the

Hermes project is a non-power reactor, the NRC staff considered the guidance developed to accompany NUREG-1537 to be the best available NRC guidance most applicable to licensing a test reactor project such as Hermes. As both volumes of the Final Interim Staff Guidance note, use of the guidance is not mandatory and does not substitute for compliance with NRC regulations. The NRC staff therefore ensured that its environmental review, as documented in this draft EIS, met the applicable regulations in 10 CFR Part 51 (TN250) and used the guidance associated with NUREG-1537 only as supplementary direction.

In October 2021, Kairos submitted its ER (Kairos 2021-TN7880) as Part 2 of its two-part CP application submittal, as discussed above. On November 29, 2021, the NRC notified Kairos of its decision that the application (including the ER) was sufficient to conduct its detailed review (NRC 2021-TN7893). The NRC staff published a Notice of Acceptance for Docketing in the *Federal Register* on December 1, 2021 (86 FR 68290-TN7884) and a separate *Federal Register* Notice of Intent to prepare an EIS and conduct a scoping process on February 18, 2022 (87 FR 9394-TN7885). Issuance of the scoping notice initiated the 60-day scoping period.

On March 23, 2022, the NRC held a virtual joint public outreach and scoping meeting. The NRC staff also contacted Federal, State, Tribal, regional, and local agencies to solicit comments. Correspondence between the NRC and Federal, State, Tribal, regional, and local agencies is included in Appendix C of this draft EIS. The NRC's report entitled, *Environmental Impact Statement Scoping Process Summary Report for the Kairos Hermes Construction Permit Application*, presents the comments received during the scoping process (NRC 2022-TN7953).

In March 2022, the NRC staff conducted a virtual audit to verify information in the Kairos ER. During the audit, the NRC staff reviewed specific documentation and discussed specific information needs with Kairos staff and their contractors. The information needs and the pertinent points from that audit are documented in the staff's audit summary report (NRC 2022-TN7954).

This draft EIS presents the NRC staff's analysis that considers and weighs the environmental impacts of the Hermes project at the proposed site, including the environmental impacts associated with the construction, operation, and decommissioning of the proposed facilities; the impacts of constructing, operating, and decommissioning the same facilities at an alternative site; the no-action alternative; and mitigation measures available for reducing or avoiding adverse environmental effects. It also provides the NRC staff's preliminary recommendation to the Commission regarding the issuance of the CP for the proposed Kairos Hermes facility at the site in Oak Ridge, Tennessee.

1.4 Regulatory Provisions, Permits, and Required Consultations

The applicant has identified each environmental regulatory requirement, permit, and consultation necessary for construction of the proposed Hermes project in Tables 1.4-1 and 1.4-2 of the ER (Kairos 2021-TN7880 | Sec 1-4). The applicant bears the responsibility for applying for each of the permits listed in Table 1.4-1 of the ER. The NRC staff bear the responsibility for performing each of the consultations listed in Table 1.4-2 of the ER required under the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq*. TN1010) and National Historic Preservation Act of 1966, as amended (54 U.S.C. 300101 *et seq*. TN4157).

1.5 Preconstruction Activities

In a final rule dated October 9, 2007 (72 FR 57416-TN260), the Commission established the definition of “construction” in 10 CFR 51.4 (TN250) as those activities that fall within its regulatory authority. Many of the activities required to build a test reactor are not part of the NRC action to license the Hermes facility because they do not have a reasonable nexus with radiological health and safety and/or common defense and security; therefore, they are not within the NRC’s authority to regulate. Activities associated with building the proposed facility that are not within the purview of the NRC action are grouped under the term “preconstruction.” Under 10 CFR 51.45 (TN250), applicants are required to include in an ER a description of the impacts of the applicant’s preconstruction activities.

Preconstruction activities include clearing and grading, excavating, building of service facilities (e.g., paved roads, parking lots), erection of support buildings, and other associated activities. These preconstruction activities may take place before the application for a CP is submitted, during the staff’s review of a CP application, or after a CP is granted. Consequently, the NRC evaluates preconstruction impacts as cumulative impacts and not as direct impacts resulting from the NRC’s Federal action. Although preconstruction activities are outside the NRC’s regulatory authority, many are within the regulatory authority of local, State, or other Federal agencies.

The applicant could choose to perform preconstruction work before receipt of the requested CP, or even if the NRC never issues the CP. However, because the preconstruction is a precursor to NRC-authorized construction of the proposed Kairos Hermes test reactor, and because discussion of pre-construction and construction impacts together enhances the readability of the document, Section 3.0 of this draft EIS presents a single combined discussion of preconstruction and construction impacts for each resource. Because the conclusions determined by the staff in this EIS for all combined preconstruction and NRC-authorized construction activity impact category levels are SMALL for all resource areas (e.g., land use, water resources), no further breakdown of impacts between preconstruction and NRC-authorized construction is provided.

1.6 Report Contents

The sections of this EIS are organized as follows: Section 1.0 is this introduction. Section 2.0 provides a description of the proposed Hermes project summarizing key elements of the design needed by the staff to evaluate potential environmental impacts. Most of the information in Section 2.0 is drawn from the applicant’s description of their project in the ER, PSAR, and other parts of the application. Section 3.0 describes the affected environment for each of the 12 environmental resources identified by the NRC staff through its scoping process, followed by the staff’s evaluation of potential environmental impacts on each resource. The staff independently verified and summarized the affected environment descriptions from the ER and other public documents, relying on incorporation by reference to the extent possible to simplify the EIS. The staff developed their evaluations of environmental impacts independently from the applicant, but the staff relied in part on impact data presented by the applicant after independent verification. Section 4.0 of this draft EIS presents the staff’s evaluation of a range of reasonable alternatives to the proposed action. Section 5.0 summarizes the staff’s conclusions and recommendation to the NRC Commission based on the environmental review.

The appendices to this draft EIS contain the following additional information:

Appendix A – Contributors to the Environmental Impact Statement

Appendix B – Agencies, Organizations, and Individuals Contacted

Appendix C – Chronology of Key Environmental Review Correspondence

Appendix D – Regulatory Compliance and List of Federal, State, and Local Permits and Approvals

Appendix E – Greenhouse Gas Emissions

Appendix F – Viewshed Photographs at Nearby Historic and Cultural Resources.

2.0 PROPOSED PROJECT

The proposed Federal action is for the U.S. Nuclear Regulatory Commission (NRC) to issue a construction permit (CP) to Kairos Power, LLC (Kairos) under Title 10 of the *Code of Federal Regulations* Part 50 (TN249) to construct the proposed Kairos Hermes non-power demonstration reactor in Oak Ridge, Tennessee. After receipt of a CP from the NRC, the applicant is required to apply for a separate operating license (OL) under 10 CFR Part 50 (TN249) before reactor operation and prior to initiating decommissioning activities. The NRC would perform separate environmental reviews for the OL application and for subsequent licensing actions, such as OL renewal and decommissioning. The information presented below summarizes key characteristics of the Hermes project that the NRC staff considered when assessing the environmental impacts of the proposed action. The summaries focus on construction of the proposed facilities but also include general information about operation and decommissioning of the facilities to the extent currently known. Any new and significant information not addressed in the environmental review for the CP would be addressed as necessary in any subsequent environmental reviews for an OL application or for decommissioning.

2.1 Project Overview

The Hermes project would test and demonstrate key technologies, design features, and safety functions of the Kairos Power Fluoride Salt-Cooled, High Temperature Reactor (KP-FHR) technology; and it would provide data that may be used for validation of safety analysis tools and computational methodologies used for designing and licensing future reactors using the technology (Kairos 2021-TN7880 | Sec 2.1). Kairos plans to begin construction as early as April 2023 (Kairos 2021-TN7880 | Sec 2.1) with an operational life of 4 years (Kairos 2022-TN7881). The NRC staff recognizes that the applicant's estimated dates for construction, operation, and decommissioning are approximate and that the actual dates might differ. Information related to land disturbance, onsite workers, and material usage is provided in Chapter 2 of the environmental report (ER) and summarized in the sections below.

The proposed Kairos Hermes non-power demonstration reactor would demonstrate an advanced nuclear reactor technology that leverages TRI-structural ISOtropic (TRISO) particle fuel in pebble form with a low-pressure fluoride salt coolant (Kairos 2021-TN7880 | Sec 1.3). The proposed facilities would house one Hermes reactor, as described in Section 2.3 of the ER, as supplemented (Kairos 2021-TN7880, Kairos 2022-TN7881, Kairos 2022-TN7882, and Kairos 2022-TN7883). A process flow diagram for the Hermes reactor is presented in Figure 2.3-1 of the ER, as supplemented (Kairos 2021-TN7880, Kairos 2022-TN7881, Kairos 2022-TN7882, and Kairos 2022-TN7883). The core configuration would consist of a pebble bed core, graphite moderator/reflector, and a lithium tetrafluoroberyllate (Li_2BeF_4, Flibe) molten salt coolant (Kairos 2021-TN7880 | Sec 2.3). Flibe has several important properties for use in a nuclear reactor, such as neutronic factors and stability at high temperatures. Additional information about Flibe is provided in Chapter 2 of the Kairos Topical Report Reactor Coolant for the Kairos Power Fluoride Salt-Cooled High Temperature Reactor", KP-TR-005-NP (Kairos 2020-TN7988 | Sec 2.1). The facilities would contain one unit with a maximum thermal power of 35 megawatts (MW) (Kairos 2021-TN7880 | Sec 2.3). Because Hermes would be a research and demonstration reactor, the heat generated would not be used to generate electric power. Instead, the heat would be transported out of the core by a primary heat transport system and dissipated to the atmosphere by a heat rejection radiator (Kairos 2022-TN7882). The reactor core would be fueled using graphite pebbles with a diameter of 4 centimeter (cm) with embedded coated TRISO particle fuel (Kairos 2021-TN7880 │ Sec 2.3). The particles would comprise a uranium fuel kernel and three layers of carbon and ceramic-based materials that prevent the release of radioactive fission products (Kairos 2021-TN7880 │ Sec 2.3). The maximum enrichment of the uranium would be up to 19.55 wt% (Kairos 2021-TN7880 │ Sec 2.3).

2.2 Site Location and Layout

The applicant describes the site location and layout in Section 2.2 of the ER (Kairos 2021-TN7880). Kairos is proposing the new facilities to be built at a 185 ac site in the East Tennessee Technology Park. As depicted in Figure 2.2-1 of the ER (Kairos 2021-TN7880), construction would involve approximately 135 acres (ac) of land on the site that had previously been occupied by Buildings K-31 and K-33, which were formerly part of the U.S. Department of Energy (DOE) Oak Ridge Gaseous Diffusion Plant complex on the Oak Ridge Reservation (ORR). The new facilities would occupy approximately 30 ac within the former footprint of the K-33 facility. Figure 2.2-3 of the ER (Kairos 2021-TN7880) depicts the proposed layout of the new facilities, which would include a reactor building, auxiliary systems building, maintenance and storage building, administration building, security building, security fence, and roads and parking lots. Use of the site would take advantage of existing roads and other utilities within the Heritage Center Industrial Park of the East Tennessee Technology Park, and no land outside of the indicated 135 ac would be disturbed to build, operate, or decommission the new facilities. The only new roads and parking lots that would need to be constructed would be built within the 30 ac tract to directly service the new buildings. The Hermes project would not involve building or operating transmission lines, switchyards, intake or discharge structures or pipelines, access roads, heavy haul roads, rail lines or spurs, barge facilities, heavy haul roads, batch plants, or other offsite facilities.

2.3 Site Workers and Vehicular Deliveries

The applicant estimates the numbers of site workers and vehicular deliveries in Section 2.1 of the ER (Kairos 2021-TN7880). The applicant estimates that construction would require an estimated average of 212 onsite workers, with 425 at peak times, and would involve a monthly average of 213 truck deliveries and four-offsite shipments of construction debris. Operation is estimated to involve an average of 38 workers per weekday (68 full-time positions), with an estimated monthly average of 15 truck deliveries and four-offsite waste shipments. The applicant estimates that decommissioning would require an average of 170 workers (340 workers at peak times) and a monthly average of four-truck deliveries and 170 offsite waste shipments (Kairos 2021-TN7880 │ Sec 2.1).

2.4 Equipment and Material Usage

The applicant provides estimates of anticipated equipment and material use by the project in Section 2.1 of the ER, as supplemented (Kairos 2021-TN7880, Kairos 2022-TN7882). Table 2.1-1 in the ER (Kairos 2021-TN78800) provides the applicant's estimates of material such as concrete and steel that would be consumed during construction. Table 2.1-2 in the ER (Kairos 2021-TN7880) presents a list of equipment that the applicant proposes to use during the construction and decommissioning phases. The applicant also provides estimates of anticipated shipments of coolants and other process chemicals, diesel fuel for the standby diesel generator, and other materials. Hazardous materials stored onsite during operation include Flibe, lubricating oil, and cleaning materials and consumables used for cleaning and maintenance. As much as 21,555 gallons (gal) of diesel fuel for the standby diesel generator would be stored in an onsite storage tank.

2.5 Water Consumption and Treatment

A detailed description of how the applicant would obtain, use, and discharge water is provided in Section 2.4 of the ER (Kairos 2021-TN7880). The applicant's proposed water balance diagram for the new facilities is depicted in Figure 2.4-1 of the ER (Kairos 2021-TN7880). Water demands during construction, operation, and decommissioning of the proposed facilities would be met using municipal sources or truck deliveries; and wastewater generated by the operation of the proposed facilities would be discharged into municipal sewers that service the East Tennessee Technology Park. The project would not involve the use of any raw surface water or groundwater and, therefore, would not involve building or operation of intake or discharge pipelines. The project would not involve any reservoirs, evaporation ponds, leach fields, or similar facilities. Temporary dewatering of the reactor excavation pit during construction may be necessary but would be managed in accordance with DOE, U.S. Environmental Protection Agency, and Tennessee Department of Environment and Conservation requirements and in conformance with deed restrictions (Kairos 2021-TN7880 | Sec 4.4.1.1.1). As shown in the water balance diagram in Figure 2.4-1 of the ER, the operational demand for offsite water sources would include 50 gallons per minute (gpm) of municipal water plus 12 truck shipments of 4,000 gal each of demineralized water per month, and the offsite discharges would include 16 gpm from the bathrooms and 1 gpm from the decay heat removal system (DHRS). This municipal supply water would be used for potable water and sanitation, the fire protection system, decay heat removal, systems cooling components and spent fuel, and other operational demands.

2.6 Cooling and Heat Removal Systems

The proposed cooling and heating systems are described in Section 2.5 of the ER, as supplemented (Kairos 2021-TN7880, Kairos 2022-TN7882). As noted in Section 2.5.1 of the ER, there would be no cooling water system. For this reason, there would be no need for cooling towers or for intake or discharge structures or piping to support cooling towers. The heat load from the reactor would be transferred through a heat rejection system directly to the surrounding atmosphere, which would be the ultimate heat sink. The design also contains a DHRS, as described in Section 2.5.2 of the ER with diagrammatic representation in ER Figure 2.5-1 (Kairos 2021-TN7880). If the heat rejection system were unavailable when residual heat removal is required, the DHRS would be used instead (Kairos 2022-TN7882). The applicant expects to build the heat rejection radiator stack in the auxiliary systems building just north of the reactor building (see Figure 2.2-3 of the ER for the estimated positions of these buildings on the site) (Kairos 2022-TN7882).

2.7 Waste Systems

Wastes generated during construction, operation, and decommissioning would include radioactive, nonradioactive, and hazardous wastes (Kairos 2021-TN7880 | Sec 2.6). The applicant indicates that all waste disposal would occur in permitted nonradioactive, nonhazardous, and hazardous waste facilities and licensed radioactive disposal facilities (Kairos 2021-TN7880 | Sec 2.6). The proposed radioactive liquid, solid, and gaseous waste systems are described in Section 2.6.1 of the ER, as supplemented (Kairos 2021-TN7880, Kairos 2022-TN7882). Included in the ER are descriptions of the tritium management system and fuel pebble handling and storage system. Figure 2.6-1 of the ER depicts the approximate distribution of tritium throughout the reactor system (Kairos 2021-TN7880).

The estimated types, quantities, and number of shipments of radioactive wastes are listed in Table 2.6-1 of the ER, as supplemented (Kairos 2021-TN7880, Kairos 2022-TN7882), and include inert gas system capture materials, reactor cell capture materials, Flibe, dry active waste, liquid waste, and spent fuel. The table also identifies possible destinations for each category of waste. The proposed nonradioactive and hazardous waste systems are described in Section 2.6.1 of the ER (Kairos 2021-TN7880). Direct radiation sources are described in Section 2.6.3.1 of the ER and would all be within the reactor building (Kairos 2021-TN7880). The applicant notes that ongoing operation of ORR facilities and of the existing Tennessee Valley Authority Watts Bar Nuclear Facility would also contribute to the radiation dose received by the public near the new facilities (Kairos 2021-TN7880 │ ER Sec 2.6.3). The applicant's proposed pollution prevention and waste minimization program is described in Section 2.6.4 of the ER (Kairos 2021-TN7880).

2.8 Storage, Treatment, and Transportation of Radioactive and Nonradioactive Materials

The applicant describes the proposed storage, treatment, and transportation of radioactive and nonradioactive materials in Section 2.7 of the ER, as supplemented (Kairos 2021-TN7880, Kairos 2022-TN7881). Used, or spent, TRISO fuel pebbles would be stored in canisters, each holding up to 2,100 pebbles, in the reactor building; first in an onsite water-cooled storage pool for an initial cooling period and then transferred to a larger onsite air-cooled storage cavity with a storage capacity of 192 canisters, sufficient for the anticipated period of operation (Kairos 2021-TN7880 │ Sec 2.7.1). If necessary, Kairos could store the spent TRISO fuel canisters in dry storage casks at an exterior location on the site after the cessation of operation (Kairos 2021-TN7880 │ Sec 2.7.1). Spent fuel would eventually be transported by truck or rail to a final spent fuel repository or a regional spent fuel storage facility (Kairos 2021-TN7880 │ Sec 2.7.1). Handling of low-level radioactive waste and nonradioactive materials is described in Sections 2.7.2 and 2.7.3, respectively, of the ER (Kairos 2021-TN7880).

3.0 AFFECTED ENVIRONMENT AND ENVIRONMENTAL IMPACTS

This section presents the affected environment and potential environmental impacts from the proposed action to issue a construction permit (CP) for the Kairos Power, LLC (Kairos) Hermes facilities. The section is organized into separate sections addressing specific environmental resources identified by the U.S. Nuclear Regulatory Commission (NRC) staff's scoping process as being relevant to the proposed action. Each section is organized into subsections addressing the affected environment for the resource; potential direct and indirect impacts on the resource from each of three life-cycle phases for the Hermes facilities (construction, operation, and decommissioning); and cumulative impacts from the facilities. Each section culminates in a final subsection presenting the NRC staff's conclusions regarding the significance of the environmental impacts. Certain sections addressing two substantially independent though interrelated environmental resources, e.g., air quality and noise, are divided into two subsections organized as indicated above and lead to separate conclusions. The range of possible conclusions used by the NRC staff in assessing the significance of impacts on environmental resources is presented in Section 1.0 of this environmental impact statement (EIS).

To present a complete environmental review, this draft EIS covers the potential impacts from the construction, operation, and decommissioning life-cycle phases of the Hermes project. The NRC staff recognizes that new and significant information regarding the operation and decommissioning may become available after issuance of the CP. The NRC staff would therefore review any application for an operating license (OL) for the Hermes project for new and significant information that might alter the staff's conclusions made for this CP application. If Kairos were to apply for an OL, the NRC staff would prepare a supplement to this EIS in accordance with Title 10 of the *Code of Federal Regulations* 10 CFR 51.95(b) (TN250).

The order of presentation of environmental resources follows that used in Section 19.4 of the Final Interim Staff Guidance Augmenting NUREG-1537 (NRC 2012-TN5527), with the following exceptions. First, the NRC staff considered it more efficient to combine the sections about geological environment and water resources into a single Hydrogeology and Water Resources section (Section 3.3). Although the staff presents separate analyses and conclusions regarding impacts on the geological environment and on water resources, the combined subsection emphasizes their interrelationship. Second, the staff presented the environmental justice (EJ) analysis as part of the socioeconomic analysis in Section 3.6. The staff considered it simpler to present the EJ analysis with the supporting socioeconomic information rather than forcing readers to toggle between separate sections to gain an understanding. Third, the staff developed two separate sections addressing nonradiological and radiological waste management, but not nonradiological waste. The staff termed the latter "Uranium Fuel Cycle and Radiological Waste Management" to also capture uranium fuel cycle impacts.

Finally, the staff considered it more efficient to address cumulative impacts within the sections addressing other impacts to each resource rather than in a separate section as called for in the Final Interim Staff Guidance (NRC 2012-TN5527). Cumulative impacts are defined as impacts on an environmental resource resulting from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of which Federal or non-Federal agency or private party undertakes the other actions (40 CFR 1508.1(g)(3) [TN428]). Cumulative impacts can result from individually minor but collectively significant actions taking place over time (40 CFR 1508.1(g)(3) [TN428]).

The applicant presents a list of past, present, and reasonably foreseeable projects and other actions used in their consideration of cumulative impacts in the Environmental Report (ER) Table 4.13-1 (Kairos 2021-TN7880 | Table 4.13-1). The continued U.S. Department of Energy (DOE) operations connected with the Oak Ridge National Laboratory (ORNL) and the Y-12 site; industrial development in the East Tennessee Technology Park, including the Heritage Center Industrial Park (Heritage Center) (within which the Hermes site is situated) and the Horizon Center Industrial Park (Horizon Center) to the east; and development of a general aviation airport to the south are included in the table. Additional actions included are the continued operation of the Sequoyah Nuclear Plant (Sequoyah) and Watts Bar Nuclear Plant (Watts Bar) and future construction and operation of small modular reactors at the Clinch River Nuclear (CRN) site approximately 2 miles (mi) south of the Hermes site. The NRC staff reviewed that table and concluded that it is an appropriate range of other actions for consideration in its cumulative impact assessment and incorporates it by reference. Table 4.13-1 in the ER notes that the applicant plans to build and operate a fuel fabrication facility, termed the Kairos Atlas Fuel Fabrication Facility (Atlas facility), at the Hermes site. Additionally, another energy development company, TRISO-X LLC, has recently announced that they plan to build and operate a TRISO-X fuel fabrication facility on an unused 110 ac lot in the Horizon Center east of the Heritage Center where the Hermes site is located (TRISO-X, LLC. 2022-TN7987). The staff also expects that continued general urbanization in and around the City of Oak Ridge would contribute to the cumulative impacts.

The NRC staff recognizes that only a subset of this master list of other actions is relevant to cumulative impact analysis for each environmental resource addressed. The subsections under each resource addressing cumulative impacts highlight those specific actions from ER Table 4.13-1 that are most relevant to an analysis of cumulative impacts for that resource. As explained in Section 1.0, some activities necessary to build a nuclear project such as Hermes do not fall within the purview of NRC's regulatory jurisdiction over construction as defined in 10 CFR 50.10 (TN249) and 10 CFR 51.4 (TN250) and are grouped under the term "preconstruction." The NRC staff does not consider the effects of preconstruction to be direct or indirect impacts on a licensing action, but it does recognize the need for evaluating the contribution of preconstruction to cumulative impacts. Identifying the impacts of preconstruction is also necessary to understand the setting for impacts from NRC-authorized construction activities, as well as impacts from subsequent life-cycle phases. For example, clearing portions of a site before beginning a project is preconstruction, but knowing the extent of the clearing is necessary to know what nearby ecological habitats might be affected by noise generated by subsequent regulated activities. The sections below therefore describe impacts from preconstruction and construction jointly for each resource. The joint description, when combined with information on impacts from operation and decommissioning and from other projects in the area, provides a complete basis for drawing conclusions regarding direct, indirect, and cumulative impacts.

3.1 Land Use and Visual Resources

3.1.1 Affected Environment

As described in Section 3.1.1 of the ER (Kairos 2021-TN7880), the site consists of approximately 185 acres (ac) situated in the Heritage Center in the East Tennessee Technology Park within the corporate limits of the City of Oak Ridge, Tennessee. The site is in Roane County, approximately 13 mi west of the densely developed downtown area of Oak Ridge. The site was previously part of the DOE Oak Ridge Reservation (ORR). The site formerly accommodated Buildings K-31 and K-33, two large rectangular industrial buildings that were operated until 1985 by DOE as part of the Oak Ridge Gaseous Diffusion Plant (ORGDP) (Kairos 2021-TN78800 | Sec 1.2). Table 3.1-1 (Kairos 2021-TN7880) of the ER quantifies the current land uses on the site and in the region, and Figure 3.1-1 of the ER (Kairos 2021-TN7880) depicts the current land uses graphically. Land cover on the site at present consists of approximately 72 ac of herbaceous grassland, mostly where Building K-33 formerly stood; approximately 87 ac of developed (medium and high intensity) land, mostly where Building K-31 formerly stood, that is currently being used for temporary outdoor industrial purposes; and approximately 24 ac of deciduous and mixed forest cover and woody (dominated by trees and shrubs) wetlands along the site's southern and eastern perimeters.

Figure 3.1-3 of the ER (Kairos 2021-TN7880) shows that the site is in the northwestern part of the previously developed ORGDP land. DOE completed the core cleanup of the former ORGDP lands in 2020 and privatized ownership of 1,300 ac, including the site; and DOE expects to complete the ORGDP cleanup by 2024 and privatize an additional 600 ac (DOE 2022-TN7897). DOE decontaminated Buildings K-31 and K-33 between 1998 and 2005 and razed the structures and removed their slabs between 2011 and 2015 (Kairos 2021-TN7880 | ER Sec 3.5.3). The site is zoned by the City of Oak Ridge as IND-2 (Industrial Districts IND-2) (City of Oak Ridge 2021-TN7900), a general industrial district established to provide areas in which the principal use of land is for processing, manufacturing, assembling, fabrication, and warehousing (City of Oak Ridge 2020-TN7901).

The "region" of the site is defined as the area within a 5 mi radius of the site center point. The region comprises a mixture of urban and rural uses characterized in Section 3.1.1.2 of the ER (Kairos 2021-TN7880 | ER Sec 3.1.1.2) and depicted in Figure 3.1-2 of the ER (Kairos 2021-TN7880). Section 3.1.1.2 of the ER (Kairos 2021-TN7880) provides information about navigable waterways, highways and roads, rail lines, natural gas pipelines, and airports in the region. Although the region includes agricultural land, there is no economically significant crop production. There are no chemical plants, refineries, mining or quarrying, or military facilities within 5 mi of the site.

The visual setting of the site is described in Section 3.1.2 of the ER (Kairos 2021-TN7880). It is influenced by a predominantly industrial setting to the south and east, where the currently and formerly developed areas of the Heritage Center and other East Tennessee Technology Park lands are situated; and a predominantly forested setting to the north, consisting of the forested lands on the 3,073 ac Black Oak Ridge Conservation Easement. The applicant characterizes the scenic quality of the site with the lowest available rating (that of C), using a subjective rating process developed by the Bureau of Land Management (BLM 1984-TN5536). Scenic quality is the relative worth of a landscape from a visual perception point of view. The C rating reflects the existing modifications of the site and surrounding industrial areas (Kairos 2021-TN7880 | Sec 3.1.2). The applicant subjectively characterizes the site's sensitivity level, a measure of public concern for the maintenance of scenic quality, as "low to moderate" (Kairos 2021-TN7880 | Sec 3.1.2). The sensitivity level considers the types of users, amount of use, public interest, adjacent land users, and special area management objectives. The NRC staff finds the applicant's subjective determinations to be reasonable in that they reflect the large areas of previously disturbed and graded soils on and close to the site, ongoing industrial redevelopment of the surrounding landscape, and broad areas of forest cover separating the industrial area from the closest residential land uses.

3.1.2 Environmental Impacts of Construction

Figure 2.2-1 of the ER indicates that construction would temporarily disturb approximately 138 ac of previously developed industrial lands on the site, but that the disturbance would not encroach into areas of natural vegetation (Kairos 2021-TN7880). Based on projected start dates reported in Section 2.1 of the ER (Kairos 2021-TN7880), temporary land uses would likely persist for two to three-years. Once built, the new facilities would permanently occupy approximately 30 ac of land within the footprint of the former K-33 facility (and within the area already subject to temporary disturbance). The City of Oak Ridge informed the applicant that because the proposed Hermes reactor is not designed to generate power, it fits within the range of activities allowed under the IND-2 zoning (Kairos 2022-TN7902). Had the reactor been designed to generate power, it may have required IND-3 zoning. Unlike the IND-2 zoning, IND-3 zoning specifically allows for power generation facilities (City of Oak Ridge 2020-TN7901). The DOE completed an environmental assessment (EA) in 2011 for the transfer of up to approximately 1,800 ac of East Tennessee Technology Park land including what is now the proposed Hermes site (DOE 2011-TN4888). DOE concluded that the anticipated industrial and commercial development would not significantly change the existing industrial land use character and appearance of the already highly disturbed main portion of the East Tennessee Technology Park, which includes what is now the proposed Hermes site (DOE 2011-TN4888 │Sec 3.1.2.1). DOE notes that the anticipated future land use scenarios in the transferred lands include (among other uses) research and testing facilities, including renewable and advanced energy, industrial, and scientific research laboratories that include incidental pilot plant processing operation (DOE 2011-TN4888 │Sec 2.1.1).

Building the Hermes facilities would disturb only lands whose soils were previously graded to build the former K-31 and K-33 facilities; therefore, the project has no potential to disturb natural soils potentially capable of meeting the definitions of prime or unique farmland or other special status farmland. Because there is no agricultural activity on or adjacent to the site, and only small-scale agricultural production in the region (Kairos 2021-TN7880 │Sec 3.1.1), there is little potential for noticeable impacts on agricultural land uses. Land disturbance would not encroach into any wetlands (Kairos 2021-TN7880 │Sec 4.5.1.2). Disturbances would be limited to areas mapped by the Federal Emergency Management Agency as "Zone X" (Kairos 2021-TN7880 │ Figure 3.4-2) and would not encroach into 100-year or 500-year floodplain lands (Kairos 2021-TN7880 │ Sec 3.4.1.1.7). The proposed project would not extend to the Oak Ridge Wildlife Management Area, Black Oak Ridge Conservation Easement, or other special land uses in the region (Kairos 2021-TN7880 │ Sec 4.1.1.2), although it might be distantly visible from parts of those areas. As discussed in Section 3.5 on historic and cultural resources, the proposed project would be visible from, but would not substantially interfere with, the public's use and enjoyment of nearby Manhattan Project National Historical Park (NHP).

The project would introduce new industrial facilities only into an established industrial setting and would not qualitatively alter the visual character of the setting or surrounding region. The tallest structures built on the site would be ventilation stacks with a height of 100 feet (ft) (Kairos 2021-TN7880 │ Sec 4.1.2). The applicant presents a visual simulation of the proposed facilities in Figure 4.1-1 of the ER (Kairos 2021-TN7880) as well as three-dimensional computer-generated renderings overlaying the proposed facilities on ground-level photographs from six key observation points at visually sensitive locations surrounding the site (Kairos 2021-TN7880 │ Figure 4.1-2). The selected observation points include locations in a new residential development approximately 2 miles to the west of the site, other nearby residential areas, a parking area and trailhead for the Black Oak Ridge Conservation Easement north of the Heritage Center and rest of the East Tennessee Technology Park, a historic cemetery approximately 1 mi to the south, and the K-25 Overlook and Visitor Center approximately 1 mi to the southwest. The computer renderings (Kairos 2021-TN7880 │ Figures 4.1-3 through 4.1-8) demonstrate that the view of the new facilities from the observation points would be blocked by existing vegetation (Kairos 2021-TN7880 │ Sec 4.1.2). The applicant acknowledges that the facilities might be visible in the far distance when the deciduous trees are leafless but suggests that the surrounding hills and mountains would soften the industrial appearance of the facilities (Kairos 2021-TN7880 │ Sec 4.1.2). Considering the existing industrial character of the East Tennessee Technology Park, the visual changes from construction would not be noticeable.

3.1.3 Environmental Impacts of Operation

The completed facilities would occupy approximately 30 ac within the footprint of the former Building K-33, as indicated above, for a four-year operational period. The applicant has identified the entire 185 ac site as the exclusion area for the Hermes reactor (Kairos 2021-TN7879 │ Figure 2.1-3). Under 10 CFR 100.3 (TN282), "Definitions," the exclusion area is an area surrounding a reactor, that must meet specific radiological criteria outlined in 10 CFR 100.11 (TN282), "Determination of exclusion area, low population zone (LPZ), and population center distance," in which the reactor licensee has the authority to determine all activities including exclusion or removal of personnel and property. The remaining 108 ac within the area of temporary disturbance would be available for other land uses under Kairos' control once they are no longer needed for construction. No additional land would be disturbed for the Hermes project during operation. Operational activity would be consistent with the site's zoning and industrial setting. The overall appearance of the Hermes facilities would not noticeably change during the operational period. The NRC staff therefore expects that the land use and visual impacts from operation would be minimal.

3.1.4 Environmental Impacts of Decommissioning

Land-disturbing activities during decommissioning would generally resemble those during construction and involve the use of heavy equipment to remove buildings, roadways, and other structures (Kairos 2021-TN7880 │ Sec 4.1.1.5). Although most work would take place within the approximately 30 ac of land occupied by the formerly operational facilities, the staff expects that some adjoining land within the lands temporarily disturbed for construction might be temporarily required for laydown of equipment and materials. Decommissioning could ultimately free up all or part of the site for other uses consistent with the objectives of the Heritage Center. The overall visual appearance of the site would remain industrial throughout decommissioning, but the site could then revert to a vacant appearance until the site is ultimately redeveloped. The decommissioning impacts on land use and visual resources would be bounded by the analyses in the decommissioning generic EIS (NRC 2002-TN7254). Although the conclusions of the generic EIS extend only to the site and not surrounding lands, the land use impacts for decommissioning Hermes would not involve use of surrounding land. The NRC staff therefore expects that the land use and visual impacts from decommissioning would be minimal.

3.1.5 Cumulative Impacts

Tables 4.13-1 and 4.13-2 of the ER identify past, present, and reasonably foreseeable future projects that could cumulatively contribute to the environmental impacts of the proposed action (Kairos 2021-TN7880). Key past and present actions affecting land resources and visual quality in the affected area include the Federal nuclear and energy development facilities on the ORR such as the Y-12 plant, ORNL, and other energy research facilities; the residential and commercial areas in the original townsite of the City of Oak Ridge; multiple energy and industrial park projects; a large housing development currently undergoing construction approximately 2 mi west of the site termed the Preserve at Clinch River; and other land use features of a suburban or semi-rural landscape. Key reasonably foreseeable proposed projects in the region include the Horizon Center on former ORR forest land approximately 2.3 mi northeast of the site (for which DOE has excessed land to the City of Oak Ridge and roadways have been built), anticipated industrial development of other previously developed land in the Heritage Center, and a proposed general aviation airport approximately 1.1 mi south and east of the site. Additionally, as noted above in Section 3.0, the applicant anticipates possibly using a portion of the site outside of the Hermes facilities to build and operate the Atlas fuel fabrication facility. Another company (TRISO-X, LLC. 2022-TN7987) has recently announced that they plan to build and operate a TRISO-X fuel fabrication facility on an unused 110 ac lot in the Horizon Center to the east.

The NRC staff expects that the ongoing and reasonably foreseeable projects noted above and other anticipated continued development around Oak Ridge would increase the extent of industrial and other urban land in the region but would not noticeably change its land use patterns or overall visual quality. The City and DOE have planned over several decades to attract industrial development to the East Tennessee Technology Park to offset losses of employment from closure of the ORGDP and winding down environmental cleanup. Substantial infrastructure such as roads and utilities are already in place for the East Tennessee Technology Park, including the Heritage Center and Horizon Center, although the character of specific projects that ultimately use East Tennessee Technology Park land could necessitate additional infrastructure development. The infrastructure would, however, be built in areas that already display an industrial character and visual appearance.

The reasonably foreseeable new projects that have the greatest potential to affect land uses and visual qualities in the area around the site are the proposed Atlas facility and the proposed general aviation airport. The proposed Atlas facility would be built somewhere on the same 185 ac site proposed for the Hermes project. The applicant has indicated that the Atlas facility would occupy no more than 30 ac on the site (Kairos 2022-TN7902)), located outside of the approximately 30 ac of land occupied by the Hermes facilities during operation but still within the proposed reactor's exclusion area, which encompasses the remainder of the site. According to the NRC definition of the exclusion area in 10 CFR 100.3 (TN282), activities unrelated to operation of the reactor may be allowed in an exclusion area under appropriate limitations, provided that no significant hazards to public health and safety would result. Because the Atlas facility would be built by the same applicant as the Hermes facilities, the NRC staff expects that the applicant would design the Atlas facility to be compatible with respect to land use with the Hermes project. Building the Atlas facility would not substantially alter the already industrial character and appearance of the Hermes site and the Heritage Center overall. The NRC staff would ensure the compatibility of the Atlas facility with the land uses and visual quality of the Hermes site and the Heritage Center in general when reviewing a future licensing application for the Atlas facility project.

Building the airport would require dedication of hundreds of acres of land within the East Tennessee Technology Park but would enhance rather than conflict with the City's efforts to attract employers to the Heritage Center and other former DOE lands targeted for redevelopment. It would not substantially alter the industrial appearance and visual quality of the Heritage Center. Operating an airport requires limiting nearby land uses as necessary to keep the approach and departure zones at the ends of the runways free of obstructions to aircraft. The new airport would however be situated more than 1 mi south of the Hermes site and would be oriented such that the approach and departure zones would extend east and west of the runway, not north (DOE 2016-TN7903). The applicant indicated that the tallest structure height of the proposed Hermes facilities would be less than 200 ft and therefore would not meet the definition of a flight obstruction, as established by the Federal Aviation Administration in 14 CFR 77.17 (a) (TN7902). The applicant indicated that it would still notify the Federal Aviation Administration in accordance with 14 CFR 77.9 (TN7902) before building any of the Hermes structures. Upon receipt of the notification, the Federal Aviation Administration would officially verify that none of the proposed Hermes structures constitutes a flight obstruction.

3.1.6 Conclusions

The NRC staff concludes that the potential direct, indirect, and cumulative land use and visual resource impacts of the proposed action would be SMALL. This conclusion is based primarily on the fact that the proposed test reactor and support facilities are consistent with the objectives of the Heritage Center as well as the site's zoning and are functionally and visually compatible with the existing and anticipated future land uses surrounding the site. Reuse of former industrial land provides the economic benefits of the test reactor without requiring the conversion of sensitive lands such as forests, wetlands, or agricultural land for industrial use. Use of the site would also take advantage of existing roadways and utilities at the Heritage Center.

3.2 Air Quality and Noise

Section 3.2.1 addresses air quality, and Section 3.2.2 addresses noise.

3.2.1 Meteorology and Air Quality

3.2.1.1 Affected Environment

3.2.1.1.1 Climatology and Local Meteorology

The proposed site is located in an area of Tennessee commonly referred to as "The Great Valley" (Kairos 2021-TN7880 │ Sec 3.2.1). This area is dominated much of the year by the Azores-Bermuda anti-cyclonic circulation, which is most pronounced in late summer and early fall and is accompanied by extended periods of fair weather and widespread atmospheric stagnation. Frequent incursions of warm, moist air from the Gulf of Mexico and occasionally from the Atlantic Ocean are experienced in the summer. In winter and early spring, eastward-moving migratory high- or low-pressure systems bring alternately cold and warm air masses into the area (Kairos 2021-TN7880 │ Sec 3.2.1).

To characterize the region's climate, the applicant used climatological data collected from multiple sources including data from the National Climatic Data Center. Data were gathered from multiple meteorological towers at nearby airports and from meteorological towers located on the ORR (Kairos 2021-TN7880 │ Sec 3.2.1-3.2.5). Local meteorology data were gathered using multiple sources including three meteorological towers located on the ORR (ORR Tower J, Tower L, and Tower D). Data from all three towers were used to evaluate the impact of topography on site meteorology, and Kairos relied upon existing measurements taken within ORR to address pre-operational site-specific meteorological monitoring. On May 6, 2021, Tower L was decommissioned because the land it occupies was ceded by the DOE to another party. The tower will not be relocated; instead, it has been replaced with a wind light detection and ranging measurement program (using a Vaisala WindCube remote-sensing lidar instrument) (Kairos 2021-TN7880 │ Sec 3.2.4.3).

Average wind speeds in the region are low, with a mean annual wind speed of 2.1 miles per hour (mph) at Oak Ridge (Kairos 2021-TN7880 │ Sec 3.2.1). During winter when the jet stream moves southward, the Cumberland Mountains serve to moderate cold outbreaks by blocking dense, cold polar continental air masses; and during the summer they reduce the intensity of thunderstorms 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. Therefore, thunderstorms are more frequently caused by atmospheric heating from the land during the day; and the orographic lift produced by the local topography may enhance these thunderstorms (Kairos 2021-TN7880 │ Sec 3.2.1).

Area temperatures at Oak Ridge indicate warm summers and mild winters (Kairos 2021-TN7880 │ Sec 3.2.1). 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. Relative humidity in the region, measured at Knoxville, Tennessee, averaged 73 percent based on 30 years of data from National Climatic Data Center (1981–2010) (Kairos 2021-TN7880).

Precipitation averages about 51 inches (in.) annually. Late winter (January–March) is usually the wettest season, with more than 14 in.; while late summer–early autumn (August–October) is the driest season, with less than 10 in. (Kairos 2021-TN7880 │ Sec 3.2.1). Droughts are uncommon. Snowfall, though normally light, usually occurs between November and March (Kairos 2021-TN7880 │ Sec 3.2.1).

Severe weather events include extreme wind; tornadoes and waterspouts; water precipitation extremes; hail, snowstorms, and ice storms; thunderstorms and lightning; snowpack and probable maximum winter precipitation; extreme temperatures; and restrictive dispersion conditions. The applicant discusses severe weather events for the proposed site in Section 3.2.3 of the ER (Kairos 2021-TN7880 │ Sec 3.2.3).

Atmospheric stability is a critical parameter for estimating atmospheric dispersion characteristics. Pasquill atmospheric stability is a method of categorizing the atmospheric stability of a region in terms of the horizontal surface wind, the amount of solar radiation, and the fractional cloud cover where Class A is extremely unstable conditions, Class B is moderately unstable conditions, Class C is slightly unstable conditions, Class D is neutral conditions, Class E is slightly stable conditions, Class F is moderately stable conditions, and Class G is extremely stable conditions (NOAA 2022-TN7904 and AMS 2012-TN7905). One 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. The frequency of occurrence of Pasquill (Classes A–G) atmospheric stability classes at the site were based upon temperature differences for local ORR meteorological Tower L over a two-year period (2018–2019) (Kairos 2021-TN7880 │ ER Sec 3.2.4.5). While the atmosphere at the site for the 2 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 class conditions (Classes A, B, and C) occur approximately 31 percent of the time (Kairos 2021-TN7880 │ Sec 3.2.5).

3.2.1.1.2 Air Quality

The region of influence for this air quality analysis is Roane County. In accordance with the Federal Clean Air Act of 1970, as amended (CAA) (Clean Air Act-TN1141), the U.S. Environmental Protection Agency (EPA) established National Primary and Secondary Ambient Air Quality Standards (40 CFR Part 50-TN1089) for six pollutants (often referred to as criteria pollutants) to protect the environment and public health. These pollutants include ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), lead (Pb), and particulate matter (PM). PM includes particles less than 10 micrometers (μm) in diameter and particles less than 2.5 μm in diameter—particles that have equivalent aerodynamic diameters less than or equal to 10 and 2.5 μm, respectively. Other air pollutants of concern include greenhouse gases (GHGs), such as carbon dioxide (CO_2) and methane (CH_4), and hazardous air pollutants (HAPs).

National Ambient Air Quality Standards (NAAQS) limit the concentrations of the six criteria pollutants in order to protect human health and welfare. Areas in which pollutant concentrations exceed these standards are designated as “nonattainment areas” because air quality levels do not meet the required standards. “Attainment areas” are areas in which recent monitoring data demonstrate that concentrations of criteria pollutants are lower than the NAAQS. If monitoring has been insufficient to determine whether an area meets the standards, the area is designated as an “unclassifiable area.”

The CAA (TN1141) requires development of regulatory plans for nonattainment areas to reduce pollution levels until the area meets the NAAQS within a specified timeframe. State agencies typically complete these plans, called state implementation plans, which are then approved by the EPA. After air quality has improved in an area to the point that monitoring data demonstrate the air quality requirements outlined in the NAAQS, the area is designated as a “maintenance area.”

Air quality designations are generally made at the county-level, but designations may also be made for smaller localized areas. The City of Oak Ridge spans parts of Roane and Anderson Counties, which are part of the Knoxville-Sevierville-LaFollette, Tennessee air quality area (Kairos 2021-TN7880 │ Sec 3.2.2). The immediate areas of Roane and Anderson Counties are currently in attainment for all criteria pollutants. Parts of Roane County were in nonattainment for several years for $PM_{2.5}$ and were redesignated to maintenance status in 2017. Similarly, Anderson County was in nonattainment for several years for eight hour ozone and $PM_{2.5}$ but was redesignated to maintenance status in 2015 for eight hour ozone and in 2017 for $PM_{2.5}$ (EPA 2022-TN7906). While the immediate area surrounding the proposed facilities is in attainment for all criteria pollutants, it is approximately 5 mi away from an area designated as a maintenance area for $PM_{2.5}$. Because areas within Roane County are designated as maintenance areas, the NRC staff uses the thresholds for maintenance areas when determining the impacts from NAAQS emissions to understand whether the project could potentially further degrade the air quality in those maintenance areas. Table 3-1 presents the national thresholds contained in 40 CFR 93.153 (TN2495) for maintenance areas.

HAPs are pollutants known or suspected to cause cancer or other serious health effects, such as reproductive effects, birth defects, or adverse environmental effects. Under the CAA (TN1141), the EPA regulates a list of 188 HAPs (EPA 2022-TN7907).

Table 3-1 National Ambient Air Quality Standards for Maintenance Areas

Criteria Pollutant	Threshold (TPY)
Ozone (O_3), nitrogen oxides (NO_X), SO_2 or NO_2	
All maintenance areas	100
Ozone (O_3), (volatile organic compounds [VOC])	
Maintenance areas inside an ozone transport region	50
Maintenance areas outside an ozone transport region	100
CO	
All maintenance areas	100
PM_{10}	
All maintenance areas	100
$PM_{2.5}$	
Direct emissions, SO_2, NO_X, VOC, and ammonia	100
All maintenance areas	100
Pb	
All maintenance areas	25

Key: TPY = ton(s) per year; O_3 = ozone; NO_X = nitrogen oxides, SO_2 = sulfur dioxide; NO_2 = nitrogen dioxide; volatile organic compounds = VOC; CO = carbon monoxide; PM = particulate matter; Pb = lead.

Source: 40 CFR Part 93-TN2495.

EPA promulgated the Regional Haze Rule to improve and protect visibility in national parks and wilderness areas from haze that many diverse sources across a broad region may cause (40 CFR 51.308–51.309) (TN1090). Specifically, 40 CFR Part 81 (TN255), Subpart D, lists mandatory Class I Federal Areas where visibility is an important value. The Regional Haze Rule requires states to develop regional haze state implementation plans to reduce visibility impairment at Class I Federal Areas (40 CFR 51.300 through 51.309) (TN1090). The closest two Federal Class I areas are approximately 62 mi from the site: Joyce Kilmer-Slickrock Wilderness Area and Great Smoky Mountains National Park. (Kairos 2021-TN7880 | Sec 3.2.2). If the proposed project is a major source of emissions and within approximately 31 mi (50 kilometers [km]) of a Class I area, then a Class I visibility impact analysis would be completed (NPS 2010-TN7925).

3.2.1.1.3 Federal and State New Source Permitting Requirements

New facilities that emit air pollutants, such as the proposed Hermes facilities, could be subject to Federal requirements, depending on the location and the type and amount of emitted air pollution. The following sections summarize these requirements.

<u>Prevention of Significant Deterioration and Nonattainment New Source Reviews</u>

The New Source Review regulations are broken down into two separate programs: Prevention of Significant Deterioration (PSD) and Nonattainment New Source Review. PSD is a Federal permitting program that applies to sources classified as major sources (as defined in 40 CFR 52.21) (TN4498) under the PSD program and located in attainment areas. The purpose of the program is to prevent degradation of air quality in areas where air quality is good. New or modified sources of criteria pollutants that exceed de minimis emission rates are subject to the program. For purposes of this air quality analysis, the 250 tons per year (TPY) of any criteria pollutant threshold (40 CFR 52.21) (TN4498) will be considered when determining the significance of air quality impacts for operation. A nonattainment new source review applies to new major sources or major modifications at existing sources for pollutants at a source location that is within a NAAQS nonattainment area (Part D of Title I of the CAA) (TN1141). Nonattainment new source review requirements are customized for the nonattainment area. All nonattainment new source review programs require (1) the installation of the lowest achievable emission rate, (2) emission offsets, and (3) opportunity for public involvement (EPA 2022-TN7908). Minor new source reviews are for pollutants from stationary sources that do not require PSD or nonattainment new source review permits. The purpose of minor new source review permits is to prevent the construction of sources that would interfere with attainment or maintenance of a NAAQS or violate the control strategy in nonattainment areas (EPA 2021-TN7909). Emissions from new sources are evaluated by the State of Tennessee through the PSD program (EPA 2022-TN7910).

Title V of the Clean Air Act

Title V of the CAA (TN1141) requires a Federally enforceable operating permit program that applies to large, new, and existing sources of air pollution. Any facility with the potential to emit 100 TPY or more of any criteria pollutant, 10 TPY of any HAP, or 25 TPY of any combination of HAPs is required to obtain a valid Title V permit and is considered a major air emission source (EPA 2022Q). For purposes of this air quality analysis, the 100 TPY of any criteria pollutant threshold for a Title V operation permit will be considered in determining the significance of air quality impacts for operation. The applicant would be required to obtain a permit from the Tennessee Department of Environment and Conservation (TDEC) (EPA 2022-TN7910).

Greenhouse Gas Rules

In September 2009, the EPA issued a final rule for mandatory GHG reporting by large GHG emission sources in the United States (74 FR 56260-TN1024). The purpose of the rule is to collect and use comprehensive and accurate data about CO_2 and other GHG emissions to inform future policy decisions. In general, the threshold for reporting is 25,000 metric tons (MT) or more of carbon dioxide equivalent (CO_2eq)[1] emissions per year, excluding mobile-source emissions.

In May 2010, the EPA issued the GHG Tailoring Rule. This rule set the thresholds for a phase-in approach to regulating GHG emissions under the PSD and Title V permitting programs (75 FR 31514-TN1404). According to the rule, operating permits issued to major sources of GHG under the PSD or Title V Federal permit programs must contain provisions requiring the use of best available control technology to limit the emissions of GHGs, if those sources would be subject to PSD or Title V permitting requirements because of their non-GHG pollutant emission potentials and if their estimated GHG emissions are at least 75,000 TPY of CO_2eq. In June 2014, the U.S. Supreme Court issued its decision in *Utility Air Regulatory Group v. EPA*, 573 U.S. 302 (2014), in which it held that EPA may not treat GHGs as an air pollutant for determining whether a source is a major source required to obtain a PSD or Title V permit. The Court also stated that EPA could continue to require PSD and Title V permits otherwise required based on emissions of conventional pollutants (Utility Air Regulatory Group v. Environmental Protection Agency et al. 2014-TN7924).

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[1] The CO_2eq is a metric used to compare the emissions of GHGs based on their global warming potential (GWP). GWP is a measure used to compare how much heat a GHG traps in the atmosphere. GWP is the total energy that a gas absorbs over a period of time compared to CO_2. The CO_2eq is obtained by multiplying the amount of the GHG by the associated GWP.

State Air Quality Permitting

Unless specifically exempted, any person wishing to construct an air emission source or to modify an existing air emission source is required to obtain a CP from the Tennessee Division of Air Pollution Control (TDAPC; TDEC 2022-TN7911).

Under Tennessee law, air contaminant sources typically are classified as major or minor sources depending on their potential to emit pollutants. Major sources generally are:

- sources that are in specific source categories listed in Part 1200-03-09-.01(4)(b)1 of the Tennessee Air Pollution Control Regulations and have potential total facility emissions greater than 100 TPY; and
- other sources with potential total facility emissions greater than 250 TPY or more of the following criteria pollutants: carbon monoxide (CO), particulate matter (PM), nitrogen dioxide, sulfur dioxide (SO_2), lead (Pb) and ozone (O_3) (indirectly determined from emissions of volatile organic compounds (VOCs) and nitrogen oxides (NOx).

Examples of major sources are large power plants, chemical manufacturers, some secondary metal production facilities, and large printing operations (TDEC 2022-TN7911).

Minor sources are sources of air contaminants that are not major sources and are not specifically exempt from the CP requirements of Tennessee. Examples include concrete batch plants and small surface coating and printing operations (TDEC 2022-TN7911).

3.2.1.1.4 Environmental Impacts of Construction

During construction, air quality may be affected near the proposed facilities. Air pollutants would include fugitive dust from earth-moving equipment and other vehicles, exhaust gases from diesel engines, and exhaust gases from worker vehicles and delivery vehicles as they commute to and from the proposed facilities. These activities generate combustion product emissions such as carbon monoxide (CO), nitrogen oxides (NO_x) and, to a lesser extent, sulfur dioxide (SO_2). Painting, coating, and similar activities during construction generate emissions from the use of volatile organic compounds. Over the two-year construction schedule, the applicant estimates a monthly average of 213 truck deliveries, 4 offsite shipments of construction debris, and an average of 212 onsite workers with a peak construction workforce estimated to be 425 (Kairos 2021-TN7880 │ Sec 2.1). Table 3-2 lists the air emission estimates for the project for criteria pollutants during the two-year construction phase. The estimates of air emissions for all criteria pollutants are below the thresholds presented in Table 3-1. The applicant would still be required to apply for any needed state air quality permits for minor sources for construction. Because the proposed project is not a major source, and the project is more than 31 mi (50 km) away from the nearest Class 1 area, a Class I visibility impact analysis is not needed. Lastly, the HAPs are estimated to be below 10 TPY for any single pollutant and below 25 TPY for all HAPs combined (Kairos 2021-TN7880 │ Sec 4.2.1.1).

Impacts from fugitive dust and other air emissions could be further reduced by mitigation measures and would reduce impacts on local ambient air quality and impacts on the site and nearby offsite areas. According to the applicant (Kairos 2021-TN7880 │ Sec 4.2.1.1), specific mitigation measures available to control air emissions including fugitive dust could 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;
- 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; and
- proper maintenance of construction vehicles to maximize efficiency and minimize emissions.

Table 3-2 National Ambient Air Quality Standards Air Emissions During Construction for Hazardous Air Pollutants

Emission Effluent	Emissions During Construction (T)[a]
NO_X	5.79
CO	2.49
Sulfur oxides (SO_x)	0.10
VOC	0.51
PM_{10}	0.40
$PM_{2.5}$	0.38

Key: T = ton(s); NO_X = nitrogen oxides, CO = carbon monoxide; SO_x = sulfur oxides; volatile organic compounds = VOC; PM = particulate matter.
(a) The emissions totals presented in Table 3.2-2 are for the two-year construction period.
Source: (Kairos 2022-TN7912).

3.2.1.1.5 Environmental Impacts of Operation

Air emissions of nonradiological gaseous criteria pollutants and HAPs would be emitted during the operation 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 during maintenance activities, (3) diesel-powered trucks that deliver material and haul off wastes, and (4) worker commuter vehicles (Kairos 2021-TN7880). Shipment-related emissions could be emitted beyond the region of interest (ROI) and would traverse various counties, air quality control regions, and states; therefore, the air quality analysis presented below focuses on emissions from generators, combustion gas turbines, delivery trucks and waste removal, and worker commuting. Because the proposed Hermes facilities would not have cooling towers, the analysis does not address issues related to cooling tower operation such as salt drift, ground-level fogging and icing, plume shadowing, and ground-level temperature and humidity increases.

Table 3-3 lists the air emission estimates during operation for criteria pollutants for the proposed Hermes facilities. The applicant stated in its ER that emissions from the proposed Hermes facilities would be smaller than those estimated by Tennessee Valley Authority (TVA) from its small modular nuclear reactor at the CRN site (Kairos 2022-TN7912). The Clinch River early site permit (ESP) EIS analyzed air emissions and included emissions from auxiliary boilers and cooling towers (Kairos 2022-TN7912). The NRC staff incorporated by reference Table 5-3 from the CRN ESP EIS, and because the proposed Hermes facilities are not expected to use auxiliary boilers or cooling towers, the staff removed the emission estimates from those sources to create Table 3-3. Intermittent emissions from standby power generation sources such as generators or combustion gas turbines would operate less than 500 hr/yr and would produce insignificant emissions (less than 5 TPY for criteria pollutants and less than 1,000 pounds (lb) per year for an individual HAP), as defined in Chapter 1200-03-09 of the Tennessee Air Pollution Control Regulations. If used exclusively for replacement or standby service and at or less than 500 hr/yr, 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 (Kairos 2021-TN7880 │ Sec 4.2.1.2.2).

Table 3-3 National Ambient Air Quality Standards Annual Air Emissions During Operation

Emission Effluent	Emissions During Construction (TPY)[(a)]
NO_X	20.65
CO	1.85
SO_x	0.0125
VOC[(b)]	0.3575
PM (PM_{10})[(c)]	0.15

Key: TPY = ton(s) per year; NO_X = nitrogen oxides, CO = carbon monoxide; SO_x = sulfur oxides; volatile organic compounds = VOC; PM = particulate matter.
(a) Emissions from diesel generators and gas turbines are based on four-hour of operation per month.
(b) As total hydrocarbon.
(c) The emission estimates for PM_{10} (≤10 μm) encompass the $PM_{2.5}$ (≤2.5 μm) emissions.

Source: Adapted from (NRC 2019-TN6136), (Kairos 2022-TN7912).

The estimates of air emissions for all criteria pollutants are below the thresholds presented in Table 3-1. The estimated emissions are well below the thresholds for the Title V and PSD permits discussed above. In addition, because the project is located in an attainment area for all criteria pollutants, the proposed project is not subject to a Nonattainment New Source Review. Because the proposed project is not a major source, and the project is more than 31 mi (50 km) away from the nearest Class 1 area, a Class I visibility impact analysis is not required. Lastly, the HAPs are estimated to be below 10 TPY for any single pollutant and below 25 TPY for all HAPs combined during operation (Kairos 2021-TN7880 │ Sec 4.2.1.2).

3.2.1.1.6 GHG Emissions

Gases found in the Earth's atmosphere that trap heat and play a role in the Earth's climate are collectively termed GHGs. GHGs include CO_2; CH_4; nitrous oxide (N_2O); water vapor (H_2O); and fluorinated gases, such as hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride (SF_6). Climate change is a subject of national and international interest because of how it changes the affected environment. *Commission Order CLI-09-21* (NRC 2009-TN6406) provides the current direction to the NRC staff to include the consideration of the impacts of the emissions of CO_2 and other GHGs that drive climate change in its environmental reviews for major licensing actions.[1] Estimates of GHG emissions from a reference 1,000 megawatt electric (MWe) reactor were developed using the approach in Interim Staff Guidance COL/ESP-ISG-026

[1] The Commission stated that "the Staff's analysis for reactor applications should encompass emissions from the uranium fuel cycle as well as from construction and operation of the facility to be licensed" (CLI-09-21 [NRC 2009-TN6406], at 6).

(NRC 2014-TN3767), "Interim Staff Guidance on Environmental Issues Associated with New Reactors" (NRC 2014-TN3768), and the Council on Environmental Quality's (CEQ's) 2016 final guidance on considering GHGs emissions and effects of climate changes in NEPA reviews (CEQ 2016-TN4732), and are presented in in Appendix E of this draft EIS.

GHGs are emitted from equipment and vehicles used during construction, operation, the uranium fuel cycle, transportation of fuel and waste, and decommissioning including extended SAFe STORage (SAFSTOR). Appendix E estimates GHG emissions for life-cycle phases for a reference 1,000 MWe reactor with an 80 percent capacity factor. The calculation of GHG emissions for the proposed Hermes facilities assumes that one 35 megawatt thermal (MWt) advanced reactor would be installed. Advanced reactors can have efficiencies of up to 45 percent; therefore, the proposed facilities would generate approximately 15 Mwe, if it were producing electricity.[1] Assuming that GHG emission estimates for construction, operation, and decommissioning, including extended SAFSTOR for the proposed Hermes plant, would be based on the plant's physical size, the estimates for these stages would be scaled down to 1.5 percent of the totals calculated in Appendix E. No additional scaling was needed to account for the size or number of the reactors at the proposed site. However, GHG emission estimates for the uranium fuel cycle and transportation of fuel and waste would be based on the anticipated efficiency of the proposed plant. To provide bounding values, the estimates for GHG emissions for uranium fuel cycle activities and fuel and waste transport associated for the proposed Hermes facilities the staff calculated the values as 1.5 percent of the totals presented for the reference 1,000 MWe reactor in Appendix E multiplied by 3 to account for the efficiency of the reactor. Consistent with the approach used in Appendix E, which is based on COL/ESP-ISG-26, the staff halved the emissions estimated for the construction equipment and workforce calculated for the proposed Hermes facilities to determine the estimates for GHG emissions during decommissioning. The staff expects that, for a small reactor such as the proposed Hermes project, the SAFSTOR workforce would be much less than that for a power reactor similar to those currently licensed in the United States, so the staff halved the emissions estimate. Additionally, to add conservatism to the calculation the staff did not change the life cycle assumed in Appendix E. The staff calculated that the GHG emissions for the proposed Hermes facilities to be approximately 37,000 MT CO_2eq using the assumptions discussed above to scale the reference 1,000 MWe reactor in Appendix E. These emissions can be compared with 2019 total gross annual U.S. energy sector emissions of 5,410.8 million metric ton (MMT) CO_2eq (EPA 2021-TN6965). Even when taking the conservative approach and comparing the entire life cycle estimated GHG emissions from construction, operation, uranium fuel cycle, transportation of fuel and waste, and decommissioning activities to the 2019, the total gross annual U.S. energy sector emissions the project's GHG emissions are about 0.00068 percent of the 2019 GHG emissions from the U.S. energy sector.

3.2.1.1.7 Environmental Impacts of Decommissioning

Decommissioning includes decontamination and dismantling facilities to the ultimate end state of demolition (Kairos 2021-TN7880 | Sec 4.2.1.3). Demolition 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 those during the construction phase because decommissioning activities are less extensive than construction activities (Kairos 2021-TN7880 | Sec 4.2.1.3).

[1] The proposed Hermes facilities will host a test reactor and will not be producing electricity for use on the grid (Kairos 2022-TN7881). The 15 MWe value is for calculating the GHG emissions for the proposed facilities.

3.2.1.1.8 Cumulative Impacts

Table 4.13-1 of the ER identifies past, present, and reasonably foreseeable future projects that could cumulatively contribute to the environmental impacts of the proposed action (Kairos 2021-TN7880). Key past, present, and reasonably foreseeable actions affecting air quality in the region include the Federal nuclear and energy development facilities on the ORR such as the Y-12 Plant, ORNL, and the proposed CRN site. Continued development including transportation projects, new industrial facilities, and new large-scale residential development will affect local air quality. Continued operation of industrial parks and energy facilities such as TVA fleet (i.e., Kingston Fossil Plant) will also affect air quality (Kairos 2021-TN7880 | Table 4.13-1). New projects would all be governed by new construction air permits processed through TDEC. The permit process would ensure that counties potentially impacted would continue to be in attainment or maintenance. Additionally, any facilities that are currently operating would continue to operate within their permit limits. Permitting reviews performed by the TDEC are conducted to ensure that new permits do not result in regional air quality degradation. The incremental impact on air quality from construction, operation, and decommissioning activities from the proposed facilities would not be significant.

3.2.1.1.9 Conclusions

The NRC staff concludes that the potential direct, indirect, and cumulative meteorology and air quality impacts of the proposed action would be SMALL. Air emissions from the proposed Hermes facilities are well below all thresholds considered in the analysis and would not be a major source of air emissions. GHG emissions would be 0.00068 percent of the overall energy sector, and the potential changes to the affected environment as a result of climate change would not change the conclusions discussed in this DEIS.

3.2.2 Noise

3.2.2.1 Affected Environment

Noise is unwanted or unwelcome sound usually caused by human activity that is added to the natural acoustic setting (Kairos 2021-TN7880 | Sec 3.2.6). Although sound pressure levels are measured in decibels (dB), noise levels in environmental analyses are commonly expressed using A-weighted sound levels (dBA) that are adjusted to better reflect how the human ear perceives the sound. The applicant correlates ranges of dBA levels to common noise experiences in Section 3.2.6 of the ER (Kairos 2021-TN7880 | Sec 3.2.6). A change of at least 3 dBA is necessary for most people to perceive an increase in noise, while a change of 5 dBA would be readily noticeable (Kairos 2021-TN7880 | Sec 3.2.6). The applicant notes that the nearest noise receptors within a 5 mi radius of the Hermes site include two parks (the adjacent Black Oak Ridge Conservation Easement and the Oak Ridge Country Club 4.9 mi to the northeast), one rehabilitation facility (Michael Dunn Center, approximately 4.6 mi southwest), and several churches (Kairos 2021-TN7880 | Sec 3.2.6). The nearest resident is situated approximately 1.1 mi to the northwest. There are also other noise contributors in the area, such as a railroad station and yard to the west, a marina approximately 2 mi southwest, and ORNL facilities; other new noise sources, including a new airport approximately 1.1 mi south of the site, are anticipated (Kairos 2021-TN7880 | Sec 3.2.6).

The applicant conducted baseline noise monitoring in June 2021 for two locations (Kairos 2021-TN7880 | Sec 3.2.6), one inside the proposed Hermes site and one on the boundary of the site (Kairos 2021-TN7880 | Figure 3.2-22). The applicant chose the location inside the currently undeveloped site to be representative of nearby areas away from publicly accessible roads and chose the location on the site boundary to be representative of nearby areas close to publicly accessible roads (Kairos 2021-TN7880 | Sec 3.2.6). The results of the baseline noise measurements are presented in Tables 3.2-9 and 3.2-10 of the ER (Kairos 2021-TN7880). The tables show a baseline Day-Night Sound Level (L_{dn}) of 53 dBA at the location on the site boundary and of 46 dBA at the quieter location inside the site. A L_{dn} refers to a 24-hour average noise level with a 10 dB penalty applied to noise levels between 10 p.m. and 7 a.m. due to increased sensitivity to noise during those hours (Kairos 2021-TN7880 | Sec 3.2.6).

3.2.2.2 Environmental Impacts of Construction

Construction noise would cause temporary increases and fluctuations in noise levels around the site during an anticipated two-year construction period between 2023 and 2025. The applicant reported that the existing ambient noise level at two sensitive locations close to the proposed Hermes site, one a greenway approximately 1 mi away (the nearest park) and the other approximately 1.1 mi away (the nearest resident), was measured at an average noise level (L_{eq}) of 38 dBA (Kairos 2022-TN7912). The applicant then calculated projected noise levels at each of the two sensitive locations of each type of construction equipment likely to be used to build the proposed facilities (Kairos 2022-TN7912). Projected noise levels L_{eq} from use of most construction equipment at the nearest residence and park would not increase by more than 3 dBA over the ambient level of 38 dBA and therefore would not likely be perceptible to persons at the two sensitive locations (Kairos 2022-TN7912). The applicant notes that operation of a pile driver vibratory hammer, or simultaneous operation of multiple pieces of heavy equipment, could increase noise levels by more than 3 dBA (Kairos 2022-TN7912) and therefore could be perceptible to persons at the two sensitive locations. The applicant also notes that simultaneous operation of multiple types of construction equipment may result in perceptible noise increases for temporary periods (Kairos 2022-TN7912). The NRC staff reviewed the information provided in the ER and finds the applicant’s conclusions to be reasonable. The NRC staff further notes that any perceived noise increases would likely be typical of construction sites in industrial parks such as the Heritage Center, and that forest cover separating the industrial areas from the nearest residential areas would help blunt the noise even if the noise might be perceptible. This would also be true regarding any temporary increases in noise from construction vehicles and equipment using local roadways to access the Hermes site. The NRC staff expects that the noise resulting from building the proposed Hermes facilities would not be objectionable to the Oak Ridge community.

3.2.2.3 Environmental Impacts of Operation

Operation of equipment at the proposed Hermes facilities would generate noise typical of industrial activities, but most equipment generating noise would be enclosed within buildings such as the reactor building, auxiliary building, and maintenance and storage building, which would minimize outdoor noise generation (Kairos 2022-TN7912). Operation of some outdoor equipment such as heat exchange fans, exhaust and ventilation stacks, and vehicles could generate operational noise perceptible in the immediate vicinity of the site (Kairos 2022-TN7912). However, because the site is situated within an existing industrial park, the operational noises can be expected to blend into and be consistent with other operational noises typical of an industrial park. Additionally, the nearest residential areas are more than a mile distant and separated by forest land. Based on the setting of the operation within an existing industrial park and the distance to nearby sensitive noise receptors, and the presence of forest cover between the site and the receptors, the NRC staff expects that area residents and users of public facilities in the area would not notice the operational noises of the facilities.

3.2.2.4 Environmental Impacts of Decommissioning

Noise generation during decommissioning is expected to be similar to, or less than that during construction (Kairos 2021-TN7880 | Sec 4.2.2.3). The decommissioning impacts from noise would be bounded by the analyses in the decommissioning generic EIS (NRC 2002-TN7254). Based on the analysis summarized above for construction, and the expected similarity of decommissioning noise to construction noise, the NRC staff expects that the noise resulting from decommissioning the proposed Hermes facilities would be brief and temporary, and not objectionable to the Oak Ridge community.

3.2.2.5 Cumulative Impacts

Table 4.13-1 of the ER identifies past, present, and reasonably foreseeable future projects that could cumulatively contribute to the environmental impacts of the proposed action (Kairos 2021-TN7880). Key past and present actions affecting noise in the affected area include the Federal nuclear and energy development facilities on the ORR such as the Y-12 Plant and ORNL. Continued development of the Heritage Center can be expected to increase noise levels to those of a typical industrial park, as can continued development of the Horizon Center to the east. The most likely noticeable increase in noise in the surrounding lands would be from operation of the proposed general aviation airport south of the site. DOE's EA for transfer of land to build the proposed airport states that cumulative noise levels with the airport would remain below levels considered compatible with residential areas (65 dBA L_{dn}) (DOE 2016-TN7903 | Sec 3.3.2.1). Maps overlaying projected airport operational noise levels show that levels exceeding 55 dBA (L_{dn}) would be confined to areas within approximately 3,000 feet (ft) of the new runway, encompassing portions of the southern part of the East Tennessee Technology Park and some lands immediately straddling Highway 58 (TN7903 | Figure 3.2). Airport operational noise levels shown on the map for what is now the proposed Hermes site and the sensitive receptors considered by the Hermes ER are at or below 40 dBA L_{dn}, too low to substantially interact with noise generated by the Hermes facilities.

3.2.2.6 Conclusions

The NRC staff concludes that the potential direct, indirect, and cumulative land use impacts of the proposed action would be SMALL. Noise generated by use of pile driving equipment and multiple pieces of heavy construction equipment could be perceptible at some sensitive locations close to the site for brief periods, but the brief and temporary nature of the pile driver noise would likely prevent the noise from noticeably interfering with use and enjoyment of the affected properties. Otherwise, the noise generated by construction, operation, and decommissioning of the Hermes facilities would likely blend in with the expected noise levels expected from an active industrial park.

3.3 <u>Hydrogeology and Water Resources</u>

3.3.1 Hydrogeology

3.3.1.1 Affected Environment

The Hermes site is within the southwestern portion of the Valley and Ridge physiographic province. The province is characterized by a series of long, parallel ridges consisting primarily of limestone with interbedded shale and dolostone, and limestone bedrock following a northeast to southwest trend. The K-31/K-33 Area, which contains the proposed Hermes site, is underlain by bedrock of the upper Knox Group in the northern portion of the area, and the lower

Chickamauga Group formations occupy the southern portion of the area (DOE 2021-TN7913). Weathering of these limestones and dolomites has produced approximately 20 ft of silt, sand, and clay intermingled with alluvial material that is overlain by approximately 4 ft of undifferentiated fill. The bedrock of the Knox and Stones River Group ranges between 20 to 40 ft below the ground surface at the Hermes site (Figure 3-1).

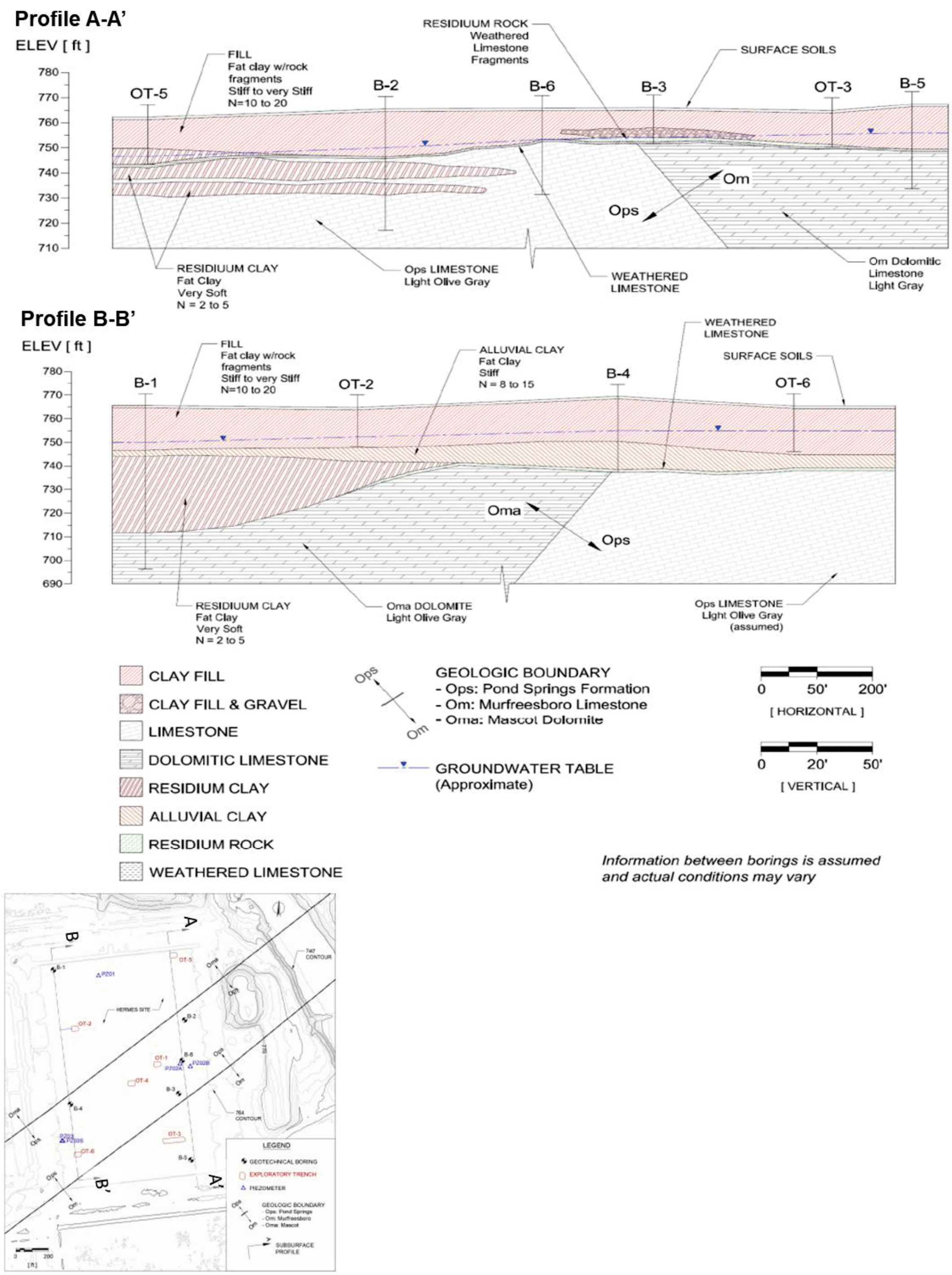

Figure 3-1 Cross-Sections A-A' and B-B' Across the Hermes Site. Source: Kairos 2021-TN7879

Surface soils were previously reworked to accommodate the K-31 and K-33 building construction and their subsequent demolition and removal. After decontamination, decommissioning, and demolition, the slabs of the former buildings were removed or grouted into place to accommodate reindustrialization of the Hermes site (Kairos 2021-TN7880 | Sec 3.3.3). Portions of the former building foundations have been encountered less than 12 ft below the ground surface (Kairos 2021-TN7880 | Sec 3.3.3.3). Recent investigations in the Hermes site area have included mapping of the K-25 site, a final remedial investigation of the East Tennessee Technology Park, an EA for the transfer of land and facilities within the East Tennessee Technology Park and surrounding area, and a K-31/K-33 groundwater remedial site evaluation report for the East Tennessee Technology Park (Kairos 2021-TN7880 | Sec 3.3.1). Geotechnical soil properties of the site soils are provided in the preliminary safety analysis report (PSAR) (Kairos 2021-TN7879 | Sec 2.5.2.2). Hermes site-specific investigations have included installation and evaluation of geotechnical borings, observation trenches, groundwater monitoring wells, and a laboratory testing program (Kairos 2021-TN7880 | Sec 3.3.3.3).

Primary potential geologic hazards within the Hermes site region include faults and sinkholes. Consistent with the northeast to southwest trending axis of the surface ridges and valleys, the faults follow a similar trend within the area of the Hermes site. Details of the local and regional seismicity are discussed in Section 2.5 of the PSAR (TN7879 | Sec 2.5). Preparation for construction of the K-31 and K-33 facilities in the early 1950s included minor leveling of the Hermes site and filling of karstic sinkholes (Kairos 2021-TN7880 | Sec 3.3.6). The Hermes site is not vulnerable to soil liquefaction, landslides, tsunamis, or volcanism due to the soil composition, geology, and surrounding geography of the site location.

3.3.1.2 Environmental Consequences of Construction

Building the proposed facilities would temporarily disturb approximately 138 ac of the site previously affected by industrial development and long-term operation. Primary effects on the geologic environment of deformation and disturbance would occur on a local scale due to excavation, exposure of potentially contaminated soils, and, if required for construction, bedrock blasting. The applicant stated that excavated material during Hermes site grading and construction would be stockpiled onsite and used as backfill, while unsuitable material would be placed as non-structural fill (Kairos 2021-TN7880 | Sec 4.3.2). The applicant anticipates that offsite borrow areas will not be needed (Kairos 2021-TN7880 | Sec 4.3.2). Construction effects would be temporary and localized. Before construction, topsoil would be removed, stockpiled or regraded, and potentially reused after decommissioning. Therefore, the common effects of construction on geology and soil resources from continued operation would be low.

The geology of the Hermes site and surrounding region is similar to the surrounding area with no rare or unique geologic resources, economically viable rock material, minerals, or energy resources, that could be affected. The potential for landslides and subsidence in Roane County is not considered high (Kairos 2021-TN7880 | Sec 4.3.1), and landslides on the relatively level Hermes site are very unlikely. The site has been previously disturbed during construction for the K-31/K-33 facilities. Anticipated construction on the Hermes site would not adversely affect the surface or subsurface geologic environment, given the applicant's implementation of grading permits and best management practices (BMPs) during grading, including a sediment and erosion control plan. Although the Hermes site area would be disturbed by excavation and grading, the disturbance would not be substantially greater than the disturbance from the previous construction and subsequent demolition of the former industrial buildings on the Hermes site.

For the Reactor Building and the Auxiliary Systems Building, the applicant anticipates an excavation depth of approximately 30 ft below a final grade of 765 ft. Utilities are anticipated to have a nominal depth of 5 ft below ground surface. The applicant estimated that other Hermes site buildings would have an excavation depth of approximately 10 ft below grade. An estimated total of approximately 113,000 cubic yards (cy or yd^3) of material would be excavated and reused onsite. The applicant stated that the final Hermes site grading is to be determined based on material excavated onsite; however, grading activities would be managed to have minimal impact on the existing site drainage and topography (Kairos 2022-TN7902). Any potentially contaminated soils encountered would be managed in coordination with the DOE requirements for the property (TN7902). Construction mitigation strategies including construction BMPs, development of a Storm Water Pollution Prevention Plan (SWPP) in accordance with the rules of the TDEC, and implementation of the necessary erosion control measures would effectively minimize the impacts of soil erosion and soil compaction. The NRC staff finds that the effects of construction on the geologic environment would likely be low given that the implementation of mitigation strategies will need to be in compliance with local building code requirements.

3.3.1.3 Environmental Consequences of Operation

Based on the NRC staff's evaluation of this CP application, no geologic resources would be used or altered during the four-year operational life of the facility; therefore, the facility would have a negligible effect on the geologic environment. At the OL stage, NRC staff will review the application for any new and significant information that might alter the staff's conclusions made for this CP application.

3.3.1.4 Environmental Consequences of Decommissioning

Based on the information provided in this CP application, decommissioning would have little effect on the geologic environment because the Hermes site is a brownfield undergoing reindustrialization in a previously disturbed industrial park. In addition to NRC requirements for decommissioning, applicable demolition permits and BMPs would minimize the effects of decommissioning impacts on the geologic environment. Therefore, the NRC staff determined that no mitigation is necessary to minimize adverse geological environment impacts.

3.3.1.5 Cumulative Impacts

Table 4.13-1 of the ER identifies past, present, and reasonably foreseeable future projects that could cumulatively contribute to the environmental impacts of the proposed action (Kairos 2021-TN7880). Soil erosion and sediment runoff is a typical effect of surface disturbances due to construction, operation, and decommissioning. Past, current, and reasonably foreseeable projects in the area would add to the total extent of disturbed soil permanently altering the building sites and soils. Within the Hermes site area, most of the proposed actions would take place in the reindustrialization area where similar construction of roads, parking lots, buildings, and utility lines has occurred or has been planned. The staff also recognizes that Kairos may build a planned fuel fabrication facility (referred to as Kairos Atlas Fuel Fabrication Facility or Atlas facility) on the same site as the Hermes reactor. The staff anticipates that the applicant would use the same construction BMPs described above in compliance with Federal, State and local environmental laws, rules, regulations and statutes in coordination with the DOE.

As with the adjacent Atlas facility, measures similar to those implemented at the proposed facility—such as securing appropriate construction and building permits and BMPs—would be applied at these nearby projects, including erosion and sediment control measures, further limiting the compounded impact. Neither the existing projects nor the proposed action would further contribute to impacts on the geologic environment because there are no identified sensitive or economic geologic resources in the area and the proposed facility would be located in a previously disturbed reindustrialized area.

3.3.1.6 Conclusions

The NRC staff concludes that the potential direct, indirect, and cumulative geological impacts of the proposed action would be SMALL. This conclusion is based primarily on the lack of disturbances to areas of natural terrain and the fact that the disturbances to geology and soils that will occur would be limited to previously disturbed industrial lands of low economic value as geologic resources. Reuse of former industrial land provides the economic benefits of the test reactor without requiring the disturbance of natural ground or areas of economically viable geologic resources that have not been previously disturbed.

3.3.2 Water Resources

3.3.2.1 Affected Environment

Hydrologically, the 185-ac Hermes site is bounded by Poplar Creek to the east and south, the Clinch River arm of the Watts Bar Reservoir and secondary drainage features including the K-901 Holding Pond to the west, and a rapid increase in topography from approximately 765 ft at the Hermes site to over 1,000 ft just north of the site. Poplar Creek is a part of the Clinch River arm of the Watts Bar Reservoir (Kairos 2021-TN7880 | Sec 3.4.1.1), whose water levels and flow patterns are controlled by the power generation and release schedules of the Watts Bar, Fort Loudon, and Melton Hill Dams. During past decontamination, decommissioning and demolition of the former industrial facilities on the Hermes site, the upper 10 ft of surface soils were removed. Within the area of the Hermes site, the shallow aquifer materials predominately consist of clay with sandy clay lenses of the alluvial fill (Figure 3-1). Beneath the shallow aquifer, a deeper groundwater zone consists of weathered bedrock grading to fractures and joints of the underlying competent bedrock. Groundwater flow directions on the Hermes site are influenced by runoff infiltration from the highlands to the north and subsequent discharge to nearby surface water bodies. As indicated by DOE studies (TN7913 | Figures 3.1 and 3.2), the highland infiltration creates a radial groundwater flow pattern toward Poplar Creek to the east, Clinch River to the south, and secondary surface water drainage features to the west and southwest. Subsequent regrading has resulted in a relatively flat site with no distinguishable surface water drainage features.

Considering the past industrial history of the Hermes site and surrounding area, the groundwater and adjacent surface water bodies in the area are expected to be of a poor quality. Poplar Creek and the Clinch River arm of the Watts Bar Reservoir are considered impaired waters, as listed by the EPA (EPA 2021-TN7914). Both surface water features are impaired by mercury and polychlorinated biphenyls (PCBs), while pesticides are also listed for the Clinch River arm of the Watts Bar Reservoir (Kairos 2021-TN7880 | Sec 3.4.3.1). The primary pollutant in soils and sediment is mercury. Historical industrial activities produced and used a variety of chemicals including VOCs, PCBs, and radionuclides (primarily uranium, tritium and strontium-90), which remain present at low concentrations in groundwater on the Hermes site and in the surrounding area. The DOE continues to monitor surface water and groundwater at various locations (DOE 2021-TN7913 | Figure 2.2, DOE 2021-TN7915 | Figure 3.24) within the

Hermes site area. The applicant does not intend to use onsite groundwater for construction, operation, or decommissioning (Kairos 2021-TN7880 | Sec 3.4.2.2).

For groundwater monitoring, the applicant will implement a quarterly radiological environmental monitoring plan consistent with NUREG-1301 (TN5758, TN7879 | Sec 11.1.7), complementing existing DOE sampling locations (TN7913, Figure 2.2 and TN7915, Figure 3.24) and monitoring obligations within the Hermes site area (Kairos 2021-TN7880 | Sec 4.8.3.2, TN7902). Neither the surficial nor bedrock aquifers at or near the Hermes site are classified as EPA sole source aquifers (EAP 2022-TN7916). The applicant stated that there would be no liquid effluent release pathways and consequently no detectable radionuclides released to surface waters (Kairos 2021-TN7880 | Sec 4.8.3.2). Therefore, surface water monitoring is not included in the applicant's radiological environmental monitoring plan.

Within Roane County, over 70 percent of the water supply is derived from surface water sources and the remainder from groundwater. Within the area of the Hermes site, potable water is supplied through the City of Oak Ridge Public Works Department by way of Melton Hill Lake. The applicant estimated the total daily demand for water to be approximately 49 gallons per minute (gpm) or 0.07 million gallons per day (mgd), with an infrequent fire suppression system requirement of 3,170 gpm (4.56 mgd) and an associated makeup requirement of 793 gpm (1.14 mgd) within eight hours (Kairos 2021-TN7880 | Sec 3.4.2.3) for a static total storage requirement of approximately 380,400 gallons (gal). (Kairos 2022-TN7902). The applicant would not directly use any raw surface water or groundwater (Kairos 2021-TN7880 | Sec 4.4.2). Formerly owned and operated by the DOE, the City of Oak Ridge has owned and operated the current water supply treatment plant since 2000 (Kairos 2021-TN7880 | Sec 4.4.2.1). The City of Oak Ridge plans to design and construct a new ultrafiltration membrane drinking water treatment plant to replace the several decades old conventional treatment plant, which is currently at capacity and beyond its useful life (EAP 2022-TN7916). The new plant will have the capacity to treat up to 16 mgd with completion and operation targeted to occur in 2025 (Kairos 2021-TN7880 | Sec 3.4.2.1).

The Clinch River Industrial Park, the East Tennessee Technology Park, Horizon Center, and Rarity Ridge are served by the Rarity Ridge Wastewater Treatment Plant (WWTP), which has a wastewater treatment capacity of 0.6 mgd. Correspondingly, the applicant's proposed facilities within the East Tennessee Technology Park would be served by the Rarity Ridge WWTP. Currently the Rarity Ridge WWTP operates at peak (0.6 mgd) capacity during wet weather; however, the applicant stated that the City of Oak Ridge is currently working toward reducing inflow and infiltration coming into the WWTP (Kairos 2021-TN7880 | Sec 5.2). To date, the Oak Ridge Public Works Department has continued to make progress in reducing unnecessary inflow and treatment of rainfall runoff, thereby preserving the capacities of the existing WWTPs (NRC 2022-TN7955). Under a capacity, management, operation, and maintenance program for upkeep of sewer collection systems, the City of Oak Ridge plans to evaluate the timing of a Rarity Ridge WWTP expansion during fiscal year 2022 (City of Oak Ridge 2021-TN7917).

Given the planned expansion of the City of Oak Ridge's municipal water supply and wastewater treatment improvement program, municipal capacities would be sufficient for the anticipated water supply and water treatment requirements for the planned facilities. The NRC staff confirmed that the Oak Ridge Public Works Department has sufficient capacity to meet the water supply and wastewater treatment requirements of the proposed facility (NRC 2022-TN7955).

3.3.2.2 Environmental Consequences of Construction

Building the proposed facilities would involve temporary disturbance of approximately 138 ac on the Hermes site (Kairos 2021-TN7880 | Sec 4.5.1.3). The applicant would use approximately 30 ac of the previously developed land for the proposed plant and associated facilities. The applicant anticipates an excavation depth of approximately 30 ft below a finished grade of 765 ft for the Reactor Building and the Auxiliary Systems Building. Other ancillary buildings would be excavated to an estimated depth of approximately 10 ft below grade (Kairos 2021-TN7880 | Sec 4.3.2). The water table is approximately 6 to 8 ft below the anticipated approximate finished grade of 765 ft.

Groundwater would not be used during construction activities but may be extracted as a consequence of dewatering for the Reactor Building and the Auxiliary Systems Building excavation because these excavations are anticipated to be up to 30 ft deep (Kairos 2021-TN7880 | Sec 4.3.2). Using site-specific parameters derived from field studies, the applicant has estimated a total dewatering upper bound of approximately 2.2 million gal over an approximately 30-day foundation construction period (Kairos 2022-TN7902). Because the Hermes site is hydraulically bounded by Poplar Creek and the Clinch River arm of the Watts Bar Reservoir, the NRC staff determined that the influence of dewatering would be limited to the shallow groundwater system on the site and that the effects would be negligible at offsite locations. Because of past industrial activities at the Hermes site, the quit claim deed includes a site prohibition for use of groundwater in any way unless such use is approved by the DOE, EPA, and TDEC (Kairos 2021-TN7880 | Sec 4.4.1.1). The dewatering action would have minimal effects on the surrounding surface water quality because of BMPs, the TDEC stormwater discharge permit restrictions, and the regulatory oversight of extracted water as managed by the DOE, EPA, and the TDEC. The storm-water discharge permit would prescribe the amount of any surface water discharge and establish the parameters to minimize impacts on the surrounding waters (Kairos 2021-TN7880 | Sec 4.4.1.1) in compliance with EPA, TDEC, and DOE requirements (TN7902).

In ER Table 1.3-1, the applicant summarized the Federal, State and local regulations and permits applicable to surface water hydrology and quality applicable to construction, operation and decommissioning for the project (Kairos 2021-TN7880 | Sec 4.4.1.1). Although the Hermes site will be temporarily disturbed by construction activities, there are no distinguishable surface water features on the site that could be affected. There are no discernible surface water features draining the Hermes site and the majority of rainfall runoff flows directly to Poplar Creek and to the K-901-A Holding Pond (Kairos 2021-TN7880 | Sec 3.5.2). No direct use of raw surface water or groundwater would be used during the Hermes site construction. Adherence to DOE, EPA, and TDEC quit claim deed requirements, BMPs, and implementation of a SWPP and associated permits during construction would result in minimal effects on the groundwater and surface water quality surrounding the Hermes site. Based on its review of the ER, the NRC staff expects that building the proposed facilities would have at most minimal impacts on water resources on or near the Hermes site.

3.3.2.3 Environmental Consequences of Operation

Impacts on water resources from the proposed four-year period of operation would be similar to those described above for the period of construction. As described by the applicant, groundwater withdrawal and dewatering discharge during operation would not be required (Kairos 2021-TN7880 | Sec 4.4.1.1). No raw surface water or groundwater would be used for Hermes site operation and the City of Oak Ridge would supply the site with potable water.

Based on an estimated daily water use of approximately 48 gpm (0.07 mgd) for the plant and the City of Oak Ridge's pending construction and completion of a new water treatment plant with a capacity of 16 mgd, the proposed facility would have sufficient potable water supply. Periodic supply to the fire suppression system would include an initial fill and occasional makeup water refill (Kairos 2021-TN7880 | Sec 3.4.2.3). The City of Oak Ridge municipal supply system would provide for the initial and any required subsequent refills of the fire suppression storage system. With the facility's water supply provided by the City of Oak Ridge, and demineralized water trucked into the facility, the applicant would have no need for a raw surface water supply or surface water cooling intake (Kairos 2021-TN7880 | Sec 6.3.3). Consistent with other facilities within the East Tennessee Technology Park, wastewater service for the proposed facility would be provided by the City of Oak Ridge (NRC 2022-TN7955 | personal communication) and the applicant anticipates no direct discharge to surface water bodies (Kairos 2021-TN7880 | Sec 6.3.3). Stormwater BMPs combined with the required permitting for stormwater management, including initial discharge to an onsite stormwater pond and later release to Poplar Creek, would minimize the effects of Hermes site runoff. Therefore, the applicant does not propose any mitigation (Kairos 2021-TN7880 | Sec 4.4.1), and the NRC staff finds that none is necessary to minimize adverse water resource impacts based on the NRC staff's evaluation of this CP application. At the OL stage, NRC staff will review the application for any new and significant information that might alter the staff's conclusions made about this CP application.

3.3.2.4 Environmental Consequences of Decommissioning

The applicant noted that no decommissioning activities would occur in the surface water bodies of Poplar Creek or the Clinch River (Kairos 2021-TN7880 | Sec 4.4.1). As stated by the applicant, an SWPP similar to that required by construction, including a sediment and erosional control plan, would be required for decommissioning and the existing stormwater retention pond used during operation could be used for decommissioning (Kairos 2021-TN7880 | Sec 4.4.1). Although no groundwater would be used onsite, dewatering may be needed to complete removal of building foundations. As previously discussed, the extraction, consumption, and exposure to or the use of groundwater on the Hermes site requires approval from the DOE, EPA, and the TDEC (Kairos 2021-TN7880 | Sec 4.4.1). Depending on the duration and volume of groundwater extracted, minor impacts could be associated with discharges of the extracted groundwater to Poplar Creek; however, the extraction of groundwater would be managed in compliance with the DOE, EPA, and TDEC permitting requirements (TN7902). The NRC staff expects that decommissioning impacts on water resources would be bounded by the analyses in the decommissioning generic EIS (NRC 2002-TN7254 | Supplement 1) and the stormwater discharge permit requirements for discharge and quality of stormwater. The applicant does not propose any mitigation (Kairos 2021-TN7880 | Sec 4.4.1), and the NRC staff finds at this time that none is necessary to minimize adverse water resource impacts based on the evaluation of this CP application.

3.3.2.5 Cumulative Impacts

Table 4.13-1 of the ER identifies past, present, and reasonably foreseeable future projects that could cumulatively contribute to the environmental impacts of the proposed action (Kairos 2021-TN7880). Key past and present actions affecting water resources in the Hermes site area include the Federal nuclear and energy development facilities on the Oak Ridge Reservation such as the Y-12 Plant and ORNL; the residential and commercial areas in the City of Oak Ridge; multiple energy and industrial park projects; a planned General Aviation Airport 1.1 mi east of the Hermes site; a large housing development, (the Preserve at Clinch River), currently undergoing construction approximately 2 mi west of the site; and other land use features of a suburban or semi-rural landscape. Construction, operation, and decommissioning actions for the proposed Hermes facilities or the planned Atlas facility adjacent to the Hermes site would not directly use groundwater or surface water. The Atlas facility is anticipated to use the same BMPs in compliance with Federal, State and local environmental laws, rules, regulations and statutes in coordination with the DOE. Therefore, the staff finds that the proposed action would implement appropriate stormwater management, spill prevention and response plans, an environmental monitoring program, and comply with stormwater permit requirements including the SWPP. Further, because the proposed action would be built and operated within an existing industrial park, the NRC staff finds it would not contribute to the adverse cumulative impacts on groundwater or surface water resources in Poplar Creek or in the Clinch River arm of the Watts Bar Reservoir.

3.3.2.6 Conclusions

The NRC staff concludes that the potential direct, indirect, and cumulative water resource impacts of the proposed action would be SMALL. This conclusion is based primarily on the fact that the water demands of the Hermes facilities would be met through municipal or commercial suppliers, there would be no direct groundwater or surface or water use, and that disturbances to groundwater from potential dewatering would be temporary and localized to the hydrologically isolated onsite shallow aquifer in accordance with BMPs and the required permits. The NRC staff recognizes that there could be minor impacts on the municipal water supply due to the relatively small increased daily demand of the facility (0.07 mgd); however, the planned increases in the City of Oak Ridge's municipal water supply and existing wastewater treatment capacity would be adequate to service the facility and the future water treatment plant would create additional reserve capacity. Given the municipal water supply source and the low water demands of the Hermes project, the proposed facilities would result in minimal effects on aquifers and surface water bodies.

3.4 Ecological Resources

3.4.1 Affected Environment

The site is situated in the Southern Limestone/Dolomite Valley and Low Rolling Hills ecoregion, which is characterized by limestone and cherty dolomite with rolling ridges and valleys with soils of varying productivity (Kairos 2021-TN7880 │ Sec 3.5.1). Section 3.5.7.1 of the ER describes terrestrial habitats on the site (Kairos 2021-TN7880). The 185 ac site consists of 88 ac of developed land, 72 ac of herbaceous grassland, 19 ac of deciduous forest, and 6 ac of mixed evergreen/deciduous forest. As seen in Figure 3.1-1 of the ER (Kairos 2021-TN7880), the developed land and herbaceous grassland correspond mostly to lands previously occupied by former DOE Buildings K-31 and K-33, while the forested land occurs only in perimeter areas on riparian lands separating the previously developed lands from Poplar Creek. The ER notes that the only wetland on the site occurs in the forested perimeter lands adjoining Poplar Creek, and that none occurs in the previously disturbed lands that formerly accommodated DOE Buildings K-31 and K-33 (Kairos 2021-TN7880 │ Sec 3.5.6 and Figure 3.5-2). The NRC staff accessed the online National Wetlands Inventory mapper maintained by the U.S. Fish and Wildlife Service (FWS) on March 9, 2022; and the mapper showed only one wetland on or adjacent to the site, the channel of Poplar Creek, but it did not show the wetlands mentioned in the ER (FWS 2022-TN5327). There are no aquatic habitats on the site, although the site adjoins Poplar Creek, a tributary to the Clinch River arm of Watts Bar Reservoir (Kairos 2021-TN7880 │ Sec 3.5.5).

A 17 ac holding pond (K-901-A Holding Pond) is approximately 700 ft west-southwest of the site (Kairos 2021-TN7880 │ Sec 3.5.5.3).

Given its industrial history, the site can be expected to provide poor quality ecological habitat (Kairos 2021-TN7880 │ Sec 3.5.2). The developed and grassland areas on the site consist of grasses and forbs typical of previously disturbed soils, as characterized in Section 3.5.7.1 of the ER (Kairos 2021-TN7880). Terrestrial wildlife expected to occur on the site—including mammals, birds, reptiles, and amphibians—is described in Section 3.5.7.2 of the ER (Kairos 2021-TN7880). Species of wildlife expected in the previously developed lands formerly occupied by DOE Buildings K-31 and K-33 are the regionally abundant species typical of open field habitats. The applicant characterizes the aquatic biota of the Clinch River arm of the Watts Bar Reservoir; including fish, benthic macroinvertebrates, and plankton; in Section 3.5.5.1 of the ER. Because the reach of Poplar Creek adjoining the site is influenced by water levels in the reservoir, the applicant posits in Section 3.5.5.2 of the ER that the aquatic habitat in that part of the creek can be expected to be similar. Due to the history of disturbance on the site and surrounding areas, and in the adjoining reach of Poplar Creek, the terrestrial and aquatic biota in the area has been substantially influenced by invasive species (Kairos 2021-TN7880 │ Sec 3.5.8). The applicant also describes aquatic biota in the K-901 Holding Pond in Section 3.5.5.3 of the ER, but the Hermes project is unlikely to affect this pond, which is located approximately 700 ft away from the site. The applicant summarizes the history of ecological monitoring by DOE under the ORR Biological Monitoring and Abatement Program in Section 3.5.10 of the ER.

Section 3.5.11 of the ER identifies and characterizes species protected under Federal and State regulations based on a review of databases maintained by the FWS and TDEC (Kairos 2021-TN7880). Species addressed include those listed as threatened or endangered under the Federal Endangered Species Act (ESA) (TN1010) (or designated with another special Federal status), species designated with a State protected status, migratory birds protected under the Migratory Bird Treaty Act, and eagles protected under the Bald and Golden Eagle Protection Act. Each species with a Federal or State protected status is listed in Table 3.5-2 of the ER (Kairos 2021-TN7880). The applicant accessed the FWS Information for Planning and Consultation (IPaC) database on May 24, 2021, to identify Federally listed species and habitats for purposes of preparing the ER. The NRC staff accessed the database independently on February 24, 2022, and received similar results. Both the applicant and NRC staff used the 185 ac site as the action area for the IPaC search because the site is a large lot within an established industrial park (the Heritage Center within the East Tennessee Technology Park). The action area therefore encompasses the lands previously distributed by former DOE operations, but for conservatism also includes the slivers of riparian forested land on the site bordering Poplar Creek that might be affected by project-related noise. Neither the applicant nor the NRC staff extended the action area beyond the site boundary because it would then encompass areas distinctly different from those actually affected by the Hermes project.

The IPaC searches indicate that four Federally listed endangered species, four Federally listed threatened species, and one Federal candidate species could potentially occur at the site. The endangered species include two mammal species, the gray bat (*Myotis grisescens*) and Indiana bat (*M. soldalis*); and two freshwater clam species, the finerayed pigtoe (*Fusconaia cuneolus*) and shiny pigtoe (*F. cor*). The threatened species include one bat species, the northern long-eared bat (*M. septentrionalis*); one fish species, the spotfin chub (*Erimonax monachus*); and two plant species, the Virginia spiraea (*Spiraea virginiana*) and white fringeless orchid (*Platanthera integrilabia*).

A biological assessment (BA) recently completed for the nearby CRN site (NRC 2019-TN6136 | Appendix M), approximately 2 mi south of the Hermes site, addresses the gray bat, Indiana bat, and northern long-eared bat. For each of the three bat species, the BA characterizes the range, status and threats, life history, and baseline data from past field surveys in the region. According to the BA, gray bats hibernate in deep caves during the winter but disperse within the protection of forest canopy to a broader variety of caves during the rest of the year to form maternity colonies. Indiana and northern long-eared bats also hibernate in caves (the latter also in mines or human-made structures) and disperse to forested areas to form maternity roosts in trees. The BA reports the results of past field studies, including mist netting studies and acoustic studies, for the three bat species in the Oak Ridge area. Based on information in the BA, the NRC staff expects that each of the three bat species may potentially forage, and thus could be transiently present anywhere in the Oak Ridge area. However, the absence of trees or vegetation other than ruderal vegetation in the area where the Hermes facilities would be sited suggests that even transient presence in the affected area is unlikely. The 135 ac of land potentially subject to temporary or permanent disturbance for building, operating, and decommissioning the Hermes facilities contains trees and thus lacks any potential roost or maternity trees.

The NRC staff recognizes that the subject bat and plant species would be unlikely to occur anywhere in the action area other than in the forest and other riparian vegetation separating the project lands from Poplar Creek, and that the only part of the action area where the clam and fish species could occur is the channel of Poplar Creek. The searches did not indicate the presence of critical habitat identified under the ESA.

The NRC staff initiated its own informal consultation under ESA Section 7 through written correspondence with the FWS dated March 10, 2022 (NRC 2022-TN7918). The staff received an E-mail from FWS dated April 15, 2022 (FWS 2022-TN7956) requesting that NRC include in this draft EIS a biological evaluation addressing the potential impacts from the Hermes project to potentially affected resources covered by the Endangered Species Act. Table 3-4, together with information included in the subsections below, constitute the NRC staff's biological evaluation. The staff is presently working with FWS to close the consultation process.

3.4.2 Environmental Consequences of Construction

Building the proposed facilities would involve temporary disturbance of approximately 138 ac on the site, of which 58 ac consist of herbaceous grassland and the remainder consists of existing developed land (Kairos 2021-TN7880 | Table 4.5-1). As depicted in Figure 2.2-1 of the ER (Kairos 2021-TN7880), no naturally vegetated land would be disturbed, including the deciduous and mixed evergreen/deciduous forest on the site. Approximately 30 ac of the temporarily disturbed herbaceous grassland would be permanently converted to industrial land cover. Because all of the disturbed vegetation occupies previously disturbed soils, the disturbances would not further promote establishment of invasive species. The applicant plans to restore herbaceous grassland to the remaining temporarily disturbed land (Kairos 2021-TN7880 | Sec 4.5.1.3). No wetlands or aquatic habitats would be disturbed (Kairos 2021-TN7880 | Sec 4.5.1.2). The applicant proposes to manage stormwater on the site using BMPs as required by the TDEC (Kairos 2021-TN7880 | Sec 4.5.1.2). Common BMPs for managing stormwater runoff into aquatic habitats near construction sites include the use of silt fences, vegetative stabilization of exposed soils, and stormwater ponds. Because of the historical disturbance of the affected land and the lack of disturbance to forest and other natural vegetation, wetlands, or aquatic habitat, the NRC staff expects that effects on terrestrial wildlife habitats would be minimal.

Mobile terrestrial wildlife can be expected to avoid areas where construction equipment is in use (Kairos 2021-TN7880 │ Sec 4.5.1.3). Less mobile wildlife could be injured or killed by equipment, but because of the low-quality of the affected habitat, any losses are unlikely to be ecologically substantial. Birds might be injured or killed by collision with tall structures or equipment such as construction cranes (Kairos 2021-TN7880 │ Sec 4.5.1.3), but a recent literature review by the NRC staff indicates that bird collisions with structures at nuclear power sites are generally not substantive (NRC 2013-TN2654 │ Sec 4.6.1.1). That review focused on structures such as natural draft cooling towers, communications towers, or electric transmission lines that are taller or pose a greater risk to birds than the structures proposed for the Hermes project. The proposed Hermes project would not include any cooling towers or transmission lines. The NRC staff also recognizes that vehicles using roads to access and traverse the site could injure or kill wildlife; but considering the low number of projected site workers and the already disturbed character of the habitats on the site and nearby portions of the East Tennessee Technology Park, vehicular collisions with wildlife would likely be too infrequent to noticeably affect regional populations. Overall, the NRC staff recognizes that the ecological quality of habitat affected by the Hermes project is low and that the potential effects on wildlife are likewise low.

The applicant indicated that excavation to build the Hermes reactor would necessitate temporary dewatering of the excavation pit (Kairos 2021-TN7880 │ Sec 4.4.1.1.1). The applicant confirmed that the dewatering would involve no more than 2.2 million gal over a period of approximately 30 days (Kairos 2022-TN7902). The applicant confirmed that the dewatered groundwater would be transported offsite for disposal or would be treated onsite and returned to the groundwater in accordance with applicable EPA, DOE, and State of Tennessee requirements (TN7902). The dewatering could temporarily reduce water levels in wetlands in nearby forested riparian lands bordering Poplar Creek, but any effects would be temporary. These brief and temporary effects on water levels in the wetlands would be less severe than expected from short droughts that commonly occur as part of the natural hydroperiod of the wetlands. Because of the brevity of the effects, the functional characteristics and habitat quality of the affected wetlands are unlikely to be changed.

The applicant acknowledges that building the Hermes facilities would result in a localized, minor, and temporary increase in noise that may be noticeable to wildlife on or close to the site (Kairos 2021-TN7880 │ Sec 4.5.2.3). The applicant describes most noise as being within 3 dbA of ambient noise 1 mi from the site (Kairos 2021-TN7880 │ Table 4.2-3), but recognizes that temporary periods of greater noise would occur even at that distance when some construction equipment such as pile drivers are in use, or when multiple pieces of construction equipment are in use simultaneously (Kairos 2021-TN7880 │ Sec 4.2.2). The NRC staff recognizes that wildlife using the fragments of forested habitat remaining within the East Tennessee Technology Park might experience occasional periods of elevated noise that could cause startle responses or cause wildlife to avoid some areas for brief periods of time. But the staff also recognizes that the habitat quality within the East Tennessee Technology Park, including within the remaining fragments of forested habitat within the East Tennessee Technology Park, is not of high-quality and that large areas of superior habitat are available outside of the East Tennessee Technology Park for displaced wildlife. Furthermore, the affected wildlife is likely already acclimated to noise from other ongoing industrial and urban activity within the East Tennessee Technology Park.

Although Federally and State-listed protected species are present in forested and other naturally vegetated lands and in water bodies near the site (Kairos 2021-TN7880 │ Sec 4.5.2.1), no habitat potentially suitable for those species would be disturbed. All of the protected species noted as occurring in Roane County in Table 3.5-2 of the ER (Kairos 2021-TN7880) require aquatic, wetland, or other naturally vegetated habitats that would not be disturbed by building the proposed new facilities. The applicant states that no Federally protected plant species has been observed on the site and that only one Federally listed species has a greater than low potential to occur on the site, the endangered Indiana bat; but the applicant explains that there are no trees of species favorable to the Indiana bat in the adjoining riparian lands along Poplar Creek (Kairos 2021-TN7880 | Sec 4.5.1.5).

Based on its review of the project, the NRC staff expects that building the proposed facilities may affect, but is not likely to adversely affect, certain species listed as threatened or endangered under the ESA (Table 3-4). Preparing the site and building the Hermes facilities would not disturb any trees, forest cover, or natural vegetation and therefore would have little potential to adversely affect the three Federally-listed bats or two listed plants identified in the IPaC searches. The three bat species all hibernate in caves and when dispersing from the caves move, roost, breed, and forage in forested and semi-forested areas, not in large, developed areas without trees (NRC 2019-TN6136 | Appendix M) such as the area where the Hermes facilities would be built and operated (see Table 3-4 for more information). Noise from building the Hermes facilities could be audible to bats transiently present while foraging in forested areas along Poplar Creek, but those thin fragments of habitat are unlikely to attract bats for extended time periods. The project would also have little potential to adversely affect the monarch butterfly, an insect species identified in the IPaC searches as a Federally listed candidate species that could potentially be transiently present in the area. Because the project would not withdraw or discharge cooling water or industrial process water (see Section 3.3 of this draft EIS) or disturb surface water or shoreline habitats, it would have no potential to adversely affect the two listed clam species or the listed fish species. As indicated above, the NRC staff initiated informal consultation under Section 7 of the ESA through written correspondence with the FWS dated March 10, 2022 (NRC 2022-TN7918). The NRC staff is working with FWS as appropriate to close the consultation process.

3.4.3 Environmental Consequences of Operation

Impacts on ecological resources from the proposed 4 years of operation of the completed facilities would be less than those described above for the construction period. Only about 30 ac of former terrestrial habitat, all presently supporting herbaceous grassland within the former footprint of DOE Building K-33, would remain occupied by the Hermes facilities during the operational period. No additional land, and hence no additional habitat, would be physically disturbed by operation. Noise generation would affect wildlife in the same way as described above for construction but would not include brief periods of higher noise generation using exceptionally noisy equipment such as pile drivers. The potential for bird collisions with structures would be as described above for construction. The applicant would use occasional applications of herbicides in developed areas on the site for lawn maintenance and to control weeds (Kairos 2021-TN7880 | Sec 4.5.2.3). Use of properly labeled herbicides in developed areas in accordance with instructions on the label is unlikely to adversely affect nearby habitats. The applicant does not propose any mitigation measures (Kairos 2021-TN7880 | Sec 4.5.2.5), and the NRC staff expects the effects from operation to be minimal, so no mitigation would be necessary to minimize adverse ecological impacts. Because operations would not disturb natural terrestrial or aquatic habitats and would have little potential to affect wildlife through noise or collisions, they would have little potential to adversely affect threatened or endangered species.

3.4.4 Environmental Consequences of Decommissioning

The applicant reports that ecological impacts from decommissioning would be similar to those from construction (Kairos 2021-TN7880 │ Sec 4.5.3). The NRC staff expects that land disturbance during decommissioning would take place mostly within already developed areas within the 30 ac area permanently occupied by the proposed new facilities but may require exterior storage of debris or equipment in adjoining exterior areas of previously disturbed soils on the 185 ac site. The NRC staff also expects that noise generated during decommissioning may involve intermittent generation of higher noise levels than during operation as buildings and structures are demolished, with effects on wildlife as described above for construction. Additionally, the NRC staff expects that decommissioning impacts on ecological resources on the site would be bounded by the analyses in the decommissioning generic EIS (NRC 2002-TN7254 │ Supplement 1). Although the generic conclusion does not extend to offsite ecological impacts from decommissioning, the offsite impacts would be minimal for the reasons indicated above. The applicant does not propose any mitigation measures (Kairos 2021-TN7880 │ Sec 4.5.3), and the NRC staff feels that the effects from operations would be so minimal that no mitigation is necessary to minimize adverse ecological impacts. Decommissioning would have no more potential than construction to affect threatened or endangered species.

3.4.5 Cumulative Impacts

Table 4.13-1 of the ER identifies past, present, and reasonably foreseeable future projects that could cumulatively contribute to the environmental impacts of the proposed action (Kairos 2021-TN7880). Key past and present actions affecting ecological resources in the affected area include the Federal nuclear and energy development facilities on the ORR such as the Y-12 Plant, ORNL, and other energy research facilities; the residential and commercial areas in the original townsite of the City of Oak Ridge; multiple energy and industrial park projects; a large housing development presently undergoing construction approximately 2 mi west of the site (called “the Preserve at Clinch River”); and other land use features of a suburban or semi-rural landscape. Key reasonably foreseeable proposed projects in the region include the Horizon Center on former ORR forest land approximately 2.3 mi northeast of the site (for which DOE has excessed land to the City of Oak Ridge and roadways have been built), anticipated industrial development of other previously developed land in the Heritage Center, and a proposed general aviation airport approximately 1.1 mi south and east of the site. If the applicant were to build the Atlas facility on the site, it would only affect the herbaceous grassland and developed land formerly disturbed by DOE Buildings K-31 and K-33 and therefore would not further contribute to loss or degradation of ecological habitats. Because of the close proximity of the Hermes and Atlas facilities, the addition of the Atlas facility would not likely alter the patterns of noise and physical obstructions experienced by wildlife.

Past and present urban and industrial development in the surrounding area has already resulted in a landscape of fragmented areas of forest and other terrestrial habitats. The proposed action would not further contribute to this fragmentation because it would be sited entirely within an existing developed area. The new facilities, especially the proposed airport (DOE 2016-TN7903), would contribute noise, artificial light, and wildlife hazards to some natural habitats to the south of the site but would not result in substantial decreases in the overall quality of nearby habitats. Building the airport would also result in the loss of approximately 132 ac of forested, riparian, shrub, and grassy areas, but DOE notes that the losses would constitute only a small percentage of similar habitats in the surrounding area and would affect mostly areas already influenced by development in the East Tennessee Technology Park. Because the proposed action would not involve physical disturbance of aquatic, wetland, or riparian habitats and not involve withdrawals or discharges of water to aquatic habitats, it would not cumulatively contribute to degradation of aquatic habitats in Poplar Creek, the Clinch River arm of the Watts Bar Reservoir, or other water bodies in the area.

3.4.6 Conclusions

The NRC staff concludes that the potential direct, indirect, and cumulative ecological impacts of the proposed action would be SMALL. This conclusion is based primarily on the proposed action not physically disturbing aquatic, shoreline, or wetland habitats or natural terrestrial vegetation; the location of the site within an existing industrial park; and disturbances being limited to herbaceous grassland in previously disturbed industrial lands of low value as wildlife habitat. Reuse of former industrial land within an existing industrial park setting provides the economic benefits of the test reactor without requiring the disturbance of sensitive terrestrial or aquatic habitats that have not been previously disturbed. The staff recognizes that there could be minor effects from noise and lighting on terrestrial wildlife in habitats elsewhere surrounding the site, but the affected habitats are of low quality because of their proximity to other industrial activity and the affected wildlife can be expected to acclimate to the noise and lighting conditions. In particular, the staff recognizes the anticipated effects on surrounding habitats from future construction and operation of a new regional airport but does not expect the proposed action to substantially contribute to those effects. The staff recognizes that because no naturally vegetated areas would be disturbed, no special maintenance or conservation practices or mitigation measures (beyond BMPs typically employed for soil erosion and sediment control and for stormwater management) would be necessary to protect ecological resources.

Table 3-4 below presents the NRC staff's biological evaluation, prepared for review by the FWS under Section 7 of the ESA, of the possible effects of the Hermes project on Federally listed species potentially occurring in an action area consisting of the 185 ac Hermes site. For conservatism, the action area for the biological evaluation encompasses the entire site, including strips of riparian forest on the site that would not be physically disturbed by the project. All project work would be confined to lands previously disturbed by former DOE Buildings K-31 and K-33 and currently being used for exterior industrial storage or herbaceous grasslands planted to stabilize previously disturbed soils. The NRC staff used the same conclusion terminology used by the FWS when responding to consultation requests under Section 7 of the ESA. The NRC staff concluded that the Hermes project may affect, but is not likely to adversely affect, or would have no effect, on each of the species considered.

Table 3-4 Biological Evaluation of Federally Listed Species from Proposed Kairos Hermes Project

Species	Federal Status	NRC Staff Evaluation	Conclusion
Gray bat (*Myotis grisescens*)	Endangered	Baseline information: Flying mammal. Hibernates and breeds in caves, such as those that occur in undeveloped lands in the karst landscape located in the Oak Ridge area (NRC 2019-TN6136 | Sec M.6.1.1). Moves and forages under forest cover (NRC 2019-TN6136 | Sec M.6.1.1). Factors contributing to population declines include human disturbance of the hibernacula, flooding, and use of pesticides (NRC 2019-	May affect, but not likely to adversely affect (MA-NLAA)

Species	Federal Status	NRC Staff Evaluation	Conclusion
		TN6136 │ Sec M.6.1.1). May be susceptible to white nose disease, a fatal fungal disease that infects hibernating bats (NRC 2019-TN6136 │ Sec M.6.1.1) and observed through frequent mist net and acoustic study-based observations conducted in Oak Ridge area from 2000–2015 (NRC 2019-TN6136 │ Sec M.6.1.1). Impacts: May forage transiently in riparian forest along Poplar Creek. Unlikely to enter lands where the Hermes facilities would be built, operated, and decommissioned, because those lands are not currently forested (or contain trees) and would not be forested or contain trees for the duration of the Hermes life cycle. Bats are expected to avoid areas of human activity, so the potential for injuries is minimal.	
Indiana bat (*M. soldalis*)	Endangered	Baseline information: Flying mammal. Hibernates in caves and mines and forms maternity roosts in mature trees over 5-in diameter at breast height, especially trees with exfoliating barks (NRC 2019-TN6136 │ Sec M.6.1.2). Roosts and forages in forested or semi-forested areas (NRC 2019-TN6136 │ Sec M.6.1.2). Threats include disturbance to the hibernacula, loss and fragmentation of forested swarming and staging habitat, chemical contaminants, collision with wind turbines, and white nose disease (NRC 2019-TN6136 │ Sec M.6.1.2). Closest known maternity roost in Blount County, TN, is roughly 30 mi away (NRC 2019-TN6136 │ Sec M.6.1.2). One or more individuals were detected acoustically in forested areas at CRN site in 2013, but maternal roosting is not suspected (NRC 2019-TN6136 │ Sec M.6.1.2). Impacts: May forage transiently in the riparian forest along Poplar Creek. Expected to avoid lands where the Hermes project would be built, which presently contain only ruderal vegetation of no foraging value.	MA-NLAA
Fine-rayed pigtoe (*Fusconaia cuneolus*)	Endangered	Baseline information: Freshwater mollusk. Prefer substrate in streams with running water. Unlikely to thrive in stream channels influenced by	MA-NLAA

Species	Federal Status	NRC Staff Evaluation	Conclusion
		impoundments such as Poplar Creek, adjacent to the Hermes site. Impacts: Hermes project would not involve physical disturbances of aquatic or riparian habitats. Water demands would be met by municipal or commercial suppliers. BMPs to control sedimentation and runoff. Stormwater on the Hermes site would be managed by BMPs throughout the project life cycle.	
Shiny pigtoe (*F. cor*)	Endangered	Baseline information: Freshwater mollusk. Prefer substrate in streams with running water. Unlikely to thrive in stream channels influenced by impoundments such as that of Poplar Creek, adjacent to the Hermes site. Impacts: Hermes project would not involve physical disturbances of aquatic or riparian habitats. Water demands would be met by municipal or commercial suppliers. BMPs to control sedimentation and runoff. Stormwater on the Hermes site would be managed by BMPs throughout the project life cycle.	MA-NLAA
Northern long-eared bat (*M. septentrionalis*)	Threatened	Baseline information: Winged mammal. Hibernates in caves, mines, and human-made structures and forms maternity roosts in trees with exfoliating barks or holes, or that are dead (NRC 2019-TN6136 | Sec M.6.1.3). Roosts and forages in forested or semi-forested areas (NRC 2019-TN6136 | Sec M.6.1.3). Prefers to roost in interior of late successional forests (NRC 2019-TN6136 | Sec M.6.1.3). Listed as threatened in 2015 due to the effects of white nose disease (NRC 2019-TN6136 | Sec M.6.1.3). Detected acoustically in forested areas at the CRN site in 2013, but maternal roosting is not suspected (NRC 2019-TN6136 | Sec M.6.1.3). Impacts: May forage transiently in the riparian forest along the Poplar Creek. Expected to avoid lands where the Hermes project would be built, which currently contain only ruderal vegetation of no foraging value.	MA-NLAA
Spotfin chub (*Erimonax monachus*)	Threatened	Baseline information: Fish. Prefer streams with boulders and swift currents (NRC 2019-TN6136 | Sec M.6.1.7). Unlikely to thrive in impounded stream	MA-NLAA

Species	Federal Status	NRC Staff Evaluation	Conclusion
		channels such as that of Poplar Creek adjacent to the Hermes site. Impacts: Hermes project would not involve physical disturbances of aquatic or riparian habitats. Water demands would be met by municipal or commercial suppliers. Stormwater managed by BMPs. BMPs to control sedimentation and runoff. Stormwater on the Hermes site would be managed by BMPs throughout the project life cycle.	
Virginia spiraea (*Spiraea virginiana*)	Threatened	Baseline information: Shrub. Prefers stream bars and ledges (Kairos 2021-TN7880 │ Table 3.5-2). May occur in riparian forested lands along the Poplar Creek. Impacts: Physical disturbance for the Hermes project would be limited to soils previously disturbed for past industrial development. Plants not affected by noise. BMPs to control sedimentation and runoff. Stormwater on the Hermes site would be managed by BMPs throughout the project life cycle.	MA-NLAA
White fringeless orchid (*Platanthera integrilabia*)	Threatened	Baseline information: Herbaceous wildflower of acidic seeps and stream heads (Kairos 2021-TN7880 │ Table 3.5-2). May occur in riparian forested lands along the Poplar Creek. Impacts: Physical disturbance for Hermes project would be limited to soils previously disturbed for past industrial development. Plants not affected by noise. BMPs to control sedimentation and runoff. Stormwater on the Hermes site would be managed by BMPs throughout the project life cycle.	MA-NLAA

Key: NRC = U.S. Nuclear Regulatory Commission; MA-NLAA = may affect, but is not likely to adversely affect.

- Species identified through IPaC searches conducted by the applicant in May 2021 and the NRC staff in February 2022, for an action area encompassing the entire 185 ac Hermes site.
- Conclusions follow terminology used by the FWS when providing consultations under Section 7 of the ESA.
- Conclusions are inclusive for the Hermes project for construction, operation, decommissioning, and cumulative effects, based on the information available at the time of the NRC staff's environmental review of the CP.

3.5 Historic and Cultural Resources

3.5.1 Affected Environment

Historic and cultural resources refer to archaeological sites, historic buildings, traditional cultural properties important to a living community,[1] shipwrecks, and other resources considered under the National Historic Preservation Act (54 U.S.C. § 300101 *et seq*. TN4157) of 1966, as amended. Historic and cultural resources determined to be significant include those that are eligible for inclusion in or formally listed on the National Register of Historic Places (NRHP). Section 106 of the NHPA requires Federal agencies to consider the effects of their undertakings on historic properties listed or eligible for listing on the NRHP. The procedures in 36 CFR Part 800 (TN513) define how Federal agencies meet the statutory responsibilities of NHPA Section 106. If historic and cultural resources are present, the eligibility of any historic properties for listing on the NRHP is determined through the application of the NRHP criteria in 36 CFR 60.4[2] (TN1682) in consultation with the State Historic Preservation Officer, American Indian Tribes (Tribes) that attach cultural and religious significance to historic properties, and other interested parties, pursuant to 36 CFR 800.2(c) (TN513).

In accordance with 36 CFR 800.8(c) (TN513), the NRC has initiated the NHPA Section 106 consultation process and notified consulting parties, including the Advisory Council on Historic Preservation (ACHP), the Tennessee Historical Commission (THC, i.e., the State Historic Preservation Officer), Tribes, and the National Park Service (NPS), of its intent to use the NEPA (42 U.S.C. § 4321 *et seq*. TN661) process to comply with Section 106 of the NHPA (see section on consultation below).

The current NRC undertaking is the issuance of a CP to Kairos that allows for the construction of the proposed Kairos Hermes project (see Section 1.1 of this EIS). If Kairos chooses to proceed with its proposed project, they will need to apply for, and receive, a separate OL from the NRC. This authorization would constitute a separate NRC undertaking and would require the NRC to prepare a supplement to the CP final EIS and complete a separate NHPA Section 106 review and consultation.

The proposed project site is located within the East Tennessee Technology Park in the northwest quadrant of the ORR and is adjacent to the Clinch River arm of Watts Bar Reservoir in Roane County, Tennessee. The site comprises approximately 185 ac and is located on a parcel that previously housed Buildings K-31 and K-33, which were part of the K-25 complex

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[1] Traditional cultural properties are places that are important to a living community of people for maintaining its culture, including American Indian Tribes that attach cultural and religious significance to historic properties (Parker and King 1998-TN5840). It is important to note that American Indian Tribes also attach cultural and religious significance to other cultural resource types including pre-contact and historic-era archaeological sites

[2] The NRHP was established by the NHPA and is maintained by the National Park Service. The eligibility of cultural resources for listing on the NRHP are assessed based on four criteria:

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

and operated as the ORGDP. The NRC has determined that the area of potential effect (APE)[1] for the CP review includes the area at the Hermes reactor site and its immediate environs where the character and use of historic properties may be directly (i.e., physically) or indirectly (i.e., visually or auditory) impacted by land-disturbing and building activities associated with the construction and operation of the proposed facility. Specifically, the NRC defined the direct-effects APE as the approximately 185 ac site (i.e., Kairos ownership site boundary) and the indirect-effects APE as the 0.5 mi area around the site (Figure 3-2).

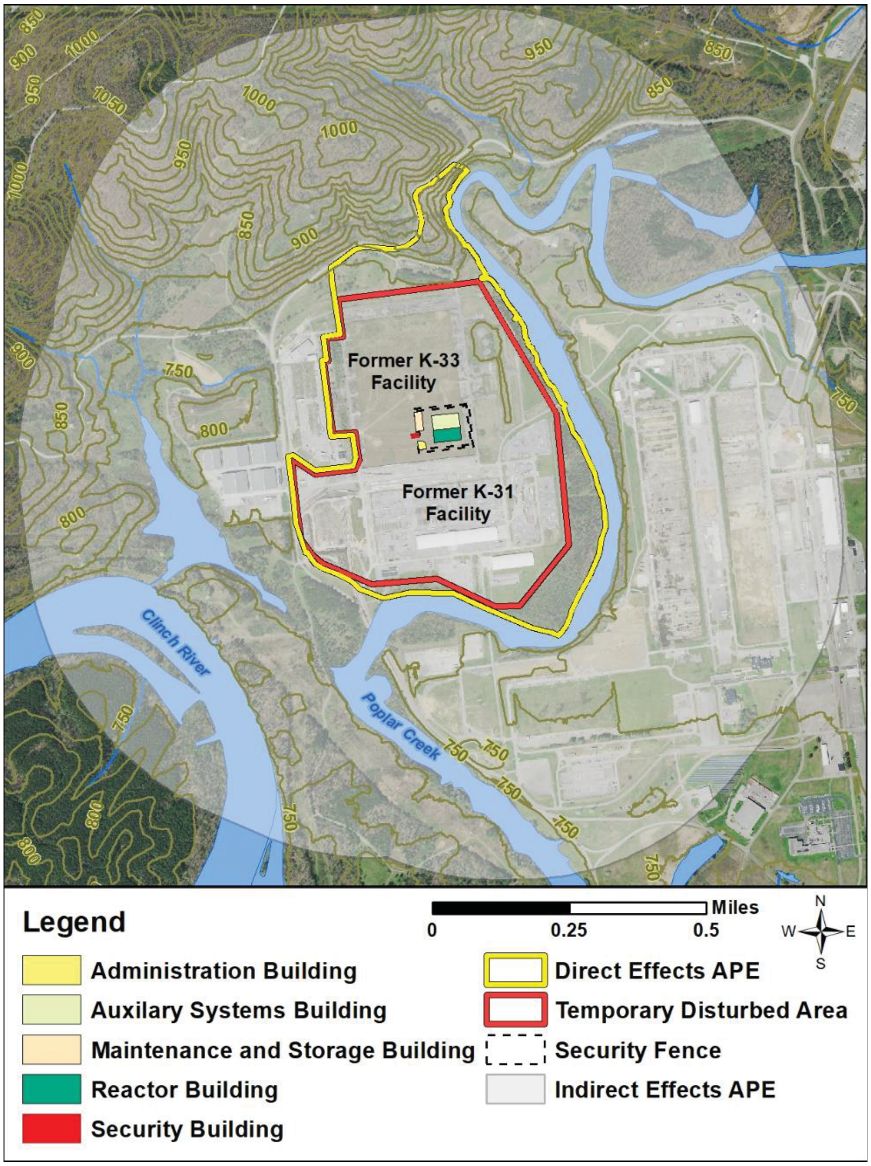

Figure 3-2 Direct- and Indirect-Effects Area of Potential Effects at the Kairos Hermes Project

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[1] 36 CFR 800.16 (d) (TN513) defines the APE as "the geographic area or areas within which an undertaking may directly or indirectly cause alterations in the character or use of historic properties if they exist. The area of potential effects is influenced by the scale and nature of an undertaking and may be different for different kinds of effects caused by the undertaking."

3.5.1.1 Cultural Background

In April 2019, the NRC published NUREG-2226 (NRC 2019-TN6136), *Environmental Impact Statement for an Early Site Permit (ESP) at the Clinch River Nuclear Site* (hereafter referred to as the CRN EIS). Because of the timeliness of this draft EIS, and the close proximity (3.5 mi) of the CRN site to the proposed Kairos test reactor site, the NRC staff considers the cultural background description in the CRN final EIS (described in Section 2.7.1) to be relevant and accurate for the assessment of the proposed Hermes project and incorporated it into this EIS by reference.

As indicated in the referenced cultural background description, human occupation in east Tennessee spans thousands of years. The cultural background is derived from the pre-contact and historic overviews provided by Hunter et al. (Hunter et al. 2015-TN4971) and Barrett et al. (Barrett et al. 2011-TN4974, Barrett et al. 2011-TN4975).

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

The Archaic period is divided into three eras: Early (8,000 to 6,000 years BC), Middle (6,000 to 3,000 BC), and Late (3,000 to 1,000 years BC). Settlement patterns associated with the Early Archaic Period are characterized by short-term resource use areas and base camps. The Middle Archaic Period reveals an increased diversity in artifact type as well as increased complexity in tool making. Settlement patterns are similar to the Early Archaic Period and are characterized by an increase in population and longer-term use of camp occupations. The Late Archaic Period is characterized by an increase in sedentary settlement patterns consisting of seasonal base camps and more short-term camps.

Two eras are associated with the Woodland Period in east Tennessee: Early (1,000 BC to 200 BC) and Middle (200 BC to A.D. 900). Archaeological evidence suggests that rather than a transition to Late Woodland after the Middle Woodland Period, there is a transition to the Mississippian Period beginning in A.D. 900. The Early Woodland Period is characterized by mound building and widespread use of pottery, along with an increase in horticultural practices, including the cultivation of seeds, berries, and grains. Burial practices include internment in mounds and the development of more complex mortuary and ritual practices. Settlement patterns associated with the Early Woodland Period continue to include seasonally based camps. The Middle Woodland Period is characterized by an increase in sedentism and the development of a more complex social system. At the end of the Middle Woodland Period, there is an abrupt shift from base camp settlement to permanent villages, which correlates with an increased dependence on the cultivation of maize. The Mississippian Period (A.D. 900 to 1540) is characterized by the increased reliance upon agriculture and the establishment of fortified villages, chiefdoms, and complex burial practices.

European explorers arrived in the vicinity of the proposed project area in 1540 as part of the DeSoto expedition and likely encountered the Coosa American Indian population (TN4971). By the 1700s, the Overhill Cherokee inhabited the area. With the arrival of fur traders in the 1700s, skirmishes between the French, British, and Indian groups increased in the area through the early 1800s. In 1796, the State of Tennessee was formed. Between 1794 and 1838, as a result of three treaties with the Cherokee Indians and through forced removal at the time of the Trail of Tears, the Cherokee Indians were evicted from their ancestral homelands and required to relocate to Oklahoma (TN4971).

After the Depression, development in the Tennessee Valley, including the establishment of the TVA, led to a more-varied economic base in the region (TN4971). The first dam built by TVA commenced operation in 1936 with the opening of the Norris Dam (TN4975). The existence and location of the Norris Dam were contributing factors in the decision to locate "Site X" of the top-secret Manhattan Project in the Clinch River Valley area (Kairos 2021-TN7880 │ Sec 3.6.1). Other factors included 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 (Kairos 2021-TN7880) │ Sec 3.6.1, which referenced Cultural Resources Management Plan for DOE Oak Ridge. "Site X" eventually became the ORR and was part of the Manhattan Project (Kairos 2021-TN7880 │ Sec 3.6.1). Land acquisition for the ORR began in 1942. Several agricultural communities in the area at that time were relocated to accommodate Manhattan Project related construction activities (Kairos 2021-TN7880 │ Sec 3.6.1).

The proposed project is located at the site of the former NRHP-eligible K-31 and K-33 buildings, which were part of the K-25 complex and operated as the ORGD, which was constructed between 1943 and 1945 (Valk et al. 2011-TN4972, Kairos 2021-TN7880 │ Sec 3.6.1). Uranium enrichment operation ceased in 1986, and restoration, decontamination, and decommissioning activities began soon thereafter (Kairos 2021-TN7880 │ Sec 3.6.1). Reindustrialization of the site, later renamed the East Tennessee Technology Park, 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 began in 1996 (Kairos 2021-TN7880 │ Sec 3.6.1). In 1998, the DOE and THC signed a Memorandum of Agreement (MOA) to resolve the adverse effects of decontamination, 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 (Kairos 2021-TN7880 │ Sec 3.6.4). This MOA was amended in 2001 to discuss which diffusion equipment and displays would be retained, and upon completion of MOA stipulations, Buildings K-29, K-31, and K-33 and the ancillary facilities were demolished (Kairos 2021-TN7880 │ Sec 3.6.4). Currently, the site is a brownfield.

3.5.1.2 Historic and Cultural Resources at the Kairos Hermes Reactor Site

In 2011, DOE completed an EA prior to transferring the land and facilities within the East Tennessee Technology Park to the Community Reuse Organization of East Tennessee. According to DOE's EA, no prehistoric archaeological resources are known to exist within the East Tennessee Technology Park, which also includes the proposed Hermes site. This is due to the massive cut and fill excavation activities associated with the construction, demolition, and decontamination of the former K-25 site and associated facilities (i.e., K-33 and K-31). As a result, there are likely no intact archaeological sites to be found within the East Tennessee Technology Park (DOE 2011-TN4888). A review of THC files indicates that there are no extant architectural resources within the direct-effects APE.

The Manhattan Project National Historical Park (NHP, established in 2015, is the only NRHP-eligible property located within the indirect-effects APE. The Manhattan Project NHP is jointly operated and administered by the DOE and the NPS (DOI 2022-TN7957). The Manhattan Project NHP consists of the K-25 History Center, which opened in 2020 and focuses on the men and women who built and operated the ORDF during the Manhattan Project and Cold War. The proposed viewing platform and associated exhibits will help visitors understand the scope and magnitude of the site, while they learn about the personal stories of the workforce (DOE 2022-TN7897). Future plans include construction of a viewing platform and wayside exhibits that are the final components of the previously mentioned MOAs related to the K-25 site (TN7897).

To verify the NRC's decision to delineate the indirect-effects APE to 0.5 mi radius around the proposed site, the NRC staff requested that Kairos take viewshed photographs from four known historic and cultural resources located within the vicinity of the proposed Kairos Hermes site (1 mi) but outside of the 0.5 mi area. These historic and cultural resources include the following: the Wheat Community Historic District (archaeological district); the Wheat Community African Burial Ground, Gallaher, and Ellis cemeteries; and the NRHP-eligible George Jones Memorial Baptist Church. Kairos provided the photographs as supplemental information, which confirms that the proposed project area is not visible from these historic and cultural resources due to screening from topographic features and vegetation (Kairos 2022-TN7926)(see Appendix F).

3.5.1.3 Traditional Cultural Properties

The Kairos ER states that previous cultural resource surveys have identified eight sites within the vicinity of ORR that include mounds and/or are known human burial sites, which could be considered sacred sites (Kairos 2021-TN7880 | Sec 3.6.2). None of these sites is located within the direct- or indirect-effects APE. The results of NRC's NHPA Section 106 consultation conducted with Tribes that attach cultural or religious significance to historic properties also indicate that no traditional cultural properties are known to be located within the Hermes direct- or indirect-effects APE at the time of publishing this draft EIS (see Appendix C).

3.5.1.4 Consultation

The NRC initiated consultation via a letter dated March 4, 2022, with the THC (NRC 2022-TN7927), the ACHP (NRC 2022-TN7928), NPS (NRC 2022-TN7929), and 18 Federally recognized Tribes (Absentee Shawnee Tribe, Alabama-Coushatta Tribe of Texas, Alabama-Quassarte Tribal Town, Cherokee Nation, Chickasaw Nation, Eastern Band of Cherokee Indians, Coushatta Tribe of Louisiana, Delaware Nation, Eastern Shawnee Tribe of Oklahoma, Jena Band of Choctaw Indians, Kialegee Tribal Town, Muscogee (Creek) Nation, Poarch Band of Creek Indians, Seminole Nation of Oklahoma, Seminole Tribe of Florida, Shawnee Tribe, Thlopthlocco Tribal Town, and United Keetoowah Band of Cherokee Indians). All letters are presented in Appendix C. There are no Federally recognized Tribes located within the State of Tennessee. The results of the NHPA Section 106 consultation efforts completed to date are described below. NRC's NHPA Section 106 consultation is ongoing and will be finalized in the Final EIS.

On March 11, 2022, the THC replied by letter stating that the project as currently proposed would not adversely affect the Manhattan Project NHP (THC 2022). Additionally, the THC has no objection to the implementation of this project as currently planned (THC 2022-TN7930).

The NRC conducted a virtual joint public outreach and scoping meeting on March 23, 2022 (NRC 2022-TN7933). No comments regarding historic and cultural resources were provided at the meeting.

On March 30 and 31, 2022, the Chickasaw Nation stated that the proposed project is outside its area of interest and declined the NRC's request for government-to-government consultation (Chickasaw 2022-TN7931, Chickasaw 2022-TN7932).

By letter dated April 12, 2020, the NPS expressed an interest collaborating with Kairos and/or the NRC to develop interpretative material at or in proximity to the proposed Kairos facility site that illustrates the history of nuclear science and technology and demonstrates linkages to the work done at K-25 during World War II (DOI 2022-TN7957). The NPS noted that it is currently working with Roane County to develop interpretation and recreation programs based at and near the waterways near the K-25 site (DOI 2022-TN7957). Additionally, the NPS expressed concerns related to other DOE planned development in the area, particularly the Oak Ridge Airport and the potential impacts to on public access to the Manhattan Project NHP.

The NRC conducted follow-up calls with Tribes in April 2022. The Eastern Shawnee Tribe stated via letter (Eastern Shawnee 2022-TN7934) that they find no known properties of historical and/or cultural significance to the Tribe that will be affected by this project. However, if this project inadvertently discovers an archeological site or object(s), the Eastern Shawnee requested that the Tribe and appropriate State agencies be contacted immediately (within 24 hours) and that all ground-disturbing activity stop until the Tribe and State agencies are consulted (TN7934).

The Delaware Nation responded that Tennessee is outside of their area of interest (Delaware Nation 2022-TN7935 | ML22095A221), and the Poarch Band of Creek Indians stated that the location of the project appears to be outside their area of interest (Poarch Band 2022-TN7936 | ML22095A224). On April 6, 2022, the Seminole Nation of Oklahoma accepted the NRC's invitation to participate in the environmental scoping process (Seminole Nation 2022-TN7937 | ML22109A188). On May 2, 2022, the NRC staff conducted a teleconference with the Tribal Historic Preservation Officer from the Cherokee Nation to discuss the proposed project, the associated direct- and indirect-effects APE, and potential impacts on historic and cultural resources. At the conclusion of the teleconference, the Cherokee Nation representative requested copies of cultural resource surveys completed in the vicinity of the proposed project. On May 17, 2022, NRC staff followed up its teleconference with an email-mail summarizing the contents of the discussion and indicated that the NRC had requested copies of the cultural resources reports from the Tennessee Division of TDOA and would send them to the Cherokee Nation upon their receipt (NRC 2022-TN7958). On July 6, 2022 NRC staff submitted the cultural resources reports to the Cherokee Nation THPO. (NRC 2022-TN7958).

3.5.2 Environmental Impacts of Construction

The proposed footprint of disturbance for the Hermes project is composed entirely of land that was previously used for industrial purposes (i.e., brownfield). No historic and cultural resources are known to exist within the proposed project area due to the massive cut and fill excavation activities associated with the construction of the former K-25 site and associated facilities (i.e., Buildings K-33 and K-31) and their subsequent decontamination, demolition, and decommissioning. As discussed by DOE (DOE 2011-TN4888), lease and/or deed restrictions require that if an unanticipated discovery of cultural materials (e.g., human remains, pottery, weapon projectiles, and tools) or sites is made during any development activities, all ground-disturbing activities in the vicinity of the discovery would be halted immediately. Per the deed restrictions, Kairos would develop and implement an Archaeological Monitoring and Discovery Plan that would establish stop work and notification procedures to address the unexpected discovery of human remains or archaeological material (Kairos 2021-TN7880 | Section 4.6.1, Kairos 2022-TN7902, DOE 2017-TN5081). These procedures would be in place prior to commencing ground-disturbing activities (Kairos 2022-TN7902). If human remains or archaeological resources were discovered, work would cease in the area, and notifications would be made in accordance with Tennessee law (T.C.A. § 11-6-107 *et seq.*-TN7938).

If human remains were discovered, Kairos would also notify appropriate local law enforcement. If the human remains were determined to be archaeological in nature, Kairos would notify the Tennessee Division of Archaeology and the THC to determine what further actions would be taken (Kairos 2021-TN7880 | Sec 4.6.1, Kairos 2022-TN7902).

No impacts are expected to occur on traditional cultural properties of significance to American Indian Tribes because none have been identified in the direct- or indirect-effects APE at the time of publishing this EIS.

The Manhattan Project NHP is located at the site of the former K-25 plant that was demolished and is the only NRHP-eligible site located within the indirect-effects APE. The major structures to be constructed for the proposed project would not exceed 100 ft in height. The overall visual setting of the proposed project is predominantly industrial and is in keeping with the current setting of the historical park, which consists of a brownfield site, newly built history center, and concrete pads. Therefore, the construction of the proposed Kairos project would not adversely affect the Manhattan Project NHP.

3.5.3 Environmental Impacts of Operation

No impacts on historic and cultural resources from operations and maintenance activities are expected to occur. Operations and maintenance activities may entail ground-disturbing activities within the direct-effects APE; however, Kairos would follow its Archaeological Monitoring and Discovery Plan and applicable Tennessee law regarding inadvertent discovery of human remains.

3.5.4 Environmental Impacts of Decommissioning

Impacts from decommissioning are expected to be similar to those resulting from construction activities. Because there are no known historic properties under 36 CFR 800.4(d)(1) (TN513) or historic and cultural resources located within the proposed Hermes reactor site, impacts on these resources would not be expected during decommissioning. Decommissioning activities would involve the use of heavy equipment to remove buildings, roadways, and other structures within the APE (Kairos 2021-TN7880 | Sec 4.6.1). However, Kairos would follow its Archaeological Monitoring and Discovery Plan and applicable Tennessee law regarding inadvertent discovery of human remains.

3.5.5 Cumulative Impacts

The description of the affected environment above serves as the baseline for the assessment of cumulative impacts on historic and cultural resources. No historic and cultural resources are known to exist within the proposed Hermes project area due to the massive cut and fill excavation activities associated with the construction of the former K-25 site and associated facilities (i.e., Buildings K-33 and K-31), and its subsequent decontamination, demolition, and decommissioning. The Manhattan Project NHP is the only NRHP-eligible site within the indirect-effects APE.

Table 4.13-1 of the ER identifies past, present, and reasonably foreseeable future projects that could cumulatively contribute to the environmental impacts of the proposed action (Kairos 2021-TN7880). Projects within the direct- and indirect-effects APE that may have a potential cumulative impact on historic and cultural resources include ongoing infrastructure improvements and future urbanization. Past activities include adverse effects associated with the decontamination, demolition, and decommissioning of K-25 and the ORGDP facilities. Adverse effects on historic properties associated with these past activities were resolved by DOE via execution of MOA(s). Ongoing and future projects listed in ER Table 4.13-1 include cleanup and redevelopment activities at the East Tennessee Technology Park, construction and operation of the Atlas facility, and redevelopment activities at the Heritage Center. Development of such projects could affect historic and cultural resources if ground-disturbing activities occur, and the severity of the impacts would vary depending upon the extent of damage caused to archaeological resources and the extent of mitigation required to address adverse effects on historic properties. If new aboveground structures are constructed as part of the present and reasonably foreseeable projects, there could be significant cumulative impacts on the Manhattan Project NHP. However, in most instances, visual impacts can be minimized using creative design and by establishing vegetative screening. Although the Manhattan Project was historically significant in U.S. national history, most of the historic structures formerly at the East Tennessee Technology Park have already been demolished. Additionally, no historic properties would be affected by development on the proposed Hermes site; therefore, no additional cumulative impacts on historic and cultural resources would occur (Kairos 2021-TN7880 | Sec 4.13.7).

Historic and cultural resources are nonrenewable, hence certain activities can result in an irretrievable loss of the resource. Therefore, the impact of destruction on historic and cultural resources is cumulative. Overall, the cumulative impacts of the proposed Hermes project combined with other past, present, and reasonably foreseeable future actions is substantial, but the contribution of the proposed Hermes project to those cumulative impacts would be minimal.

3.5.6 Conclusions

The NRC staff concludes that the potential direct, indirect, and cumulative impacts on historic and cultural resources would be SMALL. Even though other projects in the area surrounding the proposed Hermes site have resulted in past impacts and may potentially result in future impacts on historic and cultural resources, the Hermes project would not contribute further to those impacts. For the purposes of the NRC’s NHPA review, the staff concludes that there would be no adverse effect on historic properties from the proposed project.

3.6 Socioeconomics and Environmental Justice

3.6.1 Affected Environment

3.6.1.1 Socioeconomics

In April 2019, the NRC published NUREG-2226 (NRC 2019-TN6136), *Environmental Impact Statement for an Early Site Permit (ESP) at the Clinch River Nuclear Site*. The CRN site is relevant for several reasons and can reasonably serve as applicable analyses for the purpose of this EIS. First, the CRN EIS considers the environmental impacts associated with a site that is within 4 mi of the proposed Hermes reactor site, so all of the physical, geological, hydrological, and atmospheric conditions identified in the CRN EIS are very similar for the Hermes site. Second, the publication of the CRN EIS in April 2019 occurred only 2 years prior to the development of this draft EIS, so the information and data in the CRN EIS is still relevant to and useful for this project. Consequently, the NRC staff determined much of the analysis conducted for the CRN site was relevant and accurate for the assessment of socioeconomic and EJ impacts from the proposed Hermes project. For socioeconomic and EJ analyses of the Hermes project, the NRC staff used the CRN EIS's data source, the U.S. Census 2016 American Community Survey (ACS) Five-Year estimates, and identified the economic region (hereafter "the region") as the counties of Anderson, Knox, Loudon, and Roane, which in aggregate contained about 87 percent of the 2019 ORR workforce (TN6136). The Hermes ER used the Census 2019 ACS Five-Year estimates and established its economic region of interest as the four-counties listed above, plus Morgan County, which are all within 10 mi of the proposed site. To leverage the analyses used in the CRN EIS with the additional information provided in the Hermes ER, the NRC staff included Morgan County in its economic region of interest for the socioeconomic and EJ analyses. However, due to an unavailability of the 2019 ACS data set, the staff incorporated Morgan County demographic data from the U.S. Census Bureau, 2020 Census Redistricting Data (Population, Tabulation for State Legislative Apportionment Act-TN7959) at the Census Block Group (CBG) level of disaggregation. This decision was made after the staff determined the differences for representative counties' values in 2019 and 2020 ACS datasets were within 1 percent of each other. This section describes the baseline socioeconomic and EJ characteristics: the populations and the economy of the region, and the region's infrastructure and public services.

The following analysis focuses on resident populations with reference to the transient and migrant worker population analyses performed for the CRN EIS. The NRC staff's definitions for demographic cohorts follow the definitions of the U.S. Census Bureau. Table 3-5, below, provides key baseline demographic data for the economic region of the proposed project.

Table 3-5 2020 Population of Counties in the Economic Region

	Tennessee	Anderson County	Knox County	Loudon County	Morgan County	Roane County
Total	6,910,840	77,123	478,971	54,886	21,035	53,404
Hispanic or Latino	479,187	2,820	28,568	5,356	299	1,011
White	4,900,246	66,044	373,790	46,419	19,029	48,094
Black or African American	1,083,772	2,841	39,853	578	971	1,302
American Indian and Alaska Native	15,539	217	1,079	95	54	161
Asian	134,302	975	11,881	450	41	341
Hawaiian/Other Pacific Islander	3,594	53	300	2	8	19
Some Other Race	23,977	272	1,776	161	64	157
Two or More Races:	270,223	3,901	21,724	1,825	569	2,319
Number of CBG		54	301	47	14	51

Key: CBG = Census block group.

The CRN EIS indicated the population of the economic region increased at an average annual rate of about 1.2 percent between 2010 and 2015, with the fastest annual growth rate (1.96 percent per year) occurring in Loudon. Knox had the second highest annual growth rate projection at 1.31 percent, and Anderson the third highest at 0.57 percent. The slowest annual growth rate was in Roane (0.45 percent per year) (NRC 2019-TN6136 | Sec 2.5.1.1, Table 2-22). Expanding that analysis to account for the 2020 Census, the relative rankings between counties remained the same, with Loudon again the fastest at 4.04 percent per year, then Knox at 2.54 percent, Anderson at 0.81 percent, and Roane at 0.29 percent. However, Morgan County's 2010 population Census was 21,987, almost more than a thousand individuals than that recorded in the 2020 population Census, indicating an average annual loss of about 0.43 percent. Comparisons between the CRN EIS Census data for key municipalities in the economic region show changes consistent with the county-level analyses.

Table 2-24 of the CRN EIS (TN6136) displays 100 years of past and projected populations for the CRN ESP site economic region. Comparison between the projected 2020 economic region estimates in the CRN EIS and the 2020 Census data for those same areas indicates the CRN EIS overestimated population growth in the economic region, ranging between 2.04 percent (Knox) and 5.15 percent (Roane), for an average of 2.62 percent. The NRC staff determined the population projections provided in the CRN EIS were reasonable and incorporate them here by reference. Based on those population projections, the staff can reasonably assume the economic region will continue to grow in population at around 1 percent per year until about 2080.

In 2020, Loudon County had the lowest poverty rate in the economic region (13.7 percent) and ranked 12th of the 95 Tennessee counties. Roane ranked 24th with a 15.4 percent poverty rate, Knox ranked 25th with 15.8 percent, Anderson ranked 28th with 16.3 percent, and Morgan had the highest poverty rate at 22.9 percent, which makes that county 82nd in state ranking. The economic region is less racially diverse than the population of Tennessee, with more than 80 percent of the population self-identifying as “White Only,” and about 12 percent of the population divided between “Black or African American Only” (6.64 percent) and “Hispanic or Latino” (5.55 percent). Another 4.43 percent of the economic impact area population self-identify as “Two or More Races,” and the remaining 2.64 percent is divided between the remaining single race categories.

The staff used Tennessee Department of Labor and Workforce Development data to report employment and unemployment data for the five-county economic region (Table 3-6). In 2020, the total labor force for the economic region was approximately 397,000 people, with about 19,000 unemployed, representing 5.4 percent, a full percentage point lower than the Tennessee 2020 annual unemployment rate. Almost 70 percent of those unemployed in the economic region lived in Knox County, but because of the county’s much larger population, the number of unemployed did not result in a Knox County unemployment rate that was greater than that for the State. Of all the counties in the economic region, only Morgan County had an unemployment rate greater than the State’s, at 7.0 percent.

Table 3-7 presents 2020 employment for private industries in Tennessee and the five counties of the economic region. The shaded rows provide three-digit level North American Industry Classification System code values for Goods-Producing and Service-Providing sectors of the Tennessee economy. The four-digit disaggregation numbers indicate the economic region has an active workforce of 14,300 construction workers and that roughly 116,000 more construction workers live in Tennessee and could potentially support the proposed project’s construction workforce. For the purposes of this analysis, the NRC staff determined the data were not unreasonable as an approximation of the region's employment structure.

Sections 2.5.2.2.1 through 2.5.2.2.4 of the CRN EIS provide the NRC staff’s 2019 economic characterizations of the four-counties in the CRN site’s economic region and are incorporated here by reference (NRC 2019-TN6136). Morgan County has a total area of 522 square miles (mi^2) (1,352 km^2), all but a third of a mi^2 being land. The largest city in Morgan County is Harriman, with 6,136 residents. Harriman has most of its land in Roane County, and it is unclear whether Morgan County’s second largest city and county seat, Wartburg, has a larger population than the Morgan part of Harriman. Wartburg has 918 residents. The three largest industries in Morgan County are manufacturing, health care, and public administration. Morgan County has developed a 19.2 ac industrial park in Sunbright, 40 mi from Interstate 75, where tenants lease county-owned buildings. Their largest tenant is Tennier Industries, which manufactures military clothing.

Table 3-6 2020 Employment Data for the Economic Area

	Tennessee	Anderson County	Knox County	Loudon County	Morgan County	Roane County	Total Economic Region
Total labor force	3,454,168	36,308	255,750	24,574	8,325	24,633	397,210
Employed	3,234,116	34,176	242,457	23,182	7,745	22,987	330,547
Unemployed	220,052	2,132	13,293	1,392	580	1,646	19,043
Unemployment rate	6.4%	5.9%	5.25%	5.7%	7.0%	6.7%	5.45%

Source: State of Tennessee 2021-TN7960.

Table 3-7 2020 Private Employment by Industry for the Economic Region

Industry	Tennessee	Anderson County	Knox County	Loudon County	Morgan County	Roane County	Total Economic Region
101 Goods-producing	476,156	13,059	25,649	5,033	398	1,279	45,418
1011 Natural resources and mining	11,134	24	339	583	0	0	946
1012 Construction	130,050	1,147	12,364	811	0	0	14,322
1013 Manufacturing	334,972	11,888	12,945	3,639	318	899	29,689
102 Service-providing	2,026,094	21,701	176,262	9,612	1,182	14,616	223,373
1021 Trade, transportation, utilities	627,005	4,771	50,101	4,201	306	2,712	62,091
1022 Information	42,929	235	4,361	153	31	46	4,826
1023 Financial activities	155,926	1,280	12,720	364	49	240	14,653
1024 Professional & business services	414,644	7,163	37,929	1,205	210	8,183	54,690
1025 Education and health services	421,097	4,467	39,250	1,427	398	1,823	47,365
1026 Leisure and hospitality	293,033	3,166	25,355	1,770	148	1,373	31,812
1027 Other services	70,977	617	6,536	493	39	238	7,923
1029 Unclassified	482	1	12	0	0	0	13

Source: BLS 2020-TN7961.

Comparison of 2019 and current tax data indicates the tax structures in Anderson, Knox, Loudon, and Roane Counties have not changed since publication of the CRN EIS, and their data are incorporated here by reference (NRC 2019-TN6136). Morgan County has a complex property tax formula that results in an average rate of 7 mils (0.7 percent of a structure's appraised value). Tennessee assesses a 7 percent sales tax and allows local governments to add up to 2.75 percent (in quarter percent increments) for local revenue. Morgan County adds 2 percent to the Tennessee sales tax, for a total sales tax of 9 percent.

Vehicles access the ORR by State Route (SR) 58/Interstate-40 running east and west to the south of Clinch River and the proposed site, and SR 61 north of the ORR and running east and increasingly northward. From these main arteries, SR 95, SR 327, and SR 58 bring traffic closer to the ORR, where local roads provide the final leg of the journey. One major and one minor rail line also provide transportation routes to the ORR, and barge transportation via the Clinch River is possible.

In 2015, AECOM Technical Services, Inc. (AECOM) completed a traffic impact study for the CRN application. In 2021, Kairos commissioned a traffic study that determined the annual average daily traffic volumes for roads serving the ORR have grown at a rate of 2 percent per year over a 6-year period (Kairos 2021-TN7880). The NRC staff compared the data from the two studies and determined the data in the AECOM traffic study for the CRN EIS are still relevant and timely and the study is incorporated here by reference (TN6136 | Sec 2.5.2.4.1). The NRC staff also inspected the anonymized location records process used for the Kairos traffic study for estimating traffic volumes and determined that the process is reasonable. The staff therefore accepts the applicant's 2 percent annual growth assessment for the purposes of this EIS and applies it to the AECOM study conclusions.

The data provided in the CRN EIS is only 3 years old and is incorporated by reference here regarding the recreational characterization of the economic region for the proposed project (TN6136 | Sec 2.5.2.5). Morgan County is home to Frozen Head State Park and Natural Area, the headwaters of the Obed Wild and Scenic River, Lone Mountain State Forest, Catoosa Wildlife Management Area, Historic Rugby Tennessee, the Historic Brushy Mountain Penitentiary, and part of the Big South Fork National River and Recreation Area.

The CRN EIS reported about 27,400 housing units were available for purchase or rent in the EIS's economic region, along with almost 10,000 hotel rooms, most of which are in the Knoxville metropolitan area, and close to 1,500 camping sites. Given that the CRN EIS was published in 2019 and data are unlikely to have changed significantly since that time, the NRC staff determined the numbers established in the CRN EIS are still relevant and can reasonably be assumed to be accurate. Therefore, the conditions associated with housing in the CRN EIS are incorporated here by reference (NRC 2019-TN6136 | Section 2.5.2.6, Table 2-35).

Infrastructure assessments in the CRN EIS (TN6136) cover the following key points:

- The land planned for the proposed project is an abandoned industrial area, and no additional infrastructure (utilities, roadways, or rail systems) is needed to build or operate the proposed facilities

- The CRN EIS reported a current (2019) excess water capacity of over 65 mgd in the four-counties of its economic region, with the largest excess occurring in Knox County (55.7 mgd) and the smallest in Loudon County (a deficiency of about 0.2 mgd) (see Table 2-36).

- Public wastewater treatment systems in the four-county economic region indicated a similar trend, with a total excess capacity of about 33 mgd. Knox County had the highest excess capacity, with 22 mgd, and Loudon County had the lowest excess capacity, with 0.4 mgd (see Table 2-37).
- For the CRN EIS economic region, the NRC staff reported the 2019 law enforcement level at 1,300 officers and 800 civilian support staff, for a total of 2,100 law enforcement employees in the CRN four-county economic region. This results in 3.8 law enforcement officers for every 1,000 residents for Anderson County, 3.5 officers in Knox County, 2.3 officers in Loudon County, and 2.8 officers in Roane County. The national average is 2.8 officers for every 1,000 residents (see Table 2-38).
- The CRN EIS reports that the four-county economic region was served by 36 fire departments staffed by 1,167 firefighters. Anderson County has eight fire departments and 214 firefighters, for a ratio of 2.8 firefighters for every 1,000 residents. Knox County has eight fire departments and 592 firefighters, or 1.3 firefighters per 1,000 residents. Loudon County has seven fire departments and 166 firefighters, for a ratio of 3.3 firefighters per 1,000 residents, and Roane County has 13 fire departments and 195 firefighters, for a ratio of 3.7 firefighters per 1,000 residents. The four-county economic region has a ratio of 544:1, or 544 residents for each firefighter.
- The social services network that is discussed in the CRN EIS also serves Morgan County.
- The CRN EIS economic region contains 151 public schools, with 86,300 students and 5,900 teachers. The NRC staff determined the same ranking shown for water and wastewater infrastructure also applies to schools, with Knox County having 90 schools and Loudon County having only 3 schools. The CRN EIS indicates the student-to-teacher ratios for each of the economic region counties were well within Tennessee’s mandated 25:1 ratio (see Table 2-39).

Morgan County has three water service district providers—Plateau Utility, Sunbright Utility, and Wartburg Utility. Plateau Utility maintains a 2.4 mgd water plant and has a 150 million gal raw water reservoir in the Liberty area of Morgan County. Plateau has a total average daily water usage of 1 million gal and a 1.4 mgd excess capacity. Plateau Utility along with Cumberland Utility District provides around 240,000 gallons per day (gpd) of water for the Sunbright Utility District (NRC 2022-TN7962). The cities of Sunbright and Wartburg both have public sewer systems within their incorporated city limits. The Wartburg system has a current usage of 700,000 gpd and total system capacity of 1.3 mgd.

There are two police departments in Morgan County—a Ranger Station at the Frozen Head State Park and Natural Area, and the Wartburg Police Department—with a total of 402 officers. Compared to other counties, Morgan County, TN, has an unusually high number of residents working as Law Enforcement Workers Including Supervisors (5.7 times higher than expected), or more than 19 officers per 1,000 residents. There are 12 fire departments in Morgan County, TN, 10 volunteer departments serving individual communities, and 1 Federal fire department for the Division of Forestry—for a total of 150 firefighters or 7.1 firefighters for every 1,000 residents (Data USA 2022-TN7963). Morgan County School District is in Wartburg and has about 2,800 students in grades PK, K-12, and a student-teacher ratio of 14 to 1. This ratio is also well within Tennessee’s mandated 25:1 student-teacher ratio (ECS 2014-TN5395).

Applying the same reasoning for accepting the 2019 CRN EIS data for housing, the staff concluded that the data for public infrastructure (transportation, water and sewerage; police, fire, and medical services; social services; schools; and hospitals) in the economic region for the proposed project has not changed significantly since the publication of the CRN EIS and is incorporated here by reference (Section 2.5.2.7).

3.6.1.2 Environmental Justice

In 1994, the President signed Executive Order 12898, "Federal Actions to Address Environmental Justice (EJ) in Minority Populations and Low-Income Populations," (59 Federal Register [FR] Part 7629) establishing requirements for each Federal agency to identify and address, as appropriate, the disproportionately high and adverse human health and environmental effects of its programs, policies, and activities on minority and low-income populations. While the EO did not identify specific minorities to be included in EJ assessments, further guidance in 1997 from the CEQ directed Federal agencies to assess the human health and environmental effects of agency actions on six races: Black or African American, American Indian or Alaska Native, Asian, Native Hawaiian and Other Pacific Islander, some other race (not mentioned above), and Two or More Races (i.e., multiracial); and the ethnic populations of Hispanic or Latino (of any race) individuals.

CEQ established the low-income status as being individuals or families living below the poverty level as defined by the U.S. Census Bureau's Current Population Reports, Series P-60 on Income and Poverty (CEQ 1997-TN452). Because the NRC is an independent agency, CEQ's guidance is not binding on it; however, the NRC does consider CEQ's guidance on EJ when performing this procedure.

Table 3-5 above displays the racial and ethnic distribution of populations in the economic region for the five counties identified by this EIS. Knox County has the largest total population and the largest population of minorities, with slightly more than 100,000 minority residents—about 22 percent of its total population. Morgan County has the smallest total population of the economic region with around 21,000 residents, with about 2,000 self-identifying as minorities—less than 10 percent of the total population. Anderson (14 percent minorities), Loudon (15 percent), and Roane (8 percent) Counties complete the list.

The staff's first step in the review of EJ issues is to examine each CBG that is fully or partially within the economic region to determine whether that CBG should be considered a potentially affected EJ community. If application of either of the two criteria discussed below identifies a CBG, that CBG is a potentially affected EJ area.

- The EJ population for any one of the six EJ categories exceeds 50 percent of the total population of the CBG.

  or

- The percentage of the EJ population in the CBG is at least 20 percentage points greater than that same EJ population's percentage in the block group's State.

The applicant established the demographic region for EJ purposes to be a 5 mi radius from the center of the proposed project and determined none of the 14 CBGs within the demographic region met either of the two percentage criteria listed above (Kairos 2021-TN7880 | Sec 3.9). The applicant concluded "there are no minority populations subject to consideration as potential environmental justice communities of concern" in the demographic region.

The NRC staff guidance in LIC-203 Rev 4 states, "In determining the location of minority and/or low-income populations, the geographic area within a 50 mi radius is typically large enough to encompass the entire area of potential effect so the staff can perform its comparative analysis."

(NRC 2020-TN6399 │ LIC-203 Rev 4). Consequently, the staff determined the applicant's 5 mi analysis was not appropriate for the assessment of EJ issues. Instead, due to the recent nature of the CRN EIS's assessment and the proximity of the proposed CRN site to the Hermes site (within 4 mi), the staff considers the CRN EIS EJ analysis to be a sufficient analysis of the EJ characteristics of the Hermes site and incorporates by reference the CRN EIS EJ analyses. The EJ discussion below provides an overview of the CRN EIS's EJ analysis (NRC 2019-TN6136 │ Table 2-40 and Figures 2-29 and 2-30).

The CRN EIS identified 760 CBGs within a 50 mi radius of the proposed site, with 3.6 percent of the population self-identifying as having an "Aggregate Minority" status and 2.1 percent as having a "Black or African American" status that exceeded the threshold established by LIC-203 for a potentially affected EJ population. The largest concentrations of both Aggregate Minority and Black populations in the 50 mi radius occurred in Knox County, primarily because of the concentration of Black residents. None of the CBGs studied had EJ populations that exceeded the LIC-203 criteria for Asian, Other Races, or Two or More Races. About 7.6 percent of the CBGs studied had a low-income population that exceeded one of the threshold criteria; the greatest concentration of CBGs that exceeded one of the threshold criteria is in Knox County (NRC 2019-TN6136). The closest CBGs that exceeded an LIC-203 threshold are about 8 mi north of the CRN site. The CRN EIS review team did not identify any communities that have any subsistence or other unique practices that would provide a pathway for EJ effects from the proposed project.

3.6.2 Environmental Impacts of Construction

3.6.2.1 Socioeconomics

The applicant stated in its ER that "the construction phase of this project is estimated to require an estimated [sic] average of 212 onsite workers (425 at peak time)" over a two-year construction schedule (Kairos 2021-TN7880 │ Sec 2.1). NRC staff practice for estimating the impact of workers migrating into the economic region considers only the impact of peak project employment, thereby establishing that parameter as an upper bound for both the impact of smaller workforce sizes and for the duration of that impact. For the CRN EIS, TVA estimated a total workforce of 3,300 at peak employment for a 6-month period near the middle of the 72-month construction schedule (NRC 2019-TN6136), approximately eight times the size of the anticipated Hermes workforce and three times the length of the construction period. Of the 3,300 peak employment workforce, the CRN EIS estimated about one-third of the workers (1,115 workers) would be in-migrating workers (NRC 2019-TN6136). However, the Kairos ER claimed that for the construction of the project, "[t]here are no estimated labor force deficiencies [in the economic region of interest]" (Kairos 2021-TN7880 | Sec 4.7.1.1). Based upon recent experience with assessing new reactor impacts, the staff does not agree with that assessment. To establish a reasonable upper bound for the magnitude of in-migrating specialized labor, the staff applied the assumptions of the CRN EIS as an upper bound for the impacts of the Kairos construction-related impacts analysis, given that the anticipated construction workforce for an advanced test reactor is expected to be smaller than that for a power reactor.

Table 3-6 shows the rate of unemployment for each of the five counties in the economic region and Table 3-7 displays the 2020 private employment for key industries in the economic region. Knox County had the lowest unemployment rate in 2020, with 5.4 percent, and Loudon had the highest, at 7 percent. On average across the economic region, the unemployment rate was 5.45 percent, representing about 19,000 workers. Even if all the workers needed for the project's construction phase were to come from that local unemployment pool, unemployment would decrease by only about 2 percent.

In 2020, the economic region held more than 14,000 construction workers, 85 percent of whom resided in Knox County. However, the construction of nuclear facilities requires the employment of highly specialized skilled labor that meets the quality assurance requirements of 10 CFR Part 50 Appendix B (NEI 2000-TN6268), Criteria I and II for certification of nuclear capable skills. Even though the area surrounding Oak Ridge is unique in that it contains a large representation of nuclear-related services and workers, it is not unreasonable to anticipate some of the nuclear qualified skilled labor needed for construction of the Hermes facilities would need to migrate into the area from more than 100 mi away, necessitating long-term relocation to the economic region. As an upper bound for the potential impacts of in-migrating workers, the NRC staff assumed a third of the maximum construction workforce (about 140 workers) would need to in-migrate, given that the anticipated construction workforce for an advanced test reactor is expected to be smaller than that for a power reactor. This increase in population for the economic region would fall well within the population growth rates anticipated by local governments.

Similarly, the impact on socioeconomic components of the economic region derives from changes resulting from the presence of in-migrating workers as they compete for local goods and services and provide additional congestion on local roads. Assuming each of the in-migrating workers came with their families, applying the Tennessee average household size of 2.53 people (USCB 2016-TN4965), the total number of in-migrating people for the two-year construction phase of the Hermes project would be about 350 people, an increase of one-twentieth of 1 percent of the current economic region population. Even if all the in-migrating workers and their families were to move to the least populated of the economic region's counties, Morgan County (21,000 people), the increase in population would still account for less than 2 percent of the county's resident population.

Traffic impacts are derived from the entire workforce, not only the in-migrating workers that affect other aspects of the economic region. At peak employment, the NRC staff expects 425 round trip employee commutes per day, as well as any additional traffic related to shipments and deliveries (about 220 per month). The applicant's ER indicates traffic in the vicinity of the ORR increased between 2014 and 2018 at an average rate of about 2 percent per year, far lower than the magnitude needed to reduce the Level of Service (LOS, a road quality ranking from A to F) of any route into the East Tennessee Technology Park (Kairos 2021-TN7880 | Sec 3.7.2.3.1). AECOM reported a peak morning traffic magnitude of more than 2,200 vehicles per hour (NRC 2019-TN6136 | Table 2-34). The distribution of an additional 425 construction workers commuting for a single-shift construction schedule would add about 20 percent to the traffic volume for the short morning and evening commute periods, potentially enough to reduce the LOS on some roads but not sufficient to reduce the LOS to a level below the "D" LOS established as acceptable by the State of Tennessee (AECOM 2015-TN5000). Deliveries and shipments during construction includes about 32,000 gal of fuel per month (about 224,000 lb, or 28 small tanker trucks at the 80,000 lb load limit) and occasional deliveries of equipment and supplies (Kairos 2021-TN7880 | Sec 4.4.3.1.1). Because the additional traffic from so few Kairos activities would be added to the existing traffic in the area, shipments and deliveries each month would not be noticeable given the industrial nature of the East Tennessee Technology Park. Additionally, prior to startup, the applicant expects delivery of 20 one-ton shipments of low-pressure molten salt coolant (Kairos 2022-TN7882). Given the one-time nature of these deliveries, the impact of the shipments on traffic in the vicinity may be noticeable, but as soon as the deliveries are completed, the disruption to traffic would cease.

3.6.2.2 Environmental Justice

Given the nearest potentially affected EJ populations are over 8 miles from the proposed Hermes site and given the small footprint of the proposed project, both physically and in terms of personnel, the NRC staff found no construction-related pathways by which an EJ impact could reach an EJ population. Similarly, as discussed in the CRN EIS (NRC 2019-TN6136 │ Sec 4.5.6), the staff identified no unique EJ population characteristics or practices that could be affected by construction of the proposed project.

3.6.3 Environmental Impacts of Operation

3.6.3.1 Socioeconomics

The applicant stated in its ER that "During operations, an estimated average of 38 workers per weekday (68 full time positions) are required for staffing" (Kairos 2021-TN7880 │ Sec 2.1). The NRC staff considers the construction workforce to establish an upper bound for the impacts from the in-migration of operations workers and their families for the duration of the anticipated four-year operations period. Some of the in-migrating construction workers may find operations-related employment with the Hermes test reactor; but because many of the in-migrating construction workers would move out of the economic region to find other work, the transition from construction to operations should result in a net decrease in demographic impacts.

Given that 10 CFR 50.54(m)(2) (TN249) requires continuous onsite staffing, the NRC staff assumed the 38 weekday workers would cover one shift analogous to a "business day," and the remaining 30 workers would cover smaller evening and weekend shifts. During work commuting times, the addition of a maximum of 38 operation worker vehicles distributed across the 11 main routes into the ORR would constitute a de minimis increase in congestion and delay. Given the number of industrial-scale projects and operations on the ORR, shipments and deliveries should not be noticeable. Before the end of every 2 years of operations, the Hermes test reactor would require a resupply of 20 one-ton shipments of low-pressure molten salt coolant. As with the initial loading, the disruption to the quality of traffic during these deliveries in the vicinity would be of short duration.

3.6.3.2 Environmental Justice

The NRC staff considers the EJ impacts of construction to constitute an upper bound for the EJ impacts of operation on the potentially affected EJ populations within a 50 mi radius of the proposed project. Potential unique pathways for EJ impacts may exist due to the nature of the fuel and moderator used for the test reactor but, given the distance to the closest potentially affected EJ populations (about 8 mi) and the attenuation of impacts over distance and intervening terrain, the staff did not deem the potential for EJ impacts on those populations to be more than minimal.

3.6.4 Environmental Impacts of Decommissioning

3.6.4.1 Socioeconomics

The applicant's ER indicates the expected workforce for decommissioning would involve a peak employment level of 340 workers (Kairos 2021-TN7880 │ Sec 2.1). Because the decommissioning workforce would be smaller than the construction workforce, the NRC staff assumes the impacts from construction activities would establish an upper bound for the impacts from the decommissioning workforce. However, the decommissioning workforce would also be larger than the workforce needed for operation, and therefore the socioeconomic impacts from decommissioning might be slightly more noticeable than those from operations. One of the more noticeable aspects of decommissioning would relate to heavy haul traffic, with 174 monthly truck shipments or deliveries (Kairos 2021-TN7880 | Sec 2.1), but the NRC staff expects a small increase over baseline traffic (about 30 percent greater than the current traffic volume, given the 2 percent per year estimate of the ER) would be absorbed into the overall volume of traffic and would not be noticeable.

3.6.4.2 Environmental Justice

Given that the nearest potentially affected EJ populations are more than 8 mi from the proposed Hermes site and given the small footprint of the proposed project both physically and in terms of personnel, the NRC staff found no decommissioning-related pathways by which an EJ impact could reach an EJ population. Similarly, as discussed in the CRN EIS (NRC 2019-TN6136 | Sec 4.5.6), the staff identified no unique EJ population characteristics or practices that could be affected by the decommissioning of the proposed project.

3.6.5 Cumulative Impacts

The Hermes project would be a part of a continuous series of nuclear projects performed at Oak Ridge, including past completed projects (Buildings K-33 and K-31 at the proposed Hermes site), projects currently under way (the Spallation Neutron Source facility, about 5 mi to the east, and the S-50 Thermal Diffusion Plant, less than 2 mi to the south-southwest), and planned future projects, such as the proposed CRN approximately 4 mi to the east and the Atlas facility (see Sections 3.0 and 3.1 for more detail). The present and future projects would compete with the proposed Hermes project for nuclear skilled labor and resources; and the proposed new general aviation airport to be constructed within the East Tennessee Technology Park creates a special safety and security concern for a nuclear reactor with respect to severe accidents. However, the interface within and between these other projects does not rise to a level that would result in an impact on socioeconomics and EJ to be above minimal. Projects farther away from the ORR that are extant or proposed have a diminishing level of impact as the distance increases between them. Consequently, the NRC staff determined the cumulative impacts on the socioeconomic and EJ aspects of the proposed project would be minimal.

3.6.6 Conclusions

The NRC staff concludes the potential direct, indirect, and cumulative socioeconomic and EJ impacts of the proposed action would be SMALL. This conclusion is based on three considerations: First, staff relied heavily on the Clinch River ESP EIS for each socioeconomic resource area because of that project's proximity in both time and space to the proposed project. Because the Hermes reactor is smaller than the footprint of the reactors that form the Clinch River ESP's plant parameter envelope, staff concluded the Clinch River ESP socioeconomic and EJ impacts form an upper bound to the impacts of the Hermes project. Second, the surrounding land is already in a state of industrial use and further disturbance of the proposed site would not be noticeable. Third, the applicant would not need any additional infrastructure (utilities, roadways, or rail systems) to build or operate the proposed facilities.

3.7 Human Health

3.7.1 Nonradiological Human Health

The following section addresses the potential effects of occupational hazards on the health of people working on or near the Hermes site, including those caused by physical, electrical, and chemical sources. Nonradiological waste is included in the chemical hazards addressed here and is discussed further in Section 3.9 of this draft EIS.

3.7.1.1 Affected Environment

According to the applicant, no radioactive or hazardous materials are currently stored on the site (Kairos 2021-TN7880 | Sec 3.8.3). The applicant describes how DOE has remediated past contamination on the site, which previously accommodated Buildings K-31 and K-33 of the gaseous diffusion plants, to risk-based levels acceptable for transfer of the property for unrestricted industrial use (Kairos 2021-TN7880 | Sec 3.8.4). However, the applicant acknowledges that residual radioactive and nonradioactive contaminants might still be present in soils and groundwater at the site above background levels but below risk-based standards for industrial uses (Kairos 2021-TN7880 | Sec 3.8.3). The applicant provides relevant statistics for occupational injury and fatality rates for construction, operation, and decommissioning of similar facilities in the United States in Section 3.8.7 of the ER (Kairos 2021-TN7880).

3.7.1.2 Environmental Consequences of Construction

Other than the residual contamination left over from previous DOE uses of the site, the potential nonradiological occupational hazards would be those typical of construction sites when building new industrial facilities. The applicant explains in Section 4.8.1 of the ER how it expects its nonradiological effects on human health to be minimal (Kairos 2021-TN7880). The applicant expects that nonradioactive chemicals possibly present on its construction site could include (petroleum-based) fuels, oils, solvents, and other materials necessary for site preparation and building new facilities (Kairos 2021-TN7880 | Sec 4.8.1.1). The applicant estimates that air emissions would be below 100 TPY for criteria pollutants under the Federal CAA (SO_2, NO_X, PM_{10}, CO, VOCs, and Pb) during construction and decommissioning, and it plans to send any liquid effluent releases to the City of Oak Ridge for municipal treatment (Kairos 2021-TN7880 | Sec 4.8.1.4.1). Air emissions are discussed further in Section 3.2.1 of this draft EIS, and wastewater treatment is discussed further in Section 3.3 of this draft EIS.

Table 4.8-2 of the ER lists the potential types of physical, electrical, and chemical occupational hazards during the construction phase of the project (Kairos 2021-TN7880). The applicant plans to reduce or eliminate occupational physical hazards through implementation of safety practices, training, and physical control measures (Kairos 2021-TN7880 | Sec 4.8.1.5). Construction debris and other solid waste would be subject to waste reduction, recycling, and waste minimization practices (Kairos 2021-TN7880 | Sec 4.8.1.2.3). The applicant would not store or use highly hazardous chemicals on the site in quantities above the Threshold Quantities established by the U.S. Occupational Safety and Health Administration (OSHA) in Appendix A to 29 CFR 1910.119 (TN654), “List of Highly Hazardous Chemicals, Toxics and Reactives (Mandatory)” during construction (Kairos 2021-TN7880 | Sec 4.8.1.6).

The NRC staff finds that the applicant’s conclusion that the measures noted above would minimize the potential for serious occupational injury on or adjacent to the construction site for properly trained and qualified construction workers is reasonable. The physical hazards reported by the applicant to occur on the Hermes site during the construction phase of the project, as outlined in Table 4.8-2 of the ER (Kairos 2021-TN7880), are typical of industrial construction sites. Qualified construction workers could be readily trained to take the precautionary measures necessary to minimize the potential for serious injury from such hazards. For example, construction workers are routinely trained to wear hard hats, steel-toed boots, and safety goggles when around operating construction machinery.

Hearing injury caused by noise can be an occupational hazard at industrial sites. OSHA requires making hearing protection devices such as earmuffs and earplugs available to workers exposed to an eight-hour time-weighted average noise level of 85 dB or greater (29 CFR Part 1910-TN654). The applicant indicates that several pieces of construction equipment could generate maximum noise levels of 85 or more dBA at a distance of 50 ft (Kairos 2022-TN7912 | Table 4.2-3. Even higher noise levels could be experienced by construction equipment operators who may have to sit or stand closer than 50 ft from the equipment to operate it. Although the applicant does not directly address hearing protection in its ER, compliance with health safety protections established in 29 CFR Part 1910 (TN654), "Process Safety Management of Highly Hazardous Chemicals," is mandatory. The NRC staff therefore expects that workers on the construction site would be provided access to suitable hearing protection devices and trained in their use.

3.7.1.3 Environmental Consequences of Operation

Most of the analysis presented above regarding nonradiological hazards to human health for construction would be true for operations as well. Because the Hermes facilities would not have cooling towers or discharges to surface waters (other than stormwater), there would be no potential for health hazards caused by exposure to biocides or discharge streams, or from microbiological hazards resulting from warmed surface waters. Because the Hermes project would not involve building or operating high-voltage transmission lines or switchyards, there should be little potential for health hazards caused by electromagnetic fields. Stormwater discharges would be monitored as required by a National Pollutant Discharge Elimination System permit (Kairos 2021-TN7880 | Sec 4.4.3.1.2). There would be no potential for operation of Hermes to cause thermal discharges to surface waters capable of inducing the growth of pathogenic microorganisms, an issue described further in Section 3.9.3 of NUREG-1437 (NRC 2013-TN2654 | Sec 3.9.3).

As with construction, air emissions from the proposed facilities during operation would be below 100 TPY for criteria pollutants under the Federal CAA (SO_2, NO_X, PM_{10}, CO, VOCs, and Pb) (Kairos 2021-TN7880 | Sec 4.8.1.4.1). See Section 3.2.1 of this draft EIS for more information. Nonradioactive liquid wastes from operations would be discharged to the municipal sewer system for treatment at the Rarity Ridge WWTP facility (Kairos 2021-TN7880 | Sec 4.8.1.2.1). See Section 3.3 of this draft EIS for more information. Nonradioactive gaseous wastes from operating areas would be passed through a high-efficiency particulate air filtration system before being vented to the atmosphere, and additional controls may be implemented as required by local permit conditions (Kairos 2021-TN7880 | Sec 4.8.1.2.2). Nonradioactive solid wastes are characterized in Section 4.8.1.2.3 of the ER and would be subject to waste reduction, recycling, and waste minimization practices (Kairos 2021-TN7880). Table 4.8-2 of the ER lists the potential types of physical, electrical, and chemical occupational hazards during the operational phase of the project (Kairos 2021-TN7880).

The applicant has stated that operations would adhere to the regulations and standards established by OSHA and National Institute of Occupational Safety and Health (NIOSH) regulations (Kairos 2021-TN7880 │ Sec 4.8.1.5). OSHA regulations in 29 CFR Part 1910 (TN654) require implementation of specific training and notification processes to ensure the safety of workers and other persons on sites where hazardous materials and wastes are present. The NRC staff notes that compliance with the OSHA (and NIOSH) regulations is mandatory and expects that compliance would ensure the safety of properly qualified and trained site workers.

Flibe, a lithium, beryllium, and fluorine compound to be used as a low-pressure, molten salt coolant during operation of the Hermes reactor would be present on the site above the regulatory threshold quantity during operations and the applicant would therefore have to comply with 29 CFR 1910.119 (Kairos 2021-TN7880 │ Sec 4.8.1.6). Although chemically stable, Flibe contains potentially toxic constituents, including beryllium (Kairos 2021-TN7879 │ Sec 1.2.1). Workers could also be killed or injured if exposed to other chemicals used in the operation of industrial facilities such as Hermes. Flibe and most other process chemicals would be in liquid form and contained in tanks and pipes that would limit workforce exposure (Kairos 2021-TN7880 │ Sec 4.8.1.6). Although not credited for mitigation of radiological releases during postulated events, the reactor building and ventilation system would function as confinement to manage and control beryllium hazards (Kairos 2021-TN7879 │ Sec 1.2.1), as well as other nonradiological substances. The biological shield designed to protect workers and the public from radiological exposure, described in Section 4.4.1 of the PSAR (Kairos 2021-TN7879 │ Sec 4.4.1), would also reduce the potential for exposure of reactor personnel to beryllium and other hazardous chemicals. The applicant designed the heating, ventilation, and air conditioning system of the reactor building to ensure that chemical hazards remain within regulatory limits (Kairos 2021-TN7879 │ Sec 9.2.2). The NRC staff finds that compliance with the OSHA (and NIOSH) regulations and the design features noted above would help protect properly trained and qualified site workers from the hazards of working with and around Flibe. The potential hazards of worker exposure to Flibe and other chemicals used in operation of the Hermes facilities would be reconsidered at the OL stage once the applicant can provide more specific operational descriptions.

The applicant proposes in Section 4.8.1.7 of the ER to perform environmental monitoring as required by Tennessee State regulations, which may include requirements to monitor emergency management, environmental health, drinking water, water and sewage, pollution discharges, air emissions, and hazardous waste management (Kairos 2021-TN7880). The NRC staff notes that further consideration of possible nonradiological operational hazards specific to operation of the Hermes facilities may be necessary when the NRC staff conducts its environmental review of an OL application.

3.7.1.4 Environmental Consequences of Decommissioning

The analysis presented above related to construction and operations regarding nonradiological hazards to human health would apply to decommissioning as well. The NRC staff expects that impacts from decommissioning the Hermes facilities on nonradiological occupational safety would be bounded by the analyses reported for physical, chemical, ergonomic, and biological hazards in Section 4.3.10 of the decommissioning generic EIS (NRC 2002-TN7254), which concluded that the impacts would not be detectable. Further consideration of nonradiological health hazards may be necessary once the applicant applies for NRC approval for decommissioning.

3.7.1.5 Cumulative Impacts

Table 4.13-1 of the ER identifies past, present, and reasonably foreseeable future projects that could cumulatively contribute to the environmental impacts of the proposed action (Kairos 2021-Kairos 2021-TN7880). The NRC staff expects that each industrial facility in the surrounding area would comply with applicable OSHA and NIOSH regulations to ensure good occupational protection. Based on the staff's analysis of potential nonradiological human health impacts from the anticipated life cycle of the proposed Kairos Hermes facilities, the staff expects that the facilities would not substantially contribute to occupational hazards in the area. The applicant acknowledges that the nonradiological health impacts from emissions and discharges from past ORR operations in the area are noticeable, but that the incremental contribution from the proposed facilities would not be noticeable (Kairos 2021-TN7880 | Sec 4.13.8.1). The NRC staff finds that the incremental contribution of nonradiological health impacts from the Hermes project would not be noticeable, as long as the applicant complies with applicable OSHA and NIOSH regulations and implements the mitigation measures described in Section 4.8.1.8 of the ER (Kairos 2021-TN7880 | Sec 4.8.1.8).

3.7.1.6 Conclusions

The NRC staff concludes that the potential direct, indirect, and cumulative impacts of the proposed action on nonradiological human health would be SMALL. This conclusion is based primarily on the applicant's plans to reduce the potential for occupational physical hazards through implementation of safety practices, training, and physical control measures (Kairos 2021-TN7880 | Sec 4.8.1.5) and on the applicant's plans to reduce the potential for chemical exposure hazards through design of the Hermes facilities and practices to comply with applicable regulations and limit potential exposure of workers. The NRC staff may have to reevaluate the potential for occupational hazards if the applicant submits more detailed design information for operations or decommissioning in subsequent applications. The applicant would not use cooling towers (Kairos 2021-TN7880 | Sec 4.1.2) and thus would not discharge cooling tower blowdown to surface water where it could create chemical or thermal health hazards. Effluent would instead be released only to municipal sewers, where it would have to meet requirements established by the City of Oak Ridge or be trucked away to a suitable disposal location. The NRC staff recognizes that the applicant proposes to perform environmental monitoring to protect human health as required by permitting requirements (Kairos 2021-TN7880 | Sec 4.8.1.7). The NRC staff expects that specific monitoring requirements would be called for by permits the applicant receives under the Resource Conservation and Recovery Act (TN1281), CAA (TN1141), and from the State. The NRC staff's conclusion also recognizes that the applicant has committed to implementation of administrative procedures and protective measures to ensure protection of human health and the environment, BMPs to minimize pollutant discharges and emissions, and waste reduction practices such as recycling and waste minimization (Kairos 2021-TN7880 | Sec 4.8.1.8). The NRC staff expects that no additional mitigation measures will be necessary to prevent noticeable adverse nonradiological health impacts.

3.7.2 Radiological Human Health

3.7.2.1 Affected Environment

As discussed in the land use section of this draft EIS (Section 3.1), the proposed Hermes test reactor would be built within the footprint of the former K-31 and K-33 gaseous diffusion plants. These two gaseous diffusion plants had various levels of chemical and radiological contamination that DOE remediated as part of the demolition and decontamination of the areas prior to releasing them for industrial uses like the Hermes test reactor. DOE performed radiological surveys and environmental sampling under the DOE Environmental Management Program's Dynamic Verification Strategy process to assess the condition of the K-31 and K-33 property as documented in two documents, namely the covenant deferral requests for the title transfer of the former K-31 Area and K-33 Area at the East Tennessee Technology Park (DOE 2015-TN7964, DOE 2015-TN7965). As documented in these two title transfer reports, there were no exceedances of the measured maximum or average remediation level. If contamination above the remediation levels were discovered later, DOE would be required to take appropriate remediation actions. Based on the remedial actions and the environmental sampling, as documented in DOE 2015-TN7964 and DOE 2015-TN7965, the K-31 and K-33 Areas have a negligible or very low radiological risk to Hermes workers consistent with EPA's guidance for the protection of human health and the environment.

Ongoing activities on the ORR release small quantities of radionuclides to the environment. The ORR Annual Site Environmental Report (DOE 2021-TN7915) provides estimated annual doses to a hypothetical maximally exposed individual (MEI) from radionuclides released from all DOE facilities on the ORR considering all potential pathways. The most recent report estimates the maximum annual radiation dose to the MEI in 2020 to be about 0.4 millirem (mrem) from air pathways, approximately 2 mrem from water pathways (i.e., drinking, consuming fish, swimming and other recreational uses), and 0.07 mrem from wildlife consumption (e.g., two geese) harvested on ORR (DOE 2021-TN7915). The combined 2020 dose was estimated to be approximately 3 mrem (DOE 2021-TN7915). During the 5-year period from 2016 to 2020 the estimated annual all-pathways dose to the MEI averaged about 2.6 mrem except for 2019 with a dose of approximately 6.6 mrem with 4 mrem due to the sampling of fish (DOE 2021-TN7915).

In addition, several non-DOE radiological facilities on or near the ORR could potentially contribute to cumulative impacts on members of the public. Based on its review of responses for the years of 2016 and 2017 from 25 nearby non-DOE facilities regarding potential radiation doses to members of the public, DOE concluded the combined annual doses from both DOE and non-DOE sources would be significantly less than DOE's annual dose limit of 100 mrem, which is the same annual dose limit in 10 CFR 20.1301 (TN283), "Dose limits for individual members of the public" (DOE 2017-TN5081, DOE 2018-TN7989). Annual doses to members of the public from direct radiation from the non-DOE facilities ranged from 0 to 25 mrem in 2016 and from none to 2 mrem in 2017 (DOE 2017-TN5081, DOE 2018-TN7989).

Two main sources of natural background radiation exist: cosmic radiation produced by collisions of high-energy particles in the upper atmosphere, and naturally occurring terrestrial radionuclides in rocks and soils. The cosmic ray background varies with geomagnetic latitude and elevation; the cosmic ray dose rate in the region surrounding the East Tennessee Technology Park (elevation 600–1,200 ft) averages between 27 and 31 mrem per year (mrem/yr) (National Research Council 1980-TN5291). The dose rate from uranium, thorium, potassium, and related natural radionuclides depends on the underlying geology; the terrestrial dose rates in the region surrounding the East Tennessee Technology Park average between 35 and 75 mrem/yr (National Research Council 1980-TN5291). When combined with the cosmic ray contribution, direct natural radiation in this area of Tennessee ranges from 62 to 106 mrem/yr. Therefore, the naturally occurring background radiation dose rates at the East Tennessee Technology Park should be in the anticipated range of 62 to 106 mrem/yr, which is consistent with the United States average of about 100 mrem/yr from direct radiation (NCRP 2009-TN420). The breathing of radon gas typically adds an additional natural background dose of approximately 200 mrem/yr for an average total natural background of approximately 300 mrem (0.3 millisievert [mSv]) per year.

3.7.2.2 Environmental Impacts of Construction

At certain times during construction, Kairos or a designated construction contractor would be licensed to receive, possess, and use specific radioactive byproduct, source, and special nuclear material in support of construction and preparations for operation, such as for compaction testing and radiography (Kairos 2021-TN7880). These sources of low-level radiation are required to be controlled by the radiation protection program of the holder of the radioactive material license and have very specific uses under controlled conditions. The controlled conditions would include restricting access to an area when a device using a byproduct sealed source is in use to prevent radiological exposure of the general construction workforce along with possession controls to the radioactive material. The required radiation protection procedures and monitoring of the radioactive material would ensure that doses to construction workers from such uses of sources of radiation would be well below the annual dose limits for members of the public set forth in 10 CFR 20.1301 (TN283), if not negligible.

As discussed in Section 3.1 of this draft EIS, the site proposed for the Hermes test reactor is the former site of Buildings K-31 and K-33, which were part of the ORGDP complex for enriching large quantities of uranium from the 1950s until operations ceased in 1985 and the site was permanently shut down in 1987. These gaseous diffusion buildings were decontaminated, demolished, and the land was remediated of any residual radiological or chemical waste to allow for unrestricted use. However, DOE would retain responsibility for any corrective actions regarding unanticipated discovery of legacy wastes, if found during the construction of the Hermes test reactor (DOE 2015-TN7964, DOE 2015-TN7965).

Therefore, based on the controls required for the use of radioactive devices or radioactive material during construction and DOE's remediation of the land prior to any Kairos construction activity, the NRC staff concludes the radiological impacts during construction would not be significant.

3.7.2.3 Environmental Impacts of Operation

This section discusses the estimated annual doses to facility workers and members of the public from the operation of the Hermes test reactor along with radiological environmental monitoring over its anticipated four-year licensing period. Based on the design of the Hermes test reactor, the expected exposure pathways to members of the public would principally be from radiological gaseous effluent release because a small volume of radioactive liquid effluent releases (i.e., water-based releases) would be discharged to the sewer lines in accordance with 10 CFR 20 Subpart K, specifically under 10 CFR 20.2003 (TN283), "Disposal by Release Into Sanitary Sewerage" and the limits of Table 3 of Appendix B to 10 CFR Part 20 (Kairos 2021-TN7880 | Sec 2.6.1.1). Additionally, Kairos will apply for a sanitary sewer and water supply permit (Kairos 2021-TN7880 | Table 1.4-1) which requires that any liquid radiological discharges into the City of Oak Ridge wastewater treatment system must meet Municipal Code 18-308 (City of Oak Ridge 2022-TN7941). Based on prior dose modeling applying the maximum releases under NRC regulation, the sanitary sewerage pathway would present a sufficiently low health and safety risk to the public under the current regulatory structure (70 FR 68350-TN7940). Because Kairos would release small amounts of liquid radiological wastes that would be within regulatory limits, the exposure from this pathway is expected to be negligible. Section 4.8 of the ER presents an analysis of the potential annual radiation doses to the MEI located nearby from such radiological gaseous effluent releases.

The annual dose limits for members of the public are provided in 10 CFR 20.1301 (TN283), specifically 10 CFR 20.1301(a) (TN283), which limits dose to 0.1 rem/yr. However, the Atomic Safety and Licensing Board Panel determined that the limits in 40 CFR 190.10 (TN739)—and hence 10 CFR 20.1301(e) (TN283)—and 10 CFR Part 50 Appendix I (TN249) do not apply to non-light water reactors (LWRs) (ASLB 2007-TN6826). Additionally, these regulations are also specifically applicable to operations associated with the production of electrical power for public use or for light-water-cooled nuclear power reactors. Therefore, because the Hermes test reactor is based on molten salt cooling (therefore a non-LWR) and would not produce electricity, this test reactor would not be subject to the requirement in 10 CFR 20.1301(e) (TN283) to adhere to the applicable environmental radiation standards in 40 CFR 190.10 (TN739) and 10 CFR Part 50 Appendix I (TN249). However, other portions of 10 CFR Part 20 (TN283) apply to any users of radioactive material and are applicable to the Hermes test reactor. Regulations such as the dose limits in 10 CFR 20.1301(a) and the as low as is reasonably achievable requirements and regulations for radiation protection programs under 10 CFR 20.1101 (TN283) are applicable to non-LWR and non-power reactor licensees, and would ensure that radioactive effluent releases from non-LWRs and non-power reactors remain below applicable regulatory limits.

3.7.2.3.1 Occupational Doses

If an OL is issued to Kairos, they would need to control occupational doses to workers to the 5 rem annual limit as specified in 10 CFR 20.1201 and incorporate the low as is reasonably achievable provisions of 10 CFR 20.1101 (TN283) to ensure occupational doses would always be below this limit.

3.7.2.3.2 Doses from Radiological Gaseous Effluent Releases

Following the guidance in NUREG-1537 Part 1, Kairos presents an analysis of the radiological human health impacts in Section 4.8.2 of the ER (Kairos 2021-TN7880). This section of the ER discusses the various sources of radiation (gaseous, liquid, and solid) and baseline radiation levels within the facility before providing a detailed analysis of offsite doses based on radiological gaseous effluent releases with no anticipated need for holding time to allow for decay. Only a limited amount of radiological liquid effluents would be generated and, as discussed in Section 3.9 of this draft EIS for liquid radiological waste management, these effluents would be disposed via the WWTP sewerage per 10 CFR 20.2003 (TN283) with no exposure pathway to nearby residents. The Kairos radiological gaseous effluent release analysis in Section 4.8.2.4 of the ER is based on the guidance in RG 1.111 for atmospheric long-term dispersion coefficients (NRC 1977-TN5887) and RG 1.109 methodology (NRC 1977-TN90) for calculating annual doses to members of the public from the radiological effluent releases. Both analytical processes were performed by Kairos (Kairos 2021-TN7880 | Sec 4.8.2.4) with the application of the NRCDose modeling package programs XOQDOQ (Sagendorf et al. 1982-TN280) and GASPAR II (Sagendorf et al. 1982-TN280) and GASPAR II (Strenge et al. 1987-TN83,Sagendorf et al. 1982-TN280) and GASPAR II (Strenge et al. 1987-TN83), respectively, through a graphical user interface (NRC 2021-TN7050).

The Kairos analysis of long-term dispersion coefficients shown in ER Tables 4.8-14 through 4.8-20 is based on 5 years of meteorological data from a nearby ORR meteorological tower, Tower L, 1 mi south-southeast of the Hermes facility site, for the years 2016 to the end of 2020 (Kairos

2021-TN7880). During the environmental audit of the Hermes ER, the NRC staff examined the input and output files of the XOQDOQ calculations (NRC 2022-TN7954). The results of these calculations for long-term dispersion coefficients were compared to the results found for the Clinch River ESP ER, as documented in TVA's ER and the staff's final EIS (TVA 2017-TN4921 | Sec 2.7.6, NRC 2019-TN6136). Based on this review, the staff found the resulting long-term dispersion coefficients being applied by Kairos to be reasonable for use in a radiological gaseous effluent determination concerning annual doses to individual members of the public.

Kairos calculated the gaseous pathway doses to the MEI at a location with the greatest modeled concentration and deposition from airborne emissions (i.e., 0.5 mi south-southeast). For the actual nearest resident located at approximately 1.1 mi north-northwest of the site, the greatest modeled concentration and deposition in the eastern direction was applied for this location (Kairos 2022-TN7882). Kairos applied the GASPAR II computer program to calculate the radiological doses to these individual members of the public. The following activities were considered in the dose calculations: (1) direct radiation from submersion in the gaseous effluent cloud and exposure to particulates deposited on the ground; (2) inhalation of gases and particulates; (3) ingestion of meat from animals eating grass affected by gases and particulates deposited on the ground; and (4) ingestion of foods (e.g., vegetables) affected by gases and particulates deposited on the ground. Because there would not be any residential or agricultural properties within the boundary of the East Tennessee Technology Park, doses at the site boundary and the MEI do not include contributions from the ingestion of milk, meat, or vegetables. Meat and vegetable ingestion were included in the nearest resident's exposure pathways. Kairos did not identify any milk production in the vicinity of the Hermes site (Kairos 2022-TN7882). No milk production in the surrounding area was noted in the Clinch River ESP EIS either (NRC 2019-TN6136).

As a bounding calculation, Kairos applied the annual gaseous radiological release values from Table 3.5-4 of Revision 2 of the Clinch ESP ER (TVA 2017-TN4921) along with a bounding tritium emissions rate of approximately 62,500 curies per year (Ci/yr) (Kairos 2022-TN7902). Other parameters used as inputs to the GASPAR II program include vegetable production rates, meat production rates, long-term atmospheric dispersion factors, receptor locations, and consumption factors that the staff independently verified as being adequate for this analysis. Gaseous pathway doses at the site boundary to the MEI and the nearest resident, as calculated by Kairos, are shown in Table 3-8 of this draft EIS.

Kairos states in the ER that the total body and organ dose estimates for the MEI from gaseous effluents at the Hermes site would not be in excess of the 10 CFR 20.1101(d) constraint, which is a total effective dose equivalent (TEDE) of 10 mrem (0.1 mSv) per year and the 10 CFR 20.1301(a)(1) TEDE limit of 100 mrem (1 mSv) (TN283). The TEDE annual doses at several locations from the combined external dose and radiological gaseous effluents are presented in Table 3-9. Based on the fact that the Hermes reactor itself is in a heavily shielded area within the Hermes Reactor Building, direct radiation dose rates in the vicinity of facility are expected to be generally undetectable and less than 1 mrem/yr. This is based on the monitoring experience at LWR site boundaries (NRC 2013-TN2654). For this EIS, the NRC staff completed an independent evaluation of Kairos's NRCDose calculations by reviewing the inputs and subsequent results, allowing for further comparisons to the radiological dose analysis conducted under the Clinch River ESP ER, and found that the Kairos Hermes analysis was adequate. As indicated in Table 3-9, the resulting annual doses are in compliance with 10 CFR Part 20 Subparts B and D (TN283) for annual doses and a very small fraction of the annual natural background radiation exposure level of 300 mrem.

Table 3-8 Radiological Doses from Annual Radiological Gaseous Effluent Releases

			Annual Dose Rate (mrem/yr)			
Location	Pathway		Total Body	Thyroid	Maximum Organ	Maximum Organ
Site boundary (0.2 mi, north east)	External	Plume	5.7E-02	5.7E-02	1.8E-01	Skin
		Ground	8.0E-02	8.0E-02	1.4E-01	
		Subtotal	1.4E-01	1.4E-01	3.2E-01	
	Inhalation	Subtotal	4.3E-01	5.1E-01	5.2E-01	Thyroid
	Ingestion	Subtotal	N/A[(a)]			
	TOTAL		5.7E-01	6.5E-01	5.2E-01	Thyroid
MEI (0.5 mi, SSE)	External	Plume	1.5E-01	1.5E-01	4.9E-01	Skin
		Ground	4.0E-02	4.0E-02	6.8E-02	
		Subtotal	1.9E-01	1.9E-01	5.6E-01	
	Inhalation	Subtotal	1.2E+00	1.5E+00	1.5E+00	Thyroid
	Ingestion	Subtotal	N/A[(b)]			
	TOTAL		1.4E+00	1.7E+00	1.5E+00	Thyroid
Analytical nearest resident (1.1 mi, east)[(c)]	External	Plume	5.2E-02	5.2E-02	1.7E-01	Skin
		Ground	2.2E-02	2.2E-02	3.8E-02	
		Subtotal	7.4E-02	7.4E-02	2.1E-01	
	Inhalation	Subtotal	4.6E-01	5.5E-01	5.5E-01	Thyroid
	Ingestion	Subtotal	6.5E-01[(d)]	8.2E-01[(d)]	8.2E-01[(d)]	Thyroid
	TOTAL		1.2E+00	1.4E+00	1.6E+00	Thyroid

Key: mrem/yr = mrem per year; mi = miles ; N/A = not applicable; χ = atmospheric dispersion factor(s); Q = annual average normalized air concentration value(s).

(a) The ingestion pathway at the site boundary is not applicable; there is no production of food products at the site boundary.

(b) The MEI location is within the boundary of the East Tennessee Technology Park; the ingestion pathway at the MEI location is not applicable; there is no production of food products inside the boundary of the East Tennessee Technology Park.

(c) The nearest residence is north-northwest at 1.1 mi from the reactor. Dose is calculated at 1.1 mi from the reactor in the direction of maximum χ/Q without decay (see ER Table 4.8-20), which was also the direction of maximum deposition.

(d) The ingestion pathway at the site boundary does not include dairy production. There is no identified production of dairy products in the area of the site. The cultivation of vegetables and livestock for the ingestion pathways considered is assumed to occur at the location of the analytical nearest resident.

Source: (Kairos 2022-TN7882 | Table 4.8-22).

Table 3-9 Annual Total Effective Dose Equivalent to the Individual Members of the Public

Dose Receptor	Annual TEDE	Annual TEDE Dose Regulation Limits
Gaseous Effluents		
Site boundary	0.57 mrem (0.0057 mSv)	
MEI in an unrestricted area (0.5 mi)	1.4 mrem (0.014 mSv)	10 mrem(a) (0.1 mSv)
Nearest full-time resident	1.2 mrem (0.012 mSv)	
Total Dose (Combined External Dose and Gaseous Effluent)		
Site boundary	1.6 mrem (0.016 mSv)	
MEI in an unrestricted area (0.5 mi)	2.4 mrem (0.024 mSv)	100 mrem(b) (1.0 mSv)
Nearest full-time resident	1.3 mrem (0.013 mSv)	

Key: TEDE = total effective dose equivalent; mrem = millirem; mSv = millisievert; MEI = maximally exposed individual; mi = miles.
(a) 10 CFR 20.1101(d) (TN283) for airborne emissions.
(b) 10 CFR 20.1301(a)(1) (TN283) for licensed operations.
(c) Includes ingestion of meat and vegetable produced at the analytical nearest resident location.
(d) Dose is modeled at the distance of the analytical nearest resident but in the direction of the maximum deposition.
(e) The external dose was not modeled and is conservatively assumed to be 1 mrem/yr (Section 4.8.2.4.1).
Source: (Kairos 2021-TN7880 | Table 4.8-3).

3.7.2.3.3 Radiological Environmental Monitoring

Kairos discusses radiological environmental monitoring in accordance with 10 CFR 20.1302 (TN283) in PSAR Section 11.1.7 and ER Section 4.8.3 to demonstrate compliance with the dose limits for individual members of the public in 10 CFR 20.1301 (Kairos 2021-TN7880). Kairos would implement a radiological environmental monitoring program to perform the necessary monitoring for assessing the following exposure pathways: direct radiation, airborne, waterborne, and ingestion. Monitoring sites would be determined prior to operation for onsite, site perimeter, and offsite locations considering the guidance followed by LWRs, namely RG 4.1 (NRC 2009-TN3802) and NUREG-1301 (Kairos 2021-TN7880 | Sec 4.8.3.2).

To monitor the direct radiation pathway, Kairos would post thermoluminescent dosimeters at several locations onsite, at the site boundary, and at an offsite location to capture the background dose as a control measurement. Groundwater sampling would be established at locations based on the groundwater gradient where some existing East Tennessee Technology Park test wells could be used in support of the Hermes test reactor operations for addressing potential leaks and spills. Based on evaluated meteorological conditions and monitoring of the airborne exposure pathway, monitoring stations at three locations near the facility site boundary, a fourth air sampling location at a nearby community, and a fifth location farther away from the facility to provide background (i.e., control) readings, would be established. The ingestion exposure pathway would be established to monitor for deposition of PM onto edible produce in the vicinity of the facilities and specifically for the monitoring of milk, if being produced nearby. In the case of the East Tennessee Technology Park site, no dairy or goat milk production occurs within 5 mi, so milk sampling would only occur if such production were found to exist within the mentioned 5 mi.

The NRC staff will review the finalized monitoring locations and other monitoring requirements provided with the OL application. During the OL application phase, the NRC safety staff will determine whether the operational radiological environmental monitoring program will be adequate for the evaluation of environmental impacts related to operating the Hermes test reactor at the East Tennessee Technology Park site.

3.7.2.3.4 Conclusions

The NRC staff performed an independent review of the radiological gaseous effluent releases and finds that the expected annual doses to members of the public as previously described are below the appropriate dose limits in 10 CFR Part 20 (TN283). Additionally, the NRC staff will perform an independent safety review of Kairos' plans for exposure control and radiological effluent monitoring and its compliance with applicable regulatory requirements of 10 CFR Part 20, such as 10 CFR 20.1301 (TN283). The NRC staff's independent safety review will be documented in its Safety Evaluation Report. Based upon the discussion above and the staff's completion of a thorough independent safety review and evaluation of the applicant's information that states Kairos will comply with applicable requirements, the NRC staff concludes that the environmental impacts from radiological gaseous effluent releases would not be significant and further mitigation would not be warranted.

3.7.2.4 Environmental Impacts of Decommissioning

Upon cessation of operations, all radioactive material would be transferred to various types of storage containers based on the type of material (e.g., molten salts, spent TRI-structural ISOtropic [TRISO] fuel, and radioactive material from decontamination operations) and shipped to licensed disposal sites. While some trace amounts of tritium could be expected to diffuse out of such storage containers, radiation area monitoring would continue to ensure safe storage of the radioactive material until it is removed from the site or placed in a specifically designed and certified dry cask storage system, if necessary. The Decommissioning Generic Environmental Impact Statement (GEIS) discusses the expected radiological impacts that could occur during decommissioning of a large LWR (1,130 MWe pressurized water reactor or a 1,100 MWe boiling water reactor), including the appropriate practices to minimize radiological exposure to workers, and found that impacts would be small and that no additional mitigation measures are likely to be sufficiently beneficial to be warranted (NRC 2002-TN7254). The Hermes test reactor is a small fraction of a large LWR (35 MWt versus approximately 3,300 MWt LWR) and would have a proportionally small fraction of the radiological impacts discussed in the Decommissioning GEIS. Based on the small size of the Hermes test reactor and on the radiological impacts discussed in the Decommissioning GEIS, the staff concludes that Hermes radiological environmental impacts during decommissioning would be negligible.

3.7.2.5 Cumulative Impacts

Table 4.13-1 of the ER identifies past, present, and reasonably foreseeable future projects that could cumulatively contribute to the environmental impacts of the proposed action (Kairos 2021-TN7880). In addition to impacts from construction and operations, this cumulative analysis also considers other past, present, and reasonably foreseeable future actions that could contribute to cumulative radiological impacts. For the purposes of this analysis, the geographic area of interest is the area within a 50 mi radius of the Hermes site. The NRC staff finds this metric to be acceptable because historically the NRC has used the 50 mi radius as a standard bounding geographic area to evaluate population doses from routine releases from nuclear power plants (NPPs). This region contains several radiological projects or facilities. Within the geographic area of interest, reasonably foreseeable planned Federal projects on the ORR include the Sludge Processing Mock Test Facility at the Transuranic Waste Processing Center, the Uranium Processing Facility at the Y-12 Complex, and a new disposal area to replace the

DOE's Environmental Management Waste Management Facility. Other major currently operating ORR nuclear facilities include the High Flux Isotope Reactor, a nuclear research reactor located at ORNL, and the ORNL Spallation Neutron Source. Other radiological projects or facilities outside of ORR but within the geographic area of interest identified by Kairos in ER Table 4.13-1 include TVA's Watts Bar Units 1 and 2 (30 mi southwest), TVA's proposed CRN site (3.5 mi south-southeast), Energy*Solutions* Bear Creek Processing Facility, which processes low-level radioactive waste for permanent disposal (2 mi southeast), and the proposed Coquí Pharma medical isotope production facility (0.75 mi south) (Kairos 2021-TN7880 | Table 4.13-1). As identified in the CRN ESP final environmental impact statement, there is the former American Nuclear Corporation site, closed since 1970, where radioactive materials are being allowed to decay in place (NRC 2019-TN6136 | Table 7.1). These facilities have the potential to contribute to cumulative radiation exposures in conjunction with the Hermes test reactor. However, given the small radiological doses from the Hermes test reactor and the fact the radiation doses from facilities discussed in the above affected environment for this section have been shown to be low, the staff concludes that there would not be a noticeable increase in the cumulative radiological impacts of the above projects or facilities by the Hermes test reactor for the geographic area of interest.

3.7.2.6 Conclusions

The staff concludes that the potential direct, indirect, and cumulative radiological human health impacts of the proposed action during the 4 years of operation and during decommissioning, along with cumulative impacts would be SMALL. This conclusion is based primarily on the fact that the proposed Hermes test reactor is estimated to have radiological effluent releases well below the NRC requirements for potential doses to members of the public (e.g., the nearest resident) with appropriate radiological environmental monitoring and because occupational doses would be less than annual dose limits under 10 CFR Part 20 (TN283) regulations.

3.8 Nonradiological Waste

3.8.1 Affected Environment

Section 3.1 of this draft EIS Land Use and Visual Resources, provides a detailed physical description of the proposed Hermes site and its surrounding vicinity. Figures 3.1-2 and 3.1-3 of the applicant's ER provide maps detailing the current land use categories, including croplands, forested areas, and developed lands within the 5 mi region surrounding the site (Kairos 2021-TN7880). The proposed Hermes site is presently undeveloped, with portions used by DOE for construction laydown (Kairos 2021-TN7880 | Sec 3.1.1.1). There are no chemical plants, refineries, mining or quarrying facilities, or military facilities within 5 mi of the site (Kairos 2021-TN7880 | Sec 3.1.1.2). The applicant indicates there are no radioactive or hazardous materials currently stored on the site but acknowledges the potential for residual radioactive or hazardous contamination could be present at levels above background but below risk-based standards because the site was once the home of the K-31 and K-33 gaseous diffusion plants. Section 3.9 of this draft EIS discusses radiological waste management and the Uranium Fuel Cycle.

3.8.2 Environmental Impacts of Construction

Nonradiological waste hazards may arise from normal activities (emissions, discharges, and solid waste) during the construction phase of the proposed project, as well as from accidental releases in solid, liquid, or gaseous states. The applicant states all normal activity releases will be managed in accordance with applicable Federal, State, and local laws and regulations and permit requirements (Kairos 2021-TN7880 │ Sec 4.8.1).

The applicant characterizes waste to be generated during construction in Section 4.9.1.1 of the ER (Kairos 2021-TN7880 │ Sec 4.9.1.1). Solid nonradiological waste would include construction and demolition waste such as scrap lumber, bricks, sandblast grit, glass, wiring, non-asbestos insulation, roofing materials, building siding, scrap metal, concrete with reinforcing steel, and other similar materials (Kairos 2021-TN7880 │ Sec 4.9.1.1). Typical liquid nonradiological waste produced during normal activities would include fuels, oils, solvents, paints and stains, and other chemicals. The most common liquid waste would be human waste, which would be discharged via municipal sewers to the Rarity Ridge Wastewater Treatment Facility (Kairos 2021-TN7880 │ Sec 4.8.1.2.1). Other liquid chemicals would be treated onsite before shipment to the Rarity Ridge Wastewater Treatment Facility to ensure that the facility's requirements are met. The applicant estimates air emissions from the facility would fall below the 100 TPY threshold established by the TDEC for criteria pollutants (SO_2, NOx, PM_{10}, $PM_{2.5}$, CO, VOCs, and Pb) during the projected two-year construction period (Kairos 2021-TN7880 │ Sec 4.2.1.1). Management of solid waste would involve waste reduction efforts, recycling, and BMPs during all phases of the project.

3.8.3 Environmental Impacts of Operation

Although the applicant plans to register the facilities as a Small Quantity Generator under the Resource Conservation and Recovery Act (TN1281), it expects that there would be no significant sources of hazardous waste during operations (Kairos 2021-TN7880 │ Sec 4.9.1.2). The applicant plans to manage any hazardous waste, including universal wastes, in accordance with a waste management plan that conforms with applicable Federal and State regulations (Kairos 2021-TN7880 │ Sec 4.9.1.2). Operation of the reactor building would generate gaseous effluents, which would be passed through a high-efficiency particulate air filtration system prior to discharge through the ventilation stack (Kairos 2021-TN7880 │ Sec 4.8.1.2.2). Solid waste from operations would include operations, maintenance, and demolition debris; food waste and food product packaging waste; and disposable office items. As stated in the applicant’s ER, solid waste would be collected and stored temporarily onsite and either disposed of at a nearby sanitary site or recycled. Management of solid waste would involve waste reduction efforts, recycling, and BMPs (Kairos 2021-TN7880 │ Sec 4.8.1.2.3). The facilities would not release nonradioactive liquid chemicals to the environment (Kairos 2021-TN7880 │ Sec 4.8.1.4.2); and, as noted above in Section 3.3 of this draft EIS, wastewater discharges would be sent to a municipal WWTP for treatment.

3.8.4 Environmental Impacts of Decommissioning

The applicant plans to address waste management during decommissioning in a license termination plan prepared in accordance with NUREG-1757, *Consolidated Decommissioning Guidance*, Volumes 1-3, and submitted to the NRC for approval (Kairos 2021-TN7880 │ Sec 4.9.1.3). The NRC staff expects decommissioning to generate nonradiological solid waste materials such as building rubble and debris, concrete and structural materials, wood, glass, metals, gypsum and other finished materials, and office equipment, materials, and supplies. The NRC staff expects that the applicant would use BMPs to limit the amount of dust and other airborne particles. Liquid wastes from chemicals, solvents, and cleaning solutions would produce small amounts of volatilized chemicals, but BMPs would minimize their contribution to degradation of local air quality.

3.8.5 Cumulative Impacts

Table 4.13-1 of the ER identifies past, present, and reasonably foreseeable future projects that could exacerbate the environmental impacts of the proposed action (Kairos 2021-TN7880). The NRC staff expects that each industrial facility in the surrounding area would comply with applicable EPA and State regulations to ensure proper disposal of nonradiological waste. Based on the NRC staff's analysis of potential nonradiological waste impacts from the Kairos Hermes facilities, the NRC staff expects that the facilities would not substantially contribute to waste impacts in the area, due to its relatively small size and operating staff.

3.8.6 Conclusions

The NRC staff reviewed the applicant's ER and performed its own independent assessment of the nonradiological waste management discussion through a combination of independent research and the review of other NRC EISs, including the 2019 NUREG-2226 (NRC 2019-TN6136), *Environmental Impact Statement for an Early Site Permit (ESP) at the Clinch River Nuclear Site*, a project located approximately 4 mi to the east of the proposed site. The staff finds the conclusions of the Hermes nonradiological waste component to be consistent with those of the CRN EIS and finds that during all three life-cycle phases of the proposed Hermes project, the nonradiological waste impact from liquid, gaseous, and solid wastes would be SMALL, and mitigation would not be needed for releases during normal activities. As long as proper training and management practices are maintained the potential for accidental releases and environmental impact of accidental releases would also be minimal.

3.9 Uranium Fuel Cycle and Radiological Waste Management

3.9.1 Uranium Fuel Cycle

As presented in 10 CFR 51.51(a) (TN250), a light-water-cooled nuclear power reactor can use Table S-3, Table of Uranium Fuel Cycle Environmental Data, as the basis for uranium fuel cycle environmental effects. While the Hermes reactor is not a light-water-cooled nuclear power reactor, Kairos will rely upon the same uranium fuel cycle addressed by Table S-3. Thus, this section presents the Hermes reactor's contribution to the environmental effects of the current uranium fuel cycle with respect to Table S-3.

The License Renewal (LR) GEIS, NUREG-1437 Revision 1, in Section 4.12.1.1, Uranium Fuel Cycle, describes the current state of the uranium fuel cycle for the current nuclear fleet and is incorporated by reference in this EIS (NRC 2013-TN2654). The LR GEIS denotes several technological changes in the various fuel cycle operations that reduce the uranium fuel cycle impacts shown in 10 CFR 51.51 (TN250), namely Table S-3, such as:

- in situ mining of uranium rather than open pit or deep mining;
- use of more efficient isotopic enrichment processes through the gaseous centrifuge rather than the energy-intensive gaseous diffusion process; and
- less use of coal-powered electrical generation.

Two aspects of the front end of the uranium fuel cycle are different for the Hermes reactors. First, the Hermes reactor is designed to use a maximum enrichment of 19.55 wt% uranium-235 (Kairos 2021-TN7880 | Sec 2.3 and Sec 4.1.1.1). Uranium enriched to this level is known as High-Assay Low Enriched Uranium or HALEU. Additionally, the source of HALEU for the Kairos

TRISO fuel has not been finalized (Kairos 2021-TN7880 | Sec 4.1.1.1). Kairos is expecting approximately 0.93 metric tons of uranium (MTU) would be needed over the four-year licensed operating life (Kairos 2021-TN7879) compared to an average of 20 to 33 metric tons of uranium per year (MTU/yr) for the current LWRs. Thus, due to the much lower quantity of uranium needed, the impacts from uranium recovery and uranium conversion would be much less than the impacts presented in WASH-1248 (AEC 1974-TN23) and Table S-3 would still be bounding. Regarding the source of HALEU for the Hermes reactor, one potential source for the needed 0.93 MTU would be from the DOE. The DOE is supporting efforts regarding availability of HALEU for civilian domestic research, development, demonstration, and commercial use in the United States to prevent reliance on Russia or other foreign suppliers to fuel the next generation of nuclear power (87 FR 71055-TN7945). At this time, Kairos expects that HALEU material would be provided by an external source (Kairos 2021-TN7880 | Sec 2.7.1).

The second aspect concerns the Kairos Hermes reactor fuel type, which is designed to use TRISO fuel, a type of fuel that is not used in large LWRs. The source of fresh TRISO fuel may be provided from existing manufacturers or from a TRISO fuel fabrication facility built by Kairos. The manufacturing process for the Kairos-designed TRISO fuel involves three major manufacturing phases: kernel manufacturing, coated particle manufacturing, and pebble manufacturing (Kairos 2021-TN7944). Kernel manufacturing converts triuranium octaoxide (U_3O_8) powder into spherical uranium oxycarbide (UCO) kernels (a mixture of uranium dioxide [UO_2], uranium carbide [UC], and uranium dicarbide [UC_2] phases). Using chemical vapor deposition, multiple layers are added to the kernels. The final manufacturing phase is building the pebbles by pressing the kernels to a graphite core, adding a fuel-free outer matrix shell, with a final machining step. Because of the difference in chemical processes for TRISO fuel fabrication from the chemical processes described in Appendix E of WASH-1248 (AEC 1974-TN23), the Kairos TRISO manufacturing line would have fewer impacts because Kairos would employ a simpler process for converting uranium hexafluoride (UF_6) to UCO; the mechanical processes of building the TRISO pebbles (Kairos 2021-TN7944) is less extensive than the UO_2 pellet process of pelletizing, sintering, grinding, and washing; and the 0.93 MTU going through the fuel fabrication process is less than the 900 MTU/yr as assessed in Appendix E of WASH-1248 (AEC 1974-TN23). Thus, Kairos's TRISO fuel fabrication process would have fewer impacts than a more traditional UO_2 fuel fabrication process and Table S-3 would also be bounding for TRISO fuel fabrication.

Kairos has no plans for reprocessing spent TRISO fuel and would store the spent TRISO fuel onsite upon cessation of 4 years of operation until final disposition (Kairos 2021-TN7880 | Sec 2.7.1). Kairos would have enough spent TRISO fuel storage capacity within the Reactor Building to support four years of licensed reactor operation (Kairos 2022-TN7882). While Kairos has no plans at this time to use an external dry storage system, if such a decision is made after the cessation of operations, approval for building and operating such a dry storage system on an external pad would need to be sought prior to implementation of such a spent TRISO fuel management plan. The NRC staff notes that the requirements in 10 CFR Part 72 (TN4884), "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Wastes, and Reactor-Related Greater Than Class C Waste," do not apply to non-power reactor spent fuel. Depending on other nuclear industry and DOE actions in the future, Kairos may be able to ship the spent TRISO fuel offsite for interim storage or disposal. As noted by Kairos in ER Sections 2.7 and 4.10.3.1 (Kairos 2021-TN7880), transportation of spent TRISO would be conducted in a transportation package that is certified by the NRC under 10 CFR Part 71, which would meet NRC requirements and U.S. Department of Transportation regulations (TN301).

Kairos states in ER Section 4.9 that storage systems associated with continued storage of TRISO fuel would not be significantly different than those considered for LWR storage systems and "…the environmental impacts for continued storage of LWRs described in NUREG–2157 are considered to bound any impacts of the Hermes fuel storage" (Kairos 2021-TN7880). The NRC staff notes that NUREG-2157 states the Fort Saint Vrain spent fuel continues to be stored at an NRC-licensed Independent Spent Fuel Storage Installations (ISFSI) in Plattesville, Colorado, and is within the scope of the Continued Storage GEIS (NRC 2014-TN4117). Fort Saint Vrain used prismatic-block graphite fuel elements containing a form of TRISO fuel particles made from a mixture of the carbides of thorium and uranium (NWTRB 2020-TN7966, ORNL 2003-TN7950). These carbide particles of thorium and uranium were then coated with highly retentive coatings of pyrolytic carbon (C) and silicon carbide (SiC) to form the fuel particles, or kernels, much like the TRISO kernels by Kairos. These TRISO-like fuel kernels and a carbonaceous matrix were combined to form a bonded prismatic-block graphite fuel element for the Fort Saint Vrain reactor core. DOE has approximately 23 MTU of spent Fort Saint Vrain fuel in an NRC-licensed ISFSI (NWTRB 2020-TN7966). The Kairos Hermes fuel begins in a similar manner, with a UCO TRISO fuel kernel, but instead of being combined with a carbonaceous matrix, the TRISO fuel kernels are embedded in an annular shell surrounding an inner graphite core and then further coated with layers of pyrolytic C, SiC, and an outer pyrolytic C layer to form a TRISO pebble (Kairos 2021-TN7879). In Section 2.1.1.3 of NUREG-2157, the staff states that "[t]he Fort Saint Vrain spent fuel continues to be stored at an NRC-licensed ISFSI in Plattesville, Colorado, and is within the scope of this GEIS" (NRC 2014-TN4117). Because the Kairos TRISO fuel is similar to the Fort Saint Vrain coated fuel kernels, Kairos would be managing a much smaller amount of spent fuel (0.93 MTU from Hermes versus 23 MTU from Fort Saint Vrain), and the Fort Saint Vrain spent fuel is within the scope of the Continued Storage GEIS, the Kairos spent TRISO storage environmental impacts after cessation of operations would be bounded by the Continued Storage GEIS environmental impacts provided in NUREG-2157 Tables ES-3, ES-4, and ES-5 (NRC 2014-TN4117).

3.9.2 Radiological Waste Management

Liquid and solid radioactive waste-management systems would be used for collection, processing, packaging, and storage of the radioactive materials produced as byproducts during operation and decommissioning of the Hermes test reactor. Waste processing systems would be designed to meet the design objectives of 10 CFR Part 50 (TN249), "Domestic Licensing of Production and Utilization Facilities," and 10 CFR Part 20 (TN283), "Standards for Protection Against Radiation."

Kairos describes in ER Section 2.6.1 the Hermes test reactor waste systems to collect, process, store, monitor, and appropriately address the disposal of the radioactive waste. While not expecting to need a gaseous radioactive waste system (Kairos 2021-TN7880 | ER Table 2.6-1), ER Table 2.6-1 lists the estimated types and quantities of the other radioactive wastes to be generated and disposed of, and a majority of them are classified by Kairos as solid low-level radioactive waste (LLRW) (Kairos 2021-TN7880).

3.9.2.1 Liquid Radiological Waste Management

Because the Hermes reactor design does not depend on water cooling in any of the engineering systems, the only potential water-based liquid radiological waste would be from vent condensation, drains, and decontamination (Kairos 2021-TN7880 | Sec 2.6.1.1). Based in part on the fission product confinement capabilities of the TRISO fuel, the quantity and radiological content are expected to be low enough such that this waste stream could be released under

10 CFR 20.2003 to the WWTP as monitored and disposed of within the limits of 10 CFR 20 (TN283), Appendix B, Table 3 (release limits to sewers), such as 1×10^{-2} micro-curies per milliliter (μCi/mL) for tritium. Because the management of this radiological waste stream would be performed within the limits set in 10 CFR Part 20 (TN283), the environmental impacts on members of the public would be negligible over the 4 years of operation of the Hermes reactor.

The other liquid radiological waste stream involves molten salt wastes that would have their own individual radiological waste systems for the handling of Flibe. As noted in Section 3.7 of this draft EIS, Flibe molten salt generates relatively large quantities of tritium when exposed to neutrons. Thus, a major waste stream-based radiological hazard would be from tritium, along with some fission, transuranics, and activation products (Kairos 2021-TN7880 | Table 2.6-1). At the end of operations, the Flibe would be collected in containers, solidified as the salts cool during storage with a low radionuclide gamma activity such that radiation decomposition of the Flibe would not be of concern (Kairos 2022-TN7902). As discussed in Section 3.11 of this draft EIS, as much as approximately 40 tons (T) of Flibe would be shipped to a LLRW disposal site as Class B or C LLRW during decommissioning. The solidified Flibe could be classified as Class C LLRW due to the presence of the C-14 radionuclide at greater than 0.8 but less than 8.0 curies per meter cubed (Ci/m^3) along with other radionuclides being controlled by the technical specifications provided in PSAR Table 14.1.-1 (Kairos 2021-TN7879). The only commercial Class B and C LLRW disposal site is the Waste Control Specialist site west of Andrews, Texas. Since this liquid radiological waste stream would be solidified, contained, monitored, and safely stored onsite within shielded spaces inside the Reactor Building, the environmental impacts on members of the public would be negligible over the 4 years of operation.

3.9.2.2 Solid Radiological Waste Management

The solid radioactive waste system would manage typical nuclear facility operational wastes, originating as dry or wet wastes. The dry waste stream would contain the following contaminated items (Kairos 2021-TN7880 | Sec 2.6.1.2):

- personal protective equipment;
- rags, paper, and paper towels;
- plastic containers;
- laboratory apparatus;
- small parts and equipment;
- tools; and
- air filters.

Filters and sieves from the inert gas system, chemistry control system, and inert gas system oxygen and moisture absorbers would constitute the wet solid wastes (Kairos 2021-TN7880 | Sec 2.6.1.2). Both solid waste streams would be appropriately packaged for onsite storage and eventual shipping to a LLRW disposal site. Even though Hermes is a test reactor, these types of solid radioactive waste are similar to those generated at operational NPPs. The estimated annual amount of solid radioactive waste, or dry activated waste, expected to be generated by Hermes operation, namely less than 8,800 cubic feet (ft^3) annually (Kairos 2021-TN7880 | Table 2.6-1), would be less than the LLRW volume generated by an operational NPP, which is on average approximately 10,600 ft^3/yr (NRC 2013-TN2654). The LR GEIS determined for operational NPPs that the environmental impacts from this form of radiological waste management are small (NRC 2013-TN2654). Currently operating LLRW disposal facilities available to Kairos (i.e., Waste Control Specialist in Andrews County, Texas and Energy*Solutions* at Clive, Utah) have adequate capacity to accommodate the quantity of LLRW expected to be generated by the four year-operation of the Hermes test reactor (TCEQ 2020-TN7967, Energy*Solutions* 2016-TN7990). Thus, the associated radiological impacts on the environment from solid radioactive waste generated by Hermes operation would also be small.

3.9.2.3 Tritium Waste Management

To control tritium within the Kairos Hermes test reactor facility and to minimize the release of tritium to the surrounding environment, Kairos would install a tritium management system (TMS) for capturing tritium releases from the Flibe molten salt. As described in PSAR Section 9.1.3 and discussed in ER Section 2.6.1.2.3, the TMS manages tritium generated in the reactor and provides for recovery and storage of tritium from various systems (Kairos 2021-TN7879 | PSAR Sec 9.1.3.1, ER Sec 2.6.1.2.3, and Figure 2.6-1). The TMS consists of three separate system components:

- an inert gas capture system for separating tritium from the argon gas flow that is provided as a noncorrosive cover gas to multiple locations in the reactor vessel;
- a primary heat rejection system capture system for tritium separation from dry air in the cover gas; and
- a reactor cavity tritium capture system for tritium separation from dry air in Reactor Building cells.

These systems use either metal hydride or molecular sieves to capture and hold the tritium. The process for accomplishing such separations is described in PSAR Section 9.1.3 for each capture system and is incorporated by reference in this EIS (Kairos 2021-TN7879). Once the metal hydride or molecular sieves become saturated, they would be replaced and appropriately stored in preparation for shipment to a LLRW disposal site. Since the expected concentration of tritium is greater than the 40 Ci/m^3 limit for Class A LLRW per 10 CFR 61.55(a)(4) (TN5452), the material would need to be disposed as Class B LLRW, and the Waste Control Specialist site near Andrew, Texas, can accept this form of LLRW from the Hermes test reactor (Kairos 2022-TN7902). While tritium is a commercially available radionuclide, Kairos has no current plans to sell the tritium captured by the TMS (TN7902).

3.9.2.4 Spent TRISO Waste Management

Section 9.3 of the PSAR provides a detailed description of the pebble handling and storage system (PHSS) and a description of PHSS operations is provided in Section 2.7.1 of the ER (Kairos 2021-TN7879, Kairos 2021-TN7880). Both sections are incorporated by reference in this EIS. The storage portion of the PHSS (i.e., a cooling pool and an air cooled storage bay) would be designed to meet multiple principal design criteria to ensure the safe handling and storage of spent TRISO fuel in sealed containers for occupational and public safety. After 4 years of operation and reaching a burnup level of approximately 57 gigawatt-days per metric ton of uranium (GWd/MTU), Kairos could have approximately 155,200 spent TRISO pebbles to be stored in containers held in the storage portion of the PHSS (Kairos 2022-TN7902). Each container could hold approximately 1,900 to 2,100 spent TRISO fuel pebbles (Kairos 2021-TN7880). The PHSS air-cooled storage bay is sized to store all spent TRISO fuel in approximately 74 to 82 containers over the four-year licensing period. This process of managing spent TRISO fuel during the operational licensing period is similar to spent fuel management at operating NPPs, namely it involves a cooling pool supplemented with dry storage using air cooling. Sections 3.11.1.2 and 4.11.1.2 of the LR GEIS, Revision 1 of NUREG-1437, discuss the onsite storage process and the environmental impacts of spent nuclear fuel for operating NPPs for storing in a specifically designed water-cooled spent fuel pool with subsequent dry cask storage (NRC 2013-TN2654). The LR GEIS concluded that the current and potential environmental impacts from spent fuel storage onsite at the current reactor sites have been studied extensively, are well understood, and the environmental impacts were found to be small. Given that the design of the Hermes reactor TRISO fuel has multiple barriers to the release of fission products, more so than spent fuel assemblies, the onsite storage systems are similar in function, the amount of MTU of spent TRISO fuel is far less than at an operational LWR, and process of managing spent TRISO fuel would be regulated in the same manner as at the current LWRs. The environmental impacts presented in the LR GEIS also apply to the onsite storage of spent TRISO fuel for the Hermes reactor.

3.9.2.5 Gaseous Radiological Waste Management

Kairos states in the PSAR and ER that there is no anticipated need for a gaseous radioactive waste system based on the use of the TMS, and no production, storage, or disposal of radioactive gaseous waste is expected. (Kairos 2021-TN7879 | Sec 11.2.2.1, Kairos 2021-TN7880 | Sec 2.6.1.3). Radioactive gases, such as tritium gas not captured by the TMS but diffused out of various materials, would be discharged to the Reactor Building heating, ventilation, and air conditioning system, where they pass through a high-efficiency particulate air filter and are monitored prior to release (Kairos 2021-TN7879 | Sec 11.2.3, Kairos 2021-TN7880 | Sec 2.6.1.3). Impacts related to such gaseous releases of tritium during normal operations are addressed in Section 3.7 of this draft EIS.

3.9.3 Conclusions

The NRC staff concludes that the uranium fuel cycle impacts and radiological waste management impacts from operation and decommissioning of the Kairos Hermes reactor would be SMALL. This conclusion is based on the following:

- The relatively low quantity of uranium (0.93 MTU) to be used during the license period of four years is far less than the annual amount used to assess Table S-3 impacts.
- The TRISO fuel processes (i.e., HALEU enrichment and fuel fabrication) for the Hermes reactor are bounded by Table S-3 limits.
- The spent TRISO fuel environmental impacts from storage onsite or offsite upon cessation of operations are bounded by the Continued Storage GEIS.
- Any liquid or gaseous radiological waste stream releases would be in accordance with and within regulatory limits of 10 Part 20 (TN283).
- The estimated volume of LLRW from operation of the Hermes reactor would be comparable to or less than the LLRW volumes from an NPP; there is adequate capacity at LLRW disposal sites; and the waste form, especially the chemical form, is acceptable at a LLRW disposal site.

Based on the above, the onsite storage of spent TRISO fuel would be similar to current LWRs and must meet the same regulatory safety requirements.

3.10 Transportation of Radioactive Material

This section addresses the radiological and nonradiological environmental impacts from normal operating (radiological) and accident conditions (radiological and nonradiological) resulting from the shipment of unirradiated fuel to the East Tennessee Technology Park site, shipment of LLRW and mixed waste to offsite disposal facilities during operations, and shipment of spent fuel to an interim storage facility or a permanent geologic repository during decommissioning. For the purposes of these analyses, the NRC staff considered the proposed Yucca Mountain, Nevada, repository site as a surrogate destination for a monitored retrievable storage facility or permanent geologic repository.

3.10.1 Environmental Impacts from Operation

The NRC performed a generic analysis of the environmental effects of the transportation of fuel and waste to and from LWRs in the *Environmental Survey of Transportation of Radioactive Materials To and From Nuclear Power Plants* (AEC 1972-TN22) and in a supplement to WASH 1238 (NRC 1975-TN216), and found the impact to be small. These documents summarize the environmental impacts of transportation of fuel and waste to and from one LWR of 3,000 to 5,000 MWt (1,000 to 1,500 MWe). Impacts are provided for normal conditions of transport and accidents in transport for a reference 1,100 MWe LWR. Dose to transportation workers during normal transportation operations was estimated to result in a collective dose of 4 person-rem per reference reactor-year (RRY). The combined dose to the public along the route and the dose to onlookers were estimated to result in a collective dose of 3 person-rem per RRY.

In NUREG-0170, *Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes* (NRC 1977-TN417, NRC 1977-TN6497), the NRC evaluated the shipment of radioactive material, including shipments of unirradiated fuel, spent nuclear fuel, and radioactive waste to and from NPPs. The NRC concluded in NUREG-0170 that the average radiation dose to the population at risk from normal transportation is a small fraction of the limits recommended for members of the general public from all sources of radiation other than natural and medical sources and is a small fraction of the natural background dose. In addition, the NRC determined that the radiological risk from accidents in transportation is small, amounting to about 0.5 percent of the normal transportation risk on an annual basis. The NRC also determined in NUREG-0170 that the environmental impacts of normal transportation of radioactive materials and the risks attendant to accidents involving radioactive material shipments are sufficiently small to allow continued shipments by all modes. The doses from radioactive waste accidents were negligible when compared to the doses from accidents involving spent fuel shipments. WASH-1238, NUREG-0170, and other LWR transportation assessments by the staff form the basis of assessment of the transportation of radioactive material to and from the Hermes test reactor.

3.10.1.1 Fresh TRISO Fuel Shipments

Over the life of the Hermes test reactor, a number of shipments of fresh TRISO fuel would periodically take place. Section 4.10.2.1 of the ER provides details about the uranium content of fresh TRISO pebbles, how many would be consumed on an annual and lifetime basis (38,800 pebbles annually and 155,200 pebbles over 4 years), the type of existing transport packages that ship the fresh TRISO pebbles (Versa-Pac [VP]-55 or VP-110, manufactured by DAHER Group, Transport Logistics International, Inc.) (NRC 2021-TN7968), and the expected number of annual shipments using the VP-55 package to meet the needs of the Hermes test reactor operating at 35 MWth (three truck shipments per year) (Kairos 2022-TN7882).

As noted in Section 4.10.2.1 of the ER, a decision about the sourcing of fresh TRISO fuel has not been made at the time this EIS was published (Kairos 2021-TN7880). The source of fresh TRISO fuel may be provided by existing manufacturers or by a TRISO fuel fabrication facility built by Kairos, which could be near the Hermes test reactor on the East Tennessee Technology Park site (Kairos 2021-TN7880 | Sec 4.10.2.1 and Sec 4.13.1). Thus, the transportation impacts of fresh TRISO fuel could be negligible if the fuel fabrication facility is also located at the East Tennessee Technology Park site, or noticeable if the transportation distance could be significant if fuel is shipped from a distant nuclear fuel fabricator. Kairos elected for evaluation purposes in the ER to assume fresh TRISO fuel would be shipped by truck from the location of the farthest nuclear fuel manufacturer in the United States from the Hermes test reactor site, located in Richland, Washington (Kairos 2021-TN7880 | Sec 4.10.2.1). Based on an independent assessment, the NRC staff finds that shipments from such a location would bound the fresh TRISO fuel transportation impacts.

Normal conditions, sometimes referred to as “incident-free” transportation, are transportation activities during which shipments reach their destination without releasing any radioactive material to the environment (i.e., not being involved in a vehicular accident) (DOE 2002-TN418). Impacts from these shipments would be from the low levels of radiation that penetrate the shielding provided by unirradiated fuel shipping containers. Very low radiation exposures at some level would occur to the following individuals: (1) persons residing along the transportation corridors between the fuel fabrication facility and the Hermes site or alternative sites; (2) persons in vehicles traveling on the same route as an unirradiated fuel shipment; (3) persons present at vehicular stops for refueling, rest, and vehicle inspections; and (4) transportation crew workers. Calculations to estimate these low levels are completed with very conservative assumptions.

The NRC staff has performed a number of environmental evaluations of the shipment of fresh uranium fuel for LWRs operating at larger power levels than the Hermes test reactor. Incident-free, or normal operation, transportation impact analysis assumed the transportation package meets the regulatory maximum dose rate of 10 CFR 71.47 (TN301), “External radiation standards for all packages.” The accident analyses involving unirradiated fuel shipments accounted for radiological doses and nonradiological fatalities and injuries were due to the physical impacts of an accident. Staff reviewed the evaluation for the nearby Clinch River ESP final EIS, where environmental impacts of fresh uranium fuel shipment incident-free and accident impacts of an 800 MWe small modular reactor from Richland, Washington were discussed in Section 6.2 and found to be small (NRC 2019-TN6136)

Another Federal agency has also evaluated fresh TRISO fuel shipments. Specifically, the U.S. Department of Defense, 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 in the Project Pele mobile microreactor final EIS, published by DOE. This final EIS determined that the risks would be low based on 10 shipments from BWX Technologies, Inc. in Virginia to the Idaho National Laboratory site in Idaho (DOE 2022-TN7969 | Table 4.12-4). Incident-free impacts were 1.3 person-rem to populations along the route (which can be large numbers of people receiving a small dose). The Project Pele microreactor final EIS predicted the accident risks related to fresh TRISO fuel shipments would only be approximately 6×10^{-9} latent cancer fatalities. Therefore, based on small impacts in the CRN ESP final EIS and DOE final EIS, the low level of radioactivity found in unirradiated enriched uranium no matter the form (i.e., LWR or TRISO fuel), and the fact that Kairos would only need three fresh TRISO fuel shipments per year (compared to 10 for Project Pele), the NRC staff finds these prior transportation evaluations are applicable and demonstrate that the Kairos fresh TRISO fuel transportation impacts would be SMALL.

3.10.1.2 LLRW Shipments

Currently, four operating disposal facilities in the United States are licensed to accept LLRW from commercial facilities (NRC 2017-TN6518). They are located at Clive, Utah; Andrews County, Texas; Barnwell, South Carolina; and near Richland, Washington. The Energy*Solutions* disposal facility at Clive, Utah, is licensed by the State of Utah to accept Class A LLRW from all regions of the United States. The Waste Control Specialists, LLC (WCS) site in Andrews County, Texas, is licensed to accept Class A, B, and C LLRW from the Texas Compact generators (Texas and Vermont) and from outside generators with permission from the Texas Compact. Energy*Solutions* Barnwell Operations located near Barnwell, South Carolina, accepts waste from the Atlantic Compact states (Connecticut, New Jersey, and South Carolina) and is licensed by the State of South Carolina to dispose of Class A, B, and C LLRW. U.S. Ecology, located near Richland, Washington, accepts LLRW from the Northwest and Rocky Mountain Compact states (Washington, Alaska, Hawaii, Idaho, Montana, Oregon, Utah, Wyoming, Colorado, Nevada, and New Mexico) and is licensed by the State of Washington to dispose of Class A, B, and C waste. The two LLRW disposal sites that could accept LLRW shipments from Kairos Hermes facilities are the Energy*Solutions* disposal facility at Clive, Utah, accepting Class A LLRW and the WCS site in Andrews County, Texas for Class A, B, and C LLRW. In 2020, there was a total of approximately 1,010,300 ft^3 (28,610 cubic meter [m^3]) of Class A LLRW shipped to both LLRW disposal sites and 2,050 ft^3 (58 m^3) of Class B LLRW shipped to the WCS disposal site (DOE 2022-TN7991).

As provided in ER Table 2.6-1, Kairos estimates each year of operation could result in approximately 8,800 ft^3 (249 m^3) of Class A LLRW to be shipped to either the Energy*Solutions*, Clive, Utah or the WCS LLRW sites and approximately 670 ft^3 (19 m^3) of Class B LLRW to be shipped to the WCS LLRW disposal site (Kairos 2022-TN7882). This volume of LLRW from Hermes operation would be a small fraction of the annual shipments of Class A LLRW to either the Energy*Solutions* or the WCS LLRW disposal facilities or of Class B LLRW to the WCS LLRW disposal facility.

The NRC has previously evaluated the environmental impact of the transportation of radioactive materials on public roads and by air. The NRC concluded in 1977 that when radioactive material transportation is performed in compliance with all Federal regulations, the impact of such transportation is small (NRC 1977-TN417). The Commission determined that the environmental impacts, radiological and nonradiological, of normal (incident-free) transportation of radioactive materials and the risks and consequences of accidents involving radioactive material shipments in packages for which the NRC has issued design approvals meeting the performance standards of 10 CFR Part 71 were small (49 FR 9375-TN7951). Regulations, shipping practices, and package designs for transporting radioactive material have remained essentially unchanged since 1977. Since transportation performed in conjunction with operation of the Hermes facilities would be a small fraction of the annual volume of LLRW shipped to licensed disposal facilities and performed in compliance with U.S. Department of Transportation and NRC regulations, the NRC staff concludes that the impacts from transportation of LLRW during Kairos Hermes operation would be SMALL.

3.10.2 Environmental Impacts from Decommissioning

Spent TRISO fuel would be stored in the Reactor Building of the Hermes test reactor over the four-year life span of the facilities (Kairos 2022-TN7882). Following cessation of operations, the spent TRISO fuel would have to be further stored at the East Tennessee Technology Park site or shipped offsite to an interim storage facility or a permanent geologic repository. There would also be quantities of LLRW to be addressed during decommissioning for disposal at one or more commercial LLRW disposal sites in the same manner as previously discussed during the operational lifetime of the Hermes test reactor.

For decommissioning of the Hermes test reactor, options for addressing the spent TRISO fuel could be maintaining the spent fuel in a separate storage facility at the East Tennessee Technology Park site or shipping the spent fuel to an interim storage facility or a permanent geologic repository. The NRC has licensed one interim storage facility (NRC 2021- Interim Storage Partners reference below (ML21188A096)), but the distance to the once-proposed Yucca Mountain geologic repository is greater and is the disposal location that Kairos selected for analysis. Based on an independent assessment, the NRC staff finds shipping to this location would have larger impacts than shipping to a licensed interim storage facility.

The NRC staff has extensively analyzed shipments of spent LWR fuel in a number of new reactor licensing reviews to the once-proposed Yucca Mountain and for three away-from-reactor interim storage facility licensing reviews (i.e., Private Fuel Storage Facility, Holtec International Consolidated Interim Storage Facility, and the Interim Storage Partners Consolidated Interim Storage Facility). Prior NRC transportation analyses of spent LWR fuel environmental impacts in support of license renewal for burnup levels up to 62 GWd/MTU[1] were found to still be bounded by Table S-4 of 10 CFR 51.52 (TN250), as documented in NUREG-1437, Revision 1, the LR GEIS (NRC 2013-TN2654). The staff also assessed LWR spent fuel shipments in NUREG-2125, which demonstrate that the NRC regulations continue to provide adequate protection of public health and safety during the transportation of spent nuclear fuel (NRC 2014-TN3231).

Regarding the number of spent TRISO shipments during decommissioning, Kairos would need to package and ship up to 155,200 irradiated, or spent, TRISO pebbles after 4 years of Hermes operation (Kairos 2022-TN7882). As noted in Section 3.9 of this draft EIS, a spent TRISO fuel container could hold 1,900 to 2,100 spent TRISO pebbles. Thus, Kairos could have approximately 74 to 82 containers to be shipped to a disposal site during decommissioning. A modified NAC International Inc. legal weight certified truck package holding two sealed spent TRISO canisters may be used because this transportation package has been certified for and used in other spent fuel shipments (Kairos 2022-TN7902). This would result in up to 41 spent TRISO shipments. For comparison purposes, the analysis used to support Table S-4 assumed 60 normalized annual spent LWR shipments. The CRN ESP final EIS transportation analysis assessed 137 normalized annual spent LWR shipments to the once-proposed Yucca Mountain geologic repository (NRC 2019-TN6136 | Table 6-10). Therefore, the CRN ESP final EIS transportation analysis is conservative and will be applied to bound the impacts of the expected spent TRISO shipments during decommissioning of the Hermes test reactor.

As discussed for fresh TRISO fuel shipments in the above environmental impacts from operation, incident-free impacts from the shipment of spent TRISO fuel is determined based on the assumption that the transportation package meets the regulatory maximum dose rate of

[1] Burnup level is a good indicator of the radionuclide inventory quantity contained in spent nuclear fuel.

10 CFR 71.47 (TN301). For this analysis, the NRC staff is also applying the same assumption provided in the CRN ESP final EIS for spent TRISO fuel shipments, namely that the once-proposed Yucca Mountain geologic repository is a surrogate disposal location for bounding these impacts. As such, with the number of spent TRISO fuel truck shipments being less than the number assessed in the CRN ESP final EIS Section 6.2, both the incident-free and the nonradiological accident impacts of the Hermes test reactor spent TRISO shipments are bounded by the results in the CRN ESP final EIS and impacts would be SMALL.

For consideration of the radiological impacts from potential transportation accidents, the structure of TRISO is such that multiple barriers associated with the TRISO kernels and pebbles must be broken before a release of radioactive material from a shipping package could become possible. As discussed in Section 3.9 of this EIS, after reaching a burnup level of approximately 57 GWd/MTU, Kairos would place the spent TRISO pebbles into sealed canisters for storage during operation. Additionally, the structure of the types of sealed canister into which spent TRISO pebbles would be placed would provide added levels of robustness, or an additional defense-in-depth layer than already provided by the coated TRISO particles and the coated TRISO pebbles, for withstanding physical impacts beyond the thin-walled single barrier offered by the fuel pin for LWR spent fuel assembly shipments. Based on structural and thermal analyses, NUREG-2125, *Spent Fuel Transportation Risk Assessment*, showed that spent fuel within an inner welded canister in the shipping package (referred to in NUREG-2125 as canistered fuel) does not rupture even under the most severe accidents analyzed, so no radioactive material would exit the cask (NRC 2014-TN3231 | Sec E.4.3). Thus, the type of spent fuel shipping packaging being proposed by Kairos would be very similar in performance to the canistered fuel analyzed in NUREG-2125 and therefore can be expected to provide similar levels of protection.

For a significant release of radioactive material to occur as the result of a transportation accident that could breach the shipping package, a very large number of spent TRISO kernels must have their coatings cracked within a given number of TRISO pebbles, which also must have significant cracking of their pebble coatings. The internal pressure in the TRISO kernels must then be enough to move the fission products and transuranic elements out of the kernel, into the annular region of each pebble and out through the cracks in the TRISO pebbles into the inner spaces of the TRISO containers. The TRISO containers, with their more significant structure than an irradiated LWR fuel pin, must also be broken to allow the radioactive material to enter the inner volume of the shipping package and then out through the breach of that final barrier. Therefore, because of the nature of the differences in the number of barriers that must be broken for a release of radioactive material from a spent TRISO shipment versus a spent LWR fuel assembly shipment, it would be more difficult for a transportation accident involving spent TRISO to have the same environmental impact from accidents involving spent LWR fuel assembly shipments. Thus, the prior small impacts of spent LWR fuel assembly shipments transportation accidents provided in the CRN ESP final EIS (which had impacts of SMALL) would bound the spent TRISO shipments transportation accidents.

Decommissioning activities would also address disposal of all remaining LLRW with shipments to licensed LLRW disposal facilities. Outside of contaminated systems, structures, and components, such as the reactor vessel and TRISO handling equipment, the same LLRW generated during operations would be present at the time of cessation of operations and would be handled and shipped to LLRW disposal sites in the same manner as previously described, such as the tritium capture materials and dry active wastes as Class A and B LLRW. For the Flibe molten salt, this material would be classified and disposed as either Class B and potentially Class C LLRW, as set by the concentration of tritium and other radionuclides in the

Flibe and as controlled by the Hermes technical specifications of PSAR Table 14.1-1. Kairos is expected to have up to approximately 40 T of Flibe to dispose of during decommissioning, which would translate to between 16 and 20 m^3 of material (Kairos 2022-TN7902). The total amount of Class B and Class C LLRW shipped to WCS from all sources varies between 150 to 350 m^3. Thus, the amount of Flibe material to be disposed of is a small fraction of what WCS receives in a given year. Additionally, Kairos confirmed that this material is acceptable in all aspects for disposal at the WCS facility (TN7902). Thus, as is noted for LLRW shipments during operations, since this volume of material is a small fraction of the total annual volume of LLRW shipped to licensed disposal facilities and performed in compliance with U.S. Department of Transportation and NRC regulations, the NRC staff concludes that the impacts from transportation of Flibe during Kairos Hermes decommissioning would be SMALL.

The impacts associated with transporting equipment and materials (radiological and nonradiological) offsite during decommissioning of a LWR are analyzed in Section 4.3.17 of the Decommissioning GEIS and are found to be small (NRC 2002-TN665). As is the case for LWRs, the materials transported offsite would include all contaminated wastes generated onsite from deconstruction of the Hermes facilities. Radiological impacts would include exposure of transportation workers and the general public along the transportation routes. Nonradiological impacts would include increased traffic volume, additional wear and tear on roadways, and potential traffic accidents. It was concluded that the transportation impacts would not be destabilizing. The Hermes facilities are significantly smaller that the LWR evaluated in the Decommissioning GEIS and would have less contaminated material to be shipped to LLRW disposal sites. The nonradiological decommissioning transportation impacts would also be less than those presented in the Decommissioning GEIS due to the smaller size of the Hermes facility. Therefore, the potential transportation impacts during decommissioning of the Hermes facilities would also be SMALL.

3.10.3 Conclusions

Based the quantity of nuclear material and waste, the material form would be acceptable for disposal, and would employ certified transport packages in accordance with NRC and DOT regulations, the NRC staff concludes that the transportation of fuel and waste impacts from operation and decommissioning of the Hermes reactor would be SMALL.

3.11 Postulated Accidents

3.11.1 Environmental Impacts of Operation

This section discusses the potential offsite radiological consequences of the Maximum Hypothetical Accident (MHA) that could only occur during operations. The results of the analysis are compared to the NRC's dose reference values for test reactor siting given in 10 CFR 100.11 (TN282), "Determination of exclusion area, LPZ, and population center distance." The MHA is a conservative evaluation and represents the bounding consequences for potential design basis accidents (DBAs) at Kairos' proposed Hermes facilities.

The MHA is an event that could result in radiological consequences exceeding those of any credible accident. It is a bounding calculation of the radiological consequences of postulated DBAs at the proposed Hermes facilities. The MHA is based on events unique to the design of the proposed Hermes facilities that hypothetically could release radioactive materials into the environment. Kairos provides an analysis of postulated accidents and the resulting MHA doses in PSAR Chapter 13 (Kairos 2021-TN7879). A summary of the postulated events and consequences, consistent with PSAR Chapter 13, is provided in ER Section 4.11 (Kairos 2021-TN7880).

The NRC staff is conducting a thorough independent review of the safety-related structures, systems, and components, which it will document in its Safety Evaluation Report. The NRC staff will determine whether the safety-related structures, systems, and components will be designed, implemented, and maintained to ensure that they are available and reliable to perform their preventive or mitigative functions when needed so that the likelihood of serious consequences is small. If the NRC staff determines, in its SER, that Kairos has met all of the NRC regulatory requirements described above in order to clearly demonstrate that the Hermes test reactor would meet the regulatory standard of demonstrating adequate protection of public health and safety, then the likelihood of accidents would be reliably controlled.

The calculated dose of 227 mrem (2.27 mSv) as shown in Table 4.11-1 of the ER, as supplemented for the MHA at the proposed Hermes facilities' xclusion Area Boundary (EAB) at a distance of 250 meters (m), would be significantly below the whole body total radiation dose reference value of 25 rem (250 mSv) for two-hours immediately following onset of the release specified for DBAs in 10 CFR 100.11(a)(1) (Kairos 2021-TN7880, Kairos 2022-TN7883). While at the LPZ distance of 800 m, the MHA dose of 59 mrem (0.59 mSv) would be well below the dose reference values specified for DBAs in 10 CFR 100.11(a)(2) (TN282) and within the annual TEDE limit of 100 mrem (1.0 mSv) in 10 CFR 20.1301(a) (Kairos 2021-TN7880, Kairos 2022-TN7883). The respective thyroid doses are also significantly below the dose criterion of 300 rem as specified in 10 CFR 100.11(a)(1) and 100.11(a)(2) (TN282) for both locations. The dominant contributors to the MHA whole body and thyroid doses, both at the EAB and in the LPZ, are from gaseous radionuclides (Kairos 2022-TN7902). Since the nearest resident is located approximately 1,770 m (1.1 mi) from the site (Kairos 2022-TN7902) and the release is predominately gaseous, dispersion of the release between 800 m and 1,127 m would reduce the airborne concentrations, resulting in a lower dose at this location than the 59 mrem at the LPZ distance. Thus, the dose at the LPZ distance would bound any dose received offsite by the nearest resident or any other member of the public further away from the site.

Based on an independent safety review and a detailed evaluation of the applicant's information, the NRC staff must determine whether the applicant appropriately evaluated the potential events, including the radiological consequences of unplanned releases, that are relevant for the Hermes test reactor. The detailed results of the NRC staff's safety review for accidents will be available for public inspection in the Safety Evaluation Report at a future date.

As indicated in the previous discussion, an independent evaluation of the applicant's information by the NRC staff found the MHA doses at the EAB and the LPZ are below the reference doses required in 10 CFR 100.11 (TN282). Therefore, the NRC staff concludes that the environmental impacts from potential radiological accidents would be SMALL and further mitigation would not be warranted. Additionally, as an indicator of the low risks from postulated accidents, the MHA dose at the LPZ is also below the annual radiation dose limits for individual members of the public of 100 mrem TEDE under 10 CFR 20.1301(a) (TN283).

3.11.2 Cumulative Impacts

Table 4.13-1 of the ER identifies past, present, and reasonably foreseeable future projects that could cumulatively contribute to the environmental impacts of the proposed action (Kairos 2021-TN7880). The cumulative analysis considers risk from potential severe accidents at all other existing and proposed nuclear facilities that have the potential to increase risks at any location within 50 mi of the Hermes site. The 50 mi radius as the geographic area of interest was selected to encompass the magnitude and nature of expected impacts of the proposed activity, such as to cover any potential radiological release overlaps from two or more nearby nuclear facilities. Key past and present actions affecting land resources in the affected area include Sequoyah Units 1 and 2, Watts Bar Units 1 and 2, and DOE facilities on the ORR, such as Y-12. As discussed in the CRN ESP final EIS Section 7.10 (NRC 2019-TN6136), which analyzed the environmental impacts of building and operating two small modular reactors at a site in close proximity to the Hermes site, the cumulative impacts of a reactor larger than the Hermes test reactor when considered along with these same facilities were found to be SMALL. Given the small doses from any postulated accident from the Hermes reactor, the lower power level, and the prior cumulative analysis for the CRN ESP, the NRC staff concludes that the cumulative risks of severe accidents at any location within 50 mi of the Hermes site likely would not be significant, and further mitigation would not be warranted.

3.11.3 Conclusions

The NRC staff concludes that the potential direct, indirect, and cumulative postulated accident impacts of the proposed action would be SMALL. This conclusion is based primarily on the fact that the proposed Hermes test reactor must meet the NRC requirements for postulated accidents where potential doses at the EAB and in the LPZ are below the dose reference values of 10 CFR Part 100 (TN282) for test reactor siting. The potential doses, as determined by Kairos, meet the requirements of 10 CFR 100.11 (TN282) and therefore demonstrate adequate protection of the public health and safety. Additionally, as another indication of the low level of environmental impacts, the nearest resident dose from accidents is also below the radiation dose limits for individual members of the public in 10 CFR 20.1301(a) (TN283).

3.12 Climate Change

The NRC staff has determined that it is reasonably foreseeable that climate change may alter the affected environment described in this section. Climate change is a global phenomenon that the construction, operation, and decommissioning of the proposed Hermes facilities would not appreciably alter. However, climate change could provide a new environment that may result in changed impacts from the proposed Hermes project. The NRC previously analyzed the potential changes to the Oak Ridge region as a result of climate change as part of the CRN ESP final EIS, in Appendix L of that document (NRC 2019-TN6136). That appendix presented the NRC staff's assessment of the potential effects of climate change on its evaluation of the environmental impacts of the proposed action for the CRN ESP and is summarized in the paragraph below.

The appendix in the CRN ESP final EIS has three sections: (1) description of the assessment process, (2) potential climate change impacts in the region, and (3) assessment summary (NRC 2019-TN6136). The NRC considered the 2014, 2017, and 2018 U.S. Global Change Research Program (GCRP) reports when developing the analysis (USGCRP 2014-TN3472, USGCRP 2017-TN5848, USGCRP 2018-TN5847), and no new GCRP reports have been issued since 2018. The analysis considered the GCRP projections for the 2071−2099 period to be bounding for assessing the effects of climate change for the CRN project (NRC 2019-TN6136). The potential changes in the region as a result of climate change are discussed in Section L.3 (NRC 2019-TN6136). The following resource areas were analyzed in the assessment: land use, hydrology, terrestrial and wetland ecology, aquatic ecology, socioeconomics, environmental justice, historic and cultural resources, meteorology and air quality, nonradiological health, radiological impacts, nonradioactive waste, accidents, and transportation of radiological materials. For all the resource areas considered, the analysis concluded there would be no change in the construction and operation impact conclusions of the CRN project proposed action as a result of climate change (NRC 2019-TN6136).

Because of the proximity of the proposed Hermes facilities to the CRN site, the potential changes in the region as a result of climate change can be expected to be the same for both the Clinch river proposed small modular reactors site and the proposed Hermes site. The NRC staff adopts the analysis from the CRN ESP EIS (NRC 2019-TN6136) for purposes of evaluating climate effects on the Hermes project. Additionally, the proposed Hermes facilities are much smaller with smaller magnitudes of impact, and use of the analysis in the CRN ESP EIS is further considered conservative because the proposed Hermes facilities are anticipated to operate for only 4 years compared to the 60 years analyzed for CRN (20 years for the ESP and 40 years for the combined license). Therefore, the potential changes to the affected environment analyzed in the CRN ESP EIS would not be fully realized during the anticipated operation of the proposed Hermes facilities, and the staff concludes that none of the impact conclusions in this draft EIS for the Hermes facilities would change as a result of climate change.

4.0 ALTERNATIVES

This section describes alternatives to granting a construction permit for the proposed Hermes test reactor and the environmental impacts of those alternatives. The need to compare the proposed action with alternatives arises from the requirement in Section 102(2)(C)(iii) of the National Environmental Policy Act of 1969 (NEPA), as amended (42 United States Code [U.S.C.] 4321 *et seq*. TN661). NEPA states that an environmental impact statement (EIS) shall include an analysis of alternatives to the proposed action. The U.S. Nuclear Regulatory Commission (NRC) implements this requirement through regulations in Title 10 of the *Code of Federal Regulations* Part 51 (TN250) and in the Interim Staff Guidance to NUREG–1537 (NRC 2012-TN5527, NRC 2012-TN5528), which state that the EIS will include an analysis that considers and weighs the environmental effects of the proposed action, the environmental impacts of alternatives to the proposed action, and alternatives available for reducing or avoiding adverse environmental effects.

For the licensing of non-power reactors, the NRC staff considers a no-action alternative and a range of reasonable alternatives that may include alternative sites, alternative layouts of proposed facilities within a site, modification of existing facilities instead of building new facilities, alternative technologies, and alternative transportation methods (NRC 2012-TN5527, NRC 2012-TN5528). The applicant followed a systematic process for identifying a range of reasonable alternative sites for the proposed Hermes project, as outlined in Sections 5.2 and 5.3 of the Environmental Report (ER) (Kairos 2021-TN7880). The process involved systematic consideration of possible sites, leading to identification of two reasonable sites: the proposed site in the East Tennessee Technology Park in Oak Ridge, Tennessee, and an alternative site in Eagle Rock, Idaho. The applicant did not consider alternative layouts of the proposed facilities on either site. Land disturbance on the proposed site in Oak Ridge would be limited to lands previously disturbed by the former Oak Ridge Gaseous Diffusion Plant (ORGDP). Furthermore, the proposed site at the Oak Ridge site is situated in an existing industrial park already served by existing roadways and other infrastructure. Hence, consideration of other sites in the Oak Ridge area, or alternative layouts of the new buildings within the proposed site in Oak Ridge, do not offer opportunities to reduce environmental impacts. The Eagle Rock site is a large tract of relatively uniform undeveloped rangeland and cropland (Kairos 2021-TN7880 | Sec 5.4.1.1.1) without wetlands or surface water features (Kairos 2021-TN7880 | Sec 5.4.1.5.3). There are many possible layouts for the proposed facilities within the site, but none would substantially differ with respect to environmental impacts. Because neither site presently contains existing facilities, the applicant did not consider opportunities to repurpose existing facilities in lieu of building new facilities.

Because the purpose of the Hermes project is to demonstrate and test specific new technologies, specifically the Kairos Power Fluoride Salt-Cooled High Temperature Reactor (KP-FHR) technologies, the applicant did not consider alternative technologies for the Hermes reactor (Kairos 2021-TN7880 | Sec 5.3). The Hermes project does not require building offsite transmission lines, pipelines, or access roads, so the applicant did not identify proposed or alternative rights-of-way to serve either site. The applicant stated that transportation alternatives to the proposed site are limited to using existing road and rail facilities already servicing the East Tennessee Technology Park, which are adequate for the new facility (Kairos 2021-TN7880 | Sec 5.3). The Eagle Rock site is served only by roads and is not served by resources capable of supporting alternative transportation such as waterways or railroads (Kairos 2021-TN7880 | Sec 5.4.1.7.1).

The NRC staff evaluated the applicant's process for identifying reasonable alternatives to the proposed action and finds, as described below, the applicant's process to be reasonable. The staff finds that the applicant's process is analytical, logical, appropriate to the purpose and need identified in Section 1.0 of this draft EIS, and in keeping with the spirit and intent for identifying a range of reasonable alternatives for analysis in an EIS. Section 4.1 below addresses the environmental impacts from a no action alternative; and Section 4.2 addresses the potential alternative sites for the Hermes project, including environmental impacts from the Eagle Rock site.

4.1 No-Action Alternative

Under the no action alternative, the NRC would not issue a construction permit to Kairos Power, LLC (Kairos) to build a test reactor to demonstrate the KP-FHR technology. The applicant could not build the proposed Hermes reactor and would therefore not have an opportunity to test the KP-FHR technologies, design features, and safety functions at a reduced scale relative to an anticipated commercial power reactor (Kairos 2021-TN7880 | Sec 5.1). While forgoing the opportunities provided by Hermes might not necessarily preclude future development of reactors using the KP-FHR technologies, it could slow or impede safe and efficient development of the technology. None of the environmental effects described in Section 3.0 of this draft EIS would occur under the no action alternative. But because Section 3.0 characterizes all potential environmental impacts of the proposed action as SMALL, any environmental benefits from selecting the no action alternative instead of the proposed action would be minimal. Additionally, under the no action alternative, the proposed site would remain available for other government or private industrial development projects, and many of the environmental impacts resulting from land disturbance and building new industrial facilities on the site might still occur at some time in the future.

4.2 Site Alternatives

The NRC staff identified one site alternative for detailed evaluation based on the applicant's ER and other information provided by the applicant. This alternative site, termed the Eagle Rock site, is situated approximately 20 miles (mi) west of Idaho Falls, Idaho, on federally owned property in eastern Idaho. Figure 5.4-1 of the ER (Kairos 2021-TN7880) depicts the location of the Eagle Rock site and its proximity to the City of Idaho Falls and tracts of nearby Federal land managed by U.S. Department of Energy (DOE) and other agencies. As reported in Section 5.4 of the ER (Kairos 2021-TN7880), the applicant identified the Eagle Rock site as the only reasonable alternative site warranting detailed evaluation. The NRC staff reviewed the applicant's process for screening potential sites, outlined in Sections 5.3.1 and 5.3.2 of the ER (Kairos 2021-TN7880). The staff finds that the applicant used a logical approach to identify the range of reasonable alternative sites meeting the purpose and need of the Hermes project. Section 4.2.1 below summarizes the applicant's process; while Section 4.2.2 summarizes the potential environmental impacts of constructing, operating, and decommissioning the Hermes project at the Eagle Rock site.

4.2.1 Process for Identifying Reasonable Alternative Sites

The applicant followed the process described in Section 5.3.1 of the ER to evaluate potential sites for the proposed facilities (Kairos 2021-TN7880). The process follows the outline presented by the Electric Power Research Institute (EPRI) in *Advanced Nuclear Technology: Site Selection and Evaluation Criteria for New Nuclear Power Generation Facilities* (EPRI 2015-TN5285). This process involves defining a region of interest (ROI) and candidate areas within the ROI, identifying specific candidate sites for evaluation and scoring, and finally selecting sites for detailed evaluation (Kairos 2021-TN7880 | Sec 5.3.1). The applicant conducted the process using reconnaissance-level data available in the public domain with limited consultation of stakeholders (Kairos 2021-TN7880 | Sec 5.3.1).

The results of the applicant's siting process are summarized in Section 5.3.2 of the ER (Kairos 2021-TN7880). The applicant's ROI consisted of the continental United States, based on a preference for future deployment in geographic regions with a strong nexus to future domestic power markets and on the fact that the applicant does not have a specific service territory (Kairos 2021-TN7880 | Sec 5.3.2). Key site screening criteria used by the applicant included the availability of high-quality site data to support licensing and design, proximity to a national laboratory capable of supporting test plans, and connectivity to the targeted commercial reactor market (Kairos 2021-TN7880 | Sec 5.3.2). As presented in Table 5.3-1 of the ER, the applicant identified 11 potential sites in 5 candidate areas meeting the screening criteria: Eastern Tennessee; the Pacific Northwest; Eastern Idaho; Piketon, Ohio; and southeastern United States (Kairos 2021-TN7880). The key criteria used by the applicant to score the potential sites are (Kairos 2021-TN7880 | Sec 5.3.2):

- connectivity to future commercial reactor markets;
- access to construction resources;
- ability for timely acquisition;
- the existing local transportation and utility infrastructure;
- strong local community support;
- water availability;
- minimizing conflict with other major projects;
- minimizing reliance on the DOE as the landowner;
- avoiding sensitive environmental resources such as wetlands; and
- access to existing nuclear testing and research.

This process ultimately led the applicant to identify two reasonable alternative sites for a more detailed environmental analysis, consisting of the proposed Oak Ridge and Eagle Rock sites.

Although the applicant identified only one site in Oak Ridge (the proposed site in the East Tennessee Technology Park) for detailed evaluation, the applicant also considered two other sites near Oak Ridge Kairos 2022-TN7902). One site, identified in Table 5.3-1 of the ER as Site 1.1, was the Clinch River Nuclear site approximately 2 mi south of the East Tennessee Technology Park for which the Tennessee Valley Authority received an early site permit from NRC for possible future construction and operation of small modular reactors (NRC 2019-TN6136). The other site, identified as Site 1.3, was another parcel on the Oak Ridge Reservation recently evaluated by DOE for another project. The proposed site was identified as Site 1.2 in ER Table 5.3-1. Of the three sites near Oak Ridge, only the proposed site provides an opportunity to limit land disturbance to previously industrialized lands lacking natural surface soils and vegetation. Therefore, the other two sites were not considered for detailed analysis.

4.2.2 Affected Environment and Environmental Consequences for Eagle Rock Site

4.2.2.1 Affected Environment:

The applicant characterized the affected environment at the Eagle Rock site in Section 5.4 of the ER (Kairos 2021-TN7880). Key aspects of the affected environment at the Eagle Rock site that substantially differ from those described in Section 3.0 for the proposed site in Oak Ridge are summarized below.

The Eagle Rock site constitutes approximately 4,200 acres (ac) of undeveloped land within Bonneville County, in eastern Idaho (Kairos 2021-TN7880). At the Eagle Rock site, the applicant has stated that the Hermes facilities would be built somewhere within a 592 ac portion of the site formerly evaluated by the NRC (NRC 2011-TN6812) for the proposed Eagle Rock Enrichment Facility (Kairos 2022-TN7902).

As depicted in Figure 5.4-5 of the ER, the 4,200 ac site presently consists of irrigated cropland, non-irrigated pasture, and natural sagebrush steppe vegetation (Kairos 2021-TN7880). Multiple wilderness study areas, national natural landmarks, national forests, national monuments, and national wildlife refuges are located within 50 mi of the site (Kairos 2021-TN7880). According to the NRC (NRC 2011-TN6812 │ Sec 3.2.1), the Eagle Rock site is zoned as G-1 Grazing by Bonneville County, which allows for industrial development. The NRC notes that sagebrush steppe habitat has experienced more than a 98 percent decline since European settlement in North America, but the sagebrush steppe cover on the Eagle Rock site has been affected by grazing, resulting in soil disturbance and reduced cover by herbaceous species other than cheatgrass (*Bromus tectorum*) (NRC 2011-TN6812 │ Sec 3.8.1). The site and surrounding counties are attainment areas under the Clean Air Act (Kairos 2021-TN7880 │ Sec 5.4.1.2.1). Class I areas designated under the Clean Air Act near the site include the Craters of the Moon National Monument (47 mi to the west), Grand Teton National Park (65 mi to the east), and Yellowstone National Park (65 mi to the northeast). There are no rivers, lakes, streams, wetlands, or 100-year or 500-year floodplains on the site, although there are a few small drainage features that periodically carry water from irrigated agricultural areas (Kairos 2021-TN7880 │ Sec 5.4.1.4.1).

A search by the applicant of the U.S. Fish and Wildlife Service Information for Planning and Consultation (IPaC) database on February 2, 2022, identified no threatened or endangered species or critical habitat listed under the Endangered Species Act (Endangered Species Act of 1973-TN1010) for an action area consisting of that portion of the site where facilities would be built under this alternative (Kairos 2021-TN7880 │ Sec 5.4.1.5.2). The action area used for the IPaC search consisted of the entirety of the 592 ac of land containing the area subject to disturbance by the Hermes facilities, plus any necessary access roads (Kairos 2022-TN7902). Because the land subject to disturbance by the Hermes facilities construction would constitute only a small part of the action area, the search conservatively addressed lands adjacent to as well as within the area where the facilities would be built. Significant archaeological resources are known to be present on the site, and some have already been identified to be eligible for listing in the National Register of Historic Places (Kairos 2021-TN7880 │ Sec 5.4.1.6).

The Eagle Rock site is situated in a socioeconomic ROI defined by the applicant as three counties in Idaho (Bingham, Bonneville, and Jefferson Counties) located approximately 20 mi from the metropolitan area of Idaho Falls and part of the Idaho Falls-Rexburg-Blackfoot Combined Statistical Area (Kairos 2021-TN7880 │ Sec 5.4.1.7.1). The applicant characterizes the demography, economy, community characteristics, public services, and transportation facilities in Section 5.4.1.7 of the ER (Kairos 2021-TN7880). For an area surrounding the Eagle Rock site extending out by a 5 mi radius, the applicant identified no low-income populations subject to consideration as potential environmental justice communities of concern (Kairos 2021-TN7880 | Sec 5.4.1.10).

4.2.2.2 Environmental Consequences of Construction

Building the proposed Hermes facilities at the Eagle Rock site would involve the temporary disturbance of approximately 95 ac of cropland, sagebrush, pasture, and upland grasslands; including some prime farmland, of which 30 ac would remain permanently in industrial use once the new facilities are built (Kairos 2021-TN7880 | Sec 5.4.1.1.1). These land use types are abundant in eastern Idaho, and the loss of 95 ac of prime farmland typical of the surrounding landscape would not affect the ability of the region to contribute to agricultural production. Based on information about the site's zoning, as reported by the NRC (NRC 2011-TN6812), the NRC staff believes that no zoning changes would be necessary. However, the visual changes to the landscape in the surrounding relatively undeveloped, flat, and treeless natural setting would be noticeable. Building a cluster of industrial buildings in a rural area with few previously established industrial or urban lands could noticeably alter scenic vistas extending long distances into the mostly flat and treeless landscape. The applicant notes that building the project could noticeably alter views from U.S. Route 20 as it passes through what is now a rural area with an undisturbed natural appearance (Kairos 2021-TN7880 | Sec 5.4.1.1.2).

Air emissions would be the same as those described for the proposed site in Oak Ridge in Section 3.2 of this draft EIS and low enough to be offset by mitigation, and below the threshold required for Class I area modeling (Kairos 2021-TN7880 | Sec 5.4.1.2.1). Noise generation would be at levels indicated for the same facilities on the proposed site in Oak Ridge, as described in Section 3.2 of this draft EIS, but the applicant expects the noise generated at the Eagle Rock site to be imperceptible to the nearest residence, which is approximately 4.8 mi away (Kairos 2021-TN7880 | Sec 5.4.1.2.2). The NRC staff expects that the noise is unlikely to disturb residents living at that distance. The applicant proposes to use best management practices to minimize adverse impacts on soils and other landscape features (Kairos 2021-TN7880 | Sec 5.4.1.3). Building the new facilities would not involve physical disturbance of any surface water features, wetlands, or floodplains (Kairos 2021-TN7880 | Sec 5.4.1.4.1). The applicant would have to develop groundwater supply wells, although usage rates would be substantially below the annual water right appropriation (Kairos 2021-TN7880 | Sec 5.4.1.4). Municipal water sources and municipal wastewater treatment facilities are not available.

Loss and disruption of sagebrush steppe habitat and other natural vegetation within the 95 ac subject to temporary disturbance could noticeably affect wildlife (Kairos 2021-TN7880 | Sec 5.4.1.5.2). Unlike at the proposed site in Oak Ridge, ground disturbance at the Eagle Rock site would not be limited to soils previously graded and used for previous industrial development. Grading could disturb four archaeological sites located on the Eagle Rock site and possibly other uncharacterized archaeological sites (Kairos 2021-TN7880 | Sec 5.4.1.6). Unlike at the proposed site in Oak Ridge, soils on the Eagle Rock site have not been previously graded and disturbed for past industrial development. Site preparation therefore has a greater potential to disturb subsurface archaeological resources.

For certain resource areas, the environmental impacts during construction at the Eagle Rock site would resemble those at the proposed site in Oak Ridge, as presented in Section 3.0. Nonradiological and radiological human health (Section 3.8 of this draft EIS) and nonradiological waste management (Section 3.9 of this draft EIS) would have similar construction impacts. The applicant would control nonradiological and radiological hazards to human health during construction in compliance with applicable regulations and standards (Kairos 2021-TN7880 │ Sec 5.4.1.8). There are no low-income populations subject to consideration as potential environmental justice communities of concern within 5 mi of the Eagle Rock site (Kairos 2021-TN7880 │ Sec 5.4.1.10), and hence there is no potential for environmental justice impacts.

4.2.2.3 Environmental Consequences of Operation

As would also be true for the proposed site in Oak Ridge, approximately 30 ac of land at the Eagle Rock site would remain permanently in industrial use over the four-year operational life of the proposed Hermes facilities (Kairos 2021-TN7880 │ Sec 5.4.1.1.1). There would be no further visual changes to the site resulting from operation of the proposed facilities, and there would be no additional physical disturbance to natural habitats or subsurface cultural resources. Water usage for operations at the proposed site in Oak Ridge would generally be in quantities indicated in the Section 3.3 of this draft EIS, but the water supply would be obtained from onsite groundwater wells, remaining substantially below the annual water right appropriation (Kairos 2021-TN7880 │ Sec 5.4.1.4.2). According to the applicant, sanitary wastewater and nonradiological liquid waste generated over the life cycle of the Hermes facilities if built at the Eagle Rock site would be handled by portable systems or discharged to a yet to be constructed municipal wastewater treatment facility, and stormwater would be collected in a lined retention basin where it would ultimately evaporate (Kairos 2022-TN7902).

Air emissions due to operation of the Hermes facilities would be as described for the proposed site in Oak Ridge and be low enough to be offset by mitigation, and below the threshold for required Class I area modeling (Kairos 2021-TN7880 │ Sec 5.4.1.2.1). Noise would be as described for the proposed site in Oak Ridge, but is expected to be imperceptible to the nearest residence, which is approximately 4.8 mi away (Kairos 2021-TN7880 │ Sec 5.4.1.2.2). Operation of the proposed Hermes facilities would constitute only a very small portion of the total employment in the area surrounding the Eagle Rock site (Kairos 2021-TN7880 │ Sec 5.4.1.7.1). Occupational hazards and nonradiological and radiological sources, wastes, and effluents would be controlled in compliance with applicable regulations and standards (Kairos 2021-TN7880 │ Sec 5.4.1.8).

The environmental impacts during operations at the Eagle Rock site would be similar to those at the proposed site in Oak Ridge, as presented in Section 3.0 of this draft EIS. During operations, the nonradiological and radiological human health (Section 3.8 of this draft EIS), nonradiological waste management (Section 3.9 of this draft EIS), uranium fuel cycle and radiological wastes (Section 3.10 of this draft EIS), and accidents (Section 3.12 of this draft EIS) would have impacts at the Eagle Rock site similar to those at the proposed site in Oak Ridge. Regarding transportation of radioactive material, the NRC staff recognizes that the Eagle Rock site is in a different geographic region of the continental United States. However, the transportation analysis in Section 3.10 of this draft EIS for the proposed site in Oak Ridge would still bound the transportation impacts for the Eagle Rock site, if one applies the same assumptions (e.g., that fresh TRI-structural ISOtropic [TRISO] high-assay low-enriched uranium fuel is shipped from the farthest NRC-licensed fuel fabrication facility, the BWX Technologies, Inc. fuel fabrication facility in Lynchburg, VA, located at a distance of approximately 2,200 mi). The analysis would still be bounding for shipping shorter distances (e.g., shipping waste from the Eagle Rock site in Idaho to the Energy*Solutions* low-level radioactive waste [LLRW] disposal site in the adjacent state of Utah, or to the LLRW disposal site of Waste Control and Storage Services in Texas, a distance of approximately 1,200 mi). As discussed previously in this draft EIS, there would be no potential for environmental justice impacts based on the operation of the Hermes facilities.

4.2.2.4 Environmental Consequences of Decommissioning

The NRC staff expects that decommissioning of the Hermes facilities at the Eagle Rock site would proceed as described for decommissioning the same facilities at the proposed site in Oak Ridge. The staff expects that potential environmental impacts would generally resemble those described for the construction phase of the project. The staff recognizes that additional land disturbance outside of the 30 ac used during operations would be necessary during decommissioning. However, the staff believes that the additional disturbance could be readily accommodated by the remainder of the site, most likely within the 95 ac of land previously subjected to temporary disturbance during construction. For the reasons stated above for construction, there would be little potential for additional disturbance of ecological resources or subsurface cultural resources.

Potential impacts from transportation of radioactive material during decommissioning would also be bounded by the transportation impacts, as described in Section 3.10 of this draft EIS, because the LLRW disposal sites are closer to the Eagle Rock site than the proposed site in Oak Ridge. The Eagle Rock site is approximately 300 mi from the Energy*Solutions* LLRW disposal site and approximately 1,200 mi from the Waste Control and Storage Services LLRW disposal site, compared to 1,860 mi and 1,200 mi between the proposed site in Oak Ridge and each LLRW disposal site, respectively. This also holds true for the shipments of spent TRISO fuel, as these shipments would be going into the adjacent state of Nevada rather than being shipped across the United States from the proposed site in Oak Ridge.

The NRC staff expects that decommissioning impacts on most other environmental resources would be bounded by the analyses in the Decommissioning GEIS (NRC 2002-TN7254). The generic EIS concludes that impacts from decommissioning nuclear power facilities on aesthetics (including visual resources), water resources, air quality, noise, socioeconomics, human health (radiological and occupational), and transportation are typically SMALL (at most minimal) (NRC 2002-TN7254). It concludes that decommissioning impacts on land use, ecology (including threatened and endangered species), and cultural resources are typically minimal within areas used during operations; but it does not reach a conclusion regarding impacts on those resources outside of the operational area. However, the NRC staff expects that most of the effects on land use, ecology, and cultural resources from decommissioning would generally be confined to areas previously affected by site preparation. It also does not reach a generic conclusion regarding environmental justice. But as noted for construction, there are no low-income populations subject to consideration as potential environmental justice communities of concern within 5 mi of the Eagle Rock site (Kairos 2021-TN7880 | Sec 5.4.1.10), and hence there are no potential environmental justice impacts.

4.2.2.5 Cumulative Impacts

The Eagle Rock site is located in a sparsely populated rural area where past and present environmental impacts are largely limited to agriculture and ranching. Table 5.4-20 of the ER identifies three reasonably foreseeable future projects that could cumulatively contribute to the environmental impacts of the Hermes project if it were sited at the Eagle Rock location (Kairos 2021-TN7880). These include two transmission line projects and the proposed Carbon-Free Power Project (CFPP) at the Idaho National Laboratory in Idaho Falls. The NRC staff recognizes that the environmental impacts from these other major projects might be noticeable in the context of their immediate surroundings. However, the staff finds that the incremental effects of the Hermes project added to the effects of these other proposed projects would be minimal for each environmental resource, except for visual resources, ecological, and cultural resources. The cumulative adverse visual effects of the Hermes project when combined with the CFPP and new transmission lines could be noticeable in the flat, largely treeless landscape with no substantial prior industrial or urban development. Similarly, the combined loss of sagebrush and other terrestrial habitats and combined disturbance of subsurface cultural resources from building the Hermes project at the Eagle Rock site and from the other nearby major projects could be noticeable.

4.2.2.6 Conclusions

Based on the analysis presented above, the NRC staff concludes that the potential direct, indirect, and cumulative impacts of construction, operation, and decommissioning the Hermes project at the Eagle Rock site would be SMALL for each environmental resource considered, with the exceptions that the visual, ecological, and cultural resource impacts from the construction would be MODERATE. Building even a small industrial project in a rural, treeless, flat landscape that has no previous industrial or urban development could noticeably alter the area's visual characteristics. Clearing sagebrush steppe vegetation could affect increasingly rare wildlife species dependent on this specialized habitat, such as the greater sage grouse (*Centrocercus urophasianus*). Grading previously undisturbed soils such as those at the Eagle Rock site could disturb archaeological resources. Otherwise, the small size and limited land disturbance of the Hermes project, abundance of land on the Eagle Rock site, presence of similar land cover in the surrounding rural area, low employment levels and water demands of the Hermes project, and absence of sensitive natural and hydrological features at the site suggest that implementing the project at the Eagle Rock site would have at most minimal adverse environmental impacts. Furthermore, although rural and remote, the Eagle Rock site is still proximate to the City of Idaho Falls and the Idaho National Laboratory, a DOE facility with technical staff and capabilities much like those in Oak Ridge.

4.3 Cost-Benefit of the Alternatives

As required by 10 CFR 51.71(d) (TN250), an EIS must include "a consideration of the economic, technical, and other benefits and costs of the proposed action and alternatives." A principal objective of NEPA is to require each Federal agency to consider, in its decision-making process, the environmental impacts of each proposed major action and the available alternative actions. Specifically, Section 102 of NEPA (TN661) requires all Federal agencies to the fullest extent possible to:

> (B) identify and develop methods and procedures, in consultation with the Council on Environmental Quality established by Title II of this Act, which will ensure that presently unquantified environmental amenities and values may be given appropriate consideration in decision making along with economic and technical considerations (TN661).

However, neither NEPA nor the Council on Environmental Quality requires the costs and benefits of a proposed action or alternatives to be quantified in dollars or any other common metric. The purpose of this section is not to identify and quantify all the potential societal benefits and compare them to the potential costs of the proposed actions and alternatives. Instead, this section focuses only on those benefits and costs of such magnitude or importance that their inclusion in this analysis can inform the decision-making process. This section compiles and compares the pertinent analytical conclusions reached in earlier chapters of this draft EIS.

4.3.1 Benefits

In most cases, the most apparent benefit of the construction and operation of a nuclear power plant is that it generates power for thousands of residential, commercial, and industrial customers. However, the proposed Hermes project is planned as a demonstration project only and would not produce electricity. Consequently, the benefits from approval of the Hermes application include the following:

- Proof of concept: Once the test reactor is up and running, the Hermes project would be able to stimulate commercial interest in a new nuclear technology.
- Mass production of many of the components of the reactor would provide “off the shelf” standardized components that would help reduce the cost of construction and maintenance, making the full-sized KP-FHR cost-competitive with other generation methods, such as natural gas generation, in the U.S. market.
- Nuclear power is inherently carbon-free power, which would aid in achieving the United States’ climate change goals.
- Some limited economic stimuli would come from project-related incomes during the construction, operation, and decommissioning of the proposed project. However, the small scale of the construction crew (less than 500 workers) and operations crew (less than 100 workers), and the fact that most of the skills needed for construction and operations are available locally, indicate that any increase in tax revenues derived from the proposed project would be minimal and relatively short termed (12 years from groundbreaking to cessation of operations).

4.3.2 Costs

The applicant did not provide cost (internal, external, fuel, waste disposal) information for the construction, operation, or decommissioning of the proposed project. The Hermes reactor is a scaled down KP-FHR, which is an advanced reactor technology that leverages TRISO fuel in pebble form combined with a low-pressure fluoride-lithium-beryllium (Flibe) salt coolant. The applicant won $303 million in funding from the DOE’s Advanced Reactor Demonstration Program to build a prototype (NEI 2021-TN7970). The Hermes reactor would produce 35 megawatts thermal (MWth) but would not produce any commercially valued product, such as electricity. Consequently, this cost analysis acts as a placeholder for any future submittal by Kairos that includes more detailed cost estimates.

Land use costs include approximately 185 ac of land, of which the applicant identifies about 30 ac as “permanently disturbed for operations of the facility” (Kairos 2021-TN7880). No offsite lands would be disturbed or used, considering that the purpose of the project does not include transmission of electrical power, or the need for any pipelines or access roads. Because the proposed area of disturbance comprises previously disturbed soils and ruderal vegetation only, ecological costs and costs to cultural resources would be minimal.

As described in Section 3.2 of this draft EIS, emissions from diesel generators, equipment, and vehicles to the air would have a minimal impact on workers and residents. Emissions sources would be operated intermittently and would be managed in accordance with Federal, State, and local air quality limits. The NRC staff expects negligible impacts from sulfur dioxide, nitrogen oxide, carbon monoxide, carbon dioxide, and particulate matter, relative to other activities in the Oak Ridge area.

4.3.3 Summary of Benefits and Costs

On the basis of the assessments summarized in this draft EIS, the NRC staff concludes that building, operating, and decommissioning the proposed Hermes reactor (with the appropriate mitigation measures identified by the NRC staff), would have accrued benefits that most likely would outweigh its economic, environmental, and social costs. The staff draws this conclusion regardless of whether the project is sited at the proposed site in Oak Ridge or at the Eagle Rock site.

4.4 Comparison of the Potential Environmental Impacts

Table 4-1 tabulates the NRC staff's conclusions regarding the significance of potential environmental impacts for each environmental resource affected by each alternative evaluated in detail in this draft EIS. Each conclusion presented in the table is inclusive of direct, indirect, and cumulative impacts and reflects the full life cycle of the Hermes project, including construction, operation, and decommissioning. Potential environmental impacts from the no action alternative and the proposed action would be SMALL for each environmental resource identified for evaluation in this draft EIS. Potential environmental impacts from the Eagle Rock alternative would be SMALL for most environmental resources but would be MODERATE for land use and visual resources, ecological resources, and historic and cultural resources. These MODERATE conclusions reflect the fact that building the proposed Hermes facilities at the Eagle Rock site would require disturbance of soils supporting natural vegetation and potentially containing subsurface archaeological resources. Additionally, the visual appearance of the Hermes facilities could be noticeably intrusive in the rural setting of the Eagle Rock site. In contrast, building the Hermes facilities at the Oak Ridge site under the proposed action would disturb only soils previously disturbed by past industrial development of the now-razed ORGDP and would take place within an existing industrial park (the Heritage Center in the East Tennessee Technology Park) that already contains industrial infrastructure and buildings.

Based on the analysis presented above, and the significance conclusions presented in Table 4-1, the NRC staff concludes that there are no environmentally preferrable alternatives to the proposed action that meet the purpose and need of the proposed licensing action. Although the no action alternative might avoid some of the impacts described for the proposed action in Section 3.0, the no action alternative would not meet the purpose and need for the Hermes project. Furthermore, the analyses in Section 3.0 demonstrate that none of the impacts from the proposed action would be greater than SMALL, thus avoidance of the impacts would not be substantially preferable from an environmental perspective. Because the NRC staff did not identify any environmentally preferrable alternatives that meet the purpose and need of the proposed action, the staff concludes that there are no obviously superior alternatives to the proposed action from an environmental perspective.

Table 4-1 Comparison of Cumulative Environmental Impacts for Alternatives Evaluated in Detail

Resource	No Action	Proposed Action (Oak Ridge Site)	Alternative Action (Eagle Rock Site)
Land use and visual resources	SMALL	SMALL	MODERATE
Air quality and noise	SMALL	SMALL	SMALL
Geological environmental and water resources	SMALL	SMALL	SMALL
Ecological resources	SMALL	SMALL	MODERATE
Historic and cultural resources	SMALL	SMALL	MODERATE
Socioeconomics	SMALL	SMALL	SMALL
Environmental justice	SMALL	SMALL	SMALL
Human health	SMALL	SMALL	SMALL
Nonradiological waste	SMALL	SMALL	SMALL
Fuel Cycle and radiological waste management	SMALL	SMALL	SMALL
Transportation	SMALL	SMALL	SMALL
Accidents	SMALL	SMALL	SMALL

5.0 CONCLUSIONS AND RECOMMENDATIONS

This environmental impact statement (EIS) describes the environmental review conducted by U.S. Nuclear Regulatory Commission (NRC) staff for a Kairos Power, LLC (Kairos) application for a construction permit (CP) under Title 10 of the *Code of Federal Regulations* Part 50 (TN249) that would allow construction of the Hermes non-power test reactor facilities on a 185 acre (ac) site within the Heritage Center Industrial Park (Heritage Center) in Oak Ridge, Tennessee. This EIS follows the requirements in 10 CFR Part 51 (TN250), which are the NRC's regulations that implement the National Environmental Policy Act of 1969 (NEPA, TN661). This section presents conclusions and recommendations based on the NRC staff's environmental review of the CP application. Section 5.1 summarizes the environmental impacts from construction, operation, and decommissioning of the Hermes project. Section 5.2 compares the environmental impacts of the proposed action against reasonable alternatives identified by the NRC staff. Section 5.3 discusses the unavoidable impacts of the proposed action and identifies resource commitments. Section 5.4 presents the NRC staff's conclusions and recommendations.

5.1 Environmental Impacts of the Proposed Action

As indicated in Section 1.1 of this draft EIS, the proposed action is the NRC issuing a CP to Kairos authorizing construction of the proposed Hermes non-power test reactor facilities on a site in the Heritage Center in Oak Ridge, Tennessee. Section 1.2 presents the purpose and need of the Federal action, which is to demonstrate key technology of the Kairos Power Fluoride Salt-Cooled, High Temperature Reactor for possible future deployment. Section 3.0 of this draft EIS summarizes the direct, indirect, and cumulative impacts from construction, operation, and decommissioning the proposed Hermes facilities on the proposed site. As indicated in that section, the NRC staff concludes that the potential impacts from the proposed facilities would be SMALL for each potentially affected environmental resource. The staff based its conclusions on independent reviews of information provided in Kairos' application for the CP, including an Environmental Report (ER) and preliminary safety analysis report, as well as other relevant information sources. Table 5-1 summarizes the environmental impacts and the staff's conclusions for each resource considered.

Table 5-1 Summary of Environmental Impacts from Construction, Operation, and Decommissioning of Proposed Hermes Facilities

Resource Area	EIS Section	Summary of Impact	Impact Level
Land use and visual resources	3.1	Temporary disturbance of 138 ac of land previously occupied by industrial U.S. Department of Energy (DOE) buildings during construction and possibly during decommissioning. Permanent occupation of 30 ac of the same land. Limited land use options for the entire 185 ac Hermes site, which would be designated as an exclusion area throughout operation. The site is within an established industrial park. The setting is already industrial, and of low scenic quality. Facilities would have an industrial appearance compatible with an existing industrial park. The Hermes project is compatible with existing City of Oak Ridge zoning.	SMALL

Resource Area	EIS Section	Summary of Impact	Impact Level
Air quality and noise	3.2	Air emissions of criteria pollutants would be below 100 tons per year (TPY), and hazardous air pollutants would be below 10 TPY individually and 25 TPY combined. Emissions would comply with non-Title V permitting requirements. Standard control measures would be used to mitigate fugitive dust releases.	SMALL
Hydrogeology and water resources	3.3	There would be no disturbance of geological features of economic or natural value. Disturbances would be limited to previously disturbed soils. Best management practices (BMPs) would be employed for soil erosion and sediment control. Water demands would be met through municipal or commercial suppliers. There would be no use of groundwater and no direct use of surface water. No cooling towers, ponds, or reservoirs would be involved. Wastewater would be discharged for treatment to municipal wastewater treatment facilities. There would be limited, temporary dewatering of building excavations for construction. Dewatering water would be dispositioned in accordance with DOE requirements per the quit claim deed for the site. Stormwater would be managed using BMPs.	SMALL
Ecological resources	3.4	Ground disturbance would be limited to areas of previously disturbed soils that lack vegetation or support only ruderal early successional vegetation. There would be no disturbances to forest cover or other natural vegetation growing on natural soils, wetlands, surface waters, shorelines, or riparian lands. No Clean Water Act Section 404 permit would be required. BMPs would be used to control stormwater runoff that might reach wetlands or aquatic habitats. Localized, minor increases in noise may affect wildlife, but area wildlife already experience industrial noise. Limited potential exists for wildlife to collide with new structures or be injured by vehicles. The Federally endangered gray bat (*Myotis grisescens*) and Indiana bat (*M. sodalis*) and Federally threatened northern long-eared bat (*M. septentrionalis*) are known to occur in the Oak Ridge area and may forage transiently on the site, but no potential roosting or breeding habitat would be disturbed, and foraging individuals can be expected to avoid areas of human activity. The U.S. Fish and Wildlife Service (FWS) will review the NRC staff's conclusions drawn in Table 3-4 of this draft EIS regarding resources protected under the Endangered Species Act (Endangered Species Act of 1973-TN1010). The final EIS will indicate whether the FWS concurs.	SMALL

Resource Area	EIS Section	Summary of Impact	Impact Level
Historic and cultural resources	3.5	Historic properties would not be affected because none are located in the direct effects area of potential effects (APE). Ground disturbance would be limited to areas of extensive past soil disturbance with little potential for remaining archaeological resources. Kairos would also develop an Archaeological Monitoring and Discovery Plan establishing stop work and notification procedures to address unexpected discovery of human remains or archaeological material in compliance with deed requirements and Tennessee State law. The National Register of Historic Places-eligible Manhattan Project National Historical Park is located in the indirect effects APE but will not be adversely affected because the setting of the proposed Kairos project is visually compatible with the current industrial setting of the Manhattan Project National Historical Park.	SMALL
Socioeconomics and environmental justice (EJ)	3.6	Construction of the Hermes project would involve an average of 212 site workers per year over a two-year period with an estimated peak of 425 workers. Staffing during the four-year operational phase would average 38 workers per weekday (68 full-time positions). Decommissioning would involve an estimated peak employment level of 340 workers. These small numbers of workers would not substantially affect employment levels in the surrounding area, but the demand for some skilled labor might compete with other planned technology projects. The small size of the Hermes project and the distance of the site from the closest Census Blocks with populations meeting EJ criteria (over 8 miles [mi] away) indicate little potential for EJ effects.	SMALL
Human health	3.7	The site was formerly occupied by buildings that were part of the DOE Oak Ridge Gaseous Diffusion Plant used to enrich uranium, but DOE has already razed the buildings and remediated the site for unrestricted industrial reuse. DOE retains responsibility for remediation following any unanticipated discovery of legacy wastes. Based on information in the CP application, the NRC staff expects that radiological releases, doses to the public, and occupational doses would be less than the limits established for protection of human health and the environment in 10 CFR Part 20 (TN283). The applicant would implement normal safety practices contained in Occupational Safety and Health Administration regulations in 29 CFR Part 1910 (TN654) to protect occupational health. Emissions would comply with the Resource Conservation and Recovery Act (TN1281), Clean Air Act (TN1141), and other environmental regulations.	SMALL

Resource Area	EIS Section	Summary of Impact	Impact Level
Nonradiological waste management	3.8	Kairos would develop and implement a plan to manage wastes generated by the Hermes facilities. Management of solid waste, including construction and demolition wastes, would involve waste reduction efforts, recycling, and BMPs. Liquid wastes would be discharged for municipal treatment at a wastewater treatment plant or trucked offsite for proper disposal. Gaseous emissions would comply with Tennessee Department of Environment and Conservation regulations.	SMALL
Uranium fuel cycle and radiological waste management	3.9	A low quantity of uranium would be used during the four-year operational period. TRI-structural ISOtropic (TRISO) fuel processes (including enrichment and fuel fabrication) are bounded by Table S-3 in 10 CFR 51.51 (TN250), developed by NRC to protect human health and the environment. Environmental impacts from the storage of spent TRISO fuel from Hermes is bounded by the analysis in the Continued Storage Generic EIS. The estimated volume of low-level radioactive waste (LLRW) is less than or comparable to that from a light water reactor, and the staff determined that there is adequate capacity at LLRW disposal sites and that LLRW sites would accept the LLRW from Hermes. Onsite storage of spent TRISO fuel would have to meet the same regulatory requirements as currently licensed light water reactors.	SMALL
Transportation	3.10	Transportation of radioactive fuels and wastes to and from Hermes would be performed in compliance with U.S. Department of Transportation and NRC regulations and constitute only a small percentage of the total materials of these types shipped each year.	SMALL
Accidents	3.11	The NRC staff is conducting an independent review of the consequences of accidents and will document it in its Safety Evaluation Report. To receive a CP, the Hermes test reactor would have to meet the NRC requirements for postulated accidents, where potential doses at the exclusion area boundary and in the low population zone are below the dose reference values of 10 CFR Part 100 (TN282) for test reactor siting. Additionally, as another indication of the low-level of environmental impacts, the nearest resident dose from accidents is also below the radiation dose limits for individual members of the public in 10 CFR 20.1301(a) (TN283).	SMALL

5.2 Comparison of Alternatives

In Section 4.0 of this draft EIS, the NRC staff considered two alternatives to construction, operation, and decommissioning of the proposed Hermes facilities at the proposed site in the Heritage Center in Oak Ridge, Tennessee:

- the no action alternative; and
- construction, operation, and decommissioning of the Hermes facilities at a site in Eagle Rock, Idaho (the Eagle Rock alternative).

The NRC staff independently reviewed information concerning other potential alternatives, including other alternative sites, and determined that there were no other reasonable alternatives warranting detailed evaluation. Because the Hermes project is designed to test a specific energy generation technology, alternatives involving other energy generation processes would not meet the project's purpose and need and hence were not analyzed in detail. Table 4-1 presents the staff's conclusions about the no action alternative, proposed action, and Eagle Rock alternative. The staff concluded that environmental impacts from the no action alternative and the proposed action would both be SMALL. The staff concluded that impacts on many environmental resources from the Eagle Rock alternative would likewise be SMALL, but impacts on land use and visual resources, ecological resources, and historic and cultural resources would be MODERATE. Building the Hermes facilities at the proposed site in Oak Ridge would introduce new industrial buildings to a previous industrial site within an existing industrial park of low aesthetic quality, whereas building the same facilities at the Eagle Rock site would introduce new industrial buildings to an open rural landscape free of previous urban encroachment. The new industrial buildings would noticeably alter the visual character of the existing open rural Idaho landscape. Furthermore, while land disturbance to build the Hermes facilities at the proposed site in Oak Ridge would be confined to areas of previously disturbed soils within the footprint of former industrial development, building the Hermes facilities at the Eagle Rock site would involve disturbance of natural vegetation, possibly including shrub-steppe vegetation, and natural soils known to contain subsurface archaeological resources. These disturbances would noticeably degrade the quality of existing ecological and cultural resources present on the site and possibly affect those qualities in the surrounding region.

The no action alternative would not meet the purpose and need identified for the Hermes project, as presented in Section 1.0 of this draft EIS. Of the alternatives considered that would meet the purpose and need for the Hermes project, the proposed action would result in fewer environmental impacts than the Eagle Rock alternative and is therefore the environmentally preferrable alternative. The proposed site, which is the former location of two large industrial buildings that have been razed and the land remediated to allow industrial reuse, offers an opportunity to build new industrial buildings without disturbing sensitive natural or cultural resources or introducing industrial activity to areas lacking an industrial presence.

5.3 Resource Commitments

The following sections address issues related to resource commitments contributing to the cost-benefit analysis presented in Section 4.3 of this draft EIS.

5.3.1 Unavoidable Adverse Environmental Impacts

NEPA Section 102(2)(C)(ii) (TN661) requires that an EIS include information about any adverse environmental effect that cannot be avoided if the proposal is implemented. Unavoidable adverse impacts are predicted adverse environmental impacts that cannot be avoided and that have no practical means of further mitigation. The applicant addresses unavoidable adverse environmental impacts in Section 6.1 of the ER (Kairos 2021-TN7880) and summarizes the unavoidable impacts and proposed mitigation in Tables 6.1-1 and 6.1-2 of the ER (Kairos 2021-TN7880).

As noted in Section 3.0 of this draft EIS, the NRC staff concluded that impacts on all resources from construction, operation, and decommissioning of the Hermes facilities at the proposed site would be SMALL. The environmental effects would not be detectable or would be so minor that they would neither destabilize nor noticeably alter any important attribute of the resource. However, a SMALL conclusion does not necessarily indicate that there would not be any adverse effects that could be offset or minimized through mitigation. The NRC staff therefore presents the unavoidable adverse impacts from construction, operation, and decommissioning of the proposed Hermes facilities in Table 5-2, including mitigation and control measures intended to lessen adverse effects. Unless noted otherwise, the mitigation measures presented in Table 5-2 are taken from Section 6.1 of the applicant's ER, including Tables 6.1-1 and 6.1-2 (Kairos 2021-TN7880).

Table 5-2 Unavoidable Adverse Environmental Impacts for Kairos Hermes Project

Resource Area	Unavoidable Adverse Impact	Mitigation Measures
Land use and visual resources	Approximately 30 ac of unbuilt industrial land would be occupied from initiation of construction through decommissioning. An additional 108 ac may be temporarily occupied during construction and decommissioning. Limited land use options exist for the entire 185 ac Hermes site, which would be designated as an exclusion area throughout operation. New industrial buildings could be distantly visible from some nearby parks and residences.	Lands temporarily disturbed for parking or staging would be restored with native plants or landscaping when no longer needed (Kairos 2021-TN7880 │ Sec 6.1.1). The applicant would establish fencing, retain trees near the site perimeter, and install landscaping (Kairos 2021-TN7880 │ Sec 6.1.2 and Table 6.1.1). BMPs would control erosion and runoff (Kairos 2021-TN7880 │ Table 6.1.1). The applicant would have to comply with City of Oak Ridge zoning ordinances.
Air quality and noise	Emissions of criteria pollutants would be below 100 TPY and hazardous air pollutants below 10 TPY individually and 25 TPY combined. Fugitive dust releases would be possible during site preparation and decommissioning. Temporary, localized noise would be generated by some construction equipment.	BMPs would control dust (Kairos 2021-TN7880 │ Table 6.1.1). Construction equipment and vehicles would be properly maintained (Kairos 2021-TN7880 │ Sec 6.1.1). Post speed limits, traffic controls, and administrative measures such as staggered shift hours to reduce traffic noise would be implemented (Kairos 2021-TN7880 │ Sec 6.1.1 and Table 6.1.1).
Hydrogeology and water resources	Minor demands for water would be met through municipal or commercial suppliers. Limited, temporary dewatering would be necessary for the pit excavated to build the test reactor building. Stormwater would be managed using BMPs.	BMPs would be used to manage stormwater and control erosion and runoff (Kairos 2021-TN7880 │ Table 6.1.1). The applicant would develop and implement a stormwater pollution prevention plan (Kairos 2021-TN7880 │ Sec 6.1.2). Water from dewatering processes would be disposed of in accordance with DOE requirements established in the deed to the site (Kairos 2022-TN7902).

Resource Area	Unavoidable Adverse Impact	Mitigation Measures
Ecological resources	Localized, minor increases in noise that may affect wildlife in surrounding areas of existing industrial park. Limited potential exists for wildlife to collide with new structures or be injured by vehicles. Exposed soils create the potential for sedimentation of aquatic habitats.	No mitigation is proposed with respect to wildlife. BMPs would control runoff and sedimentation of aquatic habitats adjoining the site (Kairos 2021-TN7880 │ Table 6.1.1).
Historic and cultural resources	Potential, although unlikely, that there would be inadvertent discovery of cultural resources during excavation).	Development of an Archaeological Monitoring and Discovery Plan would establish stop work and notification procedures to address unexpected discoveries of human remains and archaeological material (Kairos 2021-TN7880 │ ER Sec 4.6.1 and Kairos 2022-TN7902).
Socioeconomics and EJ	Construction would involve an average of 212 site workers per year over a two-year period, with an estimated peak of 425 workers. Staffing during the four-year operational period would average 38 workers per weekday (68 full-time positions). Staffing during the four-year operational period would average 38 workers per weekday (68 full-time positions). Little potential exists for EJ effects.	No mitigation proposed.
Human health	Potential exists for physical and chemical hazards typical of any industrial facility. Workers and members of the public entering the Hermes facilities could be exposed to radiation.	BMPs would control human exposure to dust (Kairos 2021-TN7880 │ Table 6.1.1). Site-specific training of workers would minimize potential for injuries (Kairos 2021-TN7880 │ Table 6.1.1). The NRC staff expects that the applicant would implement normal safety practices contained in Occupational Safety and Health Administration regulations in 29 CFR Part 1910 (TN654).
Nonradiological waste management	Hermes would be a small quantity generator of hazardous waste.	The applicant would implement aggressive recycling and reuse programs (Kairos 2021-TN7880 │ Table 6.1.1).
Uranium fuel cycle and radiological waste management	A low quantity of uranium would be used during the four-year operational period. TRISO fuel processes (including enrichment and fuel fabrication) are bounded by Table S-3 in 10 CFR 51.51 (TN250), developed by NRC to protect human health and the environment. The estimated volume of LLRW is less than or comparable to that from a nuclear	Onsite storage of spent TRISO fuel must meet the same regulatory requirements as currently licensed light water reactors.

Resource Area	Unavoidable Adverse Impact	Mitigation Measures
	power plant, and the staff determined that there is adequate capacity at LLRW disposal sites and that LLWR sites would accept the LLRW from Hermes.	
Transportation	Transportation of radioactive fuels and wastes to and from Hermes would be performed in compliance with U.S. Department of Transportation and NRC regulations and would constitute only a small percentage of the total materials of these types shipped each year.	No mitigation measures proposed.
Accidents	The NRC staff is conducting an independent review of the consequences of accidents and will document it in its Safety Evaluation Report. Additionally, as another indication of the low level of environmental impacts, the nearest resident dose from accidents is also below the radiation dose limits for individual members of the public as mentioned in 10 CFR 20.1301(a) (TN283).	To receive a CP, the Hermes test reactor would have to meet the NRC requirements for postulated accidents, where potential doses at the exclusion area boundary and in low population zone are below the dose reference values of 10 CFR Part 100 (TN282) for test reactor siting.

5.3.2 Relationship Between Local Short-Term Uses of the Environment and Maintenance and Enhancement of Long-Term Productivity

The construction, operation, and decommissioning of the proposed Hermes facilities under the proposed action would result in short-term uses of environmental resources. “Short-term” is the period of time during which construction, operation, and decommissioning activities would take place. As noted in Section 2.0 of this draft EIS, Kairos plans to begin construction as early as April 2023 (Kairos 2021-TN7880 | Sec 2.1) with an operational life of four years (Kairos 2022-TN7881). While the applicant indicates that decommissioning would commence once the facilities reach the end of their licensed life (Kairos 2021-TN7880 | Sec 2.1), the applicant does not indicate how long decommissioning would take. Applicants for the licensing of new reactors typically do not develop a plan for decommissioning when applying for CPs and/or operating licenses.

As indicated in Section 3.1 of this draft EIS, construction, operation, and decommissioning of the proposed Hermes facilities would require the short-term use of approximately 30 ac of industrial land over the life of the project. This land would not be available for other uses during that time but could be available for other uses after decommissioning. Construction would require the temporary use of as much as 108 ac of additional previously used industrial land, and decommissioning may require the temporary use of all or part of the additional land for a second time. This additional land may be available for other uses beyond construction and decommissioning. The applicant has designated the entire 185 ac Hermes site as the exclusion area (Kairos 2021-TN7879 | Sec 2.1.1), within which it would have to limit land uses during operation to ensure that no significant hazards to public health and safety are possible (10 CFR Part 100-TN282). As indicated in Sections 3.1 and 3.5 of this draft EIS, the new facilities might be distantly visible over the life of the Hermes project from nearby parks and residential areas, but they would be part of a cluster of existing and new industrial facilities that are also part of the East Tennessee Technology Park Heritage Center. Once the new facilities are razed as part of decommissioning, they would no longer be visible.

As indicated in Sections 3.2 and 3.7 of this draft EIS, air emissions from construction, operation, and decommissioning of the Hermes facilities would introduce small amounts of criteria pollutants, greenhouse gas emissions, hazardous air pollutants, and radiological emissions at the facility site. However, such emissions are not expected to affect air quality to the extent that they would impair public health and the long-term productivity of the environment. Emission levels will be below all regulatory thresholds for major sources. Noise emitted by construction, operation, and decommissioning activities would increase the ambient noise levels onsite and in adjacent offsite areas. However, increases in noise levels are not expected to be noticeable, other than for temporary periods during construction and decommissioning. Any noticeable increases in noise levels would be brief and temporary.

As indicated in Section 3.3 of this draft EIS, the Hermes project would require the use of only small quantities of water, supplied by municipal or commercial sources, which would not even place short-term substantial demands on surface water or groundwater resources. As explained in Section 3.4 of this draft EIS, unlike projects that require the conversion of natural habitat to urban land uses, thereby displacing wildlife and reducing the availability of wildlife habitat over the life of the project, the Hermes project would be limited to empty but previously developed land that still retains foundation rubble and other industrial features from previous Department of Energy (DOE) uses. Any short-term ecological effects would be minor and cease prior to completion of decommissioning.

Increased employment, expenditures, and tax revenues generated during construction, operation, and decommissioning activities directly benefit local, regional, and State economies over the short term. As noted in Section 3.6 of this draft EIS, worker vehicles and the delivery and shipment of materials would increase the volume of traffic on local roads. There may also be small increases in demand for housing and services in Oak Ridge and the surrounding areas. But these demands and traffic increases would be short-term and expected during peak construction and decommissioning activities and during work shifts. Therefore, these demands and traffic increases would not affect long-term productivity.

As indicated in Sections 3.7 and 3.8 of this draft EIS, management and disposal of low-level radioactive waste, hazardous waste, and nonhazardous waste would require a small short-term increase in energy usage and consume space at treatment, storage, or disposal facilities. Regardless of the location of those facilities, the use of land to meet waste disposal needs would reduce the long-term productivity of the land. The contribution of Hermes to these reductions would be minimal.

While the uses of, and impacts on, environmental resources would be minimal over the short term, the long-term benefits from implementation of the Hermes project could be substantial. Operation of the Hermes facilities could help demonstrate the commercial viability of the Kairos Power Fluoride Salt-Cooled High Temperature (KP-FHR) technology and may generate data helpful in future commercial deployment of the technology. Successful future deployment of the technology could help the United States develop another economically viable source of energy and help the nation meet its climate change objectives. Use of the technology may help the United States meet its climate change goals with less reliance on more land-intensive energy generation processes, such as large complexes of solar photovoltaic cells or wind turbines, that require larger commitments of land and have a greater potential for aesthetic impact on landscapes and seascapes and physical injury to terrestrial or aquatic wildlife.

5.3.3 Irreversible and Irretrievable Commitment of Resources

This section describes the irreversible and irretrievable commitment of resources that have been noted in this draft EIS. Resource losses or degradation are irreversible when primary or secondary impacts limit future options for a resource. An irretrievable commitment refers to the use or consumption of resources that are neither renewable nor recoverable for future use. Irreversible and irretrievable commitments of resources for construction, operation, and decommissioning of a non-power test reactor facility such as Hermes include the commitment of water, energy, raw materials, and other natural and human-made resources. In general, the commitment of capital, energy, labor, and material resources for a project such as Hermes are also irreversible.

Building, operating, and decommissioning the proposed Hermes facility at the proposed site in Oak Ridge, Tennessee (proposed action), or at the alternative Eagle Rock site near Idaho Falls, Idaho (alternative action considered in detail in this draft EIS), would entail the irreversible and irretrievable commitment of energy, water, chemicals, fossil fuels, and other natural and human-made resources. Building the Hermes facilities at either site would consume concrete, structural steel, steel sheet pilings, precast piles, precast panels, asphalt, stone, roofing/siding, and temporary tent structures, as quantified by the applicant in Table 2.1-1 of the ER (Kairos 2021-TN7880). These materials would be irretrievable unless Kairos recycles them during decommissioning (e.g., finds another facility to use such materials).

During operation, the reactor core would be fueled using 4 centimeter (cm) diameter graphite pebbles with embedded coated TRISO particle fuel, with each particle comprising a uranium fuel kernel with a maximum uranium enrichment of 19.55 wt% (Kairos 2021-TN7880 | Sec 2.3). The availability of uranium ore and existing uranium stockpiles, including downblending of highly enriched uranium, in the United States and from foreign sources (e.g., Australia and Canada) that could be processed into fuel is sufficient to support the operation of the Hermes test reactor (WNA 2022-TN7971). Thus, the irreversible and irretrievable commitment of the quantity of uranium (0.93 metric tons [MT] of uranium) to be used in the Hermes test reactor would have a negligible impact on United States uranium supplies. Over the anticipated four-year operational period, the applicant estimates that 155,200 used TRISO pebbles would be produced as waste (Kairos 2022-TN7881 | Sec 2.6.1.2.4). These used TRISO fuel pebbles would be an irretrievable use of fuel and would not be available to fuel other advanced reactors.

As described in Section 3.3 of this draft EIS, the water demands of the Hermes facilities at either site would be minimal and readily met by municipal and commercial sources. These water resources are readily available at both sites, and the amounts required are not expected to deplete available supplies or exceed available system capacities. As described in Section 3.4 of this draft EIS, a small number of birds and other wildlife could be killed or injured by collision with the Hermes structures or collision with vehicles used on either site or by workers traveling to either site. These losses of wildlife would be to minor in terms of irreversibly affecting wildlife populations in the surrounding area, and any affected populations can be expected to subsequently recover. As noted in Section 4.2.2 of this draft EIS, building the Hermes facilities at the Eagle Rock site would disturb approximately 95 ac of cropland, sagebrush, pasture, and upland grasslands, including some prime farmland. Although the affected land could be restored to rural uses after the Hermes project, some of the desirable ecological properties of the sagebrush and agricultural quality of the prime farmland soils may not be fully restorable, and hence would be irreversible. Irreversible losses of natural habitat or agricultural land would not be a possibility at the proposed Oak Ridge site, because, as described in Section 3.4 of this draft EIS, soils within all of the land subject to disturbance for the Hermes project have been heavily disturbed by past industrial development and currently support only ruderal vegetation. Any disturbances to subsurface cultural resources at the Eagle Rock site could be irreversible.

As noted in Section 3.7 of this draft EIS, nonradiological irreversible commitments to occupational human health resources may occur. Such impacts would be similar to potential hazards that occur at any industrial construction site. Energy expended would be in the form of fuel for equipment, vehicles, and facility operation and electricity for equipment and facility operation. Electricity and fuel would be acquired from offsite commercial sources.

5.3.4 Unresolved Conflicts

NEPA Section 102(2)(E) (TN661) requires that the NRC staff study, develop, and describe appropriate alternatives to recommended courses of action in any proposal that involves unresolved conflicts concerning alternative uses of available resources. In reviewing the potential impacts associated with the proposed action, the NRC staff did not identify any unresolved conflicts concerning alternative uses of available resources.

5.4 Recommendation

After weighing the environmental, economic, technical, and other benefits against environmental and other costs, and considering reasonable alternatives, the NRC staff recommends, unless safety issues mandate otherwise, that the NRC issue the CP to Kairos for the Hermes facility. The NRC staff based its recommendation on the following:

- the NRC staff’s review of Kairos’ ER (Kairos 2021-TN7880) and associated responses to requests for clarifying information (RCI);
- the NRC staff’s review of comments received as part of the scoping process;
- the NRC staff’s communications with, and scoping comments received from, Federal, State, and local agencies, as well as Tribal officials; and
- the NRC staff’s independent environmental review.

The NRC’s staff’s recommendation in this draft EIS is tentative. Before identifying a final recommendation in the final EIS, the NRC staff will also consider comments received on the draft EIS from Federal, State, local, and Tribal officials, and members of the public.

6.0 REFERENCES

10 CFR Part 20. *Code of Federal Regulations*, Title 10, *Energy*, Part 20, "Standards for Protection Against Radiation." TN283.

10 CFR Part 50. *Code of Federal Regulations*, Title 10, *Energy*, Part 50, "Domestic Licensing of Production and Utilization Facilities." TN249.

10 CFR Part 51. *Code of Federal Regulations*, Title 10, *Energy*, Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions." TN250.

10 CFR Part 60. *Code of Federal Regulations*, Title 10, *Energy*, Part 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories." TN5452.

10 CFR Part 71. *Code of Federal Regulations*, Title 10, *Energy*, Part 71, "Packaging and Transportation of Radioactive Material." TN301.

10 CFR Part 72. *Code of Federal Regulations*, Title 10, *Energy*, Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater than Class C Waste." TN4884.

10 CFR Part 100. *Code of Federal Regulations*, Title 10, *Energy*, Part 100, "Reactor Site Criteria." TN282.

29 CFR Part 1910. *Code of Federal Regulations*, Title 29, *Labor*, Part 1910, "Occupational Safety and Health Standards." TN654.

36 CFR Part 60. *Code of Federal Regulations*, Title 36, *Parks, Forests, and Public Property*, Part 60, “National Register of Historic Places.” TN1682.

36 CFR Part 800. *Code of Federal Regulations*, Title 36, *Parks, Forests, and Public Property*, Part 800, "Protection of Historic Properties." TN513.

40 CFR Part 50. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 50, "National Primary and Secondary Ambient Air Quality Standards." TN1089.

40 CFR Part 51. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 51, "Requirements for Preparation, Adoption, and Submittal of Implementation Plans." TN1090.

40 CFR Part 52. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 52, "Approval and Promulgation of Implementation Plans." TN4498.

40 CFR Part 81. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 81, "Designation of Areas for Air Quality Planning Purposes." TN255.

40 CFR Part 93. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 93, "Determining Conformity of Federal Actions to State or Federal Implementation Plans." TN2495.

40 CFR Part 190. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations." TN739.

40 CFR Part 1508. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 1508, "Definitions." TN428.

49 FR 9375. March 12, 1984. “Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions and Related Conforming Amendments.” *Federal Register*, Nuclear Regulatory Commission. TN7951.

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72 FR 57416. October 9, 2007. "Limited Work Authorizations for Nuclear Power Plants." *Federal Register,* Nuclear Regulatory Commission. TN260.

74 FR 56260. October 30, 2009. "Mandatory Reporting of Greenhouse Gases; Final Rule." *Federal Register*, Environmental Protection Agency. TN1024.

75 FR 31514. June 3, 2010. "Prevention of Significant Deterioration and Title V Greenhouse Gas Tailoring Rule; Final Rule." *Federal Register*, Environmental Protection Agency. TN1404.

86 FR 68290. 2021. "Kairos Power, LLC." Construction Permit Application: Acceptance for Docketing, *Federal Register*, Nuclear Regulatory Commission. TN7884.

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TRISO-X, LLC. 2022. Letter from P.J. Pappano, President, J.K. Wheeler, Director, Regulatory Affairs, to Director, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, dated April 5, 2022, regarding "TRISO-X Fuel Fabrication Facility License Application Submittal (Docket No. 70-7027)." Rockville, Maryland. ADAMS Accession No. ML22101A200. TN7987.

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APPENDIX A

CONTRIBUTORS TO THE ENVIRONMENTAL IMPACT STATEMENT

Members of the U.S. Nuclear Regulatory Commission (NRC) Office of Nuclear Material Safety and Safeguards (NMSS); Division of Rulemaking, Environmental, and Financial Support (REFS); and Environmental New Reactor Branch (ENRB) prepared this draft environmental impact statement (EIS). Staff from other NRC branches and from Pacific Northwest National Laboratory (PNNL) provided supplemental technical support and technical editing. Table A-1 below identifies each contributor's name and affiliation, summary of education and experience, and indication of function or expertise contributed to the document.

Table A-1 List of Preparers

Name & Affiliation	Education/Experience	Function or Expertise
Barnhurst, Daniel NRC	B.S. Environmental Geology M.S. Geology 16 years of relevant experience	Project Management
Carlon, Teresa PNNL	B.S. Information Technology 25 years of relevant experience	Reference Coordinator
Davis, Jennifer NRC	B.A. Historic Preservation & Classical Civilization (Archaeology) 20 years of relevant experience	Historic and Cultural Resources
Day, Justin PNNL	M.S. Library and Information Science B.S. Chemistry/Writing 11 years of relevant experience	Comment Database
Doub, Peyton NRC	M.S. Plant Physiology B.S. Plant Sciences (Botany) Professional Wetland Scientist Certified Environmental Professional Duke NEPA Certificate 35 years of relevant experience	EIS Technical Lead Proposed Action Land Use Noise Ecology Nonradiological Health Cumulative Impacts Alternatives
Dozier, Tamsen NRC	M.S. Civil Engineering/Water Resources B.S. Civil Engineering Duke NEPA Certificate 22 years of relevant experience	Lead Environmental Project Manager
Ennor, Susan PNNL	B.A. Journalism 38 years of relevant experience	Technical Editing
Erwin, Kenneth NRC	M.S. Nuclear Engineering B.S. Nuclear Engineering 20 years of relevant experience	Branch Chief
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Giacinto, Joseph NRC	M.S. Hydrology B.S. Geology (Geophysics) Professional Geologist Duke NEPA Certificate 25 years of relevant experience	Geology Water Resources Climate Change

Name & Affiliation	Education/Experience	Function or Expertise
Glowacki, Brian NRC	B.S. Environmental Engineering 2 years of relevant experience	Comment Processing Licensing Support
Helvenston, Edward NRC	M.S. Environmental Engineering B.S. Nuclear Science and Engineering 4 years of relevant experience	Radiological Health Accidents
Kennedy, Ellen PNNL	M.A. Anthropology B.A. Historic Preservation & Anthropology 25 years of relevant experience	Historic and Cultural Resources
LaHaye, Nicole PNNL	Ph.D. Nuclear Engineering M.S. Nuclear Engineering B.S. Physics 5 years of relevant experience	PNNL Deputy Team Lead Comment Database
Montgomery, Sadie A PNNL	B.S. Mathematics 9 years of relevant experience	Comment Database
Mussatti, Daniel NRC	M.S. Industrial Economics M.A. Environmental Economics M.S. Natural Resource & Env. Economics B.S. Economics and Mathematics 35 years of relevant experience	Socioeconomics Environmental Justice Nonradiological Waste Cost-Benefit Analysis
Palmrose, Donald NRC	Ph.D. Nuclear Engineering M.S. Nuclear Engineering B.S. Nuclear Engineering Duke NEPA Certificate 36 years of relevant experience	Radiological Health Postulated Accidents Uranium Fuel Cycle Radiological Waste Transportation of Rad. Material
Parker, Mike PNNL	B.S. English Literature & Creative Writing 25 years of relevant experience	Technical Editing Document Architecture
Saulsbury, Bo PNNL	M.S. Planning B.A. History 35 years of relevant experience	PNNL Team Lead Comment Database
Sen, Kacoli PNNL	Ph.D. Cancer Biology M.S. Zoology (Ecology) B.S. Zoology Diploma in Environmental Law 6 years of relevant experience	Technical Editing Formatting
Willingham, Laura NRC	B.S. Environmental Sciences 17 years of relevant experience	Air Quality Greenhouse Gases Climate Change

APPENDIX B

AGENCIES, ORGANIZATIONS, AND INDIVIDUALS CONTACTED

The U.S. Nuclear Regulatory Commission (NRC) is providing copies of the Kairos Hermes Test Reactor Construction Permit Draft Environmental Impact Statement to the organizations and individuals listed in Table B-1 below. The NRC will also send this draft to the approximately 39 citizens that provided scoping comments and contact information during the scoping period held from February 18 to April 19, 2022. The NRC will provide copies to other interested organizations and individuals upon request.

Table B-1 List of Agencies, Organizations, and Persons to Whom Copies of this Environmental Impact Statement Are Sent

Name	Affiliation	Contact Information
	Federal and State Agencies	
Reid Nelson	Advisory Council on Historic Preservation	401 F Street NW, Suite 308 Washington DC 20001-2637
E. Patrick McIntyre	State Historic Preservation Office	2941 Lebanon Pike Nashville, TN 3721 4 section.106@tn.gov
Larry Long	U.S. Environmental Protection Agency, Region 4	NEPA Program Office USEPA Region 4 61 Forsyth Street SW Atlanta, GA 30303 long.larry@epa.gov
Mary Jennings	US Fish and Wildlife Service	U.S. Fish and Wildlife Service Tennessee Ecological Services Field Office 446 Neal Street Cookeville, TN 38501-4027 mary_e_jennings@fws.gov
Kris Kirby	National Park Service: Manhattan Project National Historical Park	12795 West Alameda Parkway P.O. Box 25287 Denver, Colorado 80225-0287 nps_environ_rev@nps.gov
Niki Nicholas	National Park Service: Manhattan Project National Historical Park	niki_nicholas@nps.gov
Dave Adler	Department of Energy	david.sdler@orem.doe.gov
	Tribes	
John Raymond Johnson, Governor	Absentee Shawnee Tribe	2025 S. Gordon Cooper Drive Shawnee, OK 74801
Nita Battise, Tribal Council Chairwoman	Alabama-Coushatta Tribe of Texas	571 State Park Road 56 Livingston, TX 77351
Wilson Yargee, Chief	Alabama-Quassarte Tribal Town	P.O. Box 187 Wetumka, OK 74883
Chuck Hoskin, Jr., Principal Chief	Cherokee Nation	P.O. Box 948 Tahlequah, OK 74465

Name	Affiliation	Contact Information
Richard Sneed, Principal Chief	Eastern Band of Cherokee Indians	Qualla Boundary P.O. Box 1927 Cherokee, NC 28719
Glenna J. Wallace, Chief	Eastern Shawnee Tribe of Oklahoma	12705 South 705 Road Wyandotte, OK 74370
Brian Givens, Town King	Kialegee Tribal Town	P.O. Box 332 Wetumka, OK 74883
David Hill, Principal Chief	Muscogee (Creek) Nation	P.O. Box 580 Okmulgee, OK 74447
Greg P. Chilcoat, Principal Chief	Seminole Nation of Oklahoma	P.O. Box 1498 Wewoka, OK 74884
Marcellus W. Osceola, Jr., Chairman	Seminole Tribe of Florida	6300 Stirling Road Hollywood, FL 33024
Benjamin Barnes, Chief	Shawnee Tribe	P.O. Box 189 Miami, OK 74354
Ryan Morrow, Town King	Thlopthlocco Tribal Town	P.O. Box 188 Okemah, OK 74859
Joe Bunch, Chief	United Keetoowah Band of Cherokee Indians of Oklahoma	P.O. Box 746 Tahlequah, OK 74465
David Sickey, Chairman	Coushatta Tribe of Louisiana	P.O. Box 818 Elton, LA 70532
B. Cheryl Smith, Principal Chief	Jena Band of Choctaw Indians	P.O. Box 14 Jena, LA 71432
	Other Organizations and Individuals	
Mark Watson	City of Oak Ridge	mwatson@oakridgetn.gov
Amy Fitzgerald	City of Oak Ridge	afitzgerald@oakridgetn.gov
Ron Woody	Roane County	ron.woody@roanecountytn.org
Peter Hastings	Kairos Power, LLC	hastings@kairospower.com
Heather Hoff	Mothers for Nuclear	heather@mothersfornuclear.org
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Kati Austgen	Nuclear Energy Institute	kra@nei.org
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Rani Franovich	The Breakthrough Institute	rani@thebreakthrough.org

APPENDIX C

CHRONOLOGY OF ENVIRONMENTAL REVIEW CORRESPONDENCE

This appendix contains a chronological list of correspondence between the U.S. Nuclear Regulatory Commission (NRC) and external parties as part of its environmental review for the Kairos Hermes Test Reactor. These documents are available electronically on the NRC's website at https://www.nrc.gov/reading-rm.html. From this website, members of the public can gain access to the NRC's Agencywide Document Access and Management Systems (ADAMS), which provides text and image files of the NRC's public documents in the Publicly Available Records component of ADAMS. The ADAMS accession numbers for each document are included below. Some of the ADAMS accession numbers below lead to a folder containing several documents. If you need assistance in accessing or searching in ADAMS, contact the Public Document Room staff at 1-800-397-4209.

September 29, 2021	Letter to NRC from Peter Hastings, Kairos Power, Submitting the Preliminary Safety Evaluation Report for the Kairos Power Fluoride Salt-Cooled, High Temperature Non-Power Reactor (Hermes) (Rev 0). (Package Accession No. ML21272A375)
October 28, 2021	Letter to NRC from Peter Hastings, Kairos Power, Submitting the Environmental Report for the Kairos Power Fluoride Salt-Cooled, High Temperature Non-Power Reactor (Hermes) (Rev 0). (Package Accession No. ML21306A131)
October 29, 2021	*Federal Register* Notice - NRC Receipt of Kairos Hermes Test Reactor Construction Permit Application (86 FR 60077)
November 29, 2021	Letter from NRC to Peter Hastings, Kairos Power, Acceptance for Docketing Application for Hermes Non-Power Test Reactor Construction Permit Application. (Accession No. ML21319A354)
December 1, 2021	*Federal Register* Notice - Construction Permit Application; Acceptance for Docketing. (86 FR 68290)
December 15, 2021	Letter from NRC to Peter Hastings, Kairos Power, Regarding the Kairos Hermes Construction Permit Application Review Schedule and Resource Estimate. (Accession No. ML21343A214)
February 2, 2022	Kairos Hermes Construction Permit Environmental Report Audit Plan. (Package Accession No. ML22056A064)
February 8, 2022	Letter from NRC to Peter Hastings, Kairos Power, Application for Construction Permit Hermes Test Reactor, Notice of Hearing, Opportunity to Petition for Leave to Intervene, and Associated Federal Register Notice. (Package Accession No. ML21364A012)
February 9, 2022	*Federal Register* Notice - Notice of Hearing and Opportunity to Petition for Leave to Intervene; Order Imposing Procedures. (87 FR 7503)

February 10, 2022	Letter to NRC from Peter Hastings, Kairos Power, Transmittal of Changes to the Construction Permit Application. (Package Accession No. ML22042A095)
February 18, 2022	Letter from NRC to Peter Hastings, Kairos Power, Notice of Intent to Prepare an Environmental Impact Statement and Conduct Scoping Related to an Early Site Permit for the Clinch River Nuclear Site. (Package Accession No. ML22053A010)
February 18, 2022	*Federal Register* Notice of Intent to Conduct Scoping Process and Prepare an Environmental Impact Statement. (87 FR 9394)
February 18, 2022	Letter to NRC from Peter Hastings, Kairos Power, Transmittal of Construction Permit Application Changes. (Package Accession No. ML22049B555)
March 1, 2022	Letter to NRC from Peter Hastings, Kairos Power, Transmittal of Changes to Maximum Hypothetical Accident Dose Results in Hermes Construction Permit Application. (Accession No. ML22060A272)
March 4, 2022	Letter from NRC to E. Patrick McIntyre, Jr., Tennessee Historical Commission, Request to Initiate Section 106 Consultation and Scoping Process for the Kairos Hermes Non-Power Test Reactor Construction Permit Review in Roane County, Tennessee (Accession No. ML22031A288)
March 4, 2022	Letter from NRC to Reid Nelson, Advisory Council on Historic Preservation, Request to Initiate Section 106 Consultation and Scoping Process for the Kairos Hermes Non-Power Test Reactor Construction Permit Review in Roane County, Tennessee (Accession No. ML22031A286)
March 4, 2022	Letter from NRC to Niki Nicholas, Manhattan Project National Historic Park, Request to Initiate Section 106 Consultation and Scoping Process for the Kairos Hermes Non-Power Test Reactor Construction Permit Review in Roane County, Tennessee (Accession No. ML22031A287)
March 4, 2022	Letter from NRC to Mary Jennings, U.S. Fish and Wildlife Service, Request For Participation In The Environmental Scoping Process And A List Of Protected Species Within The Area Under Evaluation For The Proposed Kairos Hermes Test Reactor Construction Permit Application Review. (Accession No. ML22033A241)
March 4, 2022	Letter from NRC to Larry Long, Environmental Protection Agency, Request For Participation In The Environmental Scoping Process For the Proposed Kairos Hermes Test Reactor Construction Permit Application Review. (Accession No. ML22033A246)

March 4, 2022	Letter from NRC to John Raymond Johnson, Absentee Shawnee Tribe, Request to Initiate Section 106 Consultation and Scoping Process for the Kairos Hermes Non-Power Test Reactor Construction Permit Review in Roane County, Tennessee. (Accession No. ML22031A289)
March 4, 2022	Letter from NRC to Ms. Nita Battise, Alabama-Coushatta Tribe of Texas, Request to Initiate Section 106 Consultation and Scoping Process for the Kairos Hermes Non-Power Test Reactor Construction Permit Review in Roane County, Tennessee. (Accession No. ML22031A289)
March 4, 2022	Letter from NRC to Mr. Wilson Yargee, Chief, Alabama-Quassarte Tribal Town, Request to Initiate Section 106 Consultation and Scoping Process for the Kairos Hermes Non-Power Test Reactor Construction Permit Review in Roane County, Tennessee. (Accession No. ML22031A289)
March 4, 2022	Letter from NRC to Mr. Chuck Hoskin, Jr., Principal Chief, Cherokee Nations, Request to Initiate Section 106 Consultation and Scoping Process for the Kairos Hermes Non-Power Test Reactor Construction Permit Review in Roane County, Tennessee. (Accession No. ML22031A289)
March 4, 2022	Letter from NRC to Mr. Bill Anoatubby, Chickasaw Nation, Request to Initiate Section 106 Consultation and Scoping Process for the Kairos Hermes Non-Power Test Reactor Construction Permit Review in Roane County, Tennessee. (Accession No. ML22031A289)
March 4, 2022	Letter from NRC to Mr. Richard Sneed, Principal Chief, Eastern Band of Cherokee Indians, Request to Initiate Section 106 Consultation and Scoping Process for the Kairos Hermes Non-Power Test Reactor Construction Permit Review in Roane County, Tennessee. (Accession No. ML22031A289)
March 4, 2022	Letter from NRC to Ms. Glenna J. Wallace, Chief, Eastern Shawnee Tribe of Oklahoma, Request to Initiate Section 106 Consultation and Scoping Process for the Kairos Hermes Non-Power Test Reactor Construction Permit Review in Roane County, Tennessee. (Accession No. ML22031A289)
March 4, 2022	Letter from NRC to Mr. Brian Givens, Town King, Kialegee Tribal Town, Request to Initiate Section 106 Consultation and Scoping Process for the Kairos Hermes Non-Power Test Reactor Construction Permit Review in Roane County, Tennessee. (Accession No. ML22031A289)
March 4, 2022	Letter from NRC to Mr. David Hill, Principal Chief, Muscogee (Creek) Nation, Request to Initiate Section 106 Consultation and Scoping Process for the Kairos Hermes Non-Power Test Reactor Construction Permit Review in Roane County, Tennessee. (Accession No. ML22031A289)

March 4, 2022	Letter from NRC to Ms. Stephanie A. Bryan, Tribal Chair, Poarch Band of Creek Indians, Request to Initiate Section 106 Consultation and Scoping Process for the Kairos Hermes Non-Power Test Reactor Construction Permit Review in Roane County, Tennessee. (Accession No. ML22031A289)
March 4, 2022	Letter from NRC to Mr. Greg P. Chilcoat, Principal Chief, Seminole Nation of Oklahoma, Request to Initiate Section 106 Consultation and Scoping Process for the Kairos Hermes Non-Power Test Reactor Construction Permit Review in Roane County, Tennessee. (Accession No. ML22031A289)
March 4, 2022	Letter from NRC to Mr. Marcellus W. Osceola, Jr., Seminole Tribe of Florida, Request to Initiate Section 106 Consultation and Scoping Process for the Kairos Hermes Non-Power Test Reactor Construction Permit Review in Roane County, Tennessee. (Accession No. ML22031A289)
March 4, 2022	Letter from NRC to Mr. Benjamin Barnes, Chief, Shawnee Tribe, Request to Initiate Section 106 Consultation and Scoping Process for the Kairos Hermes Non-Power Test Reactor Construction Permit Review in Roane County, Tennessee. (Accession No. ML22031A289)
March 4, 2022	Letter from NRC to Mr. Ryan Morrow, Town King, Thlopthlocco Tribal Town, Request to Initiate Section 106 Consultation and Scoping Process for the Kairos Hermes Non-Power Test Reactor Construction Permit Review in Roane County, Tennessee. (Accession No. ML22031A289)
March 4, 2022	Letter from NRC to Mr. Joe Bunch, Chief, United Keetoowah Band of Cherokee Indians, Request to Initiate Section 106 Consultation and Scoping Process for the Kairos Hermes Non-Power Test Reactor Construction Permit Review in Roane County, Tennessee. (Accession No. ML22031A289)
March 4, 2022	Letter from NRC to Mr. David Sickey, Chairman, Coushatta Tribe of Louisiana, Request to Initiate Section 106 Consultation and Scoping Process for the Kairos Hermes Non-Power Test Reactor Construction Permit Review in Roane County, Tennessee. (Accession No. ML22031A289)
March 4, 2022	Letter from NRC to Ms. B. Cheryl Smith, Principal Chief, Jena Band of the Choctaw Indians, Request to Initiate Section 106 Consultation and Scoping Process for the Kairos Hermes Non-Power Test Reactor Construction Permit Review in Roane County, Tennessee. (Accession No. ML22031A289)
March 4, 2022	Letter from NRC to Ms. Deborah Dotson, President, Delaware Nation, Request to Initiate Section 106 Consultation and Scoping Process for the Kairos Hermes Non-Power Test Reactor Construction Permit Review in Roane County, Tennessee. (Accession No. ML22031A289)

March 11, 2022	Letter to NRC from E. Patrick McIntyre, Jr., Tennessee Historical Commission, Regarding Construction of Kairos Power, LLC. Hermes Non-Power Test Reactor, ETTP, Oak Ridge, Roane County, TN. (Scoping Comment) (Accession No. ML22082A294)
March 31, 2022	Letter to NRC from Lisa Johnson., Chickasaw Nation, Regarding Kairos Hermes Construction Permit. (Scoping Comment) (Accession No. ML22090A055)
March 31, 2022	Email from NRC to Darrel Gardner, Kairos Power, Transmittal of Requests for Confirmatory Information for the Review of the Hermes Environmental Report. (Package Accession No. ML22090A060)
April 4, 2022	Letter to NRC from Paul Barton., Eastern Shawnee Tribe of Oklahoma, Project Review, Kairos Power Hermes Non-Power Test Reactor Construction Permit. (Scoping Comment) (Accession No. ML22094A125)
April 4, 2022	Email to NRC from Erin Thompson-Paden, Delaware Nation, Regarding Kairos Hermes Construction Permit. (Scoping Comment) (Accession No. ML22095A221)
April 4, 2022	Email to NRC from Larry Haikey, Poarch Band of Creek Indians, Regarding Kairos Power Hermes Non-Power Test Reactor Construction Permit Review. (Scoping Comment) (Accession No. ML22095A224)
April 6, 2022	Email to NRC from Ben Yahola, Seminole Nation of Oklahoma, Regarding Kairos Power Hermes Non-Power Test Reactor Construction Permit Review. (Scoping Comment) (Accession No. ML22109A188)
April 12, 2022	Letter to NRC from Niki Nicholas, Manhattan Project National Park, Regarding Kairos Hermes Construction Permit. (Scoping Comment) (Accession No. ML22105A022)
April 15, 2022	E-mail to NRC from Steven Alexander, U.S. Fish & Wildlife Service, Regarding Kairos Power, LLC Hermes Reactor at DOE ORR ETTP (Heritage Center) (Scoping Comment) (Accession No. 22119A261)
April 22, 2022	Letter to NRC from Peter Hastings, Kairos Power, Transmittal of Responses to NRC Requests for Confirmatory Information for the Review of the Hermes Environmental Report. (Package Accession No. ML22115A204)
April 27, 2022	Letter to NRC from Peter Hastings, Kairos Power, Transmittal of Supplemental Information for NRC Information Need HCUL-10 for the Hermes Environmental Review. (Package Accession No. ML22117A215)
April 27, 2022	Letter to NRC from Peter Hastings, Kairos Power, Transmittal of Changes to Hermes Environmental Report Resulting from NRC Environmental Review Audit. (Package Accession No. ML22117A218)

May 5, 2022	NRC Memorandum: Summary of March 23, 2022 Public Outreach Meeting on the Proposed Kairos Hermes Test Reactor with Designated Period for Receipt of Environmental Scoping Comments (Package Accession No. ML22110A018)
June 30, 2022	Letter to NRC from Peter Hastings, Kairos Power, Transmittal of Changes to the Construction Permit Application. (Package Accession No. ML22181B157)
August 01, 2022	Environmental Impact Statement Scoping Process Summary Report: Kairos Hermes Test Reactor Construction Permit Application (Package Accession No. ML22194A014)
August 24, 2022	NRC Memorandum: Summary Report for the Environmental Audit of the Kairos Hermes Test Reactor Construction Permit Application (Package Accession No. ML22196A387)

APPENDIX D

REGULATORY COMPLIANCE AND LIST OF FEDERAL, STATE, AND LOCAL PERMITS AND APPROVALS

Table D-1 contains a list of the environmental-related authorizations, permits, and certifications potentially required by Federal, State, regional, local, and affected Native American Tribal agencies related to site preparation, construction, and operation of two or more small modular reactors at the Kairos Hermes nuclear site.

Table D-1 was adapted from Table 1.4-1 of the Environmental Report submitted to the U.S. Nuclear Regulatory Commission by the applicant (Kairos 2021-TN7880).

Table D-1 Authorizations Required for Preconstruction, Construction, and Operation Activities

Agency	Authority	Requirement	Activity Covered
U.S. Nuclear Regulatory Commission	Atomic Energy Act 10 CFR 50.50Atomic Energy Act 10 CFR 50.50	Construction Permit	Construction of the facilities
	10 CFR 50.5710 CFR 50.57	Operating License	Operation of the facilities
	10 CFR Part 4010 CFR Part 40	Source Material License	Possession, use, and transfer of special nuclear material
	10 CFR Part 3010 CFR Part 30	By-Product Material License	Production, possession, and transfer of radioactive by-product material
	10 CFR Part 7010 CFR Part 70	Special Nuclear Material License	Receipt, possession, use, and transfer of special nuclear material
	National Environmental Policy Act (NEPA) 10 CFR Part 51National Environmental Policy Act (NEPA) 10 CFR Part 51	Environmental Assessment or Environmental Impact Statement in accordance with NEPA	Site approval for construction and operation of a radiation facilities
Federal Aviation Administration	Federal Aviation Act 14 CFR Part 77Federal Aviation Act 14 CFR Part 77	Construction Notice	Construction of structures that may impact air navigation (height greater than 200 feet [ft]), construction of structures above a 1 to 100 slope from nearest runway
U.S. Environmental Protection Agency	Resource Conservation and Recovery Act 40 CFR Part 261 and 262	Acknowledgement of Notification of Hazardous Waste Activity	Generation of hazardous waste
	Clean Water Act 40 CFR Part 112 Appendix F	Spill Prevention, Control, and Countermeasure Plans for Construction and Operation	Storage of oil during construction and operation
U.S. Fish and Wildlife Service	Endangered Species Act	Section 7 Consultation	Protection of endangered and threatened species and critical habitats designated under the Federal Endangered Species Act

Agency	Authority	Requirement	Activity Covered
U.S. Department of Transportation	Hazardous Material Transportation Act	Certificate of Registration	Transportation of hazardous materials
Tennessee Department of Environment and Conservation (TDEC)	Federal Clean Air Act	Air Pollution Control Construction Permit	Construction of an air pollution emission source that is not specifically exempted
		Air Pollution Control Operation Permit	Operation of an air pollution emission source that is not specifically exempted
	Federal Clean Water Act	Construction Storm Water Discharge Permit	Discharge of stormwater runoff from the construction site
		Industrial Storm Water Discharge Permit	Discharge of stormwater runoff from the site during facilities operation
Tennessee Department of Safety and Professional Services		Building Plan Review	Compliance with state building codes; required before local building permit can be issued for a commercial building
Tennessee Department of Transportation (TDOT)		Permit for Connection to State Trunk Highway	Construction of driveway connection to Highway 58
		Right-of-Entry Permit	Construction by the City of Oak Ridge of Utility Extensions across Highway 58
City of Oak Ridge		Site Plan Approval	Administrative approval of site layout, plans for parking, landscaping, lighting, etc.
		Storm Water Plan approval (may be included in Site Plan Approval)	Administrative approval of grading and drainage plans
		Erosion Control Permit (may be included in Site Plan Approval)	Administrative approval of erosion control plans
		Building Permit	Construction of buildings
		Plumbing Plan Approval	Installation of plumbing systems
		Heating, Ventilation, and Air Conditioning Plan approval	Installation of heating, ventilation, and air conditioning systems
		Occupancy Permit	Occupancy of completed buildings
		Conditional use Permit	Construction of multiple buildings on the same site

Agency	Authority	Requirement	Activity Covered
		Sanitary Sewer and Water Supply Facility Approvals	Administrative approval of construction, installation, and operation of connections to the municipal sewer and water supply systems
Tennessee State Historic Preservation Office Tribal Historic Preservation Officer	Section 106 of the National Historic Preservation Act	National Historic Preservation Act Section 106 compliance and consultation, which includes State Historic Preservation Office/Tribal Historic Preservation Officer, and identification of potentially affected resources, i.e., a site survey	Protection of archaeological and historical resources

APPENDIX E

GREENHOUSE GAS EMISSIONS

The U.S. Nuclear Regulatory Commission (NRC) staff estimated the greenhouse gas (GHG) emissions of various activities associated with the building, operating, and decommissioning of nuclear power plants (NPPs). The GHG emission estimates include direct emissions from nuclear facilities and indirect emissions from workforce and fuel transportation, decommissioning, and the uranium fuel cycle. The estimates are based on a single installation of 1,000 megawatt electric (MWe) output with an 80 percent capacity factor henceforth referred to as the reference 1,000 MWe reactor. The estimates may be roughly linearly scaled from the reference 1,000 MWe reactor for other reactor outputs.[1] This appendix discusses the calculation of GHG emission estimates for the reference 1,000 MWe reactor.

The estimated emissions from equipment used to build a NPP listed in Table E-1 are based on hours of equipment use estimated for a single NPP at a site requiring a moderate amount of terrain modification (UniStar 2007-TN1564). Construction equipment carbon monoxide (CO) emission estimates were derived from the hours of equipment use, and carbon dioxide (CO_2) emissions were then estimated from the CO emissions using a scaling factor of 172 tons (T) of CO_2 per ton of CO (Chapman et al. 2012-TN2644). The scaling factor is based on the ratio of CO_2 to CO emission factors for diesel fuel industrial engines as reported in Table 3.3-1 of AP-42 Compilation of Air Pollutant Emission Factors (EPA 2012-TN2647). A CO_2 to total GHG equivalency factor of 0.991 is used to account for the emissions from other GHGs, such as methane (CH_4) and nitrous oxide (N_2O) (Chapman et al. 2012-TN2644). The equivalency factor is based on non-road/construction equipment in accordance with relevant guidance (NRC 2014-TN3768; Chapman et al. 2012-TN2644). Equipment emissions estimates for decommissioning are assumed to be one-half of those for construction equipment. Data on equipment emissions for decommissioning are not available; the one-half factor is based on the assumption that decommissioning would involve less earthmoving and hauling of material, as well as fewer labor hours, compared to those involved in building activities (Chapman et al. 2012-TN2644).

Table E-2 lists the NRC staff's estimates of the CO_2 equivalent[2] (CO_2eq) emissions associated with workforce transportation. Construction workforce estimates for the reference 1,000 MWe reactor are conservatively based on estimates in various combined license applications (Chapman et al. 2012-TN2644), and the operational and decommissioning workforce estimates are based on Supplement 1 to NUREG–0586 (NRC 2002-TN665). Table E-2 lists the assumptions used to estimate total miles (mi) traveled by each workforce and the factors used to convert total miles to metric tons of CO_2eq. The workers are assumed to travel in gasoline-powered passenger vehicles (cars, trucks, vans, and sport utility vehicles) that get an average of 21.6 miles per gallon (mi/gal) (9.1 kilometers per liter [km/L]) of gasoline (FHWA 2012-TN2645). Conversion from gallons of gasoline burned to CO_2eq is based on U.S. Environmental Protection Agency (EPA) emission factors (EPA 2012-TN2643).

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[1] The term "model LWR" has also been used to describe a 1,000 MWe light water reactor for the purpose of evaluating the environmental considerations of the supporting fuel cycle to the annual reactor operations (WASH-1248, AEC 1974-TN23). It is assumed there are no significant differences between the 1,000 MWe reactor evaluated in WASH-1248 and the 1,000 MWe reference reactor evaluated in this appendix.

[2] A measure to compare the emissions from various GHGs on the basis of their global warming potential, defined as the ratio of heat trapped by one unit mass of the GHG to that of one unit mass of CO_2 over a specific time period.

1 **Table E-1 Greenhouse Gases Emissions from Equipment Used in Building**
2 **and Decommissioning (Metric Tons of Carbon Dioxide Equivalent**
3 **[(MT CO_2eq])**

Equipment	Building Total[(a)]	Decommissioning Total[(b)]
Earthwork and dewatering	12,000	6,000
Batch plant operations	3,400	1,700
Concrete	5,400	2,700
Lifting and rigging	5,600	2,800
Shop fabrication	1,000	500
Warehouse operations	1,400	700
Equipment maintenance	10,000	5,000
Total[(c)]	39,000	19,000

(a) Based on hours of equipment usage over a 7-year period.
(b) Based on equipment usage over a 10-year period.
(c) Results are rounded to the nearest 1,000 MT CO_2eq.

4 **Table E-2 Workforce Greenhouse Gases Footprint Estimates**

	Construction Workforce	Operational Workforce	Decommissioning Workforce	SAFSTOR Workforce
Commuting trips (round trips per day)	1,000	550	200	40
Commute distance (miles per round-trip)	40	40	40	40
Commuting days (days per year)	365	365	250	365
Duration (years)	7	40	10	40
Total distance traveled (mi)[(a)]	102,000,000	321,000,000	20,000,000	23,000,000
Average vehicle fuel efficiency[(b)] (mi/gal)	21.6	21.6	21.6	21.6
Total fuel burned[(a)] (gal)	4,700,000	14,900,000	900,000	1,100,000
CO_2 emitted per gallon[(c)] (MT CO_2)	0.00892	0.00892	0.00892	0.00892
Total CO_2 emitted[(a)] (MT CO_2)	42,000	133,000	8,000	10,000
CO_2 equivalency factor[(c)] (MT CO_2/MT CO_2eq)	0.977	0.977	0.977	0.977
Total GHG emitted[(a)] (MT CO_2eq)	43,000	136,000	8,000	10,000

Key: SAFSTOR = SAFe STORage; mi = miles; mi/gal= miles per gallon; gal=gallon; MT = metric tons; CO_2eq = carbon dioxide equivalent.
(a) Results are rounded.
(b) Source: FHWA 2012-TN2645.
(c) Source: EPA 2012-TN2643.

Title 10 of the *Code of Federal Regulations* 51.51(a) (10 CFR 51.51[a]; TN250) states that every environmental report [1] prepared for an early site permit or combined license stage of a light-water-cooled nuclear power reactor shall use Table S–3, Table of Uranium Fuel Cycle Environmental Data, as set forth in 10 CFR 51.51(b) (TN250) as the basis for evaluating the contribution of the environmental effects of uranium fuel-cycle activities to the environmental costs of licensing the nuclear power reactor. Section 51.51(a) (TN250) further states that Table S–3 shall be included in the ER and may be supplemented by a discussion of the environmental significance of the data set forth in the table as weighted in the project-specific analysis for the proposed facility.

Table S–3 of 10 CFR 51.51(b) (TN250) does not directly apply to non-light-water reactors (LWRs), nor does it provide an estimate of GHG emissions associated with the uranium fuel cycle; it only addresses pollutants that were of concern when the table was promulgated in the 1970s. However, Table S–3 states that 323,000 megawatt-hour (MWh) is the assumed annual electric energy use for the Table S–3 reference 1,000 MWe NPP and that this 323,000 MWh of annual electric energy is assumed to be generated by a 45 MWe coal-fired power plant burning 118,000 MT of coal. These assumptions are based upon 1970s uranium enrichment technology, which has changed substantially since then. The older, energy-intensive gaseous-diffusion plants have been replaced with more efficient centrifuge-based systems. The current operating gas centrifuge uranium enrichment facility in the United States is URENCO-USA (Louisiana Energy Services), which is located in Eunice, New Mexico. The URENCO-USA facility does not rely solely upon coal as an energy source (Napier 2020-TN6443). If a 1,000 MWe plant is assumed to operate at 35 percent thermal efficiency and use uranium fuel enriched to 5 percent in uranium-235 (U-235) with an average burnup of 40,000 megawatt-day per metric ton (MWd/MT) for 40 years, then it will require about 1,043 T of enriched uranium for fuel. To produce 1 T of 5 percent enriched uranium with 0.25 percent U-235 in the depleted uranium stream requires extraction of 10.3 T of natural uranium and 7,923 separative work units (Napier 2020-TN6443). The 1,043 T of uranium enriched to 5 percent U-235 required over the 40-year life of the 1,000 MWe plant would then require 8,264,000 separative work units. Because a centrifuge enrichment facility requires about 50 kWh per separative work units (WNA 2020-TN6661), a total of 413,200 MWh is needed to produce 40 years' worth of uranium enriched to 5 percent U-235 for fuel for the lifetime operation of the 1,000 MWe plant. For the existing U.S. centrifuge enrichment plant, the regional average CO_2 emission factor is 1,248 pounds per megawatt-hour (lb/MWh),[2] and the total CO_2 emission is about 243,000 MT.

Table S–3 also assumes that approximately 135,000,000 standard cubic feet (scf) of natural gas is required per year to generate process heat for certain portions of the uranium fuel cycle. The NRC staff estimates that burning 135,000,000 scf of natural gas per year results in approximately 7,440 MT of CO_2eq being emitted into the atmosphere per year because of the process heat requirements of the uranium fuel cycle.[3] For a 40-year operational life, this is 298,000 MT of CO_2eq. This amount is in addition to the CO_2eq emissions from the enrichment process.

[1] The NRC requires most applicants, including all reactor applicants, to submit an Environmental Report as part of the application. 10 CFR 51.45 and 10 CFR 51.50 [TN250]).

[2] The EPA provides estimates of emissions from electricity production for different regions in the United States at https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid for CO_2 in units of lb/kWh. The value for southeastern New Mexico has been applied here.

[3] The conversion is 0.0551 (MT CO_2/thousand scf) (https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references).

The NRC staff estimated GHG emissions related to plant operations from the typical usage of various onsite diesel generators (UniStar 2007-TN1564). CO emission estimates were derived assuming an average of 600 hours of emergency diesel generator operation per year (four generators, each operating 150 hours per year [hr/yr]) and 200 hours of station blackout diesel generator operation per year (two generators, each operating 100 hr/yr) (Chapman et al. 2012-TN2644). A scaling factor of 172 was then applied to convert the CO emissions to CO_2 emissions, and a CO_2 to total GHG equivalency factor of 0.991 was used to account for the emissions from other GHGs such as CH_4 and N_2O (Chapman et al. 2012-TN2644).

The number of shipments and shipping distances for transport of fresh nuclear fuel and spent nuclear fuel and radioactive wastes are presented in Table S-5 of Supplement 1 to WASH-1238 [NRC 1975-TN216], for a 1,100 MWe LWR with an 80 percent capacity factor. WASH-1248 (AEC 1974-TN23) assumes that truck casks weigh 50,000 pounds (lb) (23 MT) and rail casks weigh 100 T (91 MT). For this analysis, emission rates of CO_2 for trucks are taken to be 64.7 gram per ton-mile (g/T-mi) (44.2 gram per metric ton-kilometer [g/MT-km]) and for rail are taken to be 32.2 g/T-mi (22 g/MT-km) (Cefic and ECTA 2011-TN6966). For the calculation, it is also assumed that return trips with empty casks double the total miles traveled by truck or rail. Table E-3 presents estimated annual CO_2eq emissions from shipments associated with the reference 1,000 MWe reactor.

Table E-3 Annual Number of Shipments for the Reference 1,000 MWe Reactor

Material	Annual Number of Shipments for the Reference 1,000 MWe Reactor	Typical Distance (mi)[(a)]	Annual CO_2eq Emissions[(b)]
Unirradiated fuel (truck)	6	1,000	19
Spent fuel (truck)	60	1,000	194
Spent fuel (rail)	10	1,000	64
Radioactive waste (truck)	46	500	74

Key: MWe = megawatt electric; mi = mile; CO_2eq = carbon dioxide equivalent.

(a) Source: NRC (1975-TN216), Table S-5.

(b) Results are rounded to the nearest 1,000 MT CO_2e.

The total GHG emissions for fuel and waste transportation are approximately 352 MT per reference reactor-year from Table E-3. Over a 40-year operating life for the reference 1,000 MWe reactor, the total is approximately 14,000 MT of CO_2eq emitted.

Given the various sources of GHG emissions discussed above, the NRC staff estimated the total lifetime GHG footprint for the reference 1,000 MWe reactor to be about 990,000 MT CO_2eq, with a 7-year building phase, 40 years of operation, and 10 years of active decommissioning.[1] These components of the GHG emissions footprint are summarized in Table E-4. The uranium fuel cycle component of the footprint is the largest portion of the overall

1 Under the NRC's regulations, a reactor licensee has up to 60 years to complete the decommissioning of a reactor facility commencing with the licensee's certification that it has permanently ceased reactor operations (10 CFR 50.82(a)(3); TN249). The 60-year decommissioning period may be exceeded subject to NRC approval, if necessary, to protect "public health and safety." Id. The estimated 10-year decommissioning period is a subset of the 60-year decommissioning period, during which significant demolition and earthmoving activities may occur (e.g., deployment and operation of equipment at the decommissioning site and shipments by truck or rail to remove irradiated soil, rubble, and debris from the site), as discussed in Supplement 1 to NUREG–0586 (NRC 2002-TN665).

estimated GHG emissions and is directly related to the assumed power generated by the plant. The GHG emission estimates for the uranium fuel cycle are based on newer enrichment technology, assuming that the energy required for enrichment is provided by modern regional electric systems.

Table E-4 Nuclear Power Plant Life-cycle Greenhouse Gas Footprint

Source	Activity Duration (in years)[a]	Total Emissions (MT CO_2eq)
Construction equipment	7	39,000
Construction workforce	7	43,000
Plant operations	40	181,000
Operations workforce	40	136,000
Uranium fuel cycle	40	540,000
Fuel and waste transportation	40	14,000
Decommissioning equipment	10	19,000
Decommissioning workforce	10	8,000
SAFSTOR workforce	40	10,000
TOTAL[b]		990,000

Key: CO_2eq = carbon dioxide equivalent; SAFSTOR = SAFe STORage.

[a] Nuclear power plant life-cycle for estimating GHG is assumed to be 97 years which includes building, operating, and decommissioning.

[b] Results are rounded to the nearest 1,000 MT CO_2eq.

The Intergovernmental Panel on Climate Change (IPCC) released a special report about renewable energy sources and climate change mitigation in 2012 (IPCC 2012-TN2648). Annex II of the IPCC report includes an assessment of previously published works on life cycle of GHG emissions from various electric generation technologies, including nuclear energy. The IPCC report included only reference material that passes certain screening criteria for quality and relevance in its assessment. The IPCC screening yielded 125 estimates of nuclear energy life cycle GHG emissions from 32 separate references. The IPCC-screened estimates of the life cycle GHG emissions associated with nuclear energy, as shown in Table A.II.4 of the IPCC report, ranged from 1 to 220 gram (g) of carbon equivalent per kilowatt hour (CO_2eq/kWh), with 25th percentile, 50th percentile, and 75th percentile values of 8 g CO_2eq/kWh, 16 g CO_2eq/kWh, and 45 g CO_2eq/kWh, respectively. The range of the IPCC estimates is due, in part, to assumptions regarding the type of enrichment technology employed, how the electricity used for enrichment is generated, the grade of mined uranium ore, the degree of processing and enrichment required, and the assumed operating lifetime of a NPP. The NRC staff's GHG life cycle estimate of approximately 990,000 MT CO_2eq for the reference 1,000 MWe reactor is equal to about 3.5 g CO_2eq/kWh, which places the NRC staff's estimate at the lower end of the IPCC estimates in Table A.II.4 of the IPCC report. This placement is primarily because the IPCC estimates were for LWRs that used enrichment technologies that were based on the use of coal-fired generation as the electricity source.

The GHG emissions presented in Section 3.0 of this draft EIS use the values presented in this appendix but are scaled based on project-specific information. The GHG emissions for building, operation (including the fuel waste and transportation of fuel and waste), and decommissioning are discussed in Section 3.2.

E.1 References

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APPENDIX F

VIEWSHED PHOTOGRAPHS AT NEARBY HISTORIC AND CULTURAL RESOURCES

Kairos Power

KP-NRC-2204-008

April 27, 2022

Docket No. 50-7513

US Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Subject: Kairos Power LLC
Transmittal of Supplemental Information for NRC Information Need HCUL-10 for the Hermes Environmental Review

References:
1. Letter, Kairos Power LLC to Document Control Desk "Submittal of the Environmental Report for the Kairos Power Fluoride Salt-Cooled, High Temperature Non-Power Reactor (Hermes)," October 31, 2021 (ML21306A131)
2. Email, Nuclear Regulatory Commission, Tamsen Dozier to Kairos Power LLC, "Kairos Power, LLC Hermes Environmental Report Audit Plan," February 2, 2022 (ML22052A008)

By letter dated October 31, 2021 (Reference 1), Kairos Power LLC submitted its Environmental Report (ER) in support of the construction permit application (CPA) for the Hermes test reactor. As part of the Nuclear Regulatory Commission (NRC) review of the information contained in the ER, NRC announced (Reference 2) and conducted an audit of the Hermes ER.

During the audit, the NRC requested that Kairos Power provide supplemental information related to audit information need HCUL-10 (Reference 2). The enclosure to this letter submits photographs taken in the Hermes site vicinity, specifically requested by NRC staff during the audit. Kairos Power requests NRC staff review of this information in support of continued review of the Hermes non-power test reactor CPA.

If you have any questions or need any additional information, please contact Marty Bryan at bryan@kairospower.com or at (865) 369-1136, or Darrell Gardner at gardner@kairospower.com or (704) 769-1226.

I declare under penalty of perjury that the foregoing is true and correct.
Executed on April 27, 2022.

Peter Hastings, PE
Vice President, Regulatory Affairs and Quality

Enclosure: Supplemental Information for HCUL-10 for Hermes Environmental Review

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Enclosure 1
Supplemental Information for HCUL-10 for Hermes Environmental Review

(Non-Proprietary)

Kairos Power

NRC Question Number: HCUL-10
In ER Section 4.6.1, it states that the nearest listed National Register of Historic Places property is the K-25 Gaseous Diffusion Plant which is part of the Manhattan Project National Park. The ER states that "...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." Please describe or discuss any architectural surveys conducted for the proposed project to assess indirect (i.e., visual) effects to other historic and cultural resources (i.e., historic properties) within the viewshed/indirect effects APE?

Kairos Power Response:
During the audit, the NRC requested, and Kairos Power agreed to submit to the docket, supplemental information related to this Audit Information Need Historic and Cultural Resources (HCUL)-10. Specifically, photographs are provided to assess the indirect (i.e., visual) effects to selected historic and cultural resources (i.e., historic properties) within the proposed site viewshed. The following eight photographs were recently taken from the historic and cultural properties in the site vicinity, in the direction of the proposed Hermes facility.

Al photographs were taken on March 24, 2022.

Impact on Licensing Document:

This information does not result in changes to the Hermes Environmental Report.

Photo 1 - Gallaher Cemetery (Front)

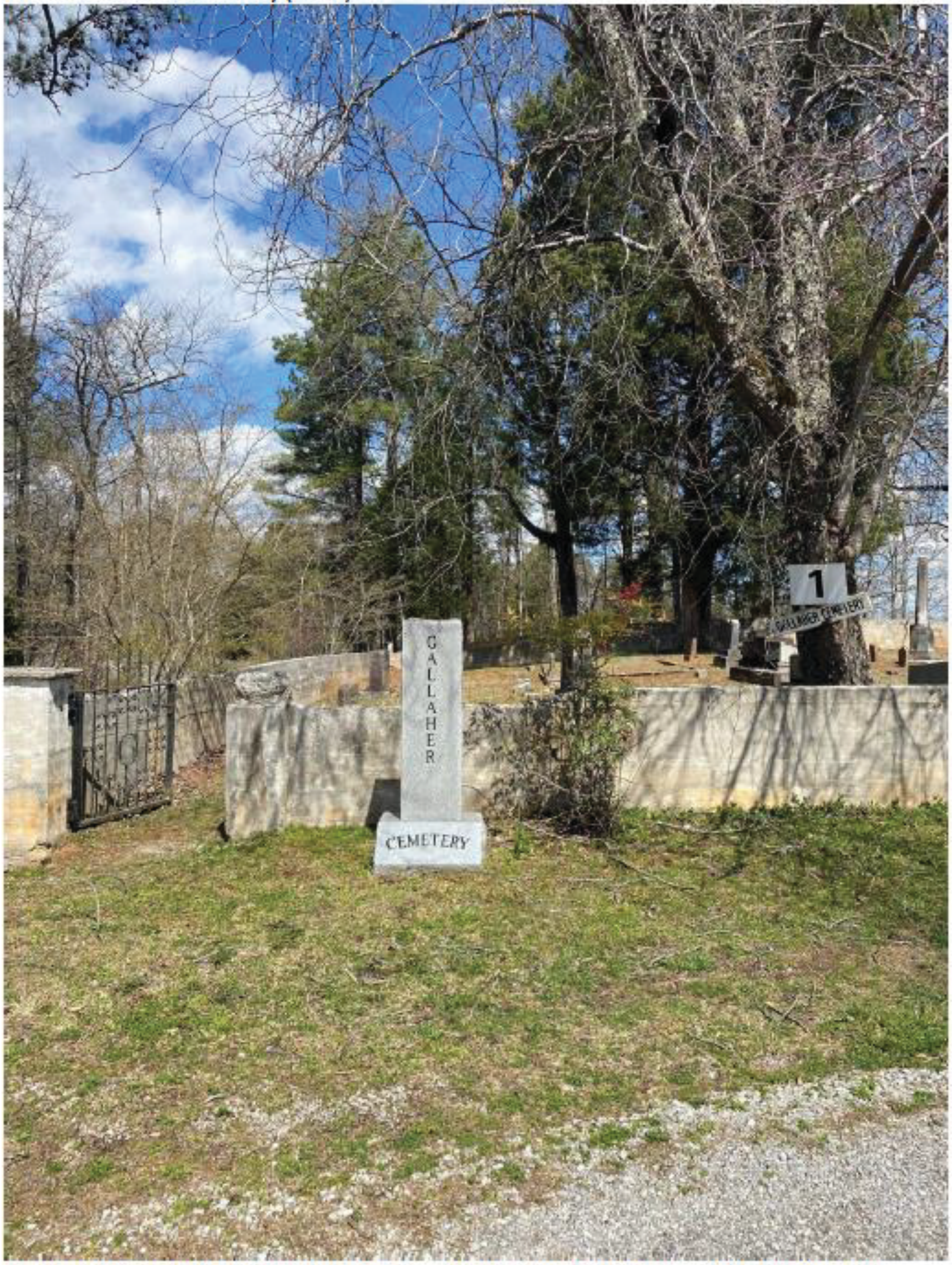

Photo 1, taken at the Gallaher Cemetery entrance and facing toward the Hermes site

1

Photo 2 - Gallaher Cemetery (Back)

Photo 2, taken at the back of the Gallaher Cemetery, facing toward the Hermes site

1

Photo 3 - African Burial Ground

1 Photo 3, taken from the African Burial Ground, facing toward the Hermes site

Photo 4 – Wheat Community African Burial Ground (Marker)

Photo 4, taken at the site of the Wheat Community African Burial Ground Marker, facing toward the Hermes site

1

Photo 5 - Wheat Community Historic Marker

Photo 5, taken at the Wheat Community Historic Marker, facing toward the Hermes site

1

Photo 6 - George Jones Memorial Baptist Church

Photo 6, taken near the George Jones Memorial Baptist Church entrance, facing toward the Hermes site

1

Photo 7 - Ellis Cemetery

Photo 7, taken from the Ellis Cemetery fenceline, facing toward the Hermes site

Photo 8 - K-25 Proposed Viewing Platform Site

Photo 8, taken from the proposed site of the K-25 Viewing Platform, facing toward the Hermes site

NRC FORM 335 (12-2010) NRCMD 3.7

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

(See instructions on the reverse)

1. REPORT NUMBER (Assigned by NRC, Add Vol., Supp., Rev., and Addendum Numbers, if any.)
NUREG-2263
Draft

2. TITLE AND SUBTITLE
Environmental Impact Statement for the Construction Permit for the Kairos Hermes Test Reactor

3. DATE REPORT PUBLISHED

MONTH	YEAR
September	2022

4. FIN OR GRANT NUMBER

5. AUTHOR(S)
See Appendix A

6. TYPE OF REPORT
Technical

7. PERIOD COVERED (Inclusive Dates)

8. PERFORMING ORGANIZATION - NAME AND ADDRESS (If NRC, provide Division, Office or Region, U. S. Nuclear Regulatory Commission, and mailing address; if contractor, provide name and mailing address.)
Division of Rulemaking, Environmental, and Financial Support
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

9. SPONSORING ORGANIZATION - NAME AND ADDRESS (If NRC, type "Same as above", if contractor, provide NRC Division, Office or Region, U. S. Nuclear Regulatory Commission, and mailing address.)
Same as above

10. SUPPLEMENTARY NOTES
Docket 50-7513

11. ABSTRACT (200 words or less)

This draft environmental impact statement (EIS) has been prepared in response to an application to the U.S. Nuclear Regulatory Commission (NRC) by Kairos Power, LLC (Kairos) for construction permit (CP) for a non-power research and test reactor termed Hermes at a site in Oak Ridge, Tennessee. Kairos plans to build and operate Hermes to demonstrate key elements of the Kairos Power Fluoride Salt-Cooled, High Temperature Reactor (KP-FHR) technology for possible future commercial deployment. This draft EIS includes the analysis that evaluates the environmental impacts of the proposed action and considers the following two alternatives to the proposed action: (1) the no-action alternative (i.e., the CP is denied) and (2) building the proposed Hermes non-power research and test reactor at a site near Idaho Falls, Idaho.

After weighing the environmental, economic, technical, and other benefits against environmental and other costs, the NRC staff's preliminary recommendation, unless safety issues mandate otherwise, is that the operating license be issued as proposed. The NRC staff based its recommendation on the following:

- the application, including the Kairos Hermes environmental report and supplemental submittals;
- consultation with Federal, State, Tribal, and local agencies;
- consideration of public comments; and
- the staff's independent review.

12. KEY WORDS/DESCRIPTORS (List words or phrases that will assist researchers in locating the report.)
Kairos Hermes Test Reactor
Kairos Power Hermes Non-Power Test Reactor
Draft Environmental Impact Statement, DEIS
National Environmental Policy Act, NEPA
NUREG-2263

13. AVAILABILITY STATEMENT
unlimited

14. SECURITY CLASSIFICATION
(This Page) unclassified
(This Report) unclassified

15. NUMBER OF PAGES

16. PRICE

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, DC 20555-0001

OFFICIAL BUSINESS

@NRCgov

NUREG-2263
Draft

Environmental Impact Statement for the Construction Permit for the Kairos Hermes Test Reactor

September 2022