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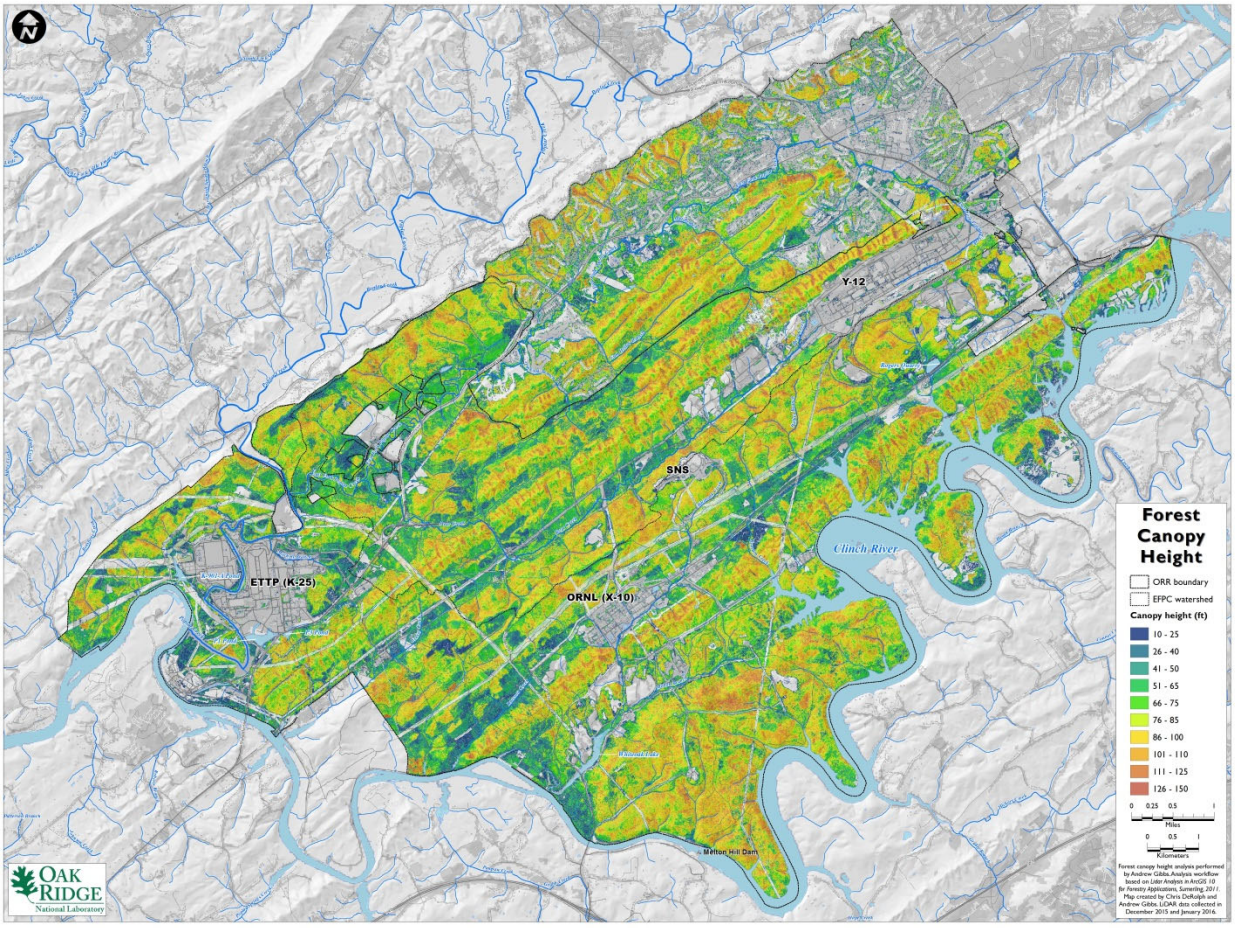

Oak Ridge Reservation Planning: Integrating Multiple Land Use Needs

February 2021

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Acronyms and Abbreviations

AOP	Airborne observation platform
ATDD	Atmospheric Turbulence and Diffusion Division
BMAP	Biological Monitoring and Abatement Program
CERCLA	Comprehensive Environmental Response, Compensation, Liability Act of 1980
CMA	Research Park Cooperative Management Area
CRESO	Clinch River Environmental Studies Organization
CROET	Community Reuse Organization of East Tennessee
DLA	Defense Logistics Agency
DOE	US Department of Energy
EFPC	East Fork Poplar Creek
EM	Environmental Management Program
EMWMF	Environmental Management Waste Management Facility
ENIGMA	Ecosystems and Networks Integrated with Genes and Molecular Assemblies
EPA	US Environmental Protection Agency
ETTP	East Tennessee Technology Park
FFA	Federal Facility Agreement
FY	Fiscal Year
LLC	Limited Liability Company
LUC	Land Use Controls
MZ	Research Park Management Zone
NEON	National Ecological Observatory Network
NNSA	National Nuclear Security Administration
NOAA	National Oceanic and Atmospheric Administration
NPL	National Priorities List
NRCS	Natural Resources Conservation Service
NSF	National Science Foundation
ORAU	Oak Ridge Associated Universities
OREM	Oak Ridge Environmental Management
ORISE	Oak Ridge Institute for Science and Education
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
ORRMT	Oak Ridge Reservation Management Team
OST	Office of Secure Transportation
OSTI	Office of Scientific and Technical Information
PES	Provisional Ecological Sites, part of NRCS work
ROD	Record of Decision
SNS	Spallation Neutron Source
TDEC	Tennessee Department of Environment and Conservation
TVA	Tennessee Valley Authority
TWPC	Transuranic Waste Processing Center
TWRA	Tennessee Wildlife Resources Agency
USDA	US Department of Agriculture
UT	The University of Tennessee
WBW	Walker Branch Watershed

WFIP	Wildland Fire Implementation Plan
WFMP	Wildland Fire Management Plan
WMU	Wildland Management Units
Y-12	Y-12 National Security Complex

Executive Summary

The Oak Ridge Reservation (ORR) in Oak Ridge, Tennessee, is a unique resource for the US Department of Energy (DOE) for addressing its technology and national science missions. DOE is committed to protecting its land inventory to meet the requirements of existing and future DOE mission-related facilities and programs. Protection of the land, facilities, and environment is also necessary to ensure continuing benefits and economic growth for the region through enhanced DOE missions. Thus, land use decision making is a crucial factor in ensuring the viability and availability of land necessary to accomplish those missions.

This document updates the 2012 report entitled, *Oak Ridge Reservation Planning: Integrating Multiple Land Use Needs* (DOE 2012). The plan complements site planning documents that address needs within the developed site areas.

The ORR is home to three major facility complexes: East Tennessee Technology Park, the National Nuclear Security Administration's Y-12 National Security Complex, and Oak Ridge National Laboratory. Oak Ridge Institute for Science and Education, located in the city of Oak Ridge, is an affiliated organization. The 32,900-acre ORR is located in Roane and Anderson counties in East Tennessee, mostly within the corporate limits of the town of Oak Ridge. Satellite imagery shows that the ORR is a large and nearly continuous 'island' of forest within a landscape fragmented by urban development and agriculture.

For more than 75 years, government missions and operations have been the primary factors in development of the ORR complex. The federal government acquired approximately 56,200 acres to build facilities for large-scale production of fissionable material for the world's first nuclear weapons. Of the original 56,200 acres, 32,900 acres remain as the ORR.

The land on the ORR is intensively used for multiple purposes to meet DOE mission goals and objectives. Uses of the land area surrounding the developed sites include safety, security, and emergency planning; research, demonstration, and education; cleanup and remediation; environmental regulatory monitoring; conservation; wildlife management; invasive species management; enhancement of pollinator habitat; reforestation of native species; protection of cultural and historic resources; wildland fire prevention; land stewardship activities; use and maintenance of reservation infrastructure; and activities in public areas.

The combination of a large land area with complex physical characteristics and diverse natural resources has provided a critical foundation for supporting DOE's environmental research mission, as well as the ability to build leading-edge facilities such as the Spallation Neutron Source.

Future uses of the ORR will, in most cases, expand and build on current land uses, not replace them. Current land and facility use are expected to continue.

1. Introduction

The Oak Ridge Reservation (ORR) in Oak Ridge, Tennessee, is a unique and irreplaceable resource for the US Department of Energy (DOE) for addressing its technology and national science missions. DOE is committed to protecting its land inventory to meet the requirements of existing and future DOE mission-related facilities and programs. Protection of the land, facilities, and environment is also necessary to ensure continuing benefits and economic growth for the region through enhanced DOE missions. Consequently, land use decision making represents a crucial factor in ensuring the viability and availability of land necessary to meet DOE mission needs.

The ORR, encompassing 32,900 acres of federally owned land and three DOE installations, is located in Roane and Anderson counties in East Tennessee, mostly within the corporate limits of the city of Oak Ridge. The estimated population was 29,302 in 2015, according to US Census Bureau Quick Facts 2015. The ORR boundary lies in the southern and southwestern quadrants of the Oak Ridge city limits. Satellite imagery shows that the ORR is a large and nearly continuous "island" of forest within a landscape fragmented by urban development and agriculture (Figure 1).

The city of Knoxville lies approximately 15 miles to the east of the Reservation. The estimated population was 185,291 in 2015, according to US Census Bureau Quick Facts 2015. Although the largest number of ORR employees reside in these two cities, the ORR facilities draw their total labor force of approximately 11,230 employees from more than 15 counties. This labor force is highly diverse and includes many people specially trained for production or high-technology oriented industry.

The ORR is home to three major facility complexes: East Tennessee Technology Park (ETTP), the National Nuclear Security Administration's (NNSA's) Y-12 National Security Complex (Y-12), and Oak Ridge National Laboratory (ORNL). Oak Ridge Institute for Science and Education (ORISE), also located in the city of Oak Ridge, is an affiliated organization.

1.1 DOE Land Use Planning Policy

DOE land use planning policy is set by DOE Order 430.1C, *Real Property Asset Management*, dated September 17, 2020. This directive (Section 4. Requirements) states: *The life-cycle management of real property must take a data-driven risk-informed, performance-based approach to align real property with DOE mission needs. Real property must be managed in a safe, secure, cost-effective, and sustainable manner to ensure real property assets are available, utilized, and in a suitable condition to support efficient mission execution.*

The directive Planning and Budgeting section states that DOE elements with real property holdings must prepare annual planning guidance, carry out real property planning, and provide five-year real property planning and budgeting documentation.

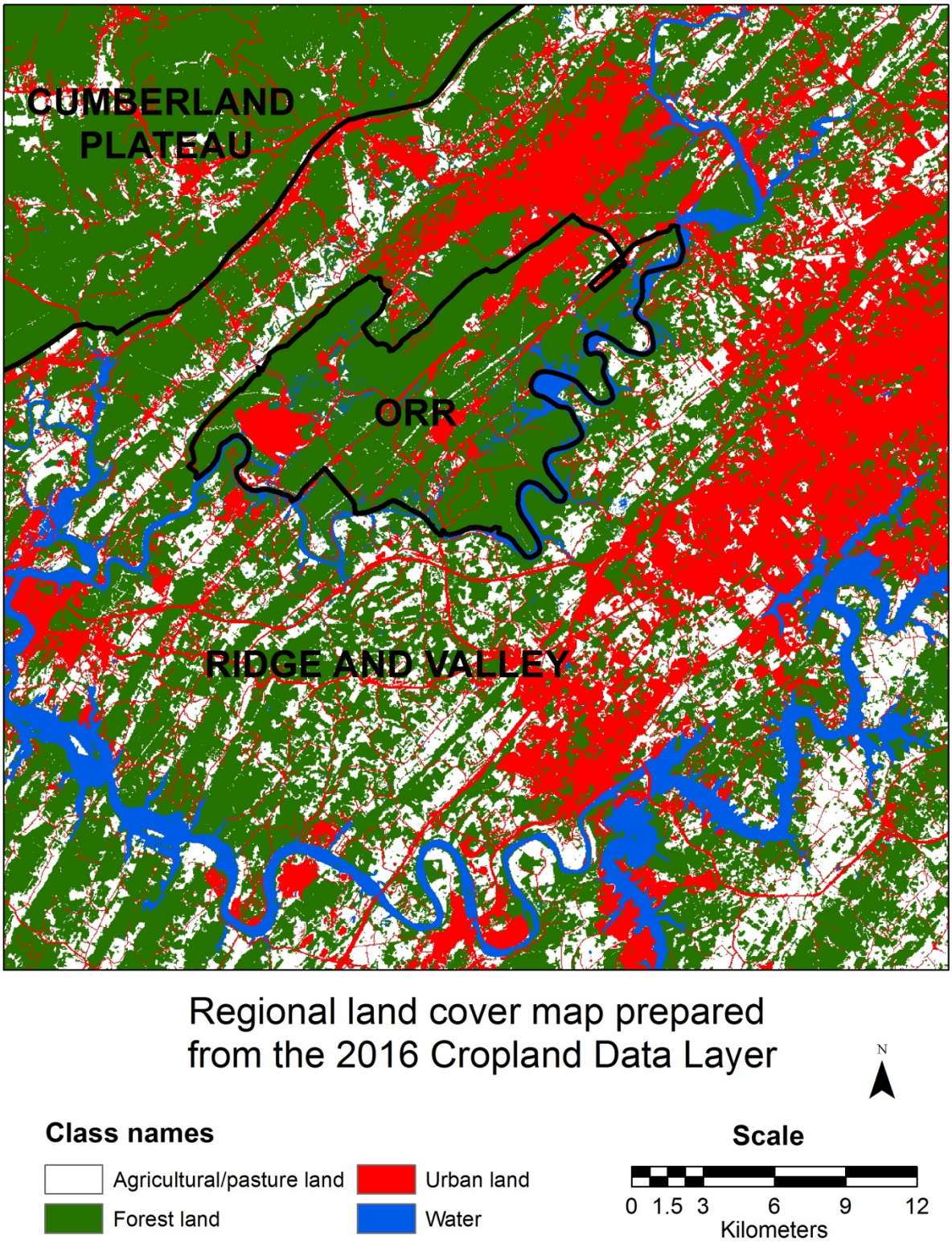

Figure 1. Regional land cover map prepared from the 2016 cropland data layer. (*Source*: USDA-NASS 2016).

DOE element real property planning must, among other requirements, ensure real property planning aligns with DOE strategic plans and program guidance. It must also ensure applicable requirements related and not limited to climate change resilience and adaptation, and sustainability; environment, health, safety, and security; earthquake risks; cultural and natural resource preservation; and historic preservation are addressed.

1.2 Oak Ridge Reservation Vision

Future uses of the ORR will, in most cases, expand and build on current land uses, not replace them. Future uses will include field research areas and facilities (e.g., environmental research, security, and monitoring systems); environmental management and long-term stewardship areas (e.g., remediated, restored, and protected contaminated areas); infrastructure improvements (e.g., communications, utilities); land responsibility actions (e.g., emergency response, wildland fire prevention, and response, conservation easements); integrated management of natural resources; and additional public and educational opportunities (e.g., greenways, stakeholder involvement).

1.3 ORR Mission Activities

For more than 75 years, government missions and operations have been the primary factor in development of the ORR complex. The federal government acquired approximately 56,200 acres to build facilities for large-scale production of fissionable material for the world's first nuclear weapons. Of the original 56,200 acres, 32,900 acres remain as the ORR.

The land on the ORR is intensively used for multiple purposes to meet DOE's mission goals and objectives. Uses of the land area surrounding the developed sites include safety, security, and emergency planning; research, demonstration, and education; cleanup and remediation; environmental regulatory monitoring; conservation areas; wildlife management; invasive species management; reforestation of native species; enhancement of pollinator habitat; protection of cultural and historic resources; wildland fire prevention; land stewardship activities; use and maintenance of reservation infrastructure; and activities in public areas.

The combination of a large land area with complex physical characteristics and diverse natural resources has provided a critical foundation to support DOE's environmental research mission, as well as the ability to build leading-edge facilities such as the Spallation Neutron Source (SNS).

1.4 ORR Users

As a result of the intensive multiple uses of the ORR, there are numerous users, including DOE; DOE contractors and their subcontractors; researchers with many state, federal, and academic affiliations; the Tennessee Wildlife Resources Agency (TWRA); the Tennessee Department of Environment and Conservation (TDEC) Natural Heritage Program and TDEC Division of Remediation Oak Ridge office; the

Tennessee Division of Forestry; US Department of Interior; National Science Foundation (NSF); Clinch River Environmental Studies Organization (CRESO); U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS); National Oceanic and Atmospheric Administration (NOAA) Atmospheric Turbulence and Diffusion Division (ATDD); Federal Bureau of Investigation; Tennessee Emergency Management Agency; Roane and Anderson County governments; the city of Oak Ridge; Community Reuse Organization of East Tennessee (CROET); Industrial Development Boards of Oak Ridge and Anderson Counties; Tennessee Valley Authority (TVA) and additional utility providers; permitted hunters; public greenway users; and others.

2. The ORR Planning Process

Each contractor on the ORR has a process in place to identify, plan, and implement land and facility use changes based on programmatic needs. Each contractor is responsible for ensuring project review for various compliance requirements within its purview and for coordinating with other DOE contractors, with ongoing coordination and final approval from DOE. This section describes the objectives, land use priorities, and review process for proposed changes in approved land use outside immediate plant site boundaries.

2.1 Planning Goals

Proposed major ORR activities or land use changes must consider the following goals:

- Incorporate the ORR vision for land use (see Section 1.2).
- Demonstrate environmental and energy sustainability and stewardship.
- Require safe and environmentally responsible evaluation and operation.
- Enhance regional economic development.
- Cluster uses and activities to achieve synergistic benefits, except where programmatic requirements dictate a specific location.
- Give priority and due consideration to reuse of disturbed areas, preserving clean, or undisturbed areas.
- Optimize future use options.
- Minimize pollution or provide innovative approaches to cleaning up existing disturbed areas.
- Ensure that ORR activities are compatible with adjacent land uses.

2.2 Land Use Priorities

Decisions about proposed activities or land use changes are made on a case-by-case basis to ensure compatibility with the following priorities:

Priority 1 - Preserve and protect land needed to meet the requirements of existing and future DOE mission-related facilities and programs that require large, biologically, and physically diverse protected land areas so that DOE can continue to meet its local, regional, and national mission obligations responsibly.

Priority 2 - Maintain land and facilities to promote sustainable economic development for the region through enhanced DOE missions, as well as through technology transfer and reindustrialization.

Priority 3 - Protect the environment, meet the requirements of scientific and technical education, and support educational research opportunities on the ORR.

2.3 Review Process and Participants

When proposed changes in land use are outside plant site boundaries, a comprehensive and integrated process is used to ensure proper planning, coordination, and communication among DOE and contractor representatives. Proposed changes in land use are evaluated by subject matter experts, program managers, and senior managers (if potential impacts are significant). Land use decisions are made by senior management based on these evaluations.

The Oak Ridge Reservation Management Team

The Oak Ridge Reservation Management Team (ORRMT), composed of DOE subject matter experts and program and support staff, reviews land use activities and proposed changes in land use designations. The ORRMT, formed in 1995, reviews activities occurring on the ORR outside fenced site boundaries. Requests for changes in land use are received by three primary routes: from the program office, from the contractor, and from external sources. Most requests for changes in land use or activities come through the DOE Real Estate Office and may be evaluated concurrently with National Environmental Policy Act or other required reviews. All requests are reviewed by subject matter experts with input from program representatives and support staff (e.g., legal and finance). Recommendations or proposed actions are formulated and sent to DOE senior management for decisions on the appropriate disposition of the action or recommendation.

Reservation Manager

The Reservation Manager facilitates communication among reservation land users and ensures comprehensive, integrated land use planning.

Stakeholder Involvement

DOE recognizes a wide complement of interested stakeholders in the Oak Ridge community with varying degrees of interest in actions affecting DOE land use. The involvement of those stakeholders in many DOE actions has been, and will continue to be, critical to DOE's success. At the same time, it is understood that DOE reserves to itself certain aspects of land use planning and decision making, such as those related to mission requirements and Secretarial initiatives.

2.4 Integration with Other Planning Processes

Approval of activities and land use changes is considered within the context of other planning documents such as program plans, site documents, and business plans. Environmental, compliance, permitting, and other requirements also must be addressed.

3. Regional Overview for the ORR

3.1 ORR and Surrounding Counties

The ORR is a unique and irreplaceable resource for DOE in addressing its technology and national science missions. DOE is committed to protecting its land inventory to meet the requirements of existing and future DOE mission-related facilities and programs. Protection of the land, facilities, and environment is also necessary to ensure continuing benefits and economic growth for the region through enhanced DOE missions. Consequently, land use decision making represents a crucial factor in ensuring the viability and availability of land necessary to meet DOE's needs.

The ORR, which contains 32,900 acres of federally owned land and three DOE installations, is located in Roane and Anderson counties in East Tennessee. Most of the land lies within the corporate limits of the city of Oak Ridge, in the southern and southwestern quadrants of the city. The city of Knoxville lies approximately 15 miles east of the ORR. Oak Ridge had an estimated population of 29,302 in 2015 and Knoxville an estimated population of 185,291 in 2015 (US Census Bureau 2015). Residents of those two cities account for the largest number of ORR employees, but its total workforce of approximately 11,230 resides in more than 15 counties. The highly diverse ORR labor force includes many people specially trained for industries related to production or advanced technology. ORR's location within the region is shown in Figure 2.

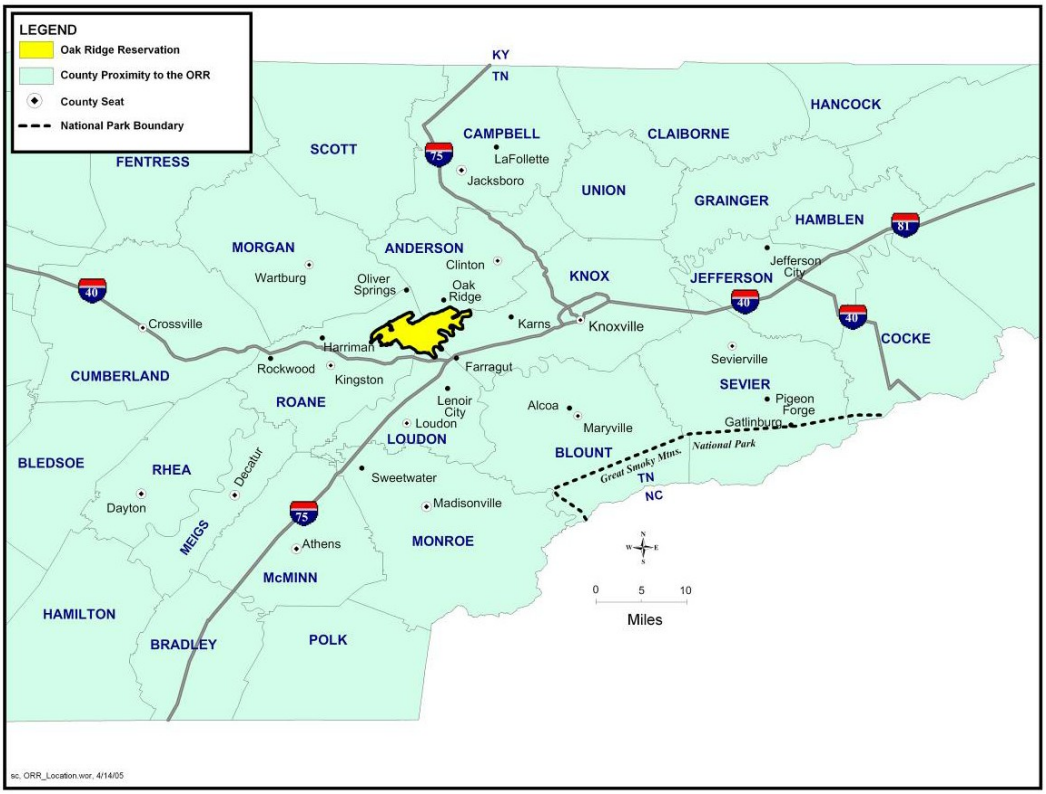

Figure 2. Location of the Oak Ridge Reservation within the region.

3.2 Regional Socioeconomic Impact

The state of Tennessee, local residents, and local governments enjoy significant economic benefits from DOE's presence in Oak Ridge. In 1998, the Center for Business and Economic Research at The University of Tennessee (UT) began conducting in-depth analyses of the annual economic benefits for Tennessee attributable to DOE operations (CBER 2009). The Howard H. Baker Jr. Center for Public Policy with the East Tennessee Economic Council (2014) compiled economic information for Fiscal Year (FY) 2013. Results of the FY 2013 study demonstrate the major contributions DOE makes to the Tennessee economy.

Key findings for FY 2013 included the following:

- Overall spending by DOE and its contractors added approximately $3.6 billion to Tennessee's state gross domestic product in FY 2013.
- Total personal income generated in Tennessee by DOE-related activities was nearly $2.2 billion in 2013. Each in-state dollar of income directly paid by DOE translates to a total of $1.89 in personal income for Tennessee residents.
- DOE spending supported 40,646 full-time jobs in the state in 2013, meaning that for every DOE job, 3.6 additional jobs were supported in other sectors of the state economy.
- DOE-related spending generated $142 million in state and local sales tax revenue in Tennessee in 2013.

- DOE operations rely on a highly trained and educated workforce. In 2013, 1,345 employees held a doctorate; 1,789 held a master's degree; and 3,351 held a bachelor's degree.

DOE and its major contractors provided 12,374 full-time jobs in Tennessee in 2018. The jobs are relatively high-wage jobs, with annual wages and salaries totaling $960.8 million.

Non-payroll expenditures (i.e., direct procurement spending) by DOE and its contractors totaled more than $718.6 million in 2013. Non-payroll spending generates millions of dollars in new income and supports thousands of jobs in a wide array of sectors in Tennessee's economy.

When DOE acquires goods and services from Tennessee businesses, it contributes to the state and local sales tax base. In 2013, the total state and local sales tax attributed to DOE was $89.2 million. In 2013, direct tax payments to state and local governments totaled $66.7 million and $22.5 million, respectively.

Many of the benefits the state of Tennessee enjoys from DOE's presence on the ORR are not easily quantified but have a broad and positive impact on the state. For example, DOE, its contractors, and employees donated more than $3.9 million in charitable contributions, community grants, and equipment bequests to schools and organizations across Tennessee in 2013.

3.3 Adjacent Land Use and Physical Characteristics

Land uses near the ORR are predominantly rural in nature, with agricultural and forest land predominating. The residential areas of the city of Oak Ridge that abut the ORR are located primarily along the northern and eastern boundaries of the Reservation. The Clinch River/Melton Hill Lake impoundment border it to the south and west. Some Roane County homes lie adjacent to the western boundary. The Clinch River forms a boundary between Knox County, Loudon County, and portions of Roane County. The topography, geology, hydrology, vegetation, and wildlife of the ORR provide a complex and intricate array of resources that directly impact land stewardship and land use decisions. The area's ridge and valley topography, with moderate to severe slopes, provides security and isolation for the ORR.

The hydrology of the ORR is complex. Highly fractured interbedded shale-limestone units are predominant, and karst features are prevalent in some areas. Protecting groundwater quality on the ORR is extremely important to ensure that no contaminants that might be present on the Reservation spread to the surrounding region.

The ORR is mostly contiguous native eastern deciduous forest. This large, relatively unfragmented area of mature eastern deciduous hardwood forest, with many forest blocks larger than 100 acres, provides habitat for numerous wildlife species. Such blocks of forested area are increasingly uncommon in the Southern Appalachian

Ridge and Valley Physiographic Province (the Ridge and Valley Province). The resulting diversity of plant and wildlife species ranges from common species found in urban and suburban areas of eastern Tennessee to species with more restrictive requirements. Many species of wildlife and plants that are no longer common elsewhere in Tennessee can be found on the ORR.

Information on physical characteristics and natural resources constitutes critical data in land use decision making. *Oak Ridge Reservation Physical Characteristics and Natural Resources* (Parr and Hughes 2006) includes information on ORR topography, geology, hydrology, vegetation (including forest resources), wildlife, wetlands, cultural resources, and special designations.

4. Overview of the ORR

DOE's Oak Ridge facilities are rich in history, dating back to the 1940s when the installations played a major role in the production of material as part of the World War II-era Manhattan Project.

4.1 History of the ORR

For more than 75 years, government missions and operations have been the primary factor in the development of the Oak Ridge installations. In the early 1940s, the U.S. government purchased approximately 56,200 acres to build facilities for the large-scale production of fissionable material for the world's first nuclear weapons. In 1943 construction began on the X-10 nuclear research facility (now the multipurpose research and development facility that is ORNL), the first uranium enrichment facility (now Y-12), and a gaseous diffusion enrichment facility (currently being reindustrialized as ETTP). By mid-1945, 'the city behind the fence' so called because of the extensive use of security checkpoints and fences on the ORR, had a population of 75,000 and employment at the three installations had reached its peak of 82,000. With the end of World War II in September 1945, the population of Oak Ridge began to decline as people returned to their prewar occupations.

A summary of management changes on the ORR from 1947 to 1999 is provided in the report Comprehensive Integrated Planning Process for the Oak Ridge Operations Sites (ORNL 1999).

4.2 Summary of Land Conveyances

DOE, its predecessor agencies (i.e., the Atomic Energy Commission, Energy Research and Development Administration), and its major contractors have always worked closely with the city of Oak Ridge and organizations within Oak Ridge associated with economic development to assist in their attempt to attain self-sufficiency. This assistance has taken many forms, from direct and indirect land transfers to financial payments, facility and infrastructure transfers, and planning assistance.

Of the total 56,200 acres acquired for the ORR, 32,900 acres currently remain as the Reservation (Figure 3) and the remainder has been transferred to the city of Oak Ridge and other entities.

DOE's historical support has included the following land transfers:

- 16,855 acres for residential, commercial, and community development
- 1,031 acres to federal agencies and for transportation easements
- 9,626 acres for preservation and recreation
- 4,247 acres for industrial development
- 11 acres for mission-related purposes

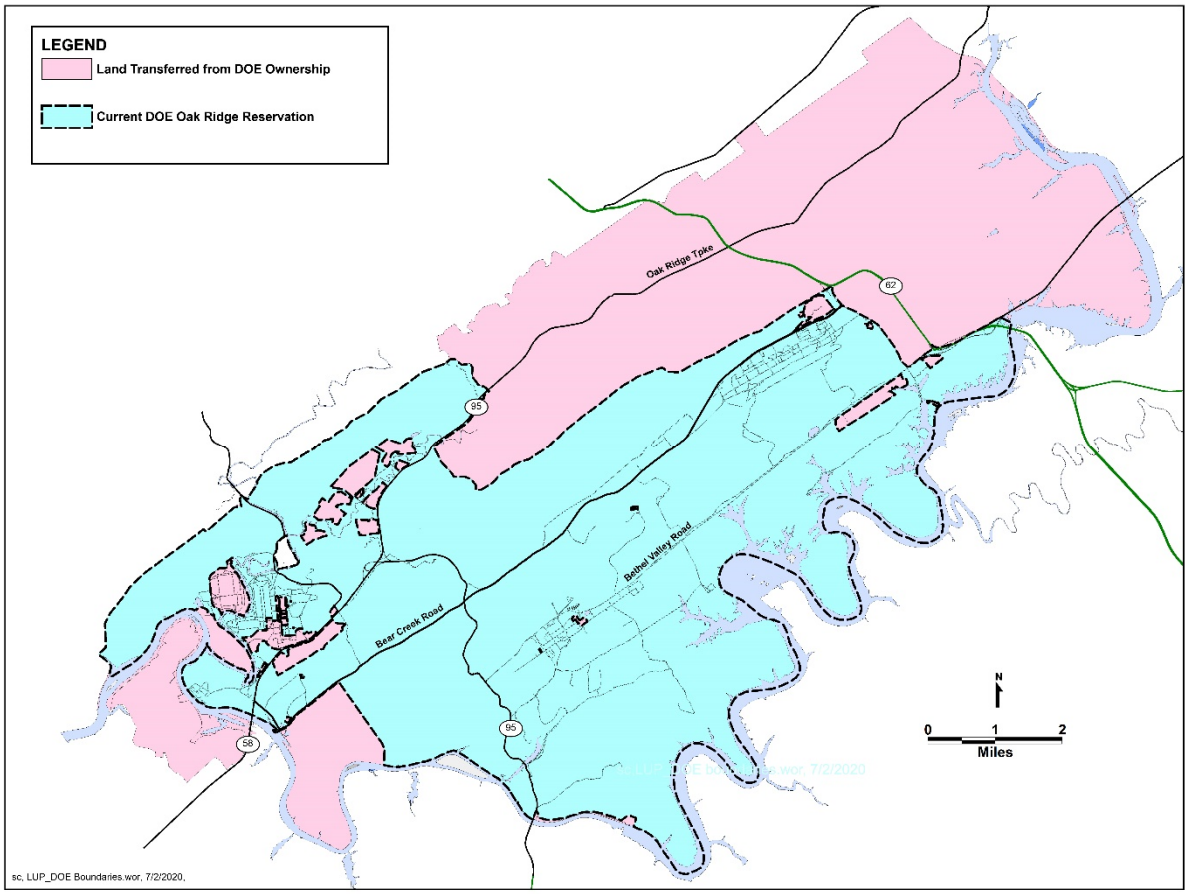

Figure 3. Original and current ORR boundaries.

More recent land grants include:

- 2,920 acres for the Three Bend permit
- 2,966 acres for the Black Oak Ridge Conservation Easement

In addition to those transfers, in 1967 the Atomic Energy Commission transferred 778 acres to TVA at no cost. TVA in turn gave the land to the city of Oak Ridge for recreational or park development. In 1968, the same mechanism was used to transfer

an additional 1,364 acres to TVA at no cost, with the stated purpose of industrial development in cooperation with the city of Oak Ridge; additionally, it was expected that the city would be involved in marketing and developing the land.

DOE has long been aware of its responsibilities for maintaining a strong partnership with Oak Ridge city officials and with the public to meet the ongoing needs of the community and region, both economically and environmentally. It has met this responsibility in part by using its real estate resources to support the community's needs by a variety of mechanisms, including working directly with the city of Oak Ridge; CROET, which the city supports; community agencies; the regional medical center in Oak Ridge; and the state of Tennessee, for preservation and recreation initiatives. All these actions support the overall well-being of the community while ensuring a viable and strong DOE presence in the area.

Recent and current actions continue to underscore DOE's strong commitment to a community partnership. DOE's ongoing mission needs are carefully scrutinized and judiciously balanced before realty interests are granted to the public and private sectors that would either end or encumber DOE's rights for continued operations. Recent initiatives have included land transfers to CROET for business development, including its subsidiaries Heritage Center, LLC; Horizon Center, LLC; and Heritage Greenways, LLC.

Excess Properties

Annually, the DOE declares properties that are identified as excess to the DOE mission. Excess is defined as property for which DOE no longer has a need or a mission-related purpose.

Parcel G (20 acres at Scarboro Road and Bethel Valley Road), previously identified as excess, has been sold in public auction through the General Services Administration.

4.3 Profiles of Current DOE Facilities

DOE operates in Oak Ridge in five distinct capacities: (1) the Consolidated Service Center, (2) the Y-12 Site Office of NNSA, (3) the ORNL Office of Science, (4) the Oak Ridge Office of Environmental Management (EM), and (5) the Office of Scientific and Technical Information (OSTI), which is part of the DOE Headquarters Office of Science.

Three major ORR facility complexes and office areas are located within the business portions of Oak Ridge: ETTP, Y-12, and ORNL. ORISE is another Oak Ridge DOE organization, and has a campus located at the eastern edge of the Reservation. Figure 4 shows the locations of these DOE facilities on the ORR.

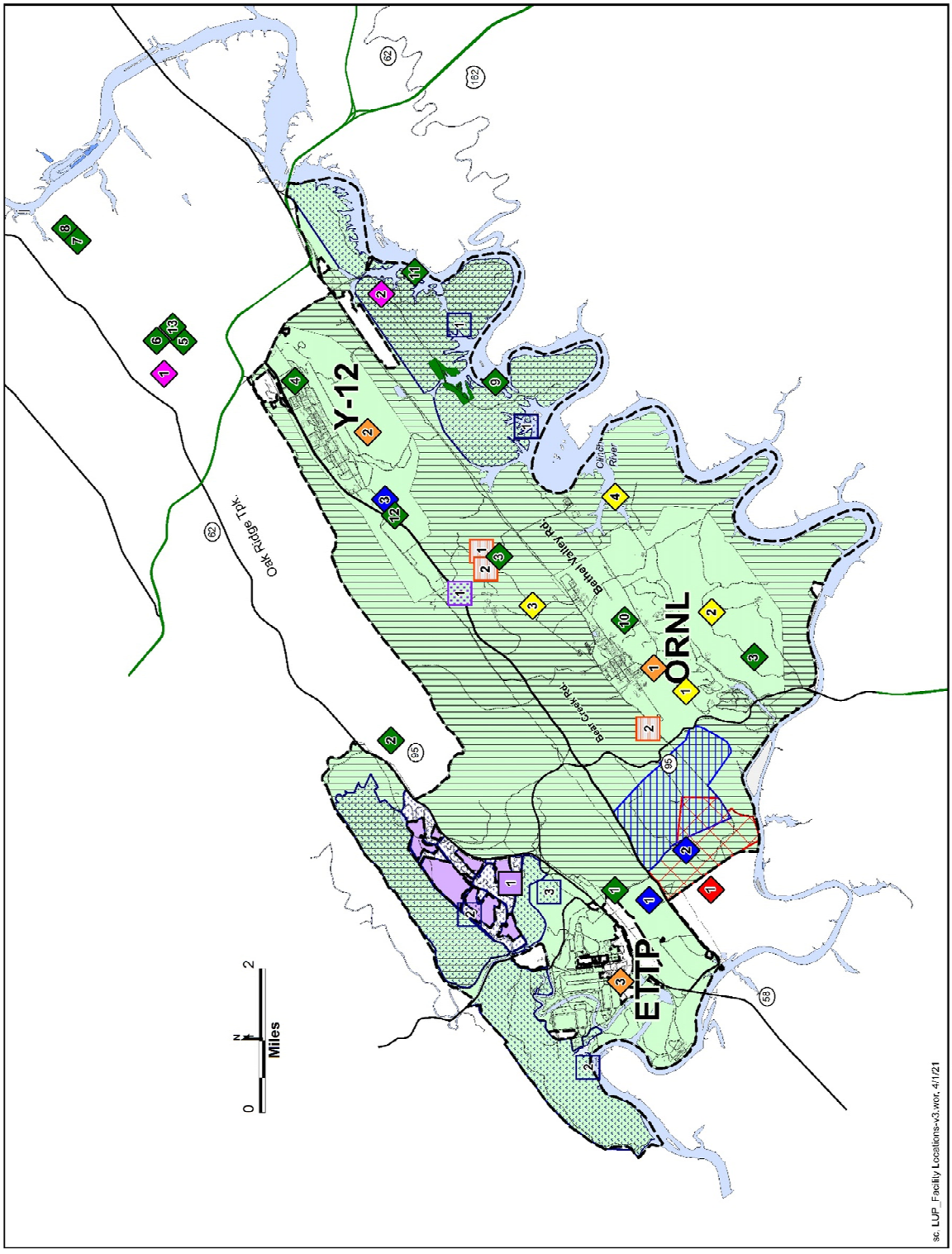

Figure 4. Locations of DOE facilities on the ORR.

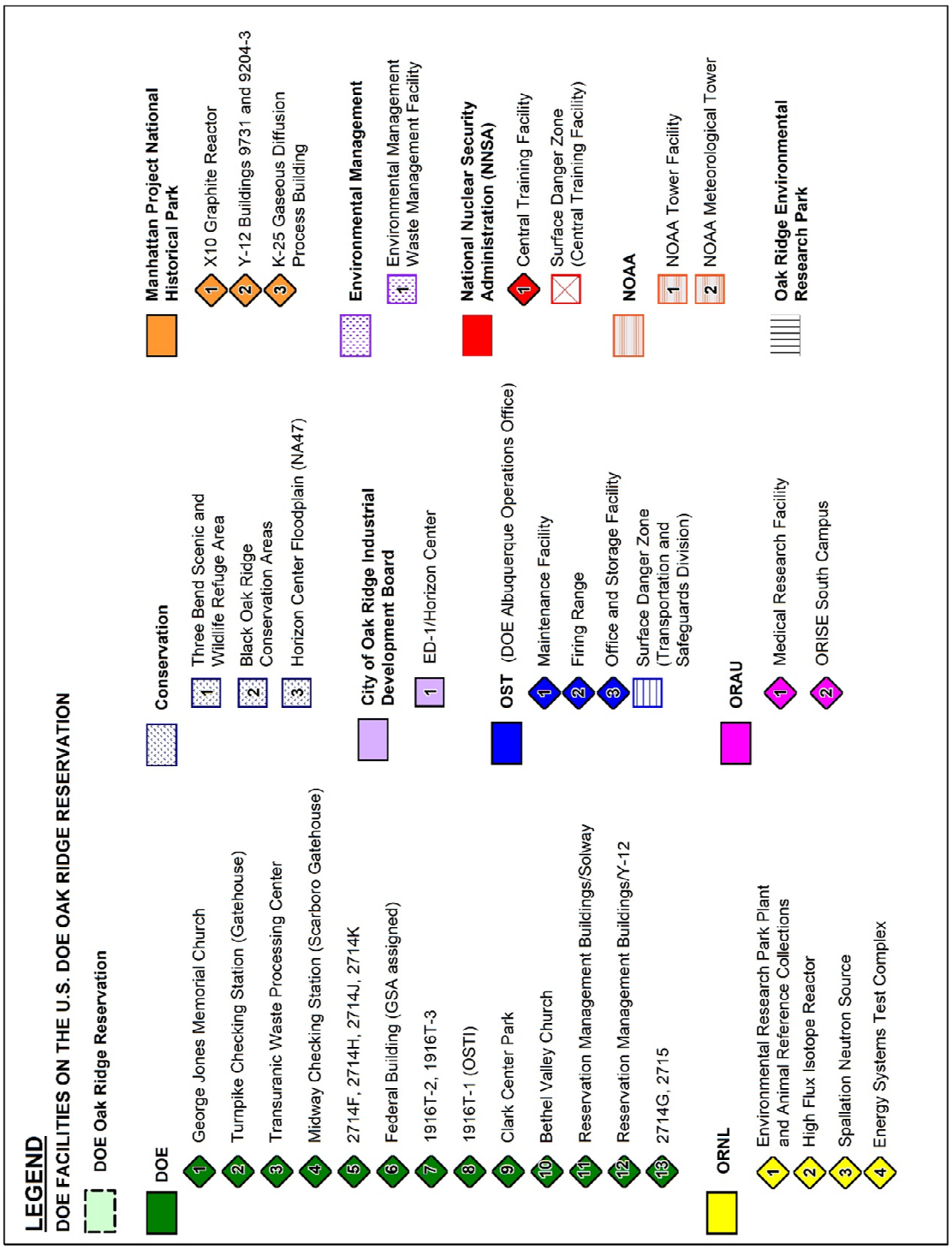

Figure 4. Legend of DOE facility locations (continued).

East Tennessee Technology Park

ETTP (Figure 5), also known as Heritage Center, is the home of the former gaseous diffusion plant known as the K-25 plant. It is the current focus for Oak Ridge Environmental Management (OREM) Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) cleanup efforts and the Reindustrialization Program. Cleanup of ETTP and conversion of a portion of the site to a private industrial park is an important mission for DOE in its efforts to make this area an economic resource for the community. Under DOE's cleanup approach, the department continues to demolish most of the facilities at the site, complete environmental remediation, and implement land use controls (LUC) appropriate for industrial use. Facility demolition work was completed at the end of calendar year 2020.

The cleanup goals at ETTP are aimed at making the site available for reindustrialization. The Reindustrialization Program transfers facilities and land that are no longer needed to support DOE missions to CROET, which then can invest in the revitalization of those assets and market them to private-sector companies.

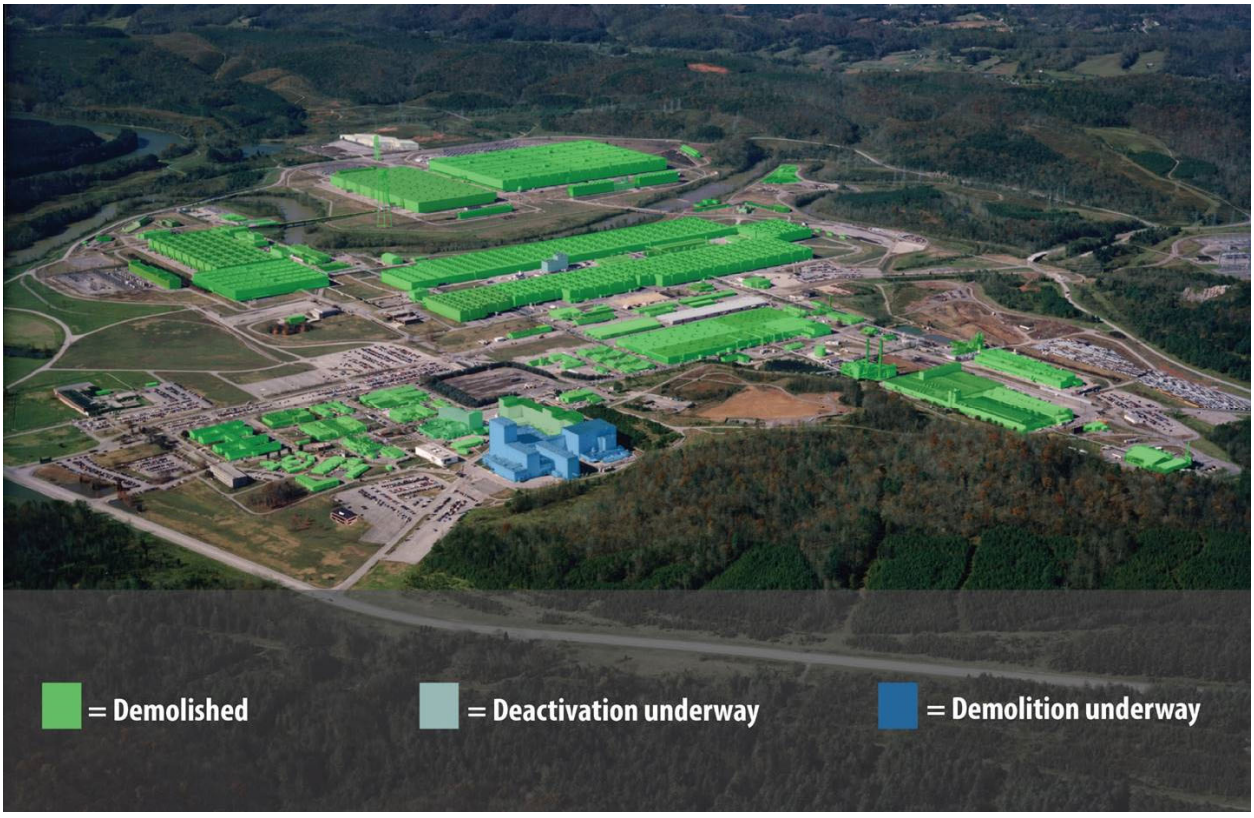

Figure 5. East Tennessee Technology Park.

National Nuclear Security Administration, Y-12 National Security Complex

Y-12 (Figure 6) was constructed as part of the World War II-era Manhattan Project. Its first mission involved electromagnetic separation of uranium-235. After World War II, Y-12 became a high-precision manufacturing facility, playing a major role in the production of components for modern thermonuclear weapons. Managed by Consolidated Nuclear Security, LLC, Y-12 is one of six production facilities in the NNSA's Nuclear Security Enterprise. Y-12's unique emphasis is the processing and storage of uranium and development of technologies associated with those activities. Currently, Y-12 has three primary national security missions that protect the United States and its allies around the world: maintaining the U.S. nuclear stockpile, reducing global threats, and fueling the U.S. nuclear navy.

Figure 6. Y-12 National Security Complex.

Oak Ridge National Laboratory

ORNL (Figure 7) is the largest DOE science and energy laboratory, with a mission to deliver scientific discoveries and technical breakthroughs needed to realize solutions in energy and national security and provide economic benefit to the nation.

Figure 7. Oak Ridge National Laboratory.

ORNL was established in 1943 as part of the Manhattan Project. It is currently managed by UT-Battelle, LLC, a partnership of UT and Battelle Memorial Institute. ORNL's researchers apply unique facilities, sophisticated tools, and signature strengths in neutron science, high-performance computing, advanced materials, nuclear science and engineering, and isotopes to benefit science and society. ORNL staff conduct research and development to advance the understanding, design and use of new materials and chemical processes; reveal scientific insights through computing and data; ensure safe, clean nuclear power and secure nuclear materials; produce rare isotopes for medicine, industry, security, research, and space exploration; and increase and exploit the understanding of biological and environmental systems, from genes to ecosystems.

ORNL is building on a legacy of discovery and innovation. Two major projects at the SNS, the Proton Power Upgrade and the Second Target Station will open new frontiers in materials research. Frontier, ORNL's exascale computer, will deliver world-leading performance starting in 2021. ORNL assets are being focused on

national artificial intelligence and quantum initiatives. New materials, software, and systems for advance manufacturing developed at ORNL are transforming nuclear energy technology. Cyber security technologies developed by ORNL are improving the resilience of the nation's electric grid and other critical infrastructure (ORNL 2020).

Each year, ORNL hosts about 32,000 guest researchers. Additionally, ORNL coordinates the many users of the DOE Oak Ridge Environmental Research Park.

Oak Ridge Institute for Science and Education

ORISE (Figure 8) provides integrated solutions to recruit and prepare the next generation of the U.S. scientific workforce; promotes sound scientific and technical investment decisions through independent peer reviews; facilitates and prepares for the medical management of radiation incidents in the United States and abroad; evaluates health outcomes in workers exposed to chemical and radiological hazards on the job; and ensures public confidence in environmental cleanup through independent environmental assessments. ORISE conducts operations at many locations, but the South Campus is the only part of ORISE's nonleased infrastructure owned by DOE. ORISE's South Campus is located on 169 acres at the intersection of Bethel Valley and Scarboro roads and consists of seven buildings totaling 100,587 gross ft^2.

Figure 8. Oak Ridge Institute for Science and Education.

4.4 Other DOE Properties

DOE operates a number of facilities in addition to ETTP, Y-12, ORISE, and ORNL. Those facilities are shown in Figure 4 and described in the following sections.

Buildings 2714 and 2715

Buildings 2714 (also called the 'Laboratory Road' facility) and 2715 (Credentialing Station) are DOE-owned facilities. Both buildings are located in the city of Oak Ridge just south of the Federal Office Building.

Central Training Facility

The Central Training Facility, primarily used by ORNL and Y-12 security forces, consists of a small office building, an indoor firing range, two classroom/storage trailers, onsite parking, fitness facilities (i.e., an outdoor track), and numerous outdoor firing ranges. The 150-acre site includes a safety buffer area and is south of Bear Creek Road. NNSA is responsible for the facilities and the Consolidated Service Center is responsible for the land.

Checking Stations

Three historic checking stations, which are DOE properties, are included in the National Register of Historic Places: The Oak Ridge Turnpike Checking Station (Turnpike Checking Station), the Scarboro Road Checking Station (Midway Checking Station), and the Bethel Valley Road Checking Station. Although these structures are listed as checking stations in the National Register, they were originally called gatehouses. The main building of the Bethel Valley Road Checking Station is located on a parcel of land that was transferred to the city of Oak Ridge. However, the small associated block building just opposite the main structure is still owned by DOE.

Clark Center Recreation Park

Clark Center Recreation Park, an area of approximately 80 acres, is currently used for recreational purposes by DOE, contractors, and the public on a limited basis. It is managed by DOE.

Federal Office Building

The Federal Office Building, located in Oak Ridge and owned by the General Services Administration, is maintained by DOE.

The Horizon Center

The Horizon Center (previously known as ED-1) was leased to CROET in 1998. In April 2003, the developable portions of the parcel, approximately 490 acres, were transferred by quitclaim deed to CROET. CROET then deeded the land to the city of Oak Ridge Industrial Development Board. The Natural Area that surrounds the East

Fork Poplar Creek (EFPC) floodplain and other locations remain under DOE responsibility.

Manhattan Project National Historical Park

The Oak Ridge site of the Manhattan Project National Historical Park includes the X-10 Graphite Reactor National Historic Landmark, Buildings 9731 and 9204-3 at Y-12, and the K-25 building site at ETTP. More information about the park is in Section 5.7.

Office of Scientific and Technical Information

OSTI is located in Buildings 1916T-1 and 1916T-2, two masonry buildings constructed as warehouses in the 1940s. The two buildings are located on a tract of approximately 5.5 acres running parallel to Oak Ridge Turnpike, east of the Federal Office Building. The DOE Information Center, located within OSTI, provides centralized public access to DOE documents and information.

Office of Secure Transportation (OST) Training Facility

The OST, Agent Operations Eastern Command Training Facility, is located east of the Central Training Facility, south of Bear Creek Road. The Eastern Command Training Facility is managed locally by the director of the Agent Operations Eastern Command, under a User Permit Agreement with DOE. The property consists of an administration area, a tactical training area, and a Surface Danger Zone. Its combined total area is approximately 1,600 acres, including approximately 180 acres of Surface Danger Zone that overlap with the Central Training Facility.

OST Vehicle Maintenance Facility

The OST Agent Operations Eastern Command Mission Facility and the Vehicle Maintenance Facility are located at the intersection of Highway 95 and Flannigan Loop Road. Both are managed locally by the director of the Agent Operations Eastern Command, under a User Permit Agreement with DOE. The property, approximately 700 acres in area, consists of an administration area, a vehicle maintenance area, and a shipping and receiving area.

Transuranic Waste Processing Center

The Transuranic Waste Processing Center (TWPC), currently managed by North Wind, LLC is located on 20 acres adjacent to the Melton Valley Storage Tanks, along Highway 95 on ORNL's western boundary. On November 3, 2006, DOE took ownership of the TWPC from Foster Wheeler.

5. Current Uses and Activities on the ORR

ORR land is intensively used for multiple purposes to meet DOE's mission goals and objectives. Uses of the land surrounding developed sites include safety, security, and emergency planning; research and education; cleanup and remediation; environmental regulatory monitoring; wildlife management; invasive species management; native species restoration; pollinator habitat enhancement; protection of cultural and historic resources; wildland fire prevention; land stewardship activities; use and maintenance of Reservation infrastructure; and activities in public areas. Figure 9 provides an overview of land designations and operational uses on the ORR.

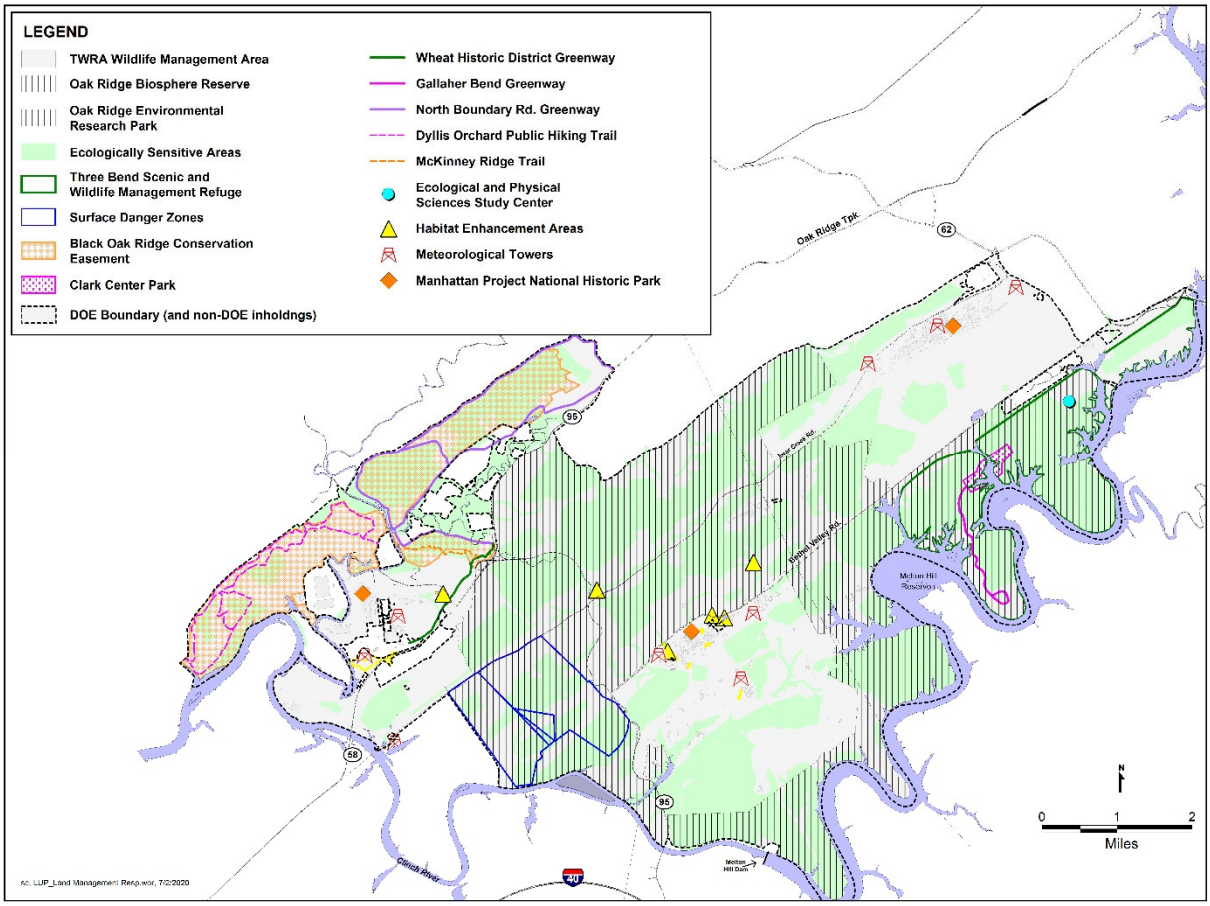

Figure 9. ORR land designations and operational uses.

5.1 Emergency Response

The map of the Oak Ridge emergency response areas (Figure 10) identifies the site responsible for providing first response, incident command and control, and, where applicable, the emergency director role for events occurring on the ORR. The map is designed to ensure that emergency response roles and responsibilities are clearly defined and well understood by all involved organizations.

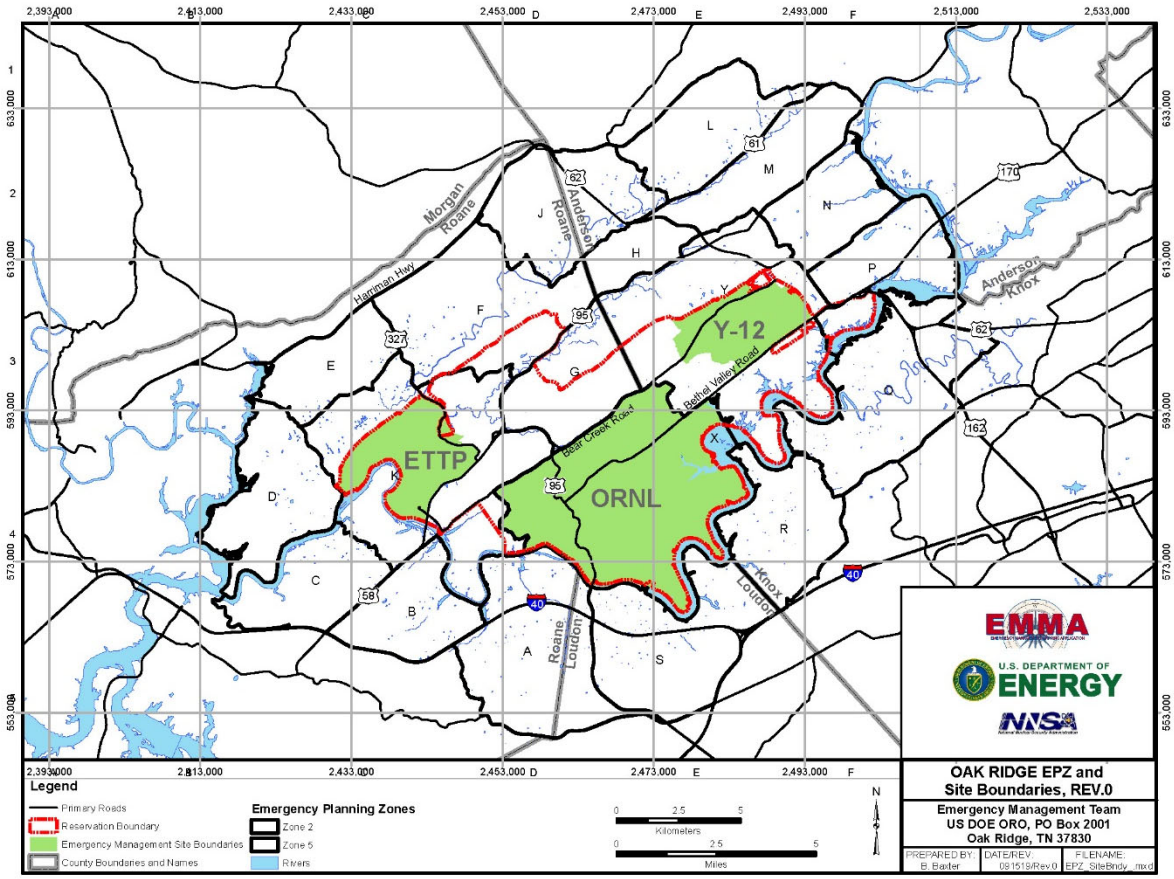

Figure 10. ORR emergency response areas.

5.2 Oak Ridge Environmental Research Park

Consisting of approximately 20,000 acres, the Oak Ridge Environmental Research Park serves as an outdoor laboratory for evaluating environmental consequences of energy use and development, as well as strategies for mitigating these effects. The combination of protected, undeveloped areas with disturbed, developed, or developing areas within the Research Park allows for demonstration and assessment of various environmental and land use options.

Major DOE Office of Science research programs use ORR land to meet mission objectives. The Office of Science considers the ORR to be of key research and scientific value and consequently provides primary operations funding. The Research Park is one of the few sites in the nation where large-scale ecological research, environmental technology, and measurement science are integrated with more than 60-years of environmental monitoring and research. It is one of a network of seven Research Parks.

Research users include TWRA, NSF, CRESO, NOAA ATDD, USDA, NRCS, individuals from academic institutions, and others.

The Research Park has attracted more than 1,500 users from ORNL, as well as from 150 colleges, universities, industries, and other state and federal government agencies over the past five years. The 495 users hosted in 2019 represented 38 organizations, including educational institutions, industry, state and federal agencies, and others (Figure 11). Additionally, public walks/events on the ORR offered to the public by the Research Park had about 90 participants in 2019.

More information on the Environmental Research Park is available at https://nerp.ornl.gov.

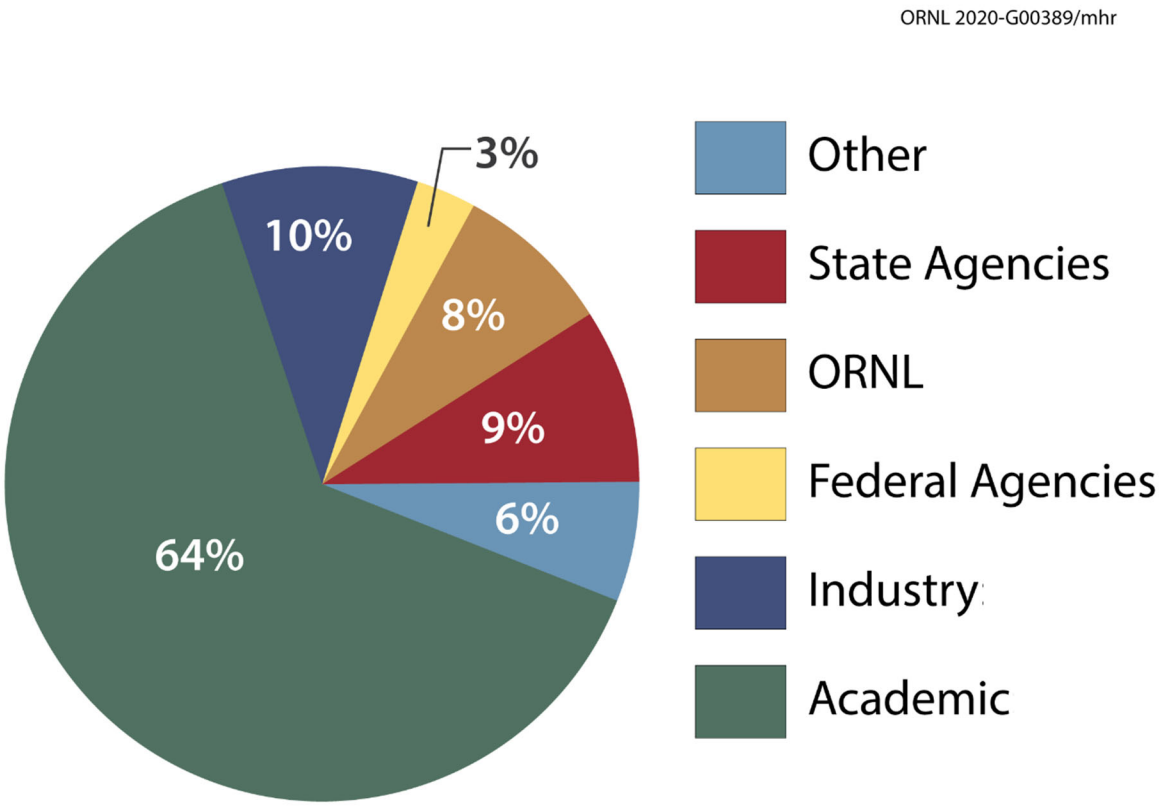

Figure 11. Categories of Oak Ridge Environmental Research Park users in 2019.

5.3 Research on the ORR

Environmental field research on the ORR addresses major national issues and contributes to national and international collaborative initiatives on global climate change (e.g., temperature, carbon dioxide, precipitation); tropospheric air quality; remediation of contaminated land; sustainable development; biodiversity; and energy operations. These uses require protected blocks of land ranging from a few acres to more than 250 acres. Figure 12 shows research areas, compliance monitoring sites and restoration areas on the ORR.

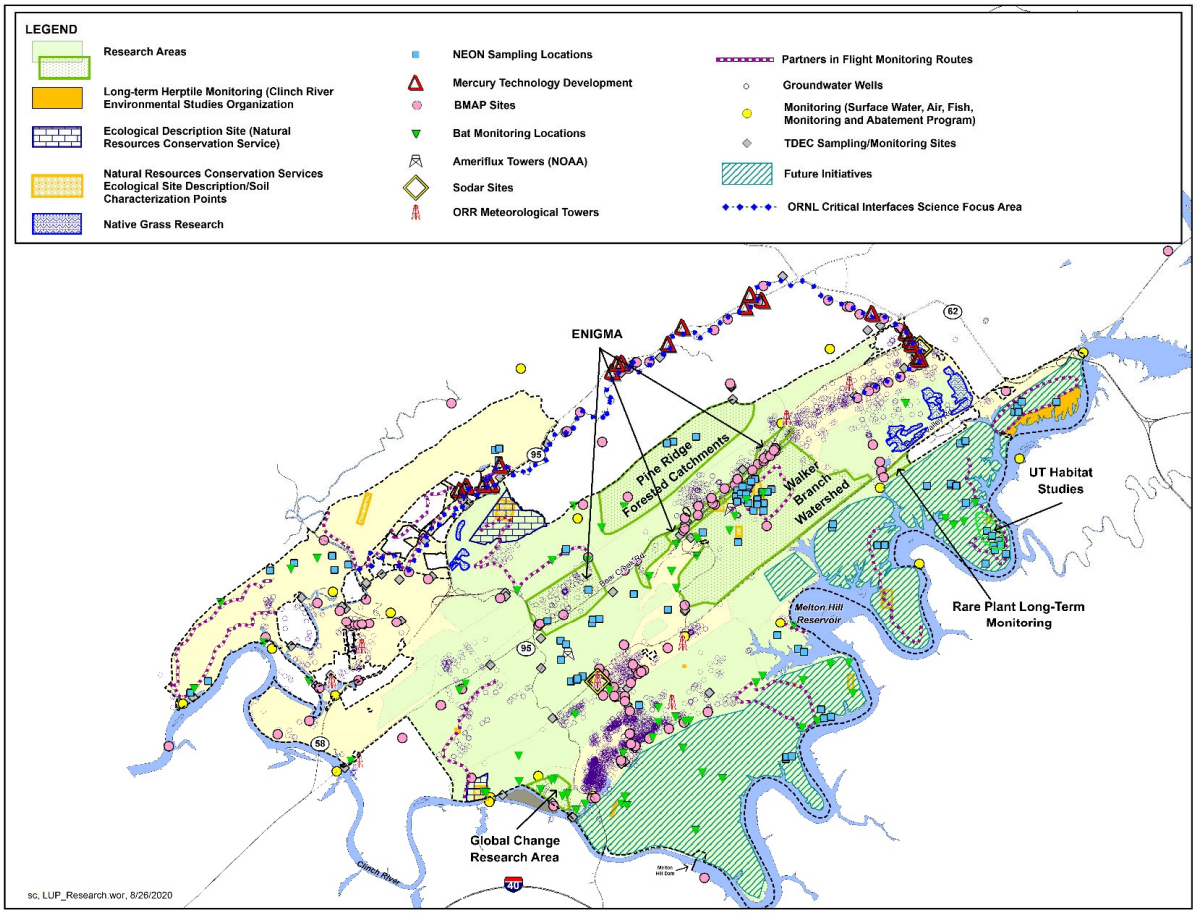

Figure 12. Research areas, compliance monitoring sites and restoration areas on the ORR.

Walker Branch Watershed

The Research Park contains intensive, long-term ecological Research Areas, most notably the Walker Branch Watershed (WBW), a gauged, 250-acre deciduous forest catchment with a 55-year record of forest and stream ecosystem experiments and monitoring. Research at WBW has included long-term studies of hydrology, atmospheric chemical deposition, forest biogeochemical cycling, plant physiology and community dynamics, and stream ecology and nutrient cycling. This long-term research site is actively used by the National Ecological Observatory Network (NEON) and the NOAA ATDD, and other research and monitoring studies.

National Ecological Observatory Network

NEON's mission is to enable understanding and forecasting of the impacts of climate change, land use change, and invasive species on continental-scale ecology by providing infrastructure and consistent methodologies to support research and education in these areas (NEON 2017). This continental-scale ecological observation facility, sponsored by NSF and operated by Battelle, gathers, and synthesizes data on how the issues mentioned impact natural resources and biodiversity. NEON collects high-quality standardized data from 81 field sites (47 terrestrial and 34 aquatic) across

the United States, including Alaska, Hawaii, and Puerto Rico. Data collection methods are standardized across sites and include in site instrument measurements, field sampling, and airborne remote sensing. Field sites are strategically selected to represent different regions of vegetation, landforms, climate, and ecosystem performance. NEON data and resources are freely available to enable users to tackle scientific questions at scales not accessible to previous generations of ecologists.

NEON Domain 07 performs year-round sampling and observations on the ORR using Tower Instrument Systems, Aquatic Instrument Systems, Terrestrial Observation Systems, and Aquatic Observation Systems. There are 72 active site/plot locations distributed throughout the ORR site.

Numerous observation/sampling activities are scheduled to be continuously executed for a 30-year period after the observatory entered full operation in 2018. Those activities are discussed in the following paragraphs:

- **NEON Airborne Observation Platform**

  The NEON airborne observation platform (AOP) collects annual remote-sensing data over the ORR using sensors mounted on an airplane. The AOP consists of a hyperspectral imaging spectrometer, a full waveform and discrete return laser light detection and ranging, and a high-resolution red-blue-green camera. Data from the AOP build a robust time series of landscape-scale changes in numerous physical, biological, and biochemical metrics such as vegetation cover and density; canopy chemistry; and topography, including elevation, slope, and aspect. The AOP provides information on vegetation cover and dominant vegetation type; vegetation structure, including height and leaf area index; vegetation condition; vegetation biochemistry and heterogeneity; canopy chemistry; topography aspects such as elevation, slope, and aspect; and vegetation greenness and health. High-level data products derived from AOP data include vegetation leaf area index, total biomass, vegetation indices, ecosystem structure, canopy biogeochemistry, and ground elevation measurements based on the Digital Elevation Model and the Digital Surface Model (NEON 2017).

- **NEON Flux Tower Measurements**

  NEON collects data using sensors mounted along and on top of towers at terrestrial field sites across the United States. Tower sensors monitor physical and chemical properties of atmosphere-related processes such as humidity and wind. They also measure net ecosystem exchange, or the amount of gas exchanged between the atmosphere and the ecosystem. Towers extend past the top of the vegetation canopy at each site to allow sensors to capture the full profile of atmospheric conditions from the top of the vegetation canopy to the ground. Automated tower sensors collect data continuously to capture patterns and cycles across time frames ranging from seconds to years. NEON calibrates and quality-checks sensors to minimize measurement errors and maximize the quality of collected data. Soil sampling and organismal sampling covering plants, animals, and microbes occurs within or near the airshed of the tower at each site.

This integrated sampling approach supports the ecosystem-level study of carbon dioxide, water vapor, and energy fluxes as they cycle through the atmosphere, vegetation, and soil. Tower data combined with soil and airborne remote-sensing data support the scaling of fluxes, soil moisture, and evapotranspiration to a continental scale. Data collected from the tower advance the understanding of ecological processes and changes in air quality, climate, and other parameters. Automated soil sensors measure physical, chemical, and biological properties at the soil surface and in the underground environment. Data on soil moisture, soil temperature, and carbon dioxide concentration are collected at multiple depths. Data on photosynthetically active radiation at soil surface, soil heat flux, throughfall, and solar radiation are collected at soil surface.

Soil samples and associated analyses characterize soil microbial communities, metagenomes, and transcriptomes; soil texture, bulk density, and organic horizon mass for initial characterization; biogeochemical analyses, including pH, cations, anions, total carbon, nitrogen, phosphorous and sulfur, fractions of carbon and phosphorous, and select soil nitrogen transformations; and coarse and fine root biomass and total carbon and nitrogen concentrations in fine root biomass (NEON 2017).

- **NEON Terrestrial Organismal Sampling**

  NEON collects data that characterize a suite of terrestrial plants, animals, pathogens, and microbes at terrestrial field sites across the continent. The project's organismal sampling design captures the long-term dynamics of abundance, diversity, pathogen prevalence, phenology, and productivity. NEON uses a standardized, consistent sampling strategy across sites, time, and focal taxa. NEON also samples organisms within the tower footprint to detect connectivity between organismal data and flux tower measurements.

  NEON organismal sampling focuses on sentinel taxa, which are sensitive organisms that indicate the health of an ecosystem and provide data relevant to public health. Changes in community dynamics of sentinel taxa affect ecological processes such as disease transmission rates, agricultural pest control, and ecosystem structure and function.

  NEON sentinel taxa selection criteria include wide geographical distribution for standardized sampling, varied life histories including lifespan and reproductive rates, phylogenetic diversity, and relevance to infectious disease ecology. NEON samples the sentinel taxa within the following groups: plants, soil microbes, breeding land birds, small mammals, ground beetles, mosquitoes, and ticks. Samples, observations, and relevant data are collected on species abundance and density, community composition and diversity, phenology of plants and mosquitoes, organism size and other trait data, leaf area index, canopy chemical composition, and litterfall.

  A subset of mosquitoes and ticks collected at NEON sites and tissue samples collected from rodents captured during small mammal trapping are tested for

infection by target pathogens. These include flaviviruses such as West Nile virus in mosquitoes, bacteria including the etiological agent of Lyme disease in ticks, and antibodies to hantaviruses in rodent blood samples. Results of pathogen testing are used to estimate the prevalence of target pathogens at NEON sites and track how infection rates change through time (NEON 2017).

- **NEON Aquatic Observations at Walker Branch Watershed**

  NEON collects data at 34 aquatic sites featuring 24 streams, three large rivers, and seven lakes. At each site, the project's aquatic observations characterize channel and lake morphology, organism abundance and diversity, seasonal climatic and hydrologic changes, and riparian phenology. These data complement aquatic sensor data that capture hydrologic conditions and surface water and groundwater quality, as well as local atmospheric conditions.

  Aquatic sites nationwide represent continental ecological variability, such as various geomorphologic and hydrologic regimes and land use types, to provide data that capture variability and improve ecosystem-level understanding. NEON uses a standardized, consistent sampling strategy across field sites, time, and focal species. Field operations crews collect observational data at regular intervals to complement data collected by automated in situ aquatic sensors. To capture a range of ecosystem processes and to detect ecosystem-level change, the aquatic observational sampling strategy collects samples based on temperature, water flow, and peak greenness. NEON collects more than 200 types of physical, chemical, and biological data at each aquatic site. Physical data collected include stream stage, discharge, and morphology; lake stage and bathymetry; sediment size; reaeration (the exchange of gases between water and atmosphere); ice on and off dates; and Secchi depth profiles. Biological data obtained include microbes (e.g., surface water and benthic); periphyton and phytoplankton (e.g., biomass and taxonomy); aquatic plants, algae, bryophytes, and lichens; macroinvertebrates and zooplankton; fish; riparian canopy identification; and riparian vegetation assessment. Chemical data are collected for surface water, groundwater, and sediment (NEON 2017).

- **NEON Aquatic Sensor Measurements**

  The aquatic sites are strategically located to represent ecological variability across the continent, including various geomorphologic and hydrologic regimes and land use types, and to provide data that detect ecological change and improve ecosystem-level understanding. At each aquatic site, suites of aquatic sensors are configured and installed using standardized methods in streams, lakes, and rivers in a variety of ecosystems. These automated sensors continuously collect aquatic data ranging from water quality measurements to localized atmospheric measurements collected near the aquatic feature. NEON collects more than 200 types of data at each aquatic site nationwide, including automated physical, chemical, and biological sensor measurements. Stream data include stage and continuous discharge; surface water quality; photosynthetically active radiation; and groundwater elevation, temperature, and specific conductance.

Meteorological sensors at each site provide information on photosynthetically active radiation, longwave and shortwave net radiation, air temperature, barometric pressure, wind speed and direction, and precipitation (NEON 2017).

National Oceanic and Atmospheric Administration

NOAA has one of the longest records of total atmospheric deposition of nitrogen and sulfur in the world at the WBW. ATDD, located in Oak Ridge, is one of several field divisions of the NOAA's Air Resources Laboratory, headquartered in College Park, Maryland. ATDD was originally created to develop diffusion models to track the dispersion of accidental releases of contaminants. This research led to participation in scientific campaigns investigating atmospheric flows in complex terrain and urban areas and the transport and surface exchange of nitrogen, sulfur, and mercury compounds. ATDD is still involved in surface–atmosphere exchange research examining how these processes affect atmospheric behavior, weather, climate, and air pollution.

ATDD's research is focused on air quality, climate, and boundary layer processes and is directed toward issues of national and global importance. Air quality research objectives include improving the understanding of air surface exchange processes and increasing the predictive capabilities of air quality models. Climate research objectives include the reference-grade measurement of climate change variables and related physical and chemical processes. ATDD maintains NOAA's Climate Reference Network, which includes designing, testing, installing, and maintaining precision monitoring stations in all 50 states. Boundary layer research objectives include the measurement of lower atmospheric processes related to surface-atmosphere energy exchanges and turbulent transport of moisture, momentum, and chemical constituents.

Research at ATDD is performed in collaboration with other NOAA laboratories, government agencies, universities, and private organizations. Two permanent research stations are in operation on the ORR, at the WBW forested experimental area and the Chestnut Ridge environmental study site.

- **NOAA ATDD Surface Layer Meteorology**

  Surface layer meteorological parameterizations used in current weather and climate models (i.e., computer models that attempt to simulate the atmosphere over time scales ranging from hourly to decadal) are based on empirical fits of sparse, idealized observations made decades ago. Scientists at ATDD are performing research to improve the measurement and theoretical basis of these parameterizations.

  The meteorological observation tower, that ATDD operates at Chestnut Ridge, provides an ideal and convenient platform for ATDD scientists to perform long-term measurements to help answer some of these questions. Measurements from the Chestnut Ridge tower are archived at ATDD and are displayed in real time on the ATDD website: http://www.atdd.noaa.gov.

As part of this research, ATDD has partnered with NOAA's National Centers for Environmental Prediction in College Park, Maryland, to use data from Chestnut Ridge to evaluate the current operational North America Mesoscale model forecast, from both the standard 12 kilometer (km) forecast and a high-resolution 4 km forecast product. ATDD provides a continuous display of forecast accuracy for the two operational products against observations from the Chestnut Ridge tower, http://www.atdd.noaa.gov. These evaluations are being used to improve weather forecasts generated from the North America Mesoscale suite of models.

Ecosystems and Networks Integrated with Genes and Molecular Assemblies

A collaborative consortium of 23 investigators at 14 institutions across the country uses the former Integrated Field Research Challenge site located in Bear Creek Valley on the ORR for the Ecosystems and Networks Integrated with Genes and Molecular Assemblies (ENIGMA) project. The project was established in 2009. ENIGMA researchers collaborate to create a multiscale, causal, and predictive understanding of microbial biology and the reciprocal impacts of microbial communities on their ecosystems. Efforts are focused on studying subsurface microbiomes within the contaminated Bear Creek aquifer at the ORR, a site with complex gradients of contaminants generated by research in and production of nuclear materials, including nitrates, acids, uranium, technetium, and volatile organic carbon species, the fate of which is mediated by the activity of subsurface microbial communities. Sophisticated field experiments are performed to measure the natural and anthropogenically perturbed dynamics of these geochemical processes and microbial community assembly and activity. From these chemical, physical, and microbial interactions, the most predictive of these dynamics are inferred; and ecological forces, both stochastic and deterministic, that shape community function are estimated. To dissect the causal basis for these observations through laboratory studies, a unique array of culturing, genetic, physiological, and imaging techniques is applied to map gene function and material flow within and among cells. Discoveries include how different genetic capabilities and regulatory strategies adapt microbes to ORR-relevant conditions and to one another, thereby delivering an unprecedented mechanistic understanding of complex environmental bioprocesses and ecology.

Mercury Remediation Technology Development

The EFPC watershed, located near the ORR northern boundary, covers an area of approximately 76.5 km2 (29.5 mi^2) from the headwaters to the mouth at Poplar Creek. Although mercury control strategies were in place to prevent losses from facilities on the ORR, approximately 128,000 kg (282,191 lbs.) of mercury is thought to have been released into EFPC from 1950 to 1963, particularly from the Y-12 plant (Brooks and Southworth 2011). Subsequently, industrial use of mercury ended, and annual releases decreased substantially. However, lower-level mercury discharges from the facilities continued after major operations ended because of contaminated surrounding soils and storm drains resulting from past spills. Mercury abatement has been a high priority for DOE and Y-12 over the past 30 years. Remedial activities have included water treatment, storm drain cleanout and lining, flow changes and reroutes, soil removal and stabilization, and evaluation of chemistry changes resulting

in decreased overall releases. In 2014, a mercury technology development plan was developed to identify effective remedial options and create a framework for defining and achieving sustainable remedial endpoints within acceptable timeframes. This framework integrates site-specific information with a detailed understanding of the physical, chemical, and biological processes that control contaminant movement. Following this framework, research and development over the past six years has moved toward increasing levels of technology readiness, scaling studies from bench- to meso- scale, and in some cases pilot tests/field deployments (Mathews et al., 2019). In 2020, a major modernization of ORNL's Aquatic Ecology Lab was completed, which allows stream water from EFPC to be transported and pumped into the Aquatics Lab facilities for meso-scale testing of various remediation technologies. Because mercury is one of the most widespread contaminants in the world, the work conducted as part of the Mercury Technology Development Program addresses not only local contamination issues, its findings will be relevant to the broader issues of mercury contamination globally. (Mathews et al., 2019)

ORNL Critical Interfaces Science Research Area

The ORNL Critical Interfaces Science Focus Area program is currently focused on determining the fundamental mechanisms of and environmental controls on mercury biogeochemical transformations in the sediments and biofilms lining low-order streams. Exchange and feedback processes that occur at critical interfaces, specifically across the sediment-water interface, are recognized as key factors limiting the predictive understanding of mercury species transformation and net methylmercury production over time and space in complex environmental systems. These exchange and feedback processes are central for determining the fluxes, stocks, and transformation rates of key constituents that control mercury speciation, distribution, and bioavailability. Mercury is used as a representative example in this focus area because of its prominent status as a pollutant of global, national, regional, and local concern and its relevance to DOE's environmental legacy. The field component of this research program is focused on EFPC, which originates within Y-12 and winds through the city and suburbs of Oak Ridge. The results of the research will extend beyond this setting and provide key insights that contribute to the broader understanding of the coupled hydro-biogeochemical processes controlling trace element fate and transformation in low-order freshwater streams.

Ecological Site Description Development

NRCS is expanding an existing initiative to develop Ecological Site Descriptions in the eastern United States. An Ecological Site is defined as a distinctive kind of land, with specific physical characteristics, which differs from other kinds of land, especially in its ability to produce a distinctive type and amount of vegetation. NRCS Ecological Site Descriptions have historically focused on rangelands in the western United States.

Ecological Site Descriptions will enhance NRCS conservation planning by providing information describing the interactions among soils, vegetation, hydrology, climate, and land management, both current and historic. These descriptions provide a

common framework for communication of natural resource information among the forestry, range, and biology disciplines; agencies; third-party vendors; conservation partners; and land managers.

Ecological Site Descriptions are developed around a central concept, based on approximation of the plant community that represents the best ecological potential for a site. Historically, this concept was based on pre-European conditions, which are often difficult to determine in the heavily settled eastern United States. Models that describe the states that commonly occupy a site and the transition pathways among states are then developed. Field sampling of representative sites for verification purposes is a key component of developing full descriptions, but identifying appropriate locations, especially of the central concept, can be challenging. Working in partnership with other agencies and organizations that have access to land and local expertise is key. The ORR represents a unique opportunity to characterize many of the ecosystems of the Ridge and Valley Province. The ORR has been well documented and intensively studied, adding to its uniqueness in the province.

NRCS has used the ORR in development of three full-scale Ecological Site Descriptions so far. Descriptions of Thermic Cherty Dolomite Upland Oak-Hickory Forest, Thermic Shallow Well Drained Alfic Limestone Uplands, and Thermic Very Deep Clayey Non-Cherty Limestone and Dolomite Residuum can be found by searching the EDIT database: edit.jornada.nmsu.edu/catalogs/esd/.

ORR was also used by NRCS for work on provisional ecological sites (PESs). These are first approximations that are used to guide future projects. PES work for the Ridge and Valley (Major Land Resource Area 128) was scheduled to be completed and reported by the end of FY 2020. Upon completion, projects are assigned based on PES priority as determined by the technical team for MLRA 128. Future fieldwork for Ecological Site Description development on the ORR is also determined during that process.

In addition to the work on Ecological Sites, NRCS uses the ORR for soils research. Soil map updates have been based on field sampling at the ORR. A digital soil mapping pilot project was also developed using the ORR.

Freels Bend Reference Area

Freels Bend serves as an important Reference Area for multiple studies investigating the impact and recovery of contaminated systems on the ORR. Detailed studies of water quality, fish communities, bioaccumulation, and bird communities at Freels Bend have shown that the site is unique on the ORR in being highly representative of unindustrialized, uncontaminated habitat. Recent research in remediation and stewardship science on the ORR has focused on the use of large-scale ecological manipulations to reduce risk while leaving wastes in place and enhancing natural resources. Such an ecological management and enhancement strategy, used for the first time nationally at a CERCLA site, is being implemented at contaminated ponds near ETTP; and Freels Bend is a key reference site for comparison in that long-term study. The Freels Bend area is a valuable reference site for nest-box studies of

mercury uptake and effects in birds, serves as an important Reference Area for reservoir sediment and biological comparisons upstream and downstream of DOE facilities, and has nearby streams used as long-term reference sites for fish and benthic macroinvertebrate community monitoring (for the Biological Monitoring and Abatement Program [BMAP]). UT students use parts of Freels Bend for plant habitat studies and research on plant-insect dynamics (Figure 12). Freels Bend, along with Gallaher Bend and Solway Bend of the Three Bend area, is a rare example of riparian, mixed grassland, and woodland community intersection and provides key sites for long-term community bird surveys (e.g., Partners in Flight routes).

Solway Bend Long-Term Field Studies

Since 2007, inventorying and monitoring of native turtles and other fauna has been conducted each summer at the Solway Bend site by students and staff with CRESO (Clinch River Environmental Studies Organization). Monitoring is focused on aquatic turtles, with data also including other flora and fauna, as well as environmental conditions. The two adjacent pond habitats at Solway Bend provide valuable layers of opportunity for young researchers (middle school through college) to develop the skills needed to conduct hands-on field science and analyze their results. This educational experience includes constructing data sheets; collecting, processing, and analyzing data; and writing research summaries. In addition to student opportunities, CRESO has conducted workshops enabling educators, DOE personnel, and members of the general public to observe and participate in the research that students conduct on the ORR.

By targeting long-lived aquatic turtles on the ORR for long-term monitoring, students experience the full range of demands involved in producing fair, high-quality data sets and in contributing valuable information that aids informed management decisions. The consistent research effort since 2007 has provided consistent data on the assemblage of the five species present in the Solway Bend ponds. Turtles are excellent indicators of environmental conditions. CRESO students and partners have gathered physical and health-related information essential for determining length-to-weight relationships, leech loads, and presence of wildlife disease (e.g., Ranavirus, snake fungal disease). Research over long time periods can greatly assist in the understanding of natural wildlife patterns and help guide decisions on wildlife and habitat management.

Student involvement in this research offers a unique opportunity to apply the One Health concept. This worldwide strategy expands interdisciplinary collaborations and communications in all aspects of health care for humans, animals, and the environment.

Research for Better Resource Management

Natural resources management requires experimenting with various methodologies to determine the best or most effective approaches to environmental issues. Management must consider not only a particular species but also the ecosystem it

occupies and other constraints, such as facilities, infrastructure, and cost. Various studies occur across the ORR, including:

- Detection of the occurrence of migratory and resident wetland bird species
- Evaluation of various management approaches for a rare plant population through long-term data collection and analyses
- Study of methods of promoting native, healthy, and self-sustaining ecosystems while maintaining safety and reducing costs of roadside management
- Promotion of the use of native plants in facility landscaping and remediation projects, including developing an aquatic plant nursery
- Conversion of fescue fields to native warm season grasses and forbs and evaluation of management impacts
- Tagging of monarch butterflies to provide international input regarding migration patterns
- Implementation of grounds-mowing reduction efforts to improve habitats and protect streams, as well as efforts to reduce maintenance costs
- Interfacing with researchers and operations managers to develop appropriate treatment methods within and adjacent to study areas or infrastructure
- Continuing work on the Y-12 native grassland project, converting the former biosludge fields at Scarboro and Bethel Valley Roads to pollinator habitat

ORR Research Information

The thousands of acres of eastern hardwood forests (Figure 13) on the ORR also support several large-scale environmental research uses. More detailed information on environmental research may be found on the ORNL Environmental Sciences Division website: www.ornl.gov/division/esd, and information about the Environmental Research Park is available on the website: https://nerp.ornl.gov. In addition to DOE, past and present sponsors of research on the site include NSF, the U.S. Department of Defense, the U.S. Environmental Protection Agency (EPA), USDA, the U.S. Forest Service, the Nuclear Regulatory Commission, NOAA, and TVA. Research collaborations are also ongoing with UT and numerous other academic institutions.

Figure 13. Native eastern hardwood forest of the ORR.

5.4 Contaminated Sites and Remediation

Federal facility operations dating from the World War II-era Manhattan Project have resulted in contamination of the environment. Consequently, in 1989 EPA listed the portion of the ORR containing ETTP, Y-12, ORNL, the Clinch River, and the Lower EFPC on the National Priorities List (NPL). The OREM program is responsible for environmental restoration of contaminated tracts within the NPL site. In 1995, a policy agreement between EPA and DOE allowed non-time critical removal actions to address the decontamination/demolition of legacy facilities to be scheduled and performed within the Environmental Restoration Program. This move immediately added all the ETTP facilities and a few facilities at Y-12 and ORNL to the Oak Ridge Federal Facility Agreement (FFA). Since this agreement, numerous excess and deteriorating facilities have been identified at ORNL and Y-12 and added to the cleanup scope of the OREM program. This agreement extended the completion time frame for the Oak Ridge NPL site to 2047.

To facilitate, streamline, and enhance consistent decision making for remediation projects, the contaminated areas of the ORR have been divided into five areas (Figure 14) roughly equivalent to the major hydrologic watersheds:

- ETTP
- Melton Valley portion of White Oak Creek at ORNL
- Bethel Valley portion of White Oak Creek at ORNL
- Upper EFPC at Y-12
- Bear Creek Valley at Y-12

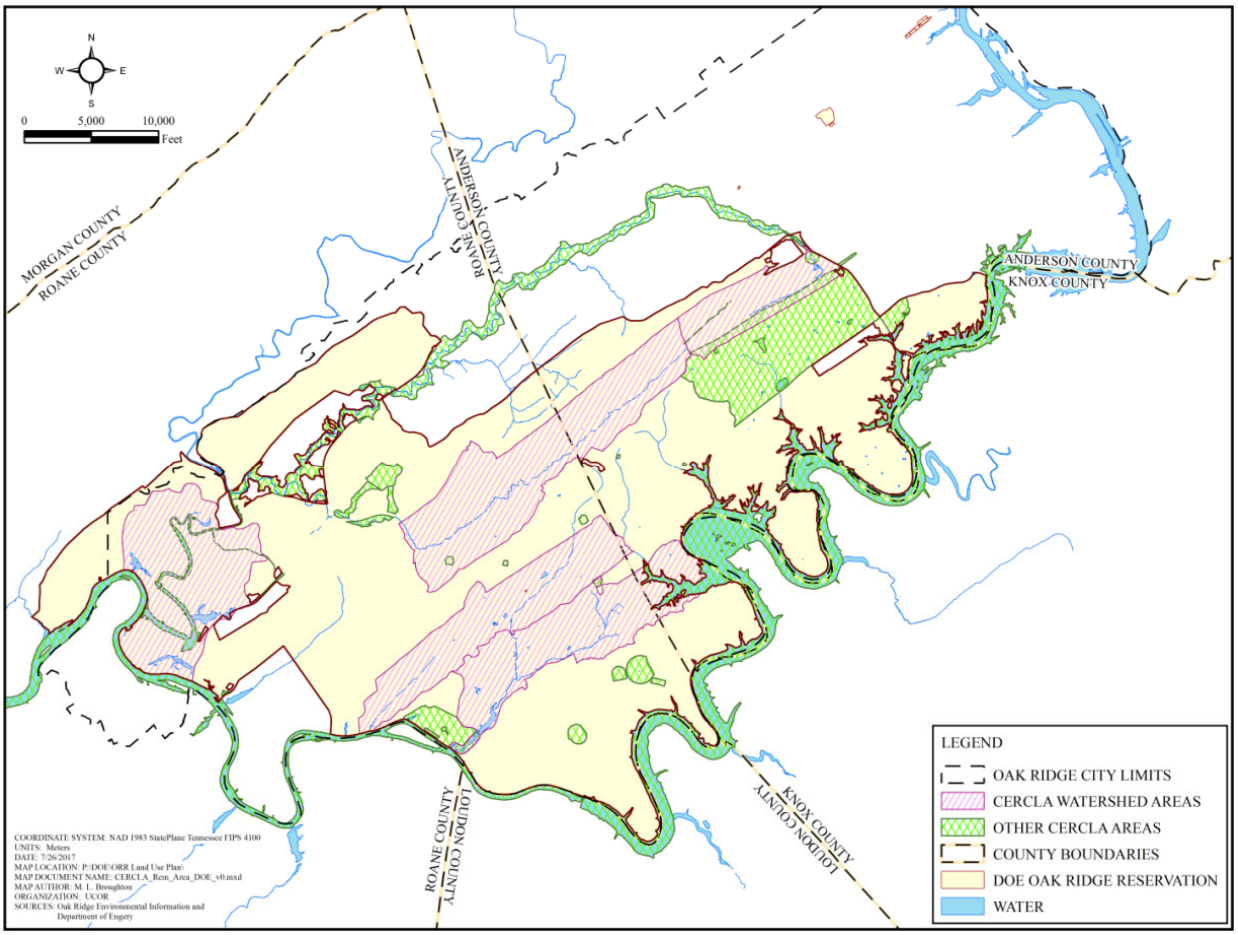

Figure 14. CERCLA remediation areas on the ORR.

Remedial actions on the Oak Ridge NPL site are regulated under CERCLA and an FFA approved by DOE, EPA, and TDEC and implemented in 1992. Numerous remedial actions have been conducted for contaminated sites throughout the Oak Ridge NPL site. In recent years, remediation decisions have evolved from narrowly focused actions, designed to address individual contaminated sites mainly contributing to offsite releases, to watershed-scale decisions designed to better address the cumulative impacts of multiple contaminated sites within a watershed. This larger-scale approach allows a decision on the anticipated end state to be made in concert with decisions on the series of remedial actions needed to protect human health and the environment in that end state. By considering the technical

practicability and cost of achieving a range of end states, decision makers can make informed, risk-based decisions consistent with the anticipated end use.

An End Use Working Group (formulated with the assistance of the OREM Site-Specific Advisory Board), was formed in January 1997 to develop end-use recommendations for contaminated areas on the ORR and identify community values that could be used to guide DOE's remedial action decision-making process. The working group was composed of private citizens and individuals with a broad range of public interests and included participation by TDEC and EPA. The group considered the contaminants, the contaminant pathways, a range of end uses, and the cost and technical implications of achieving those end uses. In July 1998, the working group published its recommendations to DOE on end uses for contaminated lands and on community values (End Use Working Group 1998).

Consistent with these recommendations, watershed Records of Decision (ROD) have been approved under CERCLA for Melton, Bethel, and Bear Creek valleys; Upper EFPC; and ETTP. In each case, remedial actions have been designed to support the collectively desirable end use for that property. Additional CERCLA decision documents are planned for Chestnut Ridge and White Wing Scrapyard and for additional small selected actions on the Reservation. The watershed-level RODs issued to date are interim decisions, designed to address specific contaminant source areas and mitigate the potential for release of contaminants. CERCLA decisions for groundwater protection and ecological concerns have been deferred to follow the completion of most actions addressing sources of contamination to the groundwater.

An annual Remediation Effectiveness Report is prepared to assess and document the effectiveness (i.e., progress toward a stated goal) of each completed remedy performed in accordance with CERCLA regulations on and around the Oak Ridge NPL site, which includes Lower EFPC, Clinch River, and Lower Watts Bar Reservoir. As part of this assessment, approved LUC (i.e., institutional controls and engineering controls) are assessed to ensure that methods holding contamination in place post-remediation are protective to both the environment and human health. Every five years, OREM produces a CERCLA Five Year Review evaluating the ongoing and completed remedies for both effectiveness and protectiveness.

5.5 Compliance and Monitoring

Operations at DOE facilities on the ORR must be conducted in compliance with federal, state, and local environmental statutes and with applicable DOE directives. TDEC and EPA are the principal regulatory agencies that issue permits, inspect operations, and oversee programs on the Reservation. The addition of new ORR facilities or operations, or other changes in land use, should be evaluated by environmental compliance staff in the early planning stages to ensure continued environmental compliance. Thousands of environmental samples and measurements are collected annually through monitoring and surveillance programs conducted on the Reservation and in surrounding areas. These programs verify compliance with applicable environmental regulations and standards, and address a variety of media such as air, surface water, groundwater, soil, vegetation, milk, fish, and wildlife.

Results of these monitoring activities show that DOE operations on the ORR are conducted in a manner that consistently achieves high rates of compliance with environmental regulations and permit limits, and that the radiation dose to the public from all ORR pathways is well below the 100 mrem limit, established by DOE. Air, surface water, groundwater, and fish monitoring locations are shown in Figure 12. The Oak Ridge Reservation Annual Site Environmental Reports, which summarizes the results of environmental monitoring and sampling programs on the Reservation each year, is available at doeic.science.energy.gov/ASER/.

Biological Monitoring and Abatement Program

The long-running BMAP was designed to evaluate biological conditions and trends in waters downstream of the DOE facilities on the ORR. The BMAP has primarily focused on evaluating site-specific biological impacts of facility operations and legacy contamination in nearby streams; identifying potential causal mechanisms; applying the knowledge gained to the development of management strategies for controlling inputs of pollutants or ameliorating their effects; and evaluating the effectiveness of implemented strategies through assessments of spatial and temporal trends in biological conditions. The program is characterized by consistent, long-term sampling and analysis methods in a multidisciplinary quantitative framework. BMAP locations cover all major stream systems on the ORR (shown in Figure 12) and offsite locations including reference streams. Major components of the BMAP include toxicity testing of invertebrates and fish; bioindicators of fish health; fish bioaccumulation; and community sampling, including periphyton, benthic macroinvertebrates, and fish.

Tennessee Department of Environment and Conservation Oversight

The TDEC Division of Remediation's Oak Ridge Office oversees DOE environmental protection and restoration activities on the ORR. The office reviews DOE remediation work and collects independent monitoring data on air, water, soil, and wildlife, both on and off the reservation. An annual Environmental Monitoring Report is compiled with the results from the monitoring, sampling and testing activities and is available on the TDEC website: www.tn.gov/environment/program-areas/rem-remediation/rem-oak-ridge-reservation-clean-up/rem-oak-ridge-reports.html (TDEC 2020).

Water Resources Restoration Program

The Water Resources Restoration Program was established by DOE to coordinate the activities of site-specific water quality programs on the ORR. The comprehensive, integrated monitoring and assessment program supports present and future environmental management decisions, gauges the effectiveness of past remedial actions, and supports the development of long-term monitoring strategies. Obligatory environmental monitoring requirements for compliance with CERCLA remedial decisions and Resource Conservation and Recovery Act post closure permits are addressed. Exit pathway, interior network, and performance assessment monitoring of groundwater, surface water, and sediment are performed reservation wide to

establish a baseline of water quality and provide an inclusive environmental assessment of the ORR. The annual Remedial Effectiveness Report and CERCLA Five Year Review serve as a summary of these results that is provided to EPA and TDEC for review and approval.

The Water Resources Restoration Program also is responsible for tracking compliance with CERCLA required LUC and engineered remedies included in decision and post-decision documents such as RODs, phase construction completion reports, and remedial action reports.

5.6 Conservation Areas

Because of the ORR's status as the largest contiguous area with protected land ownership in the Ridge and Valley Province, combined with restricted access for more than 75 years and nationally recognized biological diversity, numerous land use designations and agreements have been put into place.

Oak Ridge Wildlife Management Area

Management of wildlife on an area as large as the ORR is necessary to ensure public safety and maximize wildlife health and diversity. The ORR was designated as the Oak Ridge Wildlife Management Area through an agreement between DOE and TWRA that gives wildlife management responsibility to TWRA (Figure 9). Management includes wildlife population control through hunting, trapping, and removal; wildlife damage control; restoration of wildlife species; preservation, management, and enhancement of wildlife habitats; coordination of wildlife studies; and law enforcement. A wildlife management plan integrating TWRA and DOE wildlife management goals for the ORR was recently updated (Carter et al., 2020). DOE continues to have management responsibility for forested lands within the wildlife management area. Detailed wildlife management plans for specific areas are also prepared by TWRA.

Three Bend Scenic and Wildlife Management Refuge Area

The Three Bend Scenic and Wildlife Management Refuge Area consists of 2,920 acres of Clinch River shoreline and adjacent ridgeline set aside on June 23, 1999, through an agreement between DOE and TWRA, as a conservation and wildlife management area to be cooperatively managed for preservation purposes (Figure 9). The proclamation, signed by then Secretary of Energy Bill Richardson and George Akans, Jr., then of the Tennessee Wildlife Commission, calls for the land to be cooperatively managed under a use permit. The agreement establishes general guidelines for managing the area to preserve and enhance its natural attributes. Recent activities have included restoration of native grasses and forbs to existing fescue areas, including prescribed burns; intensive nonnative invasive plant control; vegetative plantings to attract geese away from residential and facility areas; and public bird walks. Future plans include active management of forested areas to promote understory growth and greater habitat diversity. Educational institutions use

this area as an outdoor classroom for research ranging from bird habitat characterization to invasive plant impacts.

Black Oak Ridge Conservation Easement Area

The Black Oak Ridge Conservation Easement Area was designated through an agreement-in-principle between DOE and the state of Tennessee. The agreement protects 2,966 acres at the northwest part of the ORR along Black Oak Ridge and McKinney Ridge, including Watts Bar Lake shoreline.

As compensation for natural resource damages in Watts Bar Reservoir, DOE, and the state of Tennessee, in agreement with the other natural resource trustees, executed a conservation easement on Black Oak Ridge in 2006. This analysis estimated both the ecological benefits (e.g., conservation of habitat for threatened and endangered species) and human uses (e.g., hiking) expected to be provided by the easement (IEC, 2009).

TWRA manages the land in accordance with a management plan developed jointly by TDEC and TWRA with input from the public. DOE continues to have responsibility for forest management within the easement (shown in Figure 9).

Horizon Center Floodplain (Natural Area 47)

In 2003, DOE transferred approximately 490 acres of land, now called Horizon Center, to CROET for industrial development purposes. An approximately equal acreage consisting of floodplain and wetland was retained as a conservation set-aside. Much of this acreage is already included in Research Park Natural Area 47.

Research Park Natural and Reference Areas

Rare (i.e., state and/or federal candidate and/or listed) plant and animal species are protected through preservation of the habitat required for their survival. Habitats are established based on the best available information regarding the rare species' needs and are designated Research Park Natural Areas. Areas that include more common or representative plant or animal communities that can serve as baseline areas for research and monitoring are identified as Research Park Reference Areas. These ecologically sensitive areas also provide protection to habitat that is highly likely to host rare plant or animal species but has not yet been documented as containing such species (Figure 9).

5.7 Cultural and Historic Resources

The ORR was established in the early 1940s by the Manhattan District of the U.S. Army Corps of Engineers, and the site played a vital role in the production of enriched uranium and the introduction of pioneering methods for producing and separating plutonium during the Manhattan Project and the Cold War. Pursuant to the Programmatic Agreement among the Department of Energy Oak Ridge Office, The Tennessee State Historic Preservation Officer, and the Advisory Council on Historic

Preservation Concerning Management of Historical and Cultural Properties at the Oak Ridge Reservation, a cultural resource management plan was prepared. The report entitled, *Cultural Resource Management Plan, DOE Oak Ridge Reservation, Anderson and Roane Counties, Tennessee* (DOE 2001), provides a mechanism by which DOE complies with cultural resource statutes and implements the necessary protective measures before initiating cultural resource undertakings. Figure 15 shows the historic and cultural resources on the ORR.

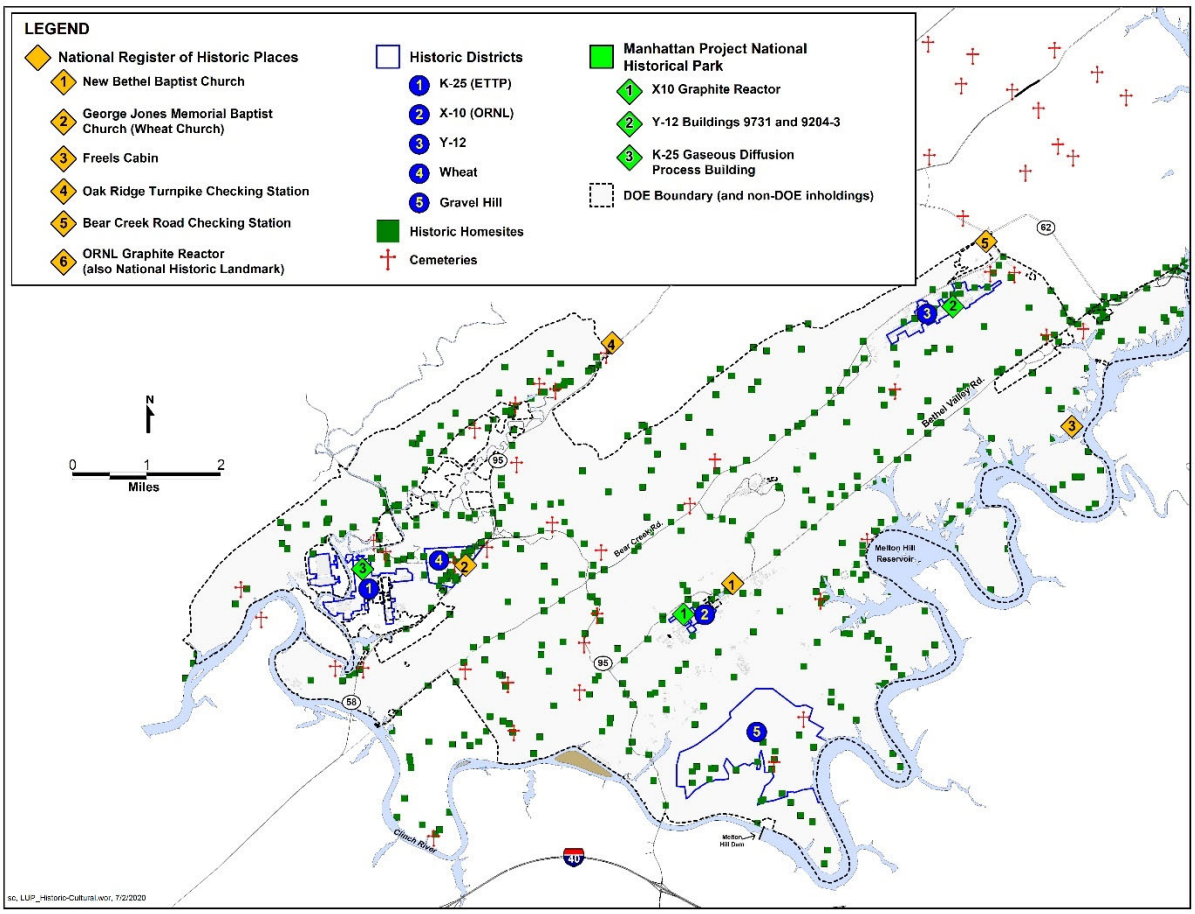

Figure 15. Historic and cultural resources on the ORR.

The Reservation contains 44 known prehistoric archeological sites, more than 250 historic pre-World War II structures, 32 cemeteries, and several historically significant Manhattan Project-era structures. There are 41 National Register of Historic Places Eligible properties on the ORR; six of them are listed on the National Register of Historic Places. The X-10 Graphite Reactor is a National Historic Landmark. On November 10, 2015, the Manhattan Project National Historical Park was established with the execution of an agreement by the secretaries of energy and the interior. On the ORR, the boundaries of the National Park encompass the X-10 Graphite Reactor, Buildings 9731 and 9204-3 at Y-12, and the K-25 footprint at ETTP.

Manhattan Project National Historical Park

The Manhattan Project National Historical Park has units in Oak Ridge; Los Alamos, New Mexico; and Hanford, Washington (NPS 2020). The three parks together cover the history and story of U.S. research and development of atomic weapons during World War II. The Oak Ridge site presents the story of 'The Secret City,' where parallel industrial operations for uranium enrichment and experimental plutonium production were carried out. The Clinton Engineer Works, which became the ORR, served as the administrative and military headquarters for the Manhattan Project and was home to more than 75,000 people, who built and operated the industrial complex and planned community in the hills of east Tennessee (NPS 2020).

5.8 Wildland Fire Prevention and Response

According to DOE Order 420.1C, the ORR is required to have, *"an integrated site-wide wildland fire management plan, consistent with the Federal Wildland Management Policy …"* The ORR has recently updated both its Wildland Fire Management Plan (WFMP) and Wildland Fire Implementation Plan (WFIP), and these will be implemented in early 2021. The WFMP outlines the overall goals and strategies necessary to manage, plan, and respond to wildland fires on the ORR and to reduce the risk of wildland fire to personnel and facilities on the DOE ORR and the public. Although the WFMP outlines the strategies and overall goals, specific elements are implemented in the companion document, the WFIP. The purpose of the WFIP is to document the annual changing strategies and to implement the overall goals and objectives of the WFMP.

The following are the primary goals of the ORR Wildland Fire Management Program:

- Protection of firefighter and public safety: The first and ultimate priority of the ORR Wildland Fire Management Program is firefighter and public safety. DOE is committed to ensuring that safety of personnel and the public is the highest priority. No natural or cultural resource or facility is worth the life of a human being. DOE Management is committed to ensuring that all strategies, goals, and policies contained within this and other documents meet this intent.
- Prevention of offsite releases: Ensure that wildland fire activities take into account the unique hazards that are posed by the sites and ensure that they are factored into any decision-making process.
- Protection of DOE property, structures, and programs: Ensure that the ORR mission is sustained and protected from wildland fire through the strategies and goals outlined within.
- Protection of public/private property: Ensure that management activities place a greater emphasis and focus on interfaces with these areas to ensure that prevention activities lower the overall risk to DOE personnel and the public.
- Protection of environmental and cultural resources: Ensure that all reservation activities, including land development, land use, and ecological sustainment,

consider fire management activities and prioritize fire management and ecological sustainability above all other activities.

The ORR has been compartmentalized by designating segments of it as Wildland Management Units (WMUs). WMUs are defined by DOE land ownership (which includes property that may lie outside so-called 'boundary' roads and fences) and excludes 'in holdings' not owned by DOE, such as those of the Horizon Center. The units are bounded by roads, fences, utilities, and watersheds as needed to approach manageable sizes, as shown in Figure 16. The WMUs tend to average 1,000 acres in size, although, when appropriate, larger units may be broken down into subunits. There are 28 WMUs that naturally follow the ridge and valley terrain and major roads. Numbered sequentially, they can be associated with Black Oak, Pine, Chestnut, Haw, and Copper Ridges and therefore fall into groups having similar response and management strategies. They can also easily be associated with the three main ORR sites. Wildland fire pre-plans are maintained for each WMU.

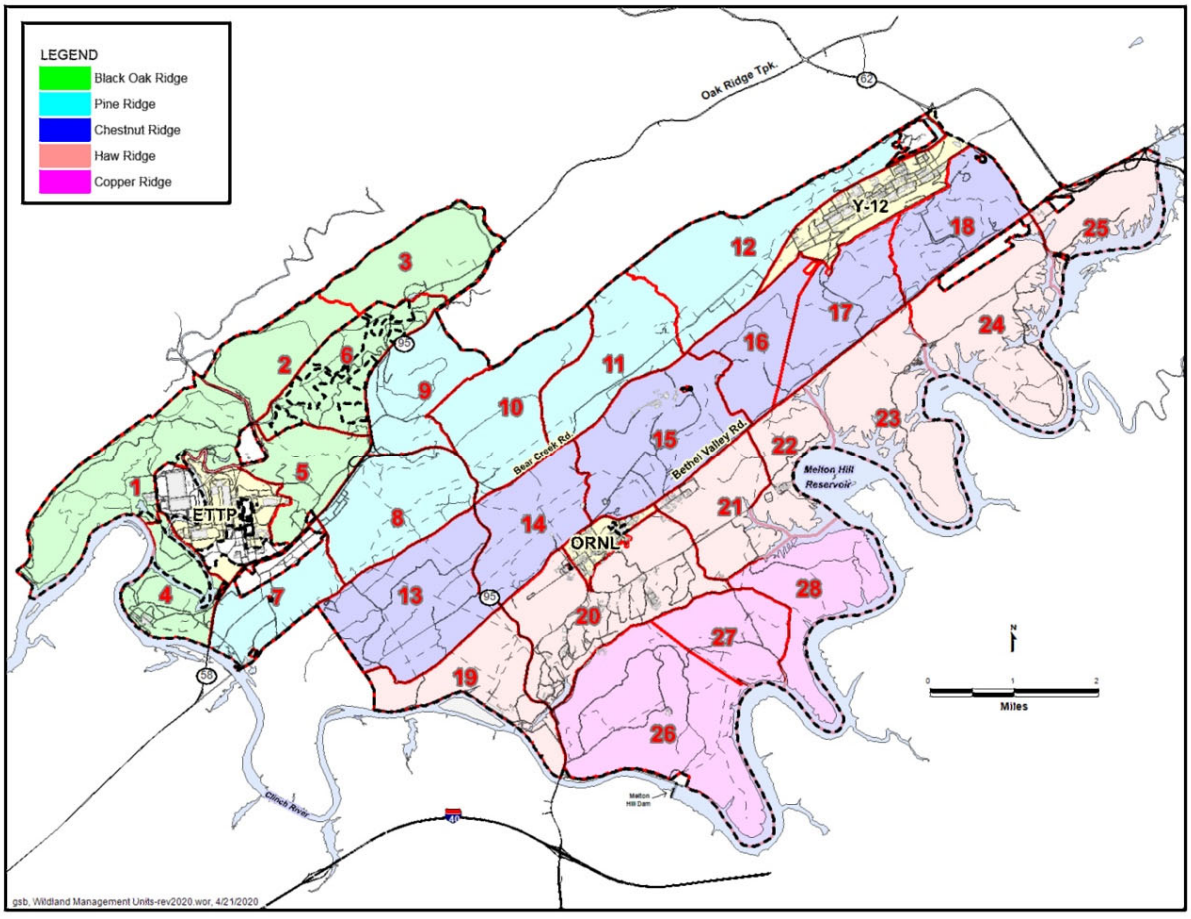

Figure 16. ORR Wildland Management Units.

5.9 ORR Infrastructure

Major utilities located on the ORR include gas, power, water, and communication lines. For many of these services, DOE contractors depend on the supplier not only for utility service to facilities within their developed areas but also for support of more remote field sites.

Communications Towers

Communications towers have been erected in seven locations across the Reservation through permission granted by DOE realty licenses.

Roads

Secondary reservation roads have multiple uses such as wildland fire control; utility maintenance; security; wildlife management; forest health activities; and access to facilities, research sites, monitoring locations, cemeteries, historic sites, and sensitive areas.

Utilities

Electric power is supplied to and metered separately for ORNL, the SNS, and Y-12 through a single contract with TVA. The contract with TVA contains two rate structures: both ORNL and Y-12 are on the seasonal rate system for manufacturers and data centers, while SNS is a directly served customer and is billed according to the 'seasonal time of use rate.'

TVA completed the construction of a new substation for ORNL to replace an antiquated 1940s-era substation. This construction, coupled with the transfer of the Kingston/ORNL 161 kV line to TVA and its subsequent upgrades, provides both adequate power distribution capabilities in support of the new supercomputers at ORNL and the ability to expand and increase power should programs expand or new programs be created that require a stable electrical power source.

In addition to the direct service contracts with TVA, the city of Oak Ridge provides electrical service to all other reservation customers.

Natural gas delivery to ORNL, SNS, and Y-12 is accomplished through four separate contracts administered through the Defense Logistics Agency (DLA) and the Consolidated Service Center Procurement and Contracts Division. The program is managed by the Reservation Management organization at the ORNL Site Office. CenterPoint Energy Services, via bulk contract with the DLA, serves as the natural gas commodity supplier. Natural gas transportation contracts, also procured through the DLA, include Tennessee Gas Pipeline and East Tennessee Natural Gas. Tennessee Gas Pipeline provides the pipeline capacity to bring natural gas to Tennessee from the Gulf of Mexico, and East Tennessee Natural Gas connects upstream and brings the gas to pumping stations B and C on the ORR. Station B supplies natural gas to ORNL and station C supplies gas to Y-12, allowing each site

to be independent of the other from both delivery and management perspectives. A small gas odorant service contract through the Oak Ridge Utility District also serves the aforementioned facilities and is procured through the Consolidated Service Center.

Because DOE operations at ETTP have ceased, the environmental management cleanup program and reindustrialization of the site are conducted by private industry, it is supplied separately from the rest of the ORR. Natural gas is delivered to ETTP through station A, which is supplied and managed by the Oak Ridge Utility District.

5.10 Public Areas/Recreation

DOE has opened several areas within the ORR for public recreation use, including greenway biking and hiking trails and Clark Center Park (Parr et al., 2015). Clark Center Park, located between Freels and Gallaher Bends, is a multiple-use recreation area.

Gallaher Bend Greenway (within the Three Bend Scenic and Wildlife Management Refuge Area) was opened in December 1997. The North Boundary Road Greenway, which follows East Ridge Road and Poplar Creek Road, was opened in 1999 and expanded in 2005. The Wheat Historic District Greenway was established in 2004. Dyllis Orchard Public Hiking Trail and McKinney Ridge Trail were opened within the Black Oak Ridge Conservation Easement Area in 2007 and 2008, respectively. The greenways are shown in Figure 9.

Other areas on the ORR are open to the public by prior arrangement (e.g., tours sponsored by American Museum of Science and Energy, public walks, and classes of the Ecological and Physical Sciences Study Center) or special permitting (e.g., TWRA hunts). The New Bethel Baptist Church and Interpretive Center is one of the few remaining original structures of pre-Manhattan Project days; it is listed on the National Register of Historic Places. This facility and the adjacent cemetery are accessible to the public through American Museum of Science and Energy-sponsored tours. Public walks (e.g., bird walks, wildflower hikes, trips to field research sites) are offered annually on the ORR.

6. Integrated Ecosystem Management Actions

The ORR is unique and valuable within the region as the largest contiguous area of protected land ownership in the Ridge and Valley Province. The overall goal of forest (and associated habitat) management initiatives on the ORR is to manage forest resources in support of current and potential future missions while maintaining forest and other habitat health and diversity. The following activities are undertaken as forest resource management (see Figure 17):

- management of game and nongame wildlife;
- identification and maintenance of special or sensitive plant and wildlife communities;
- protection of wetlands, riparian areas, and aquatic resources;

- restoration of native communities where possible, including pollinator habitat;
- management of nonnative invasive plant species;
- maintenance of a healthy forest; and
- promotion of carbon sequestration.

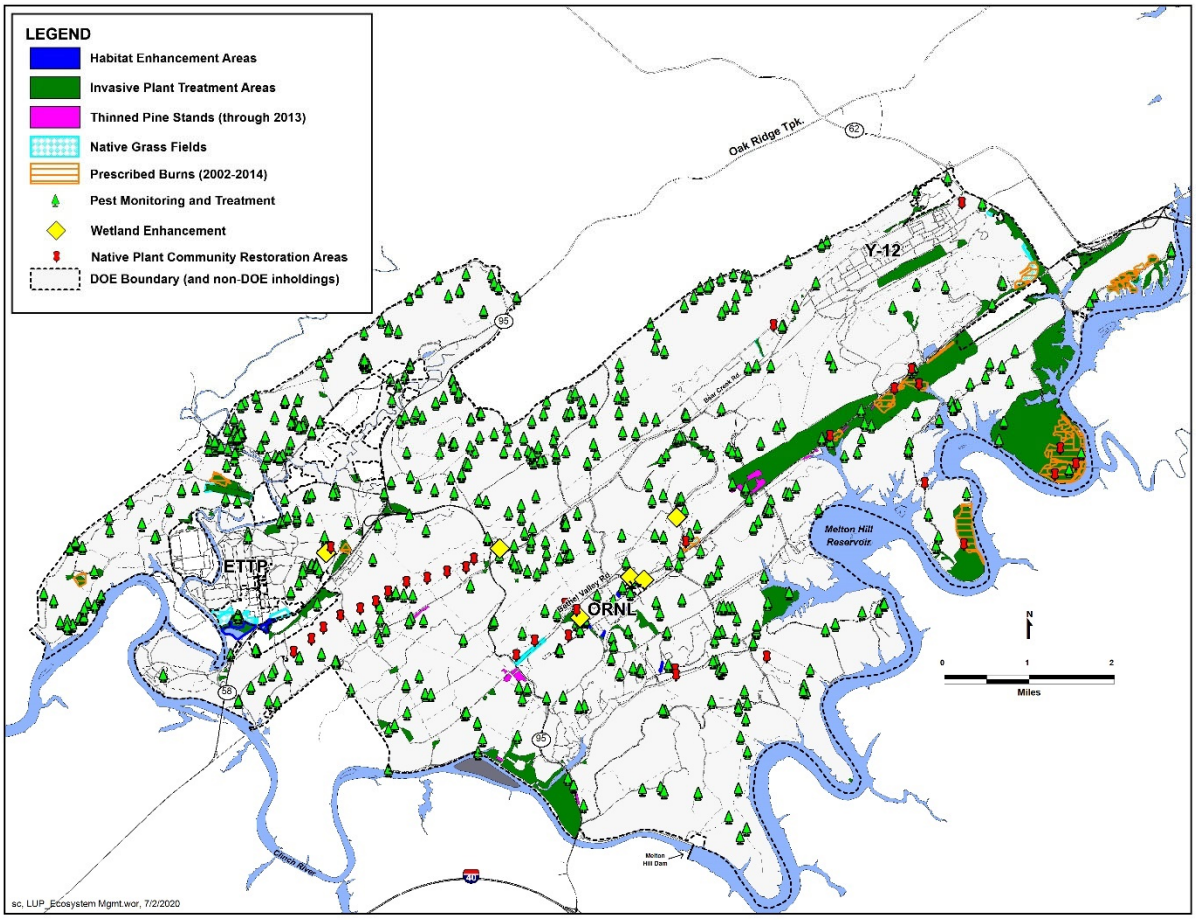

Figure 17. Ecosystem management actions on the ORR.

6.1 Wildlife Management

The ORR was designated as the Oak Ridge Wildlife Management Area through an agreement between DOE and TWRA that gives wildlife management responsibility to TWRA. Management includes wildlife population control through hunting, trapping, and removal; wildlife damage control; restoration of wildlife species; preservation, management, and enhancement of wildlife habitats; coordination of wildlife studies; and law enforcement. A Wildlife Management Plan is used to integrate TWRA and DOE wildlife management goals for the ORR (Carter et al., 2020).

The unique suite of habitat features of the ORR supports an estimated 63 fish species; 69 reptile and amphibian species; up to 213 species of migratory, transient, and resident birds; 49 mammal species, and innumerable invertebrate taxa. Among these, 25 vertebrate species are federal or state-listed (Endangered, Threatened, or In Need of Management) (Carter et al., 2020).

DOE continues to have management responsibility for forested lands within the wildlife management area.

6.2 Sensitive Area Characterization and Rare Species Protection

The ORR has evolved into a biologically rich resource over the past 75 years. More than 270 occurrences of significant plant and animal species were recognized by The Nature Conservancy in its report of biodiversity on the ORR, undertaken as part of the Common Ground DOE Future Land Use Initiative (The Nature Conservancy, 1995). In addition, using a national ranking system, The Nature Conservancy identified more than 69 preliminary conservation sites with occurrences of rare species and communities and other important features (e.g., caves, springs). These sites generally had clusters of important species or communities, with special emphasis placed on those species and elements designated as globally imperiled, rare, or uncommon by The Nature Conservancy and Natural Heritage Network ranking system. These sites are described in Parr and Hughes (2006).

WMU Research Park Natural and Reference Areas

The ORNL Natural Resources Management Program maintains a list of special habitats within the ORR collectively termed Research Park Sensitive Areas. Sensitive areas are those containing state or federally listed species or ecologically significant habitat and/or having specific management requirements. The 2017 report on Oak Ridge Natural Areas provides more detailed information (Baranski et al., 2016); this report has limited distribution.

- *Natural Areas*-Terrestrial or aquatic Natural Areas contain and protect sensitive species and have traditionally been defined as containing state and federally listed species, species under consideration for such listing, or species considered globally imperiled or rare by Nature Serve, an international network of natural heritage programs. Natural Areas are primarily terrestrial but may contain aquatic aspects.

- *Reference Areas*-The Reference Area designation (primarily terrestrial) recognizes special habitats (e.g., cedar barrens, wetlands) or features (e.g., caves), which may also serve as reference or control areas for biological monitoring, environmental remediation and characterization, and other ecological research activities. Areas on the ORR that are representative of the vegetative communities of the southern Appalachian region or that possess unique biotic features are also designated as Reference Areas. They are important as sources of baseline information for long-term observations and monitoring.

- *Research Park Cooperative Management Areas (CMAs) and Research Park Management Zones (MZs)*-CMAs and MZs (primarily utility corridors) are managed in close cooperation with other agencies and programs for special purposes, including conservation. CMAs are managed in cooperation with TWRA.

- *Research Park Habitat Areas*-Habitat Areas are known to harbor commercially exploited state-listed species.

- *Research Park Potential Habitat Areas*-Potential Habitat Areas contain habitat suitable for state or federally listed species, but those species have not yet been recorded as occurring within Potential Habitat boundaries.

Although these sensitive areas are identified through Research Park designations, they occur across the ORR, both within and outside the Research Park boundaries on DOE property.

Interior Forest and Migratory Bird Protection

The ORR's extensive forest area, amounting to approximately 70 percent of the total ORR footprint (Parr et al., 2015) is valuable not just for its size but also because of the presence of large contiguous forest tracts (Giffen, Wade, and Mueller, 2012). Contiguous forest provides habitat for several plant and animal species that are not associated with smaller patches with high edge-to-forest ratios. This is especially true for certain increasingly rare bird species. Deep-forest habitat is located away from large openings and typically has more than 70 percent canopy cover.

Up to 213 bird species have been recorded on the ORR. Partners in Flight lists 62 of the recorded bird species (includes all ORR historical records) as species of regional importance (PIF 2017). Measures are being taken to protect migratory birds on the ORR, including protection (and expansion where possible) of large contiguous areas of interior forest, management of forests to improve habitat diversity, establishment and maintenance of grasslands, and protection and management of natural riparian zones.

6.3 Habitat and Community Restoration

The forests and associated communities on the ORR provide important blocks of interior forest and include various uncommon forest habitats, grasslands, edges, barrens, river bluffs, wetlands, and successional communities. Maintaining, restoring, and expanding specific habitat types provide benefits to local as well as regional areas.

Restoration of native grass/meadow communities, particularly conversion of fescue areas, has improved wildlife habitat, enhanced aesthetics, reduced long-term maintenance costs, and provided compliance with various regulations. Prescribed burning has been an important tool in maintaining native grass communities. The overall natural resources management strategy for the ORR highlights the value of native plants, including plant species in grassland communities. Plans outlining the management strategy and role of grassland communities on the ORR are updated on a routine basis (Herold and McCracken, 2017).

The approximately 580 acres of wetlands on the ORR provide water quality benefits, stormwater control, habitat for wildlife and rare species, and landscape and biological

diversity. Wetlands occur across the ORR at low elevations, primarily in the riparian zones of headwater streams and their receiving streams, as well as adjacent to the Clinch River. Management actions have created or restored wetlands through activities such as development of water detention basins during building construction, creation of artificial wetlands as mitigation for impacts, and reestablishment of wetlands by curtailing vegetation mowing.

Former pine plantations, impacted by the pine beetle, have been allowed to reestablish as hardwood areas, thinned to allow pine regeneration and/or understory growth, or cleared and replanted with a mix of pine and hardwoods or native grasses.

6.4 Invasive Insects and Vegetation Management

An Integrated Pest Management Program has been implemented on the ORR to deal with pest insects and nonnative invasive vegetation. This approach involves a series of pest management evaluations, decisions, and controls designed to provide cost-efficient, timely management of pest issues. Potential threats to resources are identified, action thresholds are set, a monitoring program to provide early detection is initiated, preventive measures are taken, and control methods are applied when indicated by the monitoring program.

Integrated Pest Management strategies have been implemented for the southern pine beetle, hemlock woolly adelgid, emerald ash borer, and nonnative invasive plants. Other forest pests and diseases in the region that are or have been monitored include the European and Asian gypsy moth and thousand canker disease (Parr et al., 2015).

Invasive plants pose ecological threats to natural systems, as well as physical threats to facilities and infrastructure. The updated *Invasive Plant Management Plan for the Oak Ridge Reservation* (McCracken and Giffen, 2017), provides detailed information on the numerous nonnative invasive plants that are managed through this program, along with strategies for the most effective control and remediation of impacted areas.

6.5 Forest Stewardship

Seen from the air, the ORR is clearly a large, nearly continuous 'island' of forest within a regional landscape fragmented by urban development and agriculture. The forests of the ORR provide a safety and security buffer around major installations, an outdoor laboratory supporting research into the effects of various energy technologies on environmental processes, and resources for future mission needs, including space.

ORR timber is currently salvaged as a by-product of other activities (e.g., clearing for projects, research needs, security considerations), but harvesting timber for marketing purposes is not a primary objective.

The recently updated, *Forest Management Plan for the DOE Oak Ridge Reservation* (Parr et al., 2015), provides the framework within which forest resources will be managed in support of DOE missions, including environmental stewardship. The

plan provides an overview of past forest management activities, present forest conditions, and future programmatic activities.

Forest Carbon Sequestration

With the forest and grassland vegetation of the ORR, numerous opportunities exist to explore mitigation and demonstration of impacts resulting from climate stresses. Natural uptake of atmospheric carbon by vegetation through photosynthesis and storage or sequestration of the carbon in the biomass and soils may help mitigate the impacts of increased atmospheric carbon dioxide. The capacity to sequester carbon is enhanced by healthy forest systems and by actions that include using afforestation methods, avoiding conversion of forest lands to other uses, restoring degraded lands, reducing the potential for wildfire, providing continuous canopy cover, establishing multi-age and mixed-species stands, and minimizing losses to insects and diseases.

A crude estimate of the carbon stock of the ORR forest was provided by P. J. Hanson (P. J. Hanson, ORNL Environmental Sciences Division, personal communication to P. Parr, Facilities and Operations Directorate, ORNL, November 2011) and is explained in more detail in the *ORR Land Use Plan* (DOE, 2012). Ignoring differences due to stand species composition, the Reservation's 22,789 acres of forest land contain 890,920 MgC in live biomass; 75,364 MgC in forest floor carbon; and an additional 573,310 MgC stored in soils, for a total of 1,539,595 MgC stored in the forests on the ORR. In the absence of major disturbances, ORR forests are currently adding carbon at a rate of between 16,777 and 23,865 MgC/year. Therefore, the ORR is holding approximately 80 to 90 years' worth of carbon accumulation in its combined aboveground and belowground carbon stocks. Awareness of the importance of aboveground and belowground vegetation in capturing carbon has increased, including using forestlands to offset carbon dioxide emissions through the carbon market. The Nature Conservancy recently initiated the Working Woodlands Program that reinforces the importance of carbon capture by trees and provides ties to the carbon market (The Nature Conservancy, 2017).

Forest Inventory Assessment

Forest inventory assessments provide data critical for evaluation of forest health. The current inventory, initiated in 2010, will be used to determine wildland fuel load; estimate timber volumes; provide pest management observations; evaluate the need for forest health maintenance activities such as thinning, culling, or prescribed burns; identify forest research opportunities; and identify and delineate forest tracts that have unique characteristics and/or that require special management regimes. Data collected at grid points within each compartment include land use, canopy cover, ground cover, exotic invasive species, trees >2-inch diameter at breast height, species, merchantable height, and quality of timber. With these data, calculations can be made that include basal area, tree density, species dominance, wood volume, timber value, and carbon content.

Timber is a real property asset by definition and therefore is managed under DOE Order 430.1B, *Life Cycle Asset Management*. The order requires that condition assessments on all real property assets occur at least once during any five-year period using inspection methods in accordance with industry standards.

A five-year inventory planning cycle, with one-fifth of the ORR inventoried annually, would meet the DOE requirement, as well as provide needed information for management of ORR forests. Figure 18 shows the original forest compartments and an ideal five-year inventory cycle.

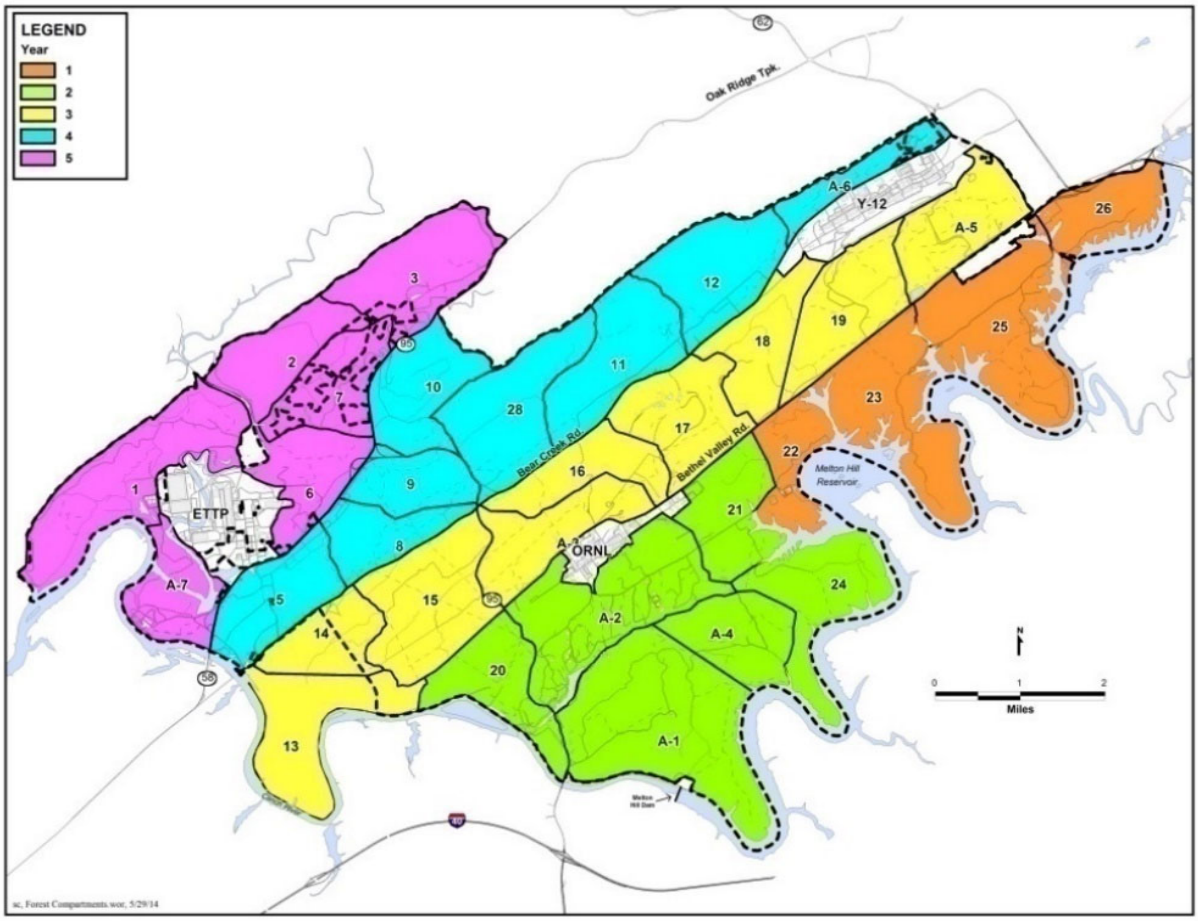

Figure 18. Forest inventory compartments on the ORR.

7. ORR Future Land Use Planning

Future uses of the ORR will, in most cases, expand and build on current land uses, not replace them. Future uses include field Research Areas and facilities (e.g., environmental research, security and monitoring systems); environmental management and long-term stewardship areas (e.g., remediated, restored, and protected contaminated areas); infrastructure improvements (e.g., communications, utilities); land responsibility actions (e.g., emergency response, wildland fire prevention and response, conservation easements); integrated management of natural resources; and additional public and educational opportunities (e.g., greenways, stakeholder involvement). Current land and facility uses are also expected to continue.

7.1 Land Ownership Changes

The cleanup goal at ETTP is to make the site available for reindustrialization. The focus of the Reindustrialization Program is to transfer facilities and land to CROET. Through the CROET program, underutilized government land and buildings are being converted into assets to be used by private-sector companies. Transfer documentation has been approved for the former powerhouse area, the area near the P-1 pond, and the proposed airport area in the Heritage Center along Oak Ridge Turnpike. Land available for transfer after 2020 includes portions of the former K-25 main plant area, which has been the focus of recent building demolition activities.

7.2 Field Research Areas and Facilities

The ORR offers unparalleled resources for large-scale ecosystem-level research within a 20,000-acre outdoor laboratory. Along with large blocks of forest and diverse vegetational communities, the Oak Ridge Environmental Research Park offers the opportunity to use or establish highly equipped sites in a secure area. Existing roads and the utility infrastructure provide critical field research components. National recognition of the ORR as a resource has led to proposed uses that are components of both regional and continental scale projects.

Future environmental research is proposed, is planned, or has high potential to be conducted across the entire reservation (except for the ETTP area), in addition to areas in which research is in progress (Figure 19).

Future field Research Areas and facilities include the following:

- aquatic-terrestrial interface studies;
- detection and simulation of ecosystem response;
- Ecological Site Descriptions by the NRCS;
- NEON;
- old-field succession free air carbon dioxide enrichment experiment; and
- artificial bat housing structure research.

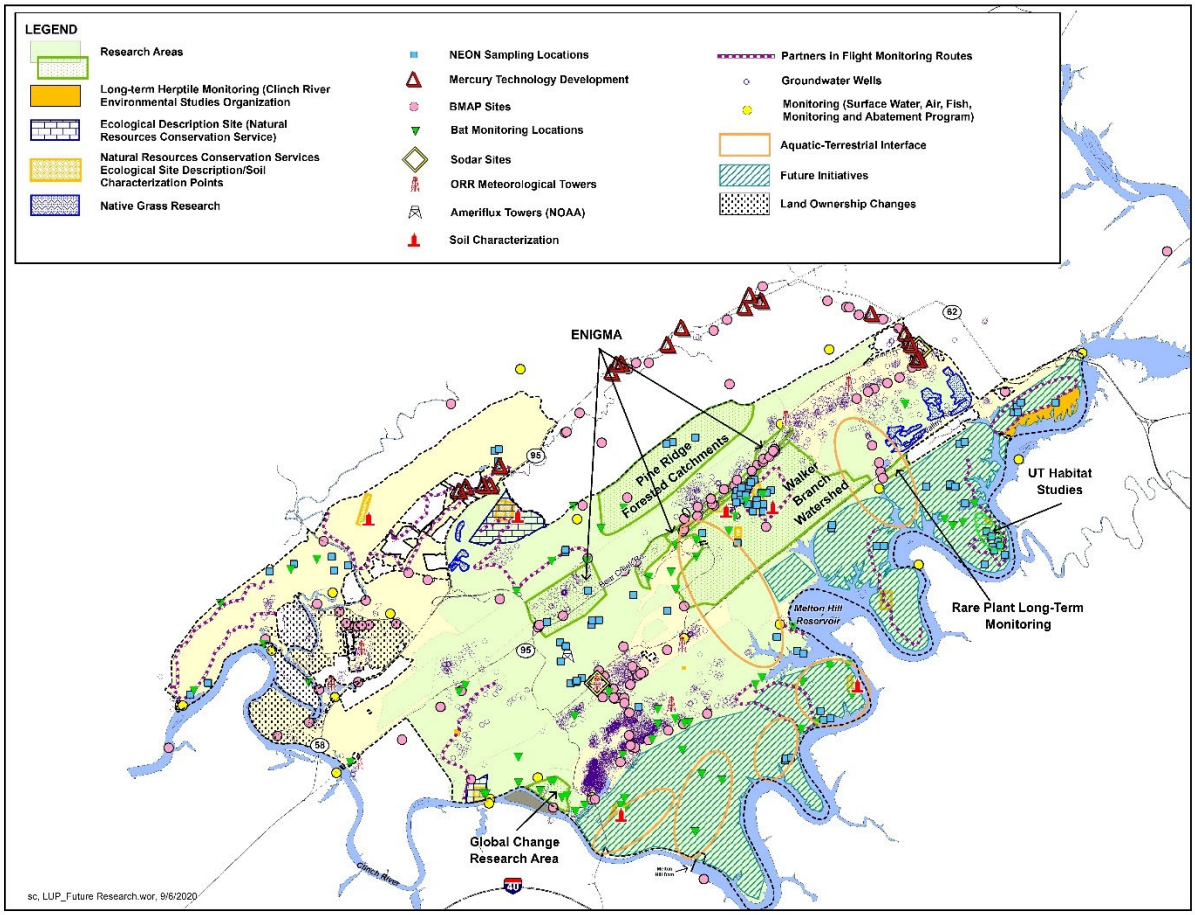

Figure 19. Areas of future research on the ORR.

Aquatic-Terrestrial Interface Studies

A number of small, essentially undisturbed watersheds that have high potential as environmental research sites are located along the southern boundary of the ORR.

The WBW is the best known and most intensively studied watershed on the Reservation, http://walkerbranch.ornl.gov, but it is not the only area worthy of attention. Bearden Creek and McCoy Branch on the WBW's west and east sides contain second and third-order perennial streams. Embayment's of Melton Hill Reservoir at the mouths of all three of these watersheds are relatively isolated and have good potential for aquatic research. There are also a number of other first and second-order watersheds along the southern shore of the Reservation that could be used for replication studies; three of these are downstream of White Oak Creek, and four are between Melton Hill Dam and the WBW.

Aquatic research at these sites could include the development and testing of new environmental tracers to measure ecological processes. The Pine Ridge Forested Catchments are relatively undisturbed tracts that offer a large potential for watershed and stream research in a different major type of geological setting.

Pine Ridge Forested Catchments

The Pine Ridge Forested Catchments consist of four adjacent first-order forested UT catchments underlain by shale and sandstone of the Rome formation. As such, they represent the second most common geology of the ORR, dominated by shale rather than the dolomite of the Knox formation (e.g., Chestnut Ridge). Although not currently an active research site, these catchments have been studied as part of the WBW project because they offer a contrast in geology and hydrology while providing similar forest vegetation.

Ecological Site Descriptions

NRCS has been using the ORR to develop Ecological Site Descriptions for Tennessee's Ridge and Valley Province. The study's focus was first on rare community types, because they potentially represent the last remaining representative of their kind in the Ridge and Valley Province and because they are listed as conservation priorities for several agencies and organizations served by NRCS. Of particular interest are soil characterization studies in areas where soil maps have not yet been created, and Ecological Site Descriptions for non-cherty dolomite and limestone uplands (e.g., Copper Ridge). Future fieldwork for Ecological Site Description development on the ORR is being prioritized. One possibility is a partnership with UT to characterize dynamic soil properties in relation to an Ecological Site Description, state, and transition model that would use the ORR as a reference plant and soil sampling site.

NRCS has stated that the ORR is extremely important to its work, and the ability to sample there has increased confidence in NRCS products. It represents a unique resource in the Ridge and Valley Province.

7.3 Natural Resources Management Research

Effective management of natural resources requires an understanding of how species, communities, and ecosystems interact and survive. New characterization, monitoring, and research activities planned for the near-term include the following:

- Developing strategies to reduce barriers to movement and connectivity for wildlife on the ORR.
- Studying the role of karst ecosystems in preserving biological diversity.
- Using pollinator habitat health to assess the success of wetland mitigations (with UT).
- Implementing eDNA-based work to inventory difficult-to-sample environments.
- Collecting data to evaluate impacts of shifting climates on cave communities.
- Assessing snake fungal disease and the association with various habitat disturbances and transmission pathways.
- Quantifying harm to wildlife by erosion netting and exploring non-harmful alternatives.

- Experimenting with the use of artificial bat housing structures to increase maternity sites for two endangered bats species on the ORR and evaluating the potential for their use in mitigation of forest loss.
- Restoring former fuel storage tank and scrap yard areas to native grass/meadow habitat (with environmental cleanup contractor UCOR and TWRA).
- Testing the effectiveness of using goats for kudzu control in impacted areas.

These ORNL Natural Resources Management team activities will provide data important in making the most effective and best management decisions for natural resources on the ORR. Although the activities are performed on the ORR, the results will be shared and serve as models for other land managers. Specific locations for the various actions are in the process of being identified and will be reviewed by DOE.

7.4 Environmental Management and Long-Term Stewardship

The document, *U.S. Department of Energy Oak Ridge Reservation End State Vision,* rev. D2 (DOE, 2004), describes the long-term vision for the Oak Ridge NPL site in support of DOE Policy 455.1, *Use of Risk-Based End States*, and the associated guidance document. The risk-based end state represents site conditions that reflect the anticipated future use of the property at the completion of the EM mission and is appropriately protective of human health and the environment consistent with that land use. The intent of this policy is to ensure that cleanup efforts throughout the DOE complex are driven by clearly defined, risk-based end states and to identify any potential variances between current cleanup plans and actions required to attain the risk-based end state.

Each major facility on the Oak Ridge NPL site has a unique expected end use. ETTP has no continuing DOE program mission and is being remediated to allow the site to be transitioned to a commercial industrial park without a significant DOE presence. ORNL will continue to be operated by the DOE Office of Science as a multidisciplinary research and development center. Y-12 will continue to be operated by NNSA for national defense operations.

The current lifecycle baseline supports the end uses contained in the RODs and is consistent with recommendations of the End Use Working Group. The baselines are currently being updated to reflect the added excess facilities at ORNL and Y-12 and the future long-term needs at ETTP. The following end uses are assumed in the lifecycle baseline plan for the ORR areas:

- *ETTP* - Unrestricted industrial use (i.e., commercial industrial park) and/or recreational use
- *Melton Valley* - Some restricted waste management areas and some DOE-controlled industrial use
- *Bethel Valley* - Some DOE-controlled industrial use and some unrestricted industrial use
- *Upper EFPC* - DOE/NNSA-controlled industrial use and some limited industrial use

- *Bear Creek Valley* - DOE/NNSA-controlled industrial use with some restricted waste management areas
- *Chestnut Ridge* - DOE/NNSA-controlled industrial use with some restricted waste management areas

Following completion of the EM mission, currently baselined for 2047, the primary hazards remaining within the Oak Ridge NPL site are expected to pertain primarily to long-term management of classified, radioactive, and hazardous waste. The areas dedicated to these wastes include capped waste disposal sites in Melton Valley, the Environmental Management Waste Management Facility (EMWMF), and the Bear Creek Burial Ground in Bear Creek Valley, as well as individually capped and/or soil-covered waste disposal site locations. Additional groundwater hazards may require access and use restrictions.

Potential risks posed by each hazard will be managed primarily through institutional controls that restrict access to them and through monitoring performed for assessment of releases. All areas requiring post-remedial action LUC will be documented in a Property Restriction Notice with the appropriate County Registrar of Deeds and captured in a watershed Remedial Action Report Comprehensive Monitoring Plan primary document approved by DOE, TDEC, and EPA.

A focused feasibility study has been initiated to evaluate disposal alternatives for the additional waste that will be generated from excess facilities and CERCLA-related cleanup actions. The current EMWMF is predicted to reach capacity before all cleanup actions have been completed on the Oak Ridge NPL site. A Bear Creek Valley site has been proposed for additional disposal needs.

7.5 ORR Infrastructure

Discussions with TVA are under way regarding the possibility of constructing small modular reactors on the TVA property once sited for the Breeder Reactor Program. The generation of power by these small reactors would allow ORNL, as well as other DOE sites and activities on the ORR, to reduce greenhouse gas emissions to near zero. These reactors are not expected to be online until after 2020.

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