



*DOE's Oak Ridge National Laboratory is the nation's largest multiprogram science and technology laboratory. ORNL's mission has grown and expanded through the years, and now it is at the forefront of supercomputing, advanced manufacturing, materials research, neutron science, clean energy, and national security.*  
*Photo by Carlos Jones*

# 5

## Oak Ridge National Laboratory

ORNL is a thriving multiprogram research campus with world-leading facilities and a talented and diverse workforce of innovators and problem solvers. Researchers use these unique facilities along with sophisticated tools and signature strengths in neutron science, high-performance computing, advanced materials, nuclear science and engineering, and isotopes to benefit science and society, making it possible to meet the following goals:

- Advance understanding, design, and use of new materials and chemical processes
- Reveal unmatched 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
- Increase and exploit understanding of biological and environmental systems, from genes to ecosystems

Nine world-class facilities that support ORNL's research and development (R&D) activities are also available to users from universities, industry, and other institutions:

- Building Technologies Research and Integration Center
- Carbon Fiber Technology Facility
- Center for Nanophase Materials Sciences
- Center for Structural Molecular Biology
- High Flux Isotope Reactor
- Manufacturing Demonstration Facility
- National Transportation Research Center
- Oak Ridge Leadership Computing Facility
- Spallation Neutron Source

ORNL is managed by UT-Battelle LLC, a partnership between the University of Tennessee and Battelle Memorial Institute. Other DOE contractors conducting activities at ORNL in 2021 included North Wind Solutions, LLC; UCOR; and Isotek Systems, LLC.

During 2021, the coronavirus disease (COVID-19) continued to present challenges and opportunities at ORNL, but UT-Battelle continued to meet commitments to provide a safe and healthy workplace, protect the public and the environment, and meet regulatory requirements and commitments. All required state and federal environmental monitoring, sampling, and reporting tasks were completed in 2021, and no environmental compliance issues resulted from changes in ORNL operations and procedures as a result of COVID-19.

## 5.1. Description of Site, Missions, and Operations

ORNL, which is managed for DOE by UT-Battelle, LLC, a partnership of the University of Tennessee and Battelle Memorial Institute, lies in the southwest corner of ORR (Figure 5.1) and includes facilities in two valleys (Bethel and Melton) and on Chestnut Ridge. ORNL was established in 1943 as part of the secret Manhattan Project to pioneer a method for producing and separating plutonium. During the 1950s and 1960s, and with the creation of DOE in the 1970s, ORNL became an international center for the study of nuclear energy and related research in the physical and life sciences. By the turn of the century, the laboratory supported the nation with a peacetime science and technology mission that was just as important as, but very different from, the work carried out in the days of the Manhattan Project.

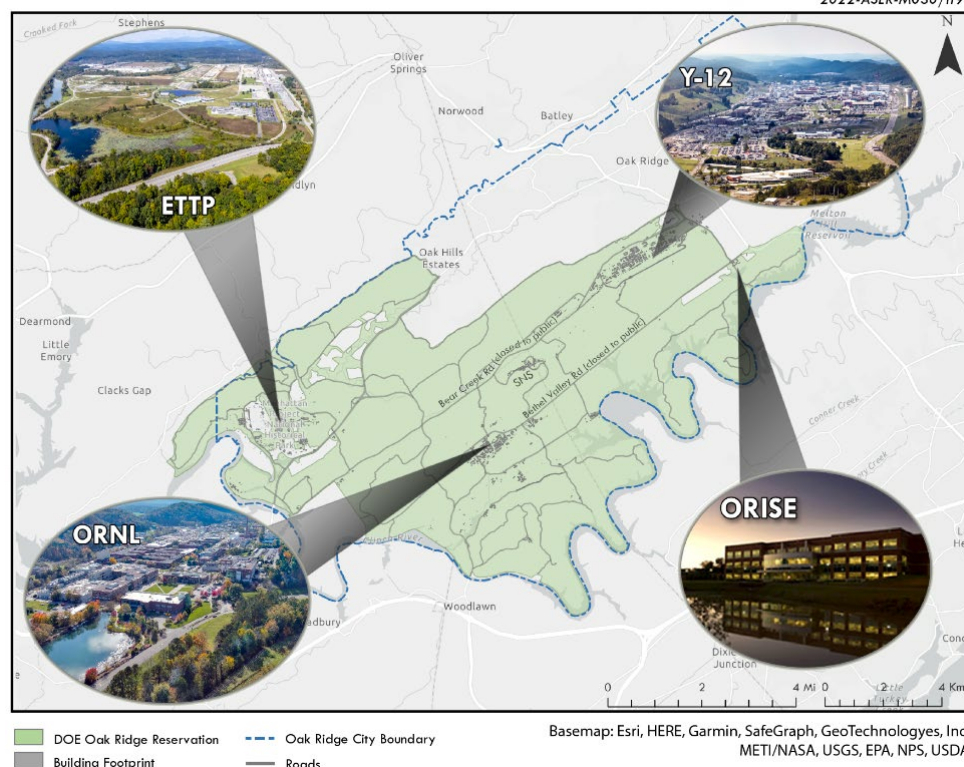
In March 2007, Isotek Systems, LLC (Isotek) assumed responsibility for the Building 3019 Complex at ORNL, where the national repository of  $^{233}\text{U}$  has been kept since 1962. In 2010, an Analysis of Alternatives was conducted to evaluate methods available for  $^{233}\text{U}$  disposition, and in 2011, the recommendations in the *Final Draft  $^{233}\text{U}$  Alternatives Analysis Phase I Report* (DOE 2011b)

were endorsed. The Phase I recommendations included (1) transfer of Zero-Power Reactor plate canisters to the National Nuclear Security Administration and disposal of Consolidated Edison Uranium Solidification Project material canisters and (2) completing a Phase II alternatives analysis for processing the remaining 50 percent of the inventory. The transfer of the reactor plate canisters was completed in 2012. Disposal of the material canisters began in 2015 and was completed in 2017. UT-Battelle provides air and water quality monitoring support for the Building 3019 complex; results are included in the UT-Battelle air and water monitoring discussions in this chapter.

Responsibility for Building 2026 was transferred from UT-Battelle to Isotek in May 2017. Isotek began processing  $^{233}\text{U}$  material inside glove boxes in Building 2026 in the fall of 2019. The processing of the  $^{233}\text{U}$  material produces a solidified, low-level radioactive waste (LLW) form that is acceptable for disposal. Additionally, Isotek is extracting  $^{229}\text{Th}$  from the material and is transferring it to a customer for use as source material for medical isotope production.

UCOR is the DOE ORR cleanup contractor for the DOE Oak Ridge Office of Environmental Management (OREM). The scope of UCOR activities at ORNL includes long-term surveillance, maintenance, and management of inactive waste disposal sites, structures, and buildings. The *2021 Cleanup Progress: Annual Report on Oak Ridge Reservation Cleanup* (UCOR 2021) [here](#) provides detailed information on UCOR activities at ORNL. These activities included demolition of the Tritium Target Preparation Facility and former Radiological Development Lab's West Cell Bank and deactivation activities at multiple facilities, including the Low Intensity Test Reactor, the Oak Ridge Research Reactor, and a group of buildings, called "Isotope Row," that were constructed in the 1950s and early 1960s to process radioisotopes. This work focuses on asbestos, lead, and universal waste removal and will ultimately eliminate high-risk contaminated structures and open space for future research missions at ORNL.

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**Acronyms:**

ETTP = East Tennessee Technology Park  
ORNL = Oak Ridge National Laboratory

ORISE = Oak Ridge Institute for Science and Education  
Y-12 = Y-12 National Security Complex

**Figure 5.1. Location of ORNL within ORR and its relationship to other local DOE facilities**

As of December 11, 2015, North Wind Solutions, LLC (NWSol) has been the prime contractor for the Transuranic Waste Processing Center (TWPC), which is located on the western boundary of ORNL on about 26 acres of land adjacent to the Melton Valley Storage Tanks along State Route 95. TWPC’s mission is to receive, process, treat, and repackage transuranic (TRU) wastes for shipment to designated facilities for final disposal. TWPC consists of the waste-processing facility, the personnel building, and numerous support buildings and storage areas. TWPC began processing supernatant liquid from the Melton Valley Storage Tanks in 2002, contact-handled debris waste in December 2005, and remotely handled debris waste in May 2008. Based on the definition of TRU waste, some waste being managed as TRU is later determined to be LLW or mixed LLW. UT-Battelle provides water quality monitoring for operations at the TWPC, and

results are included in water monitoring discussions in this chapter. Air monitoring data from TWPC are provided to UT-Battelle for inclusion in the ORR National Emission Standards for Hazardous Air Pollutants for Radionuclides (Rad-NESHAPs) annual report and is incorporated into air monitoring discussions in this chapter.

UT-Battelle manages several facilities located off the main ORNL campus for DOE. The Hardin Valley Campus (HVC) is home to the National Transportation Research Center (NTRC) (see website [here](#)), the Grid Research Integration and Deployment Center (GRID-C) (see website [here](#)), and the Manufacturing Demonstration Facility (see website [here](#)). The HVC is located on a 23-acre site owned by Pellissippi Investors, LLC, and is leased to UT-Battelle and the University of Tennessee. Approximately 152 industry partners work on the HVC to shape America’s mobility, energy infrastructure, and manufacturing future.

NTRC is DOE's only user facility dedicated to transportation and serves as the gateway to UT-Battelle's comprehensive capabilities for transportation R&D. Research focuses on fuels and lubricants, engines, emissions, electric drive technologies, lightweight and power-train materials, vehicle systems integration, energy storage and fuel cell technologies, vehicle cyber security, and intelligent transportation systems.

Grid-C (Figure 5.2) combines multiple electrification research activities (e.g., utilities, buildings, vehicles) into one facility. The combination of a variety of innovative R&D disciplines enables breakthroughs to support a resilient and secure power grid from the first instant of electricity generation to end use:

- Power and energy systems
- Vehicle and buildings science
- Power electronics

- Energy storage
- Sensors and controls
- Data science and modeling
- Cybersecurity

The Manufacturing Demonstration Facility focuses on advanced manufacturing research, including the development of carbon fiber composites and additive manufacturing involving polymers, metal wires, and metal powders. The facility hosts the Institute for Advanced Composites Manufacturing Innovation lab space and an outreach program for local high school students.

The Carbon Fiber Technology Facility (CFTF), a leased 42,000 ft<sup>2</sup> innovative technology facility located in the Horizon Center Business Park, offers a flexible, highly instrumented carbon fiber line for demonstrating the scalability of advanced carbon fiber technology and for producing market-development volumes of prototypical



Photograph by Carlos Jones. Approved for public release.

**Figure 5.2. Power electronics capabilities at the Grid Research Integration and Deployment Center on the ORNL Hardin Valley Campus**

carbon fibers. The CFTF is the world's most capable open-access facility for the scale-up of emerging carbon fiber technology. The cost of carbon fiber material remains relatively high, prohibiting widespread adoption of carbon fiber-containing composite materials in the automotive manufacturing industry, which requires lower commodity pricing. The lower-cost carbon fiber produced at ORNL meets the performance criteria prescribed by some automotive manufacturers for carbon fiber materials for use in high-volume vehicle applications.

UT-Battelle also manages several buildings and trailers located at Y-12 and in the city of Oak Ridge.

## 5.2. Environmental Management Systems

Demonstration of environmental excellence through high-level policies that clearly state expectations for continual improvement, pollution prevention, and compliance with regulations and other requirements is a priority at ORNL. In accordance with DOE Order 436.1, *Departmental Sustainability* (DOE 2011a), UT-Battelle, NWSol, UCOR, and Isotek have implemented environmental management systems (EMSs), modeled after International Organization for Standardization (ISO) 14001: 2015, to measure, manage, and control environmental impacts (ISO 2015). An EMS is a continuing cycle of planning, implementing, evaluating, and improving processes and actions undertaken to achieve environmental goals.

### 5.2.1. UT-Battelle Environmental Management System

UT-Battelle's EMS is designed to fully comply with all applicable requirements and to continually improve ORNL's environmental performance. Until August 2018, UT-Battelle was registered to the ISO 14001:2015 standard and had maintained ISO 14001 registration since 2004. In FY 2018 a management decision was made to transition

from registration to a declaration of conformance to ISO 14001:2015. Because of that decision, the external registration audits have been discontinued.

UT-Battelle's EMS is a fully integrated set of environmental management services for UT-Battelle activities and facilities. Services include pollution prevention, waste management, effluent management, regulatory review, reporting, permitting, and other environmental management programs. Through the UT-Battelle Standards-Based Management System (SBMS), the EMS establishes environmental policies and translates environmental laws, applicable DOE orders, and other requirements into laboratory-wide documents (procedures and guidelines). Through environmental protection officers, environmental compliance representatives, and waste services representatives, the UT-Battelle EMS assists the line organizations in complying with environmental requirements.

#### 5.2.1.1. Integration with the Integrated Safety Management System

The objective of the UT-Battelle Integrated Safety Management System (ISMS) is to systematically integrate environment, safety, and health (ES&H) requirements and controls into all work activities and to ensure protection of the workers, the environment, and the public. The UT-Battelle EMS and the ISMS are integrated to provide a unified strategy for the management of resources, the control and attenuation of risks, and the establishment and achievement of the organization's ES&H goals. Guided by the ISMS and EMS, UT-Battelle strives for continual improvement through "plan-do-check-act" cycles. Under the ISMS, the term "safety" also encompasses ES&H, including pollution prevention, waste minimization, and resource conservation. Therefore, the guiding principles and core functions in the ISMS apply both to the protection of the environment and to safety. The UT-Battelle EMS is consistent with the ISMS and includes all the elements in the ISO 14001:2015 standard.

### 5.2.1.2. UT-Battelle Environmental Policy for ORNL

UT-Battelle's Environmental Policy for ORNL, which can be found on the ORNL website [here](#), clearly states expectations and includes commitments to continual improvement, pollution prevention, and compliance with regulations and other requirements.

### 5.2.1.3. Environmental Management System Planning

ISO 14001 planning clause requires organizations to identify the environmental aspects and impacts of their operations, products, and services; identify applicable regulations and requirements; establish objectives; implement plans to achieve the objectives; and identify and control risks and opportunities.

#### ***UT-Battelle environmental aspects***

Environmental aspects are elements of an organization's activities, products, or services that can interact with the environment. Environmental aspects associated with UT-Battelle activities, products, and services have been identified at both the line organization level and the laboratory level. Activities that are relative to any of the aspects are carefully controlled to minimize or eliminate impacts to the environment. Nine significant environmental aspects (listed on the ORNL website [here](#)) have been identified as potentially having significant environmental impacts.

#### ***UT-Battelle legal and other requirements***

Legal and other requirements that apply to the environmental aspects identified by UT-Battelle include federal, state, and local laws and regulations; environmental permits; applicable DOE orders; UT-Battelle contract clauses; waste acceptance criteria; and voluntary requirements such as ISO 14001:2015. UT Battelle has established procedures to ensure that all applicable requirements are reviewed and that changes and updates are communicated to staff and are incorporated into work-planning

activities. UT Battelle's environmental compliance status is discussed in Section 5.3.

#### ***UT-Battelle objectives***

To improve environmental performance, UT-Battelle establishes objectives for monitoring progress for appropriate functions and activities. Laboratory-level environmental objectives are documented in the Site Sustainability Plan. Line organization objectives are developed annually, entered into a commitment tracking system, and tracked to completion. In all cases, the objectives are consistent with the UT-Battelle environmental policy for ORNL (found on the ORNL website [here](#)), are supportive of the laboratory mission, and, where practical, are measurable.

#### ***UT-Battelle programs***

UT-Battelle has established an organizational structure to ensure that environmental stewardship practices are integrated into all facets of its missions at ORNL. Programs led by experts in environmental protection and compliance, energy and resource conservation, pollution prevention, and waste management ensure that laboratory activities are conducted in accordance with the environmental policy (see Section 5.2.1.2). Information on UT-Battelle's 2021 compliance status, activities, and accomplishments is presented in Section 5.3.

Environmental protection and waste management staff provide critical support services in the following areas:

- Waste management
- Solid and hazardous waste compliance
- National Environmental Policy Act (NEPA 1969) compliance
- Air quality compliance
- Water quality compliance
- US Department of Agriculture (USDA) compliance
- Transportation safety
- Environmental sampling and data evaluation

- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA 1980) interface

Subject matter experts (SMEs) at UT-Battelle provide expertise in waste management, transportation, and disposition support services to research, operations, and support divisions:

- Pollution prevention staff manage recycling programs and work with staff to reduce waste generation and to promote sustainable acquisition.
- Radiological engineering staff provide radiological characterization support to generators and waste service representatives, develop tools to help ensure compliance with facility safety and transportation, and provide packaging support.
- Waste acceptance and disposition staff review and approve waste characterization methods, accept waste from generator areas into Transportation and Waste Management Division storage areas, review waste disposal paperwork to ensure compliance with the disposal facility's waste acceptance criteria, certify waste packages, and coordinate off-site disposition of UT-Battelle's newly generated waste.
- Waste service representatives provide technical support to waste generators to properly manage waste by assisting in identifying, characterizing, packaging, and certifying wastes for disposal;
- The waste-handling team performs waste-packing operations and conducts inspections of waste items, areas, and containers.
- The transportation management team ensures that both the on-site and off-site packaging and transportation activities are performed in an efficient and compliant manner.
- The hazardous material spill response team is the first line of response to hazardous materials spills at ORNL and controls and contains spills until the situation is stabilized.

#### 5.2.1.4. Site Sustainability

As required by DOE, Order 436.1, *Department Sustainability* (DOE 2011a), The Oak Ridge National Laboratory FY 2022 Site Sustainability Plan (SSP), an internal document that includes FY 2021 performance data, was completed in December 2021.

To attain the federal sustainability goals outlined in the SSP, sites operated by DOE are expected to contribute toward all targets and to identify strengths that can be adapted as agencywide best practices. To meet the SSP goals at ORNL, UT-Battelle identifies opportunities for continuous improvements in operational and business processes and implements practices to maximize the return on investment in modernizing facilities and equipment. Sustainable ORNL promotes systemwide best practices, management commitment, and employee engagement that will help lead ORNL into a future of efficient, sustainable operations. The Sustainable ORNL website is actively managed and is available for employee and public view [here](#).

ORNL Facilities Management Division (FMD) is tasked with the management of distinctive research facilities and extraordinary scientific equipment. The commissioning dates of the systems range from the 1940s to 2021. As such, many facilities require a customized methodology to enhance sustainability; a boilerplate approach would not be sufficient to operate efficiently and deliver the desired results. FMD's Energy Efficiency and Sustainability Program is tasked with the daily management of the energy- and water-saving projects that are the key to results in operational savings and sustainable practices.

Changes in federal government and DOE priorities resulted in a year of transition in sustainability goals and urgencies as well as increased awareness of the effects that climate change can have on government facilities and operations. In January 2021, Executive Order (EO) 14008, *Tackling the Climate Crisis at Home and Abroad* (EO 2021), established broad strategies calling for federal agencies to take the lead in confronting the

climate crisis, engage in the formation of a net-zero economy, and enhance operational resilience at federal facilities. ORNL requires a more comprehensive crosscutting process to respond to EO 14008 and DOE priorities and to enhance climate mitigation efforts. The Sustainable ORNL program established a new team of SMEs that includes R&D staff and operations staff to address enhanced operational resilience strategies, beginning with a revamped vulnerability assessment and resilience plan that is due to DOE by the end of FY 2022. Exploration for a Carbon Free Campus initiative began in 2021 under the charge of the Facilities and Operations Directorate. The goal is to develop a dynamic inventory of research and operational projects that represent opportunities to advance the ORNL campus toward net-zero strategies. The initiative aligns with DOE SC objectives as it amplifies net-zero as part of its business methods and in the budget planning process. Throughout the campus, projects are being evaluated in terms of several sustainability priorities, including reductions in energy and water use and their associated cost savings from energy conservation measures, net-zero initiatives, and operational resilience. ORNL has an opportunity and a responsibility to lead by example and integrate climate and sustainability into all operations.

Responses to changes in priorities and the issuance of new requirements will continue throughout 2022. The Energy Act of 2020 (EA 2020), which was passed in December 2020, includes requirements for identifying, funding, and implementing energy conservation measures identified by building energy and water evaluations required by the Energy Independence and Security Act Implementation plans, and new and revised guidance for sustainability and efficiency goals are anticipated to be the primary focus for Sustainable ORNL in the next few years.

#### **Sustainable ORNL awards**

Information about recognition that ORNL has received in the area of sustainability can be found on the Sustainable ORNL website [here](#). In 2021, sustainability efforts at ORNL were recognized with the following awards from DOE, *R&D*

*Magazine*, and the Federal Laboratory Consortium (FLC).

- **DOE Sustainability Award**—Strategic Partnerships for Sustainability Category. During the COVID-19 pandemic, Y-12 National Security Complex and ORNL formed a unique partnership by sharing personal protective equipment and expertise to enable both sites to create their own disinfectant product, hypochlorous acid. This safe, environmentally friendly, sustainable, and effective disinfectant is inexpensive to produce and nontoxic and it eliminates the virus on hard surfaces after five minutes of contact (details [here](#)).
- **R&D Magazine R&D 100 Awards** (details [here](#))
  - Autonomous Self-Healing Sealant. Researchers at ORNL have developed a self-healing adhesive with many potential applications in the building sector. When used in building applications, sealants strengthen the building envelope and enhance the building’s energy efficiency by minimizing air leaks (details [here](#)).
  - Precision Deicer. Researchers from ORNL developed a method to more precisely gauge the amount of deicing materials, such as salt or brine, needed to deice a particular road.
  - Ultraconductive Copper-Carbon Nanotube Composite. Copper is a key element in many electrical devices, but its resistance leads to power losses, meaning that new low-resistance conductors are needed in order to meet current clean energy goals. ORNL researchers have developed an ultraconductive copper-carbon nanotube composite as an alternative that improves on the mechanical and electrical properties of pure copper.
  - GridDamper. GridDamper is a deployment-ready technology to allow more renewable electricity in power



grids. The technology automatically updates its parameters, sensors, and actuators to guarantee power grid stability and reliability when renewable energy and electricity demand fluctuate.

- MSC MillMax. Milling cuts metal by using a rotating tool with metalworkers typically manually adjusting the machinery in an unscientific process that can take hours. This new computerized system does the precision work, reducing time, cost, and scrap metal and increasing productivity. (Developed by ORNL, MSC Industrial Supply Co., and Manufacturing Laboratories.)
- Bis-iminoguanidine Negative Emission Technology. Researchers from ORNL developed a method for separation of carbon dioxide from the air that has the potential to permanently remove billions of tons of the greenhouse gas out of the atmosphere.

▪ **FLC 2022 National Awards for Excellence in Technology Transfer**

- 3D-Printed SiC Technology Brings Zero-Carbon Energy Production to US
- Licensing Artificial Intelligence Software for Real-Time Monitoring of Additive Manufacturing
- ORNL Partners with Ateios through License for Paper-Thin, Customizable Batteries

**Sustainable ORNL notable achievements**

In FY 2021, increased focus was placed on climate vulnerability and on developing solutions to climate challenges and other operational weaknesses in federal facilities. In response to EO 14008, DOE initiatives, and increased support from SC, updated assessments and planning documents for the Sustainable ORNL program and for integration into other programs were developed. The newly released *Vulnerability Assessment and Resilience Planning Guidance Version 1.2* (VARP) (DOE 2022b) and associated

timelines will result in a new and more comprehensive assessment by September 30, 2022. An increased emphasis is on preparedness and recovery, so Sustainable ORNL’s Operational Resilience Roadmap and Core Team members are participating in training and workshops offered by the DOE Sustainability Performance Division and the Federal Energy Management Program to employ new guidance and collective resources to improve risk response.

The newly reorganized Operational Resilience Roadmap Owners and Core Team is currently evaluating other ORNL risk management programs and emergency response processes and procedures to develop collaborative approaches to all aspects of operational readiness. To address operational and climate resiliency in critical missions and operations, Facilities and Operations leadership and numerous facilities management divisions are coordinating to ensure that continued collaboration and focus on this topic is maintained. The enhanced operational resilience process is based on the inclusion of comprehensive systems and processes and continuous communications and responsiveness.

ORNL participates in training and workshops for the Federal Energy Management Program’s Technical Resilience Navigator (TRN) ([here](#)) to help ORNL manage the risk to critical missions from disruptions in energy and water services. The TRN provides a systematic approach to identifying infrastructure vulnerabilities and inefficiencies while prioritizing solutions that reduce risk. Completion of the TRN will enable ORNL to proactively identify and respond to vulnerabilities in critical systems.

Updates to the VARP, including a roadmap to action and a comprehensive list of projects, will be evaluated and modified annually as subject matter knowledge evolves. Along with net-zero initiatives, enhanced operational resilience, and other EO 14008 directives, a comprehensive and defensible analysis of the projects that will align with the resilience of the facilities and infrastructure that are most critical to ORNL’s science mission will be required. Collaboration with multiple ORNL divisions will be necessary to

ensure that these assessments are included in the laboratory's comprehensive planning process.

In FY 2021, the Facility Management Division's Energy Efficiency and Sustainability Program successfully attained DOE 50001 Ready recertification. Launched in 2017, the 50001 Ready program recognizes facilities and organizations that attest to the implementation of an ISO 50001-based energy management system. The program is a self-guided, self-paced approach for organizations to realize improvements in energy management that does not require external audits or certifications. To obtain certification, organizations are responsible for completing all 25 tasks in the 50001 Ready Navigator online tool and for measuring and improving energy performance over time. ORNL is the third federal location and the second national laboratory to receive the certification.

The program recognizes organizations that demonstrate outstanding energy management standards and best practices in their facilities. ORNL's advanced metering system aids in reporting quality energy data and enables monitoring of facility energy performance toward the goal of realizing savings in utility use and operations cost. The scope of this project involved all FMD facilities. ORNL's implementation of the 50001 Ready program is described in "Oak Ridge National Laboratory—50001 Ready Facility," a case study on the DOE Better Buildings website [here](#).

In FY 2020, FMD purchased a license for SkyFoundary's SkySpark Fault Detection and Diagnostics system and piloted the system in two buildings. Faults and key performance indicators for these buildings are now available to identify opportunities for improved performance and energy savings. Plans are being established to pursue a graded approach to the new platform while learning how to utilize the tool to its full potential.

#### **Summary of performance data for energy, water, and waste**

DOE Order 436.1 directs prime contractors to contribute to departmental sustainability goals and to manage their buildings, vehicles, and

overall operations to optimize energy and environmental performance, reduce waste, and cut costs. ORNL collects data and publishes the results in an annual sustainability report to document compliance with applicable guidance. In FY 2021, the annual SSP guidance and ORNL's submittal were updated to include modifications made as a result of executive orders and applicable federal statutes. Implementation plans for new orders as well as new and revised guidance for sustainability and efficiency goals will be the primary focus for Sustainable ORNL in the next few years. Following are current examples of sustainability performance data that are reported to DOE.

**Energy use intensity.** Based on FY 2021 data, energy use in the goal-subject buildings category at ORNL was 240,885 Btu/GSF. (See Figure 5.3.) This is a 4.5 percent increase from 2020. There has been cumulative reduction of 33.8 percent since the DOE baseline target year of FY 2003. Efforts to maintain steady progress toward energy use intensity reductions at ORNL focus on sustainable energy-efficient design in construction projects, smart repurposing of existing facilities, and continuous improvements in facility and utility operations. Modernization continues at ORNL as old energy-inefficient buildings are demolished to make way for the construction of high-performance buildings. Over the years, improvements in utilities services have reduced the costs of energy, fuel, water, and maintenance and have increased reliability in the delivery of steam, chilled water, and potable water. Energy use intensity reduction in existing ORNL facilities is data-driven, and efforts are made to quantify and bring awareness to building energy performance so that operations staff can make informed decisions. FMD pursues approaches to energy consumption awareness using data visualization and reporting. Building data analytics, including fault detection and diagnostics, are also being added to ORNL's energy conservation tools. The Utilities Division is currently conducting a comprehensive study that encompasses all major utility systems throughout the campus. The study focuses on improved operations, resiliency, and efficiency.

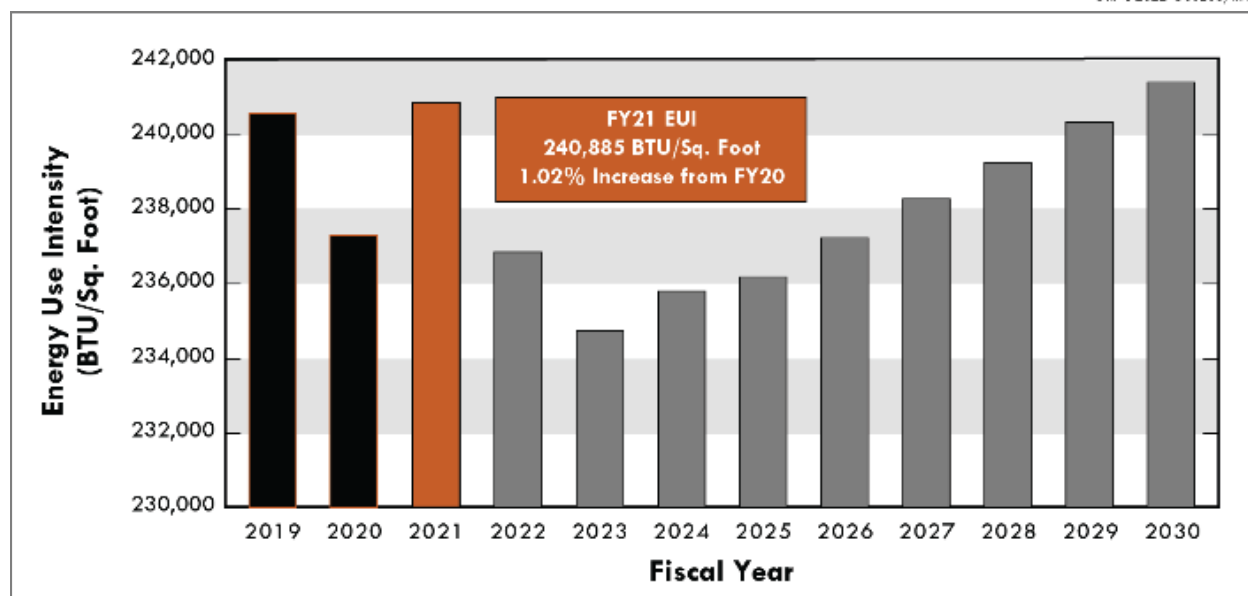


Figure 5.3. Recent, current (FY 2021), and projected energy use intensity at ORNL

**Water use intensity.** ORNL procures potable water from the City of Oak Ridge for domestic use (handwashing, flushing), cooling (cooling towers, chillers), heating (steam generation, hot water generation), laboratories, and special research processes. Well before the DOE baseline target year of 2007, numerous strategies to reduce water consumption were in place. Strategies include repairing leaks, replacing old lines in the site water distribution system, and eliminating once-through-cooling where possible. FY 2021 water consumption increased by 2.2 percent from 2020, primarily because of additional cooling tower water needed due to increases in research activities at the Spallation Neutron Source (SNS). (See Figure 5.4.) Even though water use has increased in recent years to support enhanced research facilities, total annual water use at ORNL has decreased by 23.2 percent since FY 2007. Water consumption is expected to rise to support additional high-performance computing and SNS activities. Mitigation factors (such as the comprehensive utility study being carried out by the Utilities Division to reduce costs for energy, fuel, water, and maintenance) will continue to be deployed; however, the increase in laboratory

mission growth will require a continued increase in water use intensity.

**Waste diversion.** In FY 2021, ORNL's diversion rate for municipal solid waste reached 53.7 percent, an overall improvement from the previous year; the DOE sustainability goal remained at 50 percent. Concurrently, ORNL's construction and demolition waste diversion rate for building materials and deactivation and decommissioning debris was 37.8 percent, much lower than previous performance which averaged over 70 percent due to the variability of the type of debris generated. During FY 2021, a modernization project in Building 4500N required the removal of decades-old materials containing asbestos and lead, materials that are not suitable for recycling processes. Sustainable ORNL staff plan to work with Procurement staff to continue to employ terms and conditions within construction contracts to manage construction waste and recycling. Construction and demolition waste recycle rates will vary as the proper characterization of debris dictates.

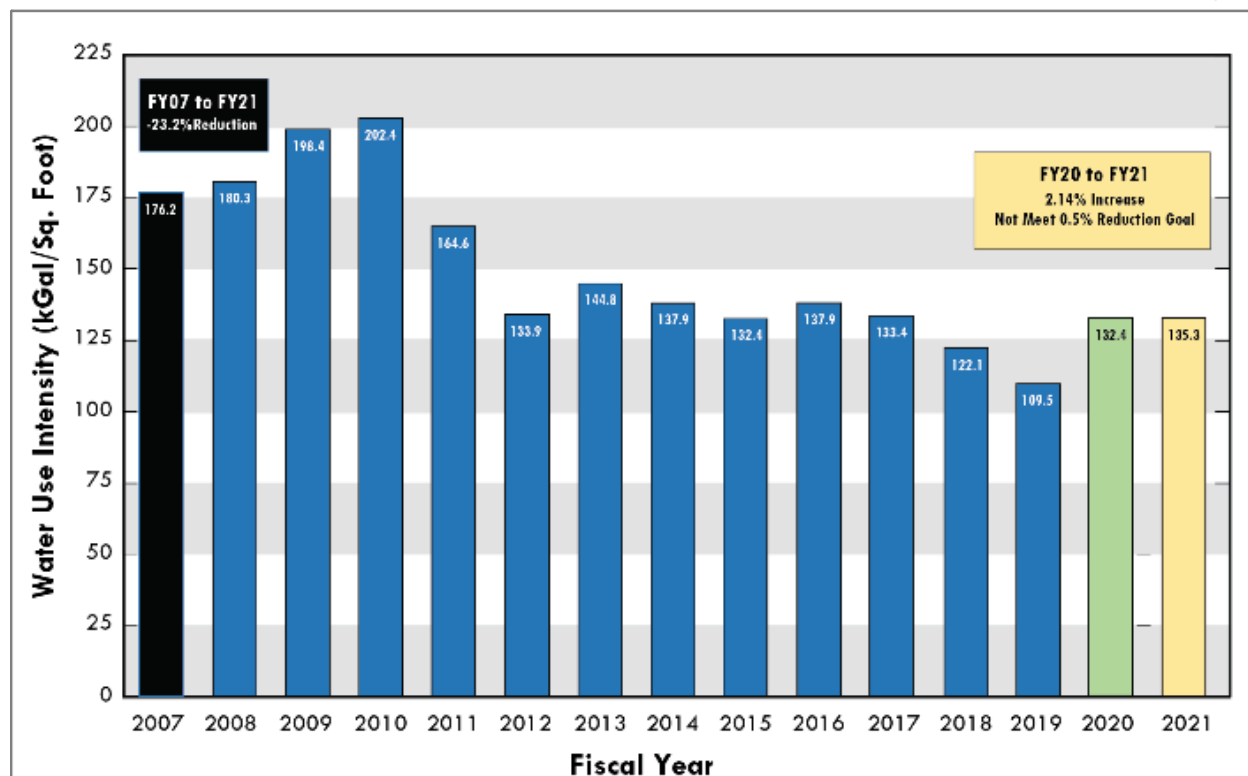
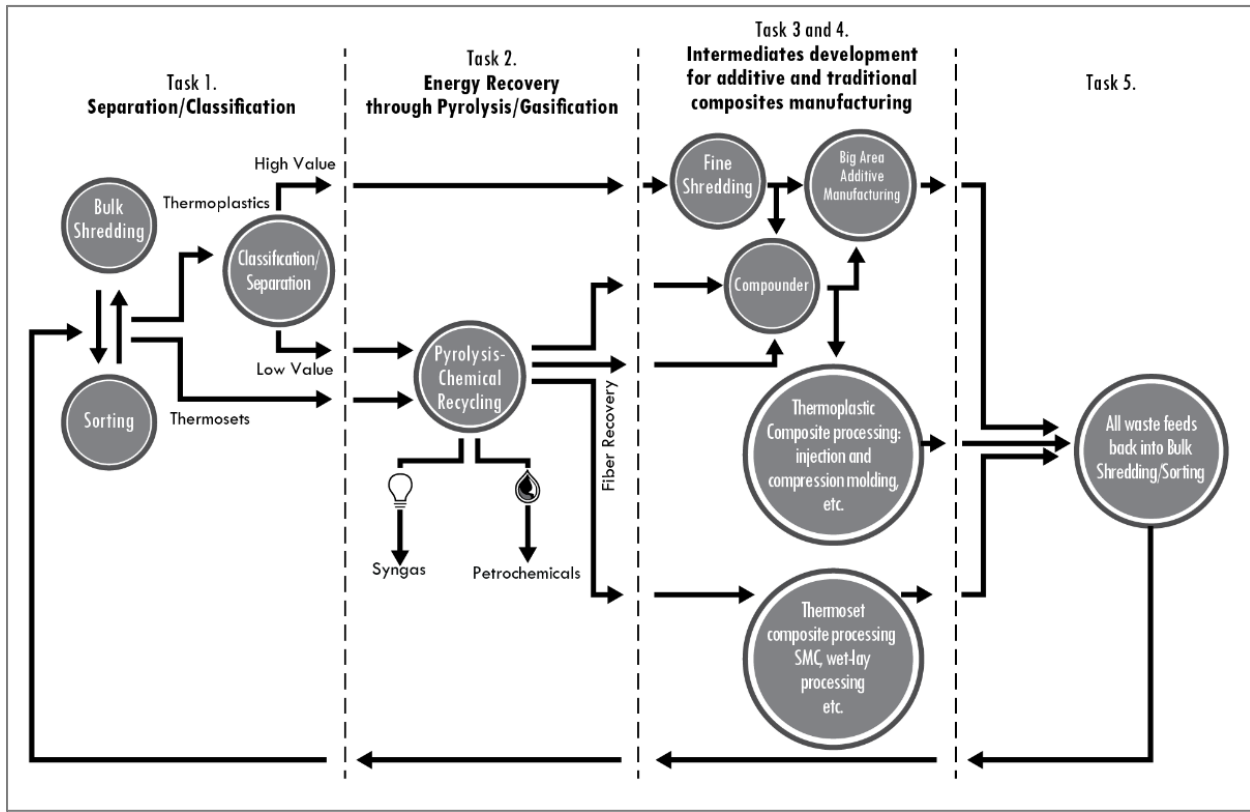


Figure 5.4. History and current (FY 2021) water use intensity at ORNL

**Pollution prevention.** Source reduction efforts at ORNL include increasing the use of acceptable nontoxic or less toxic alternative chemicals and processes while minimizing the acquisition of hazardous chemicals and materials via material substitution, operational assessments, and inventory management. In cases where the complete elimination of a particular hazardous material is not possible, a combination of actions is pursued, including controls to limit use, procurement alternatives, and recycling processes to mitigate the environmental impact. UT-Battelle implemented a total of 24 ongoing and new pollution prevention projects during 2021. These projects and ongoing reuse and recycle efforts eliminated more than 2.3 million kg of waste. Researchers at ORNL implement traditional recycling options when feasible and investigate new options when a need is identified. For instance, ORNL recycles its plastic waste through

off-site recycling when that option is available; however, ORNL researchers and commercial partners also recognize the need to close the loop on plastic recycling. The DOE Manufacturing Demonstration Facility at ORNL works with industry to conduct research focused on closing the loop on the modern material supply chain so that today's composite waste materials that are a by-product of advanced manufacturing processes become tomorrow's valuable raw materials. (See Figure 5.5).

Efforts to continue to reduce and divert the amount of material going to the landfill also include the development of contract language requiring construction contractors to recycle as much construction debris as possible. Within ORNL, the extensive use of training, awareness, presentations, and outreach encourage source reduction and recycling by all associates.



**Figure 5.5. Scheme for closing the loop of plastics manufacturing and recycling**

**Electronic stewardship.** Environmentally sound disposition (reuse or recycle) of all used electronics is accomplished at ORNL by implementing the property management and environmental management policies and procedures that are documented by resources such as SBMS. Options include transfer to other DOE contractors, nonprofit organizations, and qualified educational institutions. Traditional electronic equipment is recycled by an off-site certified recycler. These efforts continue to close the recycling loop for electronics.

**Sustainable vehicle fleet.** The ORNL vehicle fleet is leased through the General Services Administration (GSA). Leasing through GSA allows ORNL to replace older, less fuel-efficient vehicles with new alternative-fuel vehicles at a faster rate than would be possible if ORNL managed the fleet. As of the end of FY 2021, ORNL has replaced 308 vehicles in the 467-vehicle fleet with newer models. The new vehicles are more fuel-efficient; 90 percent are alternate-fuel vehicles or gas

hybrids. Furthermore, 100 percent of the light-duty vehicles operate on alternative fuels, exceeding DOE fleet management goals. Fleet managers continued to coordinate with vehicle custodians during FY 2021 to ensure vehicle rightsizing and to provide custodians with more fuel-efficient vehicles such as alternate-fuel vehicles and electric vehicles when applicable.

#### **High-performance sustainable buildings: Guiding principles**

In FY 2021, ORNL's on-site high-performance sustainable buildings (HPSBs) inventory included a total of 21 buildings that are certified by either having been grandfathered via LEED certification or having attained 100 percent of the HPSB guiding principles (GPs). This inventory meets the current DOE SSP target. Modification from prior years includes the removal of Building 3137, which was transferred from DOE SC to the DOE Environmental Management Program.

One of the ways in which ORNL achieved GP success was through a long association with the LEED certification program. Although LEED certification has been a focus for ORNL in the past, current focus is shifting to the HPSB GPs certification. LEED program information is available [here](#).

As ORNL moves forward with HPSB GPs, existing candidate buildings will be identified by Sustainable ORNL staff based on building space use, existing metering infrastructure, and known energy conservation opportunities. Action plans for achieving building-specific GPs will be developed and executed, and laboratory-wide standards will be used when feasible to fulfill applicable GP policies and procedures across multiple facilities. As experience with the GPs grows, the focus of ORNL's GP efforts remains on certifying office buildings while establishing a path for future certification in larger, more complex facilities such as laboratories and mixed-use buildings. As ORNL continues to modernize, new construction will be certified with GPs when applicable. Information about DOE's HPSB directives can be found [here](#).

#### **5.2.1.5. Storm Water Management and the Energy Independence and Security Act of 2007**

Section 438 of the Energy Independence and Security Act of 2007 (EISA) stipulates the following:

The sponsor of any development or redevelopment project involving a Federal facility with a footprint that exceeds 5,000 square feet shall use site planning, design, construction, and maintenance strategies for the property to maintain or restore, to the maximum extent technically feasible, the predevelopment hydrology of the property with regard to the temperature, rate, volume, and duration of flow (EISA 2007).

For the purposes of this provision, *development or redevelopment* is defined as follows:

any action that results in the alteration of the landscape during construction of buildings or

other infrastructure such as parking lots, roads, etc. (e.g., grading, removal of vegetation, soil compaction) such that the changes affect runoff volumes, rates, temperature, and duration of flow. Examples of projects that would fall under 'redevelopment' include structures or other infrastructure that are being reconstructed or replaced and the landscape is altered. Typical patching or resurfacing of parking lots or other travel areas would not fall under this requirement (EISA 2007).

In 2020, ORNL's approach to addressing EISA-438 requirements for storm water management was revised. Because of the soil types (low permeability) and karst geology, conditions exist at ORNL that would allow for claiming technical infeasibility, as described in technical guidance from EPA (EPA 2009b). Clay soils have low infiltrative capacities, and the introduction of more water to the subsurface in a karst geology can accelerate the formation of sinkholes. As a result of these two geological conditions at ORNL, the use of subsurface infiltration to address EISA-438 is only being pursued on a limited basis. Instead, mitigation strategies (e.g., for streams and their associated buffer zones, installation of water quality systems and devices to improve water quality, and strategies that would allow for additional evapotranspiration) are being pursued.

Implementing this revised approach to EISA-438 compliance, as opposed to claiming technical infeasibility, demonstrates ORNL's commitment to environmental stewardship. If projects take place in existing contaminated areas or where an area approach is not feasible, technical infeasibility is claimed to prevent potential movement of contamination within soil or groundwater.

When possible, this environmental stewardship approach is implemented on an area basis at ORNL. Addressing EISA-438 on an area basis, instead of a project-by-project basis, allows for the following:

- Storm water runoff from adjacent areas can be diverted around developed areas to keep water quality high.

- Water quality structures/devices can be installed to handle runoff from developed areas, therefore reducing the number of water quality structures/devices to be installed and maintained.
- Individual projects are not burdened with the costs associated with addressing EISA-438 requirements.

In 2021, several water quality improvements were completed:

- 7000 Area
  - Storm water runoff from the majority of the ridge along the southern side of the of the 7000 area was diverted to the west to prevent this water from entering the 7000 area.
  - Two water quality ponds were added, one at the western end of the 7000 area and one within the ditch that parallels Bethel Valley Road, to aid in treatment of first flush of storm water runoff and to allow infiltration and evaporation to occur.
- 6000 Area
  - A storm water detention pond for an existing paved parking lot was cleared and reconstructed. This pond will manage the majority of the runoff from the parking lot and will allow sediment to settle and cooling to occur before overflowing into the storm water system. The pond will also allow limited infiltration and evaporation to occur.

#### 5.2.1.6. Emergency Preparedness and Response

The UT-Battelle Emergency Management Program supplies the resources and capabilities to provide emergency preparedness and emergency response services. The on-site emergency management organization provides emergency call answering and dispatch, emergency medical care and transport, firefighting capability, technical rescue services, and hazardous materials release mitigation. Emergency management

personnel perform hazard surveys and hazard assessments to identify potential emergency situations. Procedures and plans have been developed to prepare for and respond to a wide variety of potential emergency situations. Training is provided to ensure appropriate response and performance during emergency events. Frequent exercises and drills are scheduled to ensure the effective execution of the procedures and plans. An environmental SME is a member of the emergency response organization. The environmental SME participates in real events, drills, and exercises to ensure that environmental requirements are met and that environmental impacts are mitigated.

#### 5.2.1.7. Environmental Management System Performance Evaluation

ISO 14001 includes requirements to monitor, measure, analyze, and regularly evaluate the performance of the EMS. EMS performance evaluations ensure that goals and objectives are being met and that opportunities to continually improve are identified.

#### *Monitoring and measurement*

UT-Battelle has developed monitoring and measurement processes for each operation or activity that can have a significant adverse effect on the environment. SBMS includes requirements for management system owners to establish performance objectives and indicators, conduct performance assessments to collect data and monitor progress, and evaluate the data to identify strengths and weaknesses in performance and areas for improvement.

#### *UT-Battelle Environmental Management System assessments*

UT-Battelle uses several methods to evaluate compliance with legal and other environmental requirements. Most of the compliance evaluation activities are implemented through the EMS or participation in line-organization assessment activities. If a nonconformance were identified, the ORNL issues-management process requires that any regulatory or management system

nonconformance be reviewed for cause and that corrective and/or preventive actions be developed. These actions would then be implemented and tracked to completion.

Environmental assessments that cover legal and other requirements are performed periodically. Additionally, management system owners are required to assess management system performance and to address issues identified from customer feedback, staff suggestions, and other assessment activities.

UT-Battelle also uses the results from numerous external compliance inspections conducted by regulators to verify compliance with requirements. In addition to regulatory compliance assessments, an internal EMS assessment is performed annually to ensure that the UT-Battelle EMS continues to conform to ISO requirements. An independent internal audit conducted in 2021 verified that the EMS conforms to ISO 14001:2015. In addition to verifying conformance, these management system assessments also identify continual improvement opportunities.

### **5.2.2. Environmental Management System for the Transuranic Waste Processing Center**

NWSol has been the prime contractor for the TWPC since 2015. The National Sanitation Foundation, International Strategic Registrations, Ltd. registered NWSol's EMS for activities at the TWPC to the ISO 14001:2015 standard (ISO 2015) in May 2020. The EMS is integrated with ISMS to provide a unified strategy for the management of resources, the control and reduction of risks, and the establishment and achievement of the organization's ES&H goals. The EMS and ISMS are incorporated into the *Integrated Safety Management System Description* (BJC 2009), and a plan-do-check-act cycle is used for continual improvement in both. National Sanitation Foundation, International Strategic Registrations, Ltd. conducted a recertification audit in August 2021. No nonconformances or issues were identified, and several significant practices were noted.

The NWSol EMS for the TWPC incorporates applicable environmental laws, DOE orders, and other requirements (i.e., DOE directives and federal, state, and local laws) according to internal NWSol documentation that describes how the various requirements are incorporated into subject area documents (procedures and guidelines). The EMS assists NWSol line organizations in identifying and addressing environmental issues.

Environmental aspects are elements of an organization's activities, products, or services that can interact with the environment. NWSol has identified environmental aspects associated with TWPC activities, products, and services at both the project and activity level and has identified waste management activities, air emissions, storm water, pollution prevention, habitat alteration, and energy as potentially having significant environmental impacts. Activities that are related to any of those environmental aspects are carefully controlled to minimize or eliminate impacts to the environment. NWSol has established and implemented objectives and measurable performance indicators for the targets associated with the identified significant impacts.

The pollution prevention programs at TWPC involve waste reduction efforts and implementation of sustainable practices that reduce the environmental impacts of the activities conducted at TWPC. The TWPC EMS establishes annual goals and targets to reduce the impact of TWPC's environmental aspects.

NWSol has a well-established recycling program at TWPC and continues to identify new material-recycling streams and to expand the types of materials included in the program. Currently, recycle streams at TWPC range from office materials such as paper, aluminum cans, plastic drinking bottles, foam beverage cups, alkaline batteries, and toner cartridges to operations-oriented materials such as cardboard, lamps, circuit boards, used oil, and batteries. The single stream recycling program established by NWSol allows the mixing of multiple types of recyclables and thus increases the amount of recyclable items and improves compliance.



“Environmentally preferable purchasing” is a term used to describe an organization’s policy to reduce packaging and to purchase products made with recycled material or bio-based materials and other environmentally friendly products. NWSol ensures that environmentally preferable products are purchased by incorporating the “green” procurement requirements in NWSol procurement procedures.

NWSol uses several methods to evaluate compliance with legal and other requirements. Most of these compliance evaluation activities are implemented by internal and external environmental and management assessment activities and by routine reporting and reviews. NWSol also uses the results from numerous external compliance inspections conducted by regulators and contractors to verify compliance with requirements.

### 5.2.3. Environmental Management System for Isotek

Isotek has developed and implemented an EMS for the U-233 Disposition Project that reflects the elements and framework found in the ISO 14001:2004 standard (ISO 2004) and satisfies the applicable requirements of DOE Order 450.1A, *Environmental Protection Program* (DOE 2008). The scope of the Isotek EMS is to achieve and demonstrate environmental excellence by identifying, assessing, and controlling the impact of Isotek activities and facilities on the environment. The EMS is designed to ensure compliance with environmental laws, regulations, and other applicable requirements and to improve effectiveness and efficiency, reduce costs, and earn and retain regulator and community trust. The Isotek EMS and ISMS are fully integrated.

Project procedures provide a systematic approach to integrating environmental considerations into all aspects of Isotek’s activities at ORNL. The Isotek EMS includes a procedure for identifying environmental aspects associated with the U-233 Disposition Project and for determining whether those aspects can have significant environmental impacts. Isotek has identified radiological air emissions as the only environmental aspect of its

operations that has potentially significant environmental impacts and has developed an environmental management plan with measurable objectives and targets to address that aspect. Isotek reviews environmental aspects, potential impacts, objectives, targets, and its environmental management plan at least annually and updates them as necessary.

The U-233 Disposition Project has a well-established recycling program that is implemented at all Isotek-managed facilities and includes Buildings 3017, 3019 Complex, 2026, and 3137. The materials currently recycled by Isotek include paper, cardboard, aluminum cans, plastic bottles, inkjet and toner cartridges, lamps, batteries, scrap metal, circuit boards, aerosol cans, and used oil.

To evaluate compliance with legal and other requirements, Isotek conducts an EMS audit every 3 years, annual management assessments, and periodic surveillances. Compliance with requirements is also evaluated through inspections performed by regulatory agencies. The results of the compliance evaluations are used for continual improvement of the EMS.

## 5.3. Compliance Programs and Status

During 2021 UT-Battelle, UCOR, NWSol, and Isotek operations were conducted to comply with contractual and regulatory environmental requirements. Table 5.1 presents a summary of environmental audits conducted at ORNL in 2021. The following discussions summarize the major environmental programs and activities carried out at ORNL during 2021 and provide an overview of the compliance status for the year. Summary information on 2021 noncompliances at ORNL is also available under Federal Services Registry ID number 110002040201 on EPA’s Enforcement and Compliance History Online website [here](#).

### 5.3.1. Environmental Permits

Table 5.2 contains a list of environmental permits that were in effect in 2021 at ORNL.

**Table 5.1. Summary of regulatory environmental audits, evaluations, inspections, and assessments conducted at ORNL, 2021**

Date	Reviewer	Subject	Issues
March 10–11	TDEC	Hazardous Waste Compliance Evaluation Inspection (including UT-Battelle, Transuranic Waste Processing Center, and UCOR)	1
March 16-17	TDEC	National Pollutant Discharge Elimination System Permit TN0002941 Compliance Inspection	0
March 9	City of Oak Ridge	CFTF Wastewater Inspection	0
July 21	KCDAQM	National Transportation Research Center Clean Air Act Inspection	0
July 22	City of Oak Ridge	CFTF Wastewater Inspection	0

**Acronyms:**

TDEC = Tennessee Department of Environment and Conservation

KCDAQM = Knox County Department of Air Quality Management

CFTF = Carbon Fiber Technology Facility

**5.3.2. National Environmental Policy Act/National Historic Preservation Act**

NEPA provides a means to evaluate the potential environmental impact of proposed federal activities and to examine alternatives to those actions. UT-Battelle, NWSol, and Isotek maintain compliance with NEPA using site-level procedures and program descriptions that establish effective and responsive communications with program managers and project engineers to establish NEPA as a key consideration in the formative stages of project planning. Table 5.3 summarizes NEPA activities conducted at ORNL during 2021.

During 2021, UT-Battelle and NWSol continued to operate under site-level procedures that provide requirements for project reviews and NEPA compliance. The procedures call for a review of each proposed project, activity, or facility to determine the potential for impacts to the environment. To streamline the NEPA review and documentation process, the DOE has approved generic categorical exclusion determinations that cover proposed bench-scale and pilot-scale research activities and generic categorical exclusions that cover proposed nonresearch activities (e.g., maintenance activities, facilities upgrades, personnel safety enhancements). A categorical exclusion is one of a category of

actions defined in 40 CFR 1508.4 that does not individually or cumulatively have a significant effect on the human environment and for which neither an environmental assessment nor an environmental impact statement is normally required.

UT-Battelle uses SBMS as the delivery system for guidance and requirements to manage and control work at ORNL. NEPA is an integral part of SBMS, and a UT-Battelle NEPA coordinator works with principal investigators, environmental compliance representatives, and environmental protection officers within each UT-Battelle division to determine appropriate NEPA decisions.

Compliance with the National Historic Preservation Act (NHPA 1966) is achieved and maintained at ORNL in conjunction with NEPA compliance. The scope of proposed actions is reviewed in accordance with the ORR cultural resource management plan (Souza et al. 2001).

**5.3.3. Clean Air Act Compliance Status**

The Clean Air Act (CAA 1970), passed in 1970 and amended in 1977 and 1990, forms the basis for the national air pollution control effort. This legislation established comprehensive federal and state regulations to limit air emissions.

Table 5.2. Environmental permits in effect at ORNL in 2021

Regulatory driver	Permit title/description	Permit number	Owner	Operator	Responsible contractor
CAA	Title V Major Source Operating Permit, ORNL	571359	DOE	UT-B	UT-B
CAA	Operating Permit, NTRC	17-0941-R1	DOE	UT-B	UT-B
CAA	Operating Permit, NWSol	071009P	DOE	NWSol	NWSol
CAA	Construction Permit, 3525 Area Off Gas System	971543P	DOE	UT-B	UT-B
CAA	Operating Permit, NWSol emergency generators	071010P	DOE	NWSol	NWSol
CAA	Title V Major Source Operating Permit, ORNL	569768	DOE	UCOR	UCOR
CAA	CFTF CAA Operating Permit (Conditional Major)	474951	DOE	UT-B	UT-B
CAA	Construction Permit, NTRC	C-21-0941-02-01	DOE	UT-B	UT-B
CAA	CAA Title V Operating Permit for Isotek operations at ORNL	576448	DOE	Isotek	Isotek
CWA	ORNL NPDES Permit (ORNL sitewide wastewater discharge permit)	TN0002941	DOE	DOE	UT-B, UCOR, NWSol, Isotek
CWA	Industrial and Commercial User Waste Water Discharge Permit (CFTF)	1-12	UT-B	UT-B	UT-B
CWA	General NPDES Permit for Storm Water Discharges Associated with Craft Resources Support Facility Construction Activities	TNR136355	DOE	UT-B	UT-B
CWA	General NPDES Permit for Stormwater for ORNL Experimental Gas Cooled Reactor Parking Lot	TNR136470	DOE	UT-B	UT-B
CWA	Tennessee Operating Permit, Holding Tank/Haul System for Domestic Wastewater	SOP-07014	UCOR	UCOR	UCOR
CWA	Tennessee Operating Permit (sewage)	SOP-02056	DOE	NWSol	NWSol
CWA <sup>a</sup>	Construction Storm Water Permit—Leadership Imaging Facility Building	TNR 135602	DOE	UT-B	UT-B
CWA <sup>a</sup>	Aquatic Resources Alteration Permit—Leadership Imaging Facility Building	ARAP-NR1803.153	DOE	UT-B	UT-B
CWA <sup>a</sup>	ARAP—General Permit for Maintenance of the Swan Pond Water Feature 5007	NR1903.038	DOE	UT-B	UT-B
CWA <sup>a</sup>	Notice of Coverage Under the General NPDES Permit for Storm Water for 2000–3000 Area Utility Modernization	TNR136015	DOE	UT-B	UT-B

Table 5.2. Environmental permits in effect at ORNL in 2021 (continued)

Regulatory driver	Permit title/description	Permit number	Owner	Operator	Responsible contractor
CWA <sup>a</sup>	Notice of Coverage Under the General NPDES Permit for Storm Water for OLCF-5 Power Line	TNR135839	DOE	UT-B	UT-B
CWA <sup>a</sup>	NWP-12 – Utility Line Activities for OLCF-5 Power Line	LNR-2019-00571	UT-B	UT-B	UT-B
CWA	TVA Section 26A Permit for OLCF-5 Power Line	TVA 4003683	UT-B	UT-B	UT-B
CWA	Notice of Coverage Under the General NPDES Permit for Storm Water for 7000 Area Infrastructure Modernization	TNR136181	DOE	UT-B	UT-B
CWA <sup>a</sup>	Notice of Coverage Under the General NPDES Permit for Storm Water for TRC Project	TNR136285	DOE	UT-B	UT-B
CWA	Notice of Coverage Under the General NPDES Permit for Stormwater for 6000 Area East Hillside Parking Lot Restoration (2 acres)	TNR136520	DOE	UT-B	UT-B
RCRA	Hazardous Waste Transporter Permit	TN1890090003	DOE	UT-B	UT-B, UCOR
RCRA	Hazardous Waste Corrective Action Permit	TNHW-164	DOE	DOE/dll	DOE/dll
RCRA	Hazardous Waste Storage and Treatment Permit	TNHW-145	DOE	DOE/ UCOR/ NWSol	UCOR/NWSol
RCRA	Hazardous and Mixed Waste Storage Permit	TNHW-178	DOE	DOE/UT-B	UT-B
PCB	PCB Risk Based Agreement between UTB and EPA	TN1890090003	DOE	UT-B	UTB

<sup>a</sup> Permit terminated during 2021.

**Acronyms:**

ARAP = Aquatic Resources Alteration Permit

CAA = Clean Air Act

CFTF = Carbon Fiber Technology Facility

CWA = Clean Water Act

DOE = US Department of Energy

Isotek = Isotek Systems, LLC

NPDES = National Pollutant Discharge Elimination System

NTRC = National Transportation Research Center

NWSol = North Wind Solutions, LLC

OLCF = Oak Ridge Leadership Computing Facility

PCB = Polychlorinated Biphenyl

RCRA = Resource Conservation and Recovery Act

TRC = Translational Research Capability

UT-B = UT-Battelle LLC

**Table 5.3. National Environmental Policy Act activities, 2021**

Types of NEPA documentation	Number of instances
<b>UT-Battelle LLC</b>	
Approved under general actions or generic CX determinations <sup>a</sup>	108
Project-specific CX determinations <sup>b</sup>	0
<b>North Wind Solutions, LLC</b>	
Approved under general actions <sup>a</sup> or generic CX determinations	2

<sup>a</sup> Projects that were reviewed and documented through the site NEPA compliance coordinator

<sup>b</sup> Projects that were reviewed and approved through the DOE Site Office and the NEPA compliance officer

**Acronyms:**

CX = categorical exclusion

DOE = US Department of Energy

NEPA = National Environmental Policy Act

It includes four major regulatory programs: the national ambient air quality standards, state implementation plans, new source performance standards, and Rad-NESHAPs. Airborne discharges from DOE Oak Ridge facilities, both radioactive and nonradioactive, are subject to regulation by the US Environmental Protection Agency (EPA) and the Tennessee Department of Environment and Conservation (TDEC) Division of Air Pollution Control. The most recent sitewide UT-Battelle Title V Major Source Operating Permit was issued in October 2021. The Title V Major Source Operating Permit for the 3039 stack, operated by UCOR, will be renewed in 2022. To demonstrate compliance with the Title V major source operating permits, more than 1,500 data points are collected and reported every year. In addition, nitrogen oxides, a family of poisonous, highly reactive gases and defined collectively as a criteria pollutant by the EPA (EPA 2016), are monitored continuously at one location. Samples are collected continuously from 8 major radionuclide sources and periodically from 14 minor radionuclide sources. There are numerous other demonstrations of compliance with generally applicable air quality protection requirements (e.g., asbestos, stratospheric ozone).

NTRC and CFTF are two off-site CAA-regulated facilities maintained and operated by UT-Battelle. An operating permit, issued by Knox County for two emergency generators located at NTRC, was issued in January 2020. The CFTF operates under

a conditional major operating permit issued to UT-Battelle by TDEC in February 2020.

In summary, there were no UT-Battelle CAA violations and no Isotek, UCOR, or NWSol CAA violations or exceedances in 2021. Section 5.4. provides detailed information on 2021 activities conducted by UT-Battelle in support of the CAA.

**5.3.4. Clean Water Act Compliance Status**

The objective of the Clean Water Act (CWA 1972) is to restore, maintain, and protect the integrity of the nation’s waters. The CWA serves as the basis for comprehensive federal and state programs to protect the nation’s waters from pollutants. (See Appendix C for water quality reference standards.). One of the strategies developed to achieve the goals of CWA was the EPA’s establishment of limits on specific pollutants allowed to be discharged to US waters by municipal sewage treatment plants (STPs) and industrial facilities. EPA established the National Pollutant Discharge Elimination System (NPDES) permitting program to regulate compliance with pollutant limitations. The program was designed to protect surface waters by limiting effluent discharges into streams, reservoirs, wetlands, and other surface waters. EPA has delegated authority for implementation and enforcement of the NPDES program to the state of Tennessee.

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In 2021, compliance with the ORNL NPDES permit was calculated based on the total 1,736 required laboratory analyses and field measurements. ORNL wastewater treatment facilities achieved a numeric permit compliance rate of more than

99 percent in 2021 (see Table 5.4). One numeric noncompliance was reported for the Sewage Treatment Plant effluent (X01) in March 2021 with an E. coli result greater than 2,420 MPN/100 mL. The permit limit is 941 MPN/100 mL.

**Table 5.4. National Pollutant Discharge Elimination System compliance at ORNL, January through December 2021**

Effluent parameters <sup>a,b</sup>	Number of numeric noncompliances	Number of compliance measurements <sup>c</sup>	Percentage of compliance <sup>d</sup>
<b>X01 (Sewage Treatment Plant)</b>			
IC <sub>25</sub> Static renewal 7-day chronic <i>Ceriodaphnia dubia</i> (%)	0	1	100
IC <sub>25</sub> Static renewal 7-day chronic <i>Pimephales promelas</i> (%)	0	1	100
Ammonia, as N (summer)	0	26	100
Ammonia, as N (winter)	0	26	100
Carbonaceous biological oxygen demand	0	52	100
Dissolved oxygen	0	52	100
<i>Escherichia coliform</i> (col/100 mL)	1	52	100
Peracetic acid	0	5	100
pH (standard units)	0	52	100
Total suspended solids	0	52	100
<b>X12 (Process Waste Treatment Complex)</b>			
IC <sub>25</sub> Static renewal 7-day chronic <i>Ceriodaphnia dubia</i> (%)	1	2	50
IC <sub>25</sub> Static renewal 7-day chronic <i>Pimephales promelas</i> (%)	0	1	100
Oil and grease	0	4	100
pH (standard units)	0	52	100
Temperature (°C)	0	52	100
<b>X16 through X27 (twelve instream monitoring locations)</b>			
Total residual oxidant	0	288	100
<b>X28 and X29 (two additional instream monitoring locations)</b>			
Peracetic acid	0	10	100
Hydrogen peroxide	0	10	100

<sup>a</sup> Only permit parameters with a numerical limit are listed.

<sup>b</sup> The inhibition concentration (IC<sub>25</sub>) is the concentration (as a percentage of full-strength wastewater) that reduces survival or reproduction of the test species by 25 percent when compared to a control treatment.

<sup>c</sup> Total number of readings taken in the year by approved method for the given parameter.

<sup>d</sup> Percentage compliance = 100 - [(number of noncompliances/number of samples) × 100].

A second numeric noncompliance was reported for the Process Waste Treatment Complex (Outfall X12) in June 2021 when the annual whole effluent toxicity test was less than the NPDES permit limit of greater than 44.3 percent effluent for *Ceriodaphnia* reproduction. A follow-up test was initiated within 7 days per the testing requirements in the permit and passed at greater than 44.3 percent.

In November 2021, water from a 6 in. water line break was released into White Oak Creek (WOC) and caused aquatic species mortality (total of five crayfish). This incident was reported as a noncompliance with narrative criteria in the permit.

ORNL received a renewed NPDES permit in May 2019. Several conditions in the permit were appealed and remained unresolved during 2021.

### 5.3.5. Safe Drinking Water Act Compliance Status

ORNL's water distribution system is designated as a "non-transient, non-community" public water system by the TDEC Division of Water Supply. TDEC's water supply rules, Chapter 0400-45-01, "Public Water Systems" (TDEC 2020), set limits for biological contaminants and for chemical activities and chemical contaminants. TDEC requires sampling for the following constituents for compliance with state and federal regulations:

- Residual chlorine
- Bacteria (total coliform)
- Disinfectant by-product (trihalomethanes and haloacetic acids)
- Lead and copper (required once every 3 years)

The City of Oak Ridge supplies potable water to the ORNL water distribution system and meets all regulatory requirements for drinking water. The water treatment plant, located on ORR, north of the Y-12 Complex, is owned and operated by the City of Oak Ridge.

In 2021, sampling results for ORNL's water system residual chlorine levels, bacterial constituents, and disinfectant by-products were all within acceptable limits. Sampling for lead and copper is not required until 2024.

### 5.3.6. Resource Conservation and Recovery Act Compliance Status

The Hazardous Waste Program under the Resource Conservation and Recovery Act (RCRA 1976) establishes a system for regulating hazardous wastes from the initial point of generation through final disposal. In Tennessee, TDEC has been delegated authority by EPA to implement the Hazardous Waste Program; EPA retains an oversight role. In 2021, DOE and its contractors at ORNL were jointly regulated as a "large-quantity generator of hazardous waste" under EPA ID TN1890090003 because, collectively, they generated more than 1,000 kg of hazardous/mixed wastes in at least one calendar month during 2021.

Mixed wastes are both hazardous (under RCRA regulations) and radioactive. Hazardous/mixed wastes are accumulated in satellite accumulation areas or in less-than-90-day accumulation areas and are stored and/or treated in RCRA-permitted units. In addition, hazardous/mixed wastes are shipped off site for treatment and disposal. The RCRA units operate under three permits at ORNL, as shown in Table 5.5. In 2021, UT-Battelle and UCOR were permitted to transport hazardous wastes under the EPA ID number issued for ORNL activities. TNHW-164 is a set of conditions pertaining to the current status of all solid waste management units and areas of concern at ETTP, ORNL, and the Y-12 Complex. The corrective action conditions require that the solid waste management units and areas of concern be investigated and, as necessary, remediated.

Reporting is required for hazardous waste activities on 12 active waste streams at ORNL, some of which involve mixed wastes. The quantity of hazardous/mixed waste generated at ORNL in 2021 was 798,638 kg; mixed wastewater accounted for 554,094 kg.

**Table 5.5. ORNL Resource Conservation and Recovery Act operating permits, 2021**

Permit number	Storage and treatment/description
<b>Oak Ridge National Laboratory</b>	
TNHW-178	Building 7651 Container Storage Unit Building 7652 Container Storage & Treatment Unit Building 7653 Container Storage Unit Building 7654 Container Storage & Treatment Unit
TNHW-145	Building 7572 Contact-Handled Transuranic Waste Storage Facility Building 7574 Transuranic Storage Facility Building 7855 Remote-Handled Transuranic Retrievable Storage Facility Building 7860A Remote-Handled Transuranic Retrievable Storage Facility Building 7879 Transuranic/Low Level Waste Storage Facility Building 7883 Remote-Handled Transuranic Storage Bunker Building 7831F Flammable Storage Unit <sup>a</sup> Transuranic Waste Processing Center (TWPC)-1 Contact-Handled Storage Area TWPC-2 Waste Processing Building Second Floor TWPC-3 Drum Aging Criteria Area TWPC-4 Waste Processing Building First Floor TWPC-5 Container Storage Area TWPC-6 Contact-Handled Marshaling Building TWPC-7 Drum-Venting Building TWPC-8 Multipurpose Building T-1 <sup>a</sup> Macroencapsulation Treatment T-2 <sup>a</sup> Solidification/Stabilization Treatment T-3 <sup>a</sup> Amalgamation Treatment T-4 <sup>a</sup> Groundwater Absorption Treatment T-5 <sup>a</sup> Size Reduction T-6 <sup>a</sup> Groundwater Filtration Treatment T-7 <sup>a</sup> Neutralization T-8 <sup>a</sup> Oxidation/Deactivation
<b>Oak Ridge Reservation</b>	
TNHW-164	Hazardous Waste Corrective Action Document

<sup>a</sup> Treatment methodologies within Transuranic Waste Processing Center facilities.

ORNL generators treated 3513 kg of hazardous waste by elementary neutralization. The quantity of hazardous/mixed waste treated in permitted treatment facilities at ORNL in 2021 was 556,075 kg. This included waste treated by macroencapsulation, size reduction, stabilization/solidification, and wastewater treatment at the Process Waste Treatment Complex (PWTC). The amount of hazardous/mixed waste shipped off site to commercial treatment, storage, and disposal facilities was 220,367 kg in 2021.

In March 2021, TDEC Division of Solid Waste Management conducted a Hazardous Waste Compliance Evaluation inspection of the following:

- ORNL generator areas
- Used oil storage areas
- Universal waste collection areas
- RCRA-permitted treatment, storage, and disposal facilities
- Hazardous waste training records



- Site-specific contingency plans
- Hazardous Waste Reduction Plan
- RCRA records

TDEC also reviewed the Hazardous Waste Transporter Permit, hazardous waste manifests and US Department of Transportation training records. One violation was identified: one satellite container was found open. The 30 gal container was used to collect waste aerosol can residue when cans were punctured prior to recycling. The operator corrected the violation when identified, returning the facility to compliance, so no follow-up inspections were conducted.

DOE and UT-Battelle operations at the HVC and CFTF were categorized as *very small-quantity generators* in 2021, meaning that less than 100 kg of hazardous waste was generated per month. Hazardous waste generator regulations allow very small-quantity generators to conduct one planned or unplanned episodic event in a year. An *episodic event* is defined as an activity that does not normally occur during a generator's operations and that causes that generator to exceed the threshold for its normal generator category for that month. On December 9, 2021, an unplanned episodic event occurred at the HVC, generating 188 kg of filters and associated personal protective equipment. Initial email notification was made to the TDEC Hazardous Waste Program manager, and to the TDEC manager of the Waste Activity Audit and RCRA Update Sections on Friday December 10, 2021. Official documentation was delivered to TDEC on December 17, 2021.

In 2021, no hazardous/mixed wastes were generated, accumulated, or shipped by DOE or UT-Battelle from the Jones Island Road 0800 Area, Property Sales, or the DOE Office of Scientific and Technical Information.

#### 5.3.7. ORNL RCRA-CERCLA Coordination

The Federal Facility Agreement for the Oak Ridge Reservation (DOE 1992) is intended to coordinate the corrective action processes of RCRA required under the Hazardous and Solid Waste Amendments permit with CERCLA response

actions. Annual updates for 2020 for ORNL's solid waste management units and areas of concern were consolidated with updates for ETTP, the Y-12 Complex, and ORR and were reported to TDEC, DOE, and the EPA Region 4 in January 2021.

Periodic updates of proposed construction and demolition activities of facilities at ORNL have been provided to managers and project personnel from the TDEC Remediation Division and EPA Region 4. A CERCLA screening process is used to identify proposed construction and demolition projects and facilities that warrant CERCLA oversight. The goal is to ensure that modernization efforts do not adversely affect the effectiveness of previously completed CERCLA environmental remediation actions and that they do not adversely affect future CERCLA environmental remediation actions.

#### 5.3.7.1. CERCLA Activities in Bethel Valley

In 2021, field work was completed on an upgrade project in the 3000 area to address aging utilities that provide electrical service and manage potable water, steam, storm water, and wastewater. Although utilities work is typically considered routine maintenance and is not performed under CERCLA, the 3000 area utilities upgrade project is large scale and has the potential to generate significant volumes of soils that may be contaminated from legacy research and development and may be remediated as a consequence of the utilities modernization efforts. Contaminated soil removed as a consequence of utilities modernization is not an attempt to address the exposure unit.

Characterization of the area was completed in 2019, and data were evaluated against remediation levels defined in the Bethel Valley Interim Record of Decision to identify the required cleanup scope. No maximum or average remediation level exceedances occurred in the surface soil or subsurface soil intervals. However, radiologically contaminated soil (below remediation levels but above free release criteria) was removed during the installation of underground steam, compressed air, and potable water services that could not be accepted at the

ORR Landfill. An addendum to the approved Waste Handling Plan was developed and approved.

A technical memorandum was developed to address utilities modernization within Bethel Valley. The document details the process for characterization activities, data evaluation to identify areas where contaminated soil will be removed to meet CERCLA requirements under the Bethel Valley Interim Record of Decision and the ORNL Soils and Sediments Remedial Design Report/Remedial Action Work Plan, and the estimated soil volumes to be removed and disposed of at the Environmental Management Waste Management Facility (EMWMF). Following completion of waste disposal, a phased construction completion report will be developed and submitted to document completed actions, final waste volumes, and waste disposition.

#### **5.3.7.2. RCRA Underground Storage Tanks**

Underground storage tanks (USTs) containing petroleum and hazardous substances are regulated under RCRA Subtitle I (40 CFR 280). TDEC has been granted authority by EPA to regulate USTs containing petroleum under TDEC Rule 400-18-01; however, hazardous-substance USTs are still regulated by EPA.

ORNL has two USTs registered with TDEC under Facility ID 0-730089. These USTs are in service (petroleum) and meet the current UST standards. No compliance inspections by TDEC occurred in 2021.

#### **5.3.8. CERCLA Compliance Status**

CERCLA, also known as Superfund, was passed in 1980 and was amended in 1986 by the Superfund Amendments and Reauthorization Act (SARA 1986). Under CERCLA, a site is investigated and remediated if it poses significant risk to health or the environment. The EPA National Priorities List is a comprehensive list of sites and facilities that have been found to pose a sufficient threat to human health and/or the environment to warrant cleanup under CERCLA.

In 1989, ORR was placed on the National Priorities List. In 1992, the ORR Federal Facility Agreement became effective among EPA, TDEC, and DOE and established the framework and schedule for developing, implementing, and monitoring remedial actions (RAs) on ORR. UCOR operates the on-site CERCLA Environmental Management Waste Management Facility (EMWMF) for DOE. Located in Bear Creek Valley, the EMWMF is used for disposal of waste resulting from CERCLA cleanup actions on ORR, including ORNL. The EMWMF is an engineered landfill that accepts low-level radioactive, hazardous, asbestos, and polychlorinated biphenyl (PCB) wastes and combinations of the wastes in accordance with specific waste acceptance criteria under an agreement with state and federal regulators.

#### **5.3.9. Toxic Substances Control Act Compliance Status**

PCB uses and waste at ORNL are regulated under the Toxic Substance Control Act (TSCA). PCB waste generation, transportation, and storage at ORNL are reported under EPA ID TN1890090003. In 2021, UT-Battelle operated six PCB waste storage areas. When longer-term storage was necessary, PCB/radioactive wastes were stored in RCRA-permitted storage buildings at ORNL. One of the PCB waste storage areas was operated at a UT-Battelle facility in the Y-12 Complex. The continued use of authorized PCBs in electrical systems and/or equipment (e.g., transformers, capacitors, rectifiers) is regulated at ORNL. Most of the equipment at ORNL that required regulation under TSCA has been dispositioned. However, some of the ORNL facilities at the Y-12 Complex continue to use (or store for future reuse) PCB equipment.

Because of the age of many of the ORNL facilities and the continued presence of PCBs in gaskets, grease, building construction, and equipment, DOE self-disclosed unauthorized use of PCBs to EPA in the late 1980s. As a result, DOE and ORNL contractors negotiated a compliance agreement with EPA (see Chapter 2, Table 2.1, under “Toxic Substances Control Act”) to address the compliance issues related to these unauthorized

uses and to allow for continued use pending decontamination or disposal. As a result of that agreement, DOE continues to notify EPA when additional unauthorized uses of PCBs, such as PCBs in paint, adhesives, electrical wiring, or floor tile, are identified at ORNL. No new unauthorized uses of PCBs were identified during 2021.

**5.3.10. Emergency Planning and Community Right-to-Know Act Compliance Status**

The Emergency Planning and Community Right-to-Know Act (EPCRA 1986) and Title III of SARA require that facilities report inventories and releases of certain chemicals that exceed specific release thresholds. The inventory report is submitted to the Emergency Response Information System (E-Plan), which is an electronic database managed by the University of

Texas at Dallas and funded by the US Department of Homeland Security. The State of Tennessee Emergency Response Commission has access to ORNL EPCRA data via the E-Plan system.

Table 5.6 describes the main elements of EPCRA. UT-Battelle complied with these requirements in 2021 through the submittal of reports under EPCRA Sections 302, 303, 311, 312, and 313. The reports contain information on all DOE prime contractors and their subcontractors who reported activities at the ORNL site.

ORNL had no releases of extremely hazardous substances, as defined by EPCRA in 2021. Releases of toxic chemicals that were greater than the reportable threshold quantities designated in Section 313 are discussed in Section 5.3.10.2.

**Table 5.6. Main elements of the Emergency Planning and Community Right-to-Know Act**

Title	Description
Sections 302 and 303, Planning Notification	Requires that local planning committee and state emergency response commission be notified of EPCRA-related planning
Section 304, Extremely Hazardous Substance Release Notification	Addresses reporting to state and local authorities of off-site releases
Sections 311–312, Safety Data Sheet/Chemical Inventory	Requires that either safety data sheets or lists of hazardous chemicals for which they are required be provided to state and local authorities for emergency planning. Requires that an inventory of hazardous chemicals maintained in quantities over thresholds be reported annually to EPA
Section 313, Toxic Chemical Release Reporting	Requires that releases of toxic chemicals be reported annually to EPA

**Acronyms:**

EPA = US Environmental Protection Agency

EPCRA = Emergency Planning and Community Right-to-Know Act

**5.3.10.1. Safety Data Sheet/Chemical Inventory (Section 312)**

Inventories, locations, and associated hazards of hazardous chemicals and/or extremely hazardous substances were submitted in an annual report to the E-Plan as required by the state of Tennessee. In 2021, there were 20 hazardous and/or extremely hazardous substances at ORNL that met EPCRA reporting criteria.

Private-sector lessees were not included in the 2021 submittals. Under the terms of their leases,

lessees must evaluate their own inventories of hazardous and extremely hazardous chemicals and must submit information as required by the regulations.

**5.3.10.2. Toxic Chemical Release Reporting (EPCRA Section 313)**

DOE submits annual toxic release inventory reports to EPA and the Tennessee Emergency Management Agency on or before July 1 of each year. The reports cover the previous calendar year and track the management of certain chemicals

that are released to the environment and/or managed through recycling, energy recovery, and treatment. (A release of a chemical means that it is emitted to the air or water or that it is placed in some type of land disposal.) Operations involving certain chemicals were compared with regulatory reporting thresholds to determine which chemicals exceeded individual thresholds on amounts manufactured, amounts processed, or amounts otherwise used. Releases and other waste management activities were determined for each chemical that exceeded one or more threshold.

In 2021, ORNL exceeded the reporting threshold and reported on the manufacture of nitrate compounds. Nitrate compounds were coincidentally manufactured as by-products of on-site sewage treatment.

#### **5.3.11. US Department of Agriculture/Tennessee Department of Agriculture**

USDA, through Animal and Plant Health Inspection Services, issues permits for the import, transit, and controlled release of regulated animals, animal products, veterinary biologics, plants, plant products, pests, organisms, soil, and genetically engineered organisms. The Tennessee Department of Agriculture issues agreements and jointly regulates domestic soil. In 2021, UT-Battelle personnel had 30 permits and agreements for the receipt, movement, or controlled release of regulated articles.

#### **5.3.12. Wetlands**

Wetland delineations are conducted to facilitate compliance with TDEC and US Army Corps of Engineers wetland protection requirements. In 2021, three wetlands, totaling 0.33 acres, were delineated for a future project along White Oak Avenue. Wetland boundaries were flagged, surveyed, and official US Army Corps of Engineers delineation forms were completed. Data from these forms were compiled into sensitive resource survey and compliance documents. In addition, four wetlands, totaling 0.23 acres, were delineated near culverts that will likely be replaced at a

future date. These delineations will guide the overall procedure for replacing these culverts and for determining what permits will be required. Assessing the potential for jurisdictional wetlands during site selection and early project planning stages can reduce adverse impacts to wetlands, design changes, and mitigation costs. Wetland delineations are conducted to facilitate compliance with TDEC and US Army Corps of Engineers wetland protection requirements.

#### **5.3.13. Radiological Clearance of Property at ORNL**

DOE Order 458.1, *Radiation Protection of the Public and the Environment* (DOE 2011d), established standards and requirements for operations of DOE and its contractors with respect to protection of members of the public and the environment against undue risk from radiation. In addition to discharges to the environment, the release of property containing residual radioactive material is a potential contributor to the dose received by the public, and DOE Order 458.1 established requirements for clearance of property from DOE control and for public notification of clearance of property.

##### **5.3.13.1. Graded Approach to Evaluate Material and Equipment for Release**

At ORNL, UT-Battelle uses a graded approach for release of material and equipment for unrestricted public use. Material that may be released to the public has been categorized so that in some cases an administrative release can be accomplished without a radiological survey. Such material originates from nonradiological areas and includes items such as the following:

- Documents, mail, diskettes, compact disks, and other office media
- Nonradioactive items or materials received that are immediately (within the same shift) determined to have been delivered in error or damaged
- Personal items or materials

- Paper, plastic products, aluminum beverage cans, toner cartridges, and other items released for recycling
- Office trash
- Housekeeping materials and associated waste
- Breakroom, cafeteria, and medical wastes
- Compressed gas cylinders and fire extinguishers
- Medical and bioassay samples
- Other items with an approved release plan

Items that are not in the listed categories and that originate from nonradiological areas within ORNL's controlled areas are surveyed before release to the public, or a process knowledge evaluation is conducted to ensure that the material has not been exposed to radioactive material or beams of radiation capable of creating radioactive material. In some cases, both a radiological survey and a process knowledge evaluation are performed (e.g., a radiological survey is conducted on the outside of the item, and a process knowledge form is signed by the custodian for inaccessible surfaces). A similar approach is used for material released to state-permitted landfills on ORR. The only exception is for items that could be internally contaminated; those items are also sampled by laboratory analysis to ensure that landfill permit criteria are met.

When the process knowledge approach is used, the item's custodian is required to sign a statement that specifies that the history of the item or material is known and that the material is known to be free of contamination. This process knowledge certification is more stringent than what is allowed by DOE Order 458.1 (DOE 2011d) in that ORNL requires an individual to take personal responsibility and accountability for knowing the complete history of an item before it can be cleared using process knowledge alone. DOE Order 458.1 allows use of procedures for

evaluating operational records and operating history to make process knowledge release decisions, but UT-Battelle has chosen to continue to require personal certification of the status of an item. This requirement ensures that each individual certifying the item is aware of the significance of this decision and encourages the individual to obtain a survey of the item if he or she is not confident that the item can be certified as being free of contamination.

A survey and release plan may be developed to direct the radiological survey process for large recycling programs or for clearance of bulk items with low contamination potential. For such projects, survey and release plans are developed based on guidance from the *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) (NRC 2000) or the *Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual* (MARSAME) (NRC 2009). MARSSIM and MARSAME allow for statistically based survey protocols that typically require survey measurements for a representative portion of the items being released. The survey protocols are documented in separate survey and release plans, and the measurements from such surveys are documented in radiological release survey reports.

In accordance with DOE Order 458.1 Section k.(6)(f)2 b, "Pre-Approved Authorized Limits," UT Battelle continues to use the preapproved authorized limits for surface contamination originally established in Table IV-1 of DOE Order 5400.5 (cancelled in 2011) and the November 17, 1995, Pelletier memorandum (Pelletier 1995) for TRU alpha contamination. UT-Battelle also continues to follow the requirements of the scrap metal suspension. No scrap metal directly released from radiological areas is being recycled. In 2021, UT-Battelle cleared more than 14,287 items through the excess items and property sales processes. A summary of items requested for release through these processes is shown in Table 5.7.

**Table 5.7. Excess items requested for release and/or recycling, 2021**

Item	Process knowledge	Radiologically surveyed
<b>Release request totals for 2021</b>		
Totals	13,120	1,667
<b>Recycling request totals for 2021</b>		
Cardboard (tons)	310,460	
Scrap metal (nonradiological areas) (tons)	1,332.136	

### 5.3.13.2. Authorized Limits Clearance Process for Spallation Neutron Source and High Flux Isotope Reactor Neutron Scattering Experiment Samples

The SNS and High Flux Isotope Reactor (HFIR) facilities provide unique neutron scattering experiment capabilities that allow researchers to explore the properties of various materials by exposing samples to well-characterized neutron beams. Because materials exposed to neutrons can become radioactive, a process has been developed to evaluate and clear samples for release to off-site facilities. DOE regulations and orders governing radiological release of material do not specifically cover items that may have radioactivity distributed throughout the volume of the material. To address sample clearance, activity-based limits were established using the authorized limits process defined in DOE Order 458.1 (DOE 2011d) and associated guidance. The sample clearance limits are based on an assessment of potential doses against a threshold of 1 mrem/year to an individual and evaluation of other potentially applicable requirements (e.g., Nuclear Regulatory Commission licensing regulations). Implementation of the clearance limits involves use of unique instrument screening and methods for prediction of sample activity to provide an efficient and defensible process to release neutron scattering experiment samples to researchers without further DOE control.

In 2021 ORNL cleared a total of 58 samples from neutron scattering experiments using the sample

authorized limits process. Of those, 54 samples were from SNS and 4 were from HFIR.

## 5.4. Air Quality Program

Permits issued by the state of Tennessee convey the clean air requirements that are applicable to ORNL. These permits and the results of 2021 air monitoring activities are summarized in the following sections.

### 5.4.1. Construction and Operating Permits

New projects are governed by construction permits until the projects are converted to operating status. The sitewide Title V Major Source Operating Permits include requirements that are generally applicable to large operations such as national laboratories (e.g., asbestos and stratospheric ozone) as well as specific requirements directly applicable to individual air emission sources. Source-specific requirements include Rad-NESHAPs (see Section 5.4.3), requirements applicable to sources of radiological air pollutants, and requirements applicable to sources of other hazardous (nonradiological) air pollutants. In August 2017, the state of Tennessee issued Title V Major Source Operating Permit 571359 to DOE and UT-Battelle for operations at ORNL. DOE and UT-Battelle also maintained a valid minor source operating permit with the Knox County Department of Air Quality Management Division for the NTRC facilities, which are in Knox County.

The CFTF was constructed at an off-site location in the Horizon Center Business Park in Oak Ridge, Tennessee. UT-Battelle applied for and received two construction permits for construction of the CFTF (Permit No. 965013P in 2012 and Permit No. 967180P in 2014). The initial start-up of the CFTF occurred in March 2013. A Conditional Major Source Operating Permit for the facility was issued in February 2020 (Permit No. 474951).

DOE/NWSol has two non-Title V Major Source Operating Permits for one emission source and two emergency generators at TWPC (Permit No. 071009P and 071010P). During 2021 no permit limits were exceeded. Isotek has a Title V Major

Source Operating Permit (576448) for the Radiochemical Development Facility (Building 3019 complex). During 2021 no permit limits were exceeded. UCOR was issued a Title V Major Source Operating Permit (569768) on September 18, 2015, for the Building 3039 Process Off-Gas and Hot Cell Ventilation System. Construction Permit 974744 was issued on November 19, 2018, to implement several proposed modifications to the Title V Operating Permit, and Significant Modification #1 to the Title V Operating Permit was issued on April 5, 2019, incorporating those modifications. Although the permit expired on September 17, 2020, it remains in effect because a timely application for renewal was submitted in March 2020. During 2021 no permit limits were exceeded.

#### 5.4.2. National Emission Standards for Hazardous Air Pollutants—Asbestos

Numerous facilities, structures, and facility components and various pieces of equipment at ORNL contain asbestos-containing material. UT-Battelle's Asbestos Management Program manages the compliance of work activities involving the removal and disposal of asbestos-containing material, which include notifications to TDEC for all demolition activities and required renovation activities, approval of asbestos work authorization requests, current use of engineering controls and work practices, inspections, air monitoring, and waste tracking of asbestos-contaminated waste material. During 2021, no deviations or releases of reportable quantities of asbestos-containing material occurred.

#### 5.4.3. Radiological Airborne Effluent Monitoring

Radioactive airborne discharges at ORNL are subject to Rad-NESHAPs and consist primarily of ventilation air from radioactively contaminated or potentially contaminated areas, vents from tanks and processes, and ventilation for hot cell operations and reactor facilities. The airborne

emissions are treated and then filtered with high-efficiency particulate air filters and/or charcoal filters before discharge. Radiological airborne emissions from ORNL consist of solid particulates, tritium, adsorbable gases (e.g., iodine), and nonadsorbable gases (e.g., noble gases).

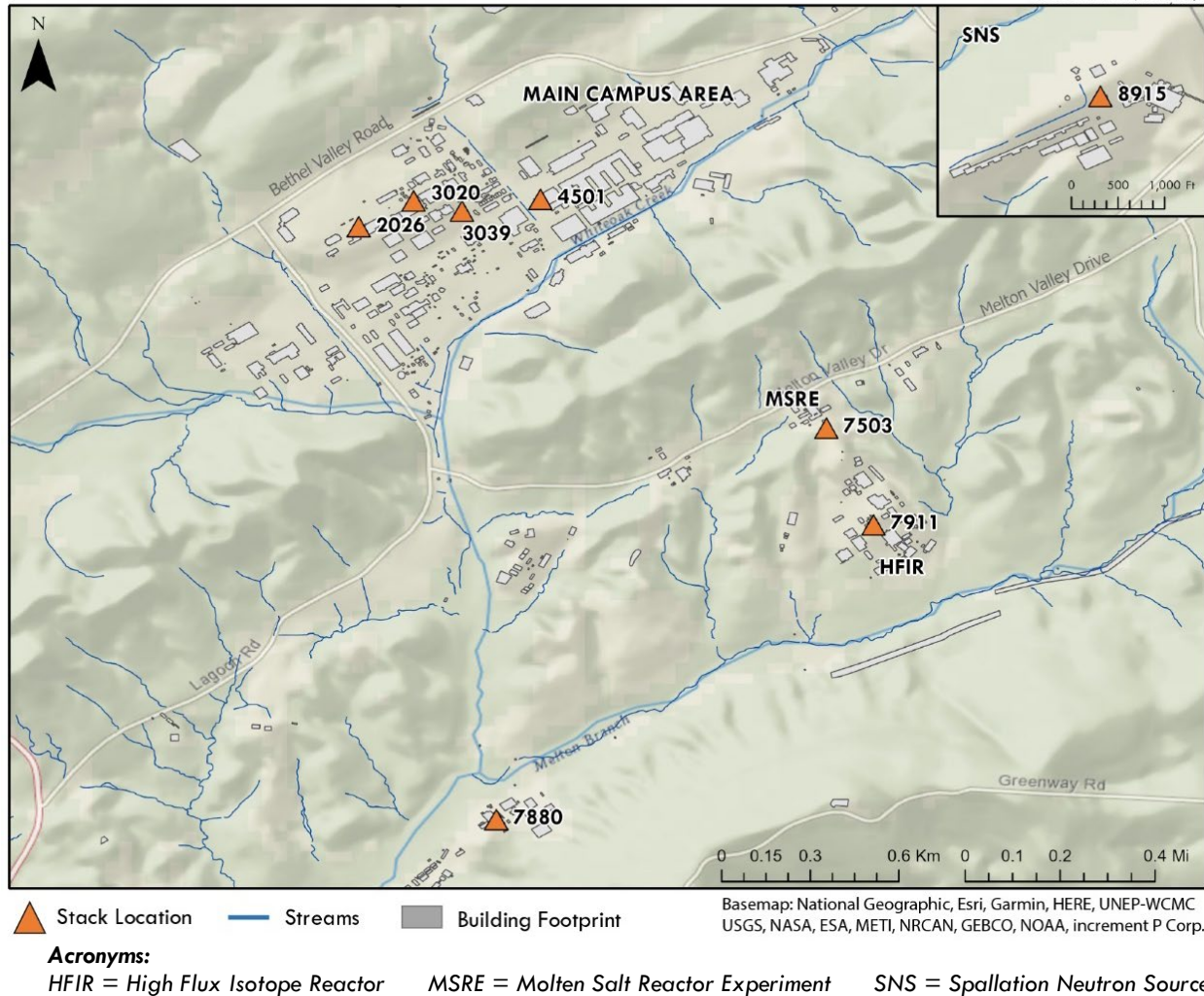
The major radiological emission point sources for ORNL consist of the following eight stacks. Seven are located in Bethel and Melton Valleys, and one, the SNS Central Exhaust Facility stack, is located on Chestnut Ridge (Figure 5.6):

- 2026 Radioactive Materials Analytical Laboratory
- 3020 Radiochemical Development Facility
- 3039 central off-gas and scrubber system, which includes the 3500 cell ventilation system, isotope area cell ventilation system, 3025/3026 cell ventilation system, 3042 ventilation system, and 3092 central off-gas system
- 4501 Radiochemistry Laboratory Area Off-Gas System
- 7503 Molten Salt Reactor Experiment Facility
- 7880 TWPC
- 7911 Melton Valley complex, which includes HFIR and the Radiochemical Engineering Development Center
- 8915 SNS Central Exhaust Facility stack

In 2021, there were 16 minor point/group sources, and emission calculations/estimates were made for each of them.

##### 5.4.3.1. Sample Collection and Analytical Procedure

Three of the major point sources (stacks 3020, 3039, and 7503) are equipped with in-stack source-sampling systems that comply with criteria in the American National Standards Institute (ANSI) standard ANSI N 13.1-1969R (ANSI 1969).



**Figure 5.6. Locations of major radiological emission points at ORNL, 2021**

The sampling systems generally consist of a multipoint in-stack sampling probe, a sample transport line, a particulate filter, activated charcoal cartridges (or canister), a silica gel cartridge (if required), flow-measurement and totalizing instruments, a sampling pump, and a return line to the stack. The 2026 (Radioactive Materials Analytical Laboratory), 4501 (Radiochemistry Laboratory), 7911 (Melton Valley complex), and 7880 (TWPC) stacks are equipped with in-stack source-sampling systems that comply with criteria in the ANSI-Health Physics Society standard ANSI/HPS N13.1-1999 (ANSI 1999).

The 2026, 4501, and 7911 sampling systems have the same components as the ANSI 1969 sampling systems used for the four major point sources but use a stainless-steel-shrouded probe instead of a multipoint in-stack sampling probe. The 7911 sampling system also consists of a high-purity germanium detector with an analog-to-digital converter and ORTEC GammaVision software, which allows for continuous isotopic identification and quantification of radioactive noble gases (e.g., <sup>41</sup>Ar) in the effluent stream. The 7880 sampling system consists of a stainless-steel-shrouded probe, an in-line filter-cartridge holder placed at the probe to minimize line losses, a particulate filter, a sample transport line, a rotary



vane vacuum pump, and a return line to the stack. The sample probes from both the ANSI 1969 and ANSI 1999 stack-sampling systems are removed, inspected, and cleaned annually. The SNS Central Exhaust Facility (8915) stack is equipped with an in-stack radiation detector that complies with criteria in ANSI/HPS N13.1-1999 (ANSI 1999). The detector monitors radioactive gases flowing through the exhaust stack and provides a continual readout of activity detected by a scintillator probe. The detector is calibrated to correlate with isotopic emissions. Velocity profiles are performed quarterly at major sources (except for the 3039 stack) and at some minor sources; the criteria in EPA Method 2 (40 CFR Part 60, Appendix A-1, Method 2) are followed.

The profiles provide accurate stack flow data for subsequent emission-rate calculations. An annual leak-check program is carried out to verify the integrity of the sample transport system. An annual comparison is performed for the 7880 stack between the effluent flow rate totalizer and EPA Method 2. The response of the stack effluent-flow-rate monitoring system is checked quarterly with the manufacturer's instrument test procedures. The stack sampler rotameter is calibrated at least quarterly in comparison with a secondary (transfer) standard. Only a certified secondary standard is used for all rotameter tests.

Starting in 2017, the 3039 emissions were calculated using a fixed stack flow rate. A fixed stack flow rate was used because the stack velocity at the sampling level is at or below the sensitivity of standard methods for measuring the velocity and therefore stack flow rates can no longer be determined. Low effluent velocity measurements are due to stack flow reductions resulting from the removal of facilities exhausting through the stack. The EPA Region 4 office approved a request to use an alternative fixed stack flow for emission calculations for the 3039 stack in a letter dated April 27, 2017 (V. Anne Heard, Acting Regional Administrator, United States Environmental Protection Agency Region 4 to Raymond J. Skwarek, Environmental Safety, Health and Quality Assurance Manager, UCOR, April 27, 2017). The 3039 stack velocity was

successfully measured with new equipment in November 2019 and in July 2020. Both results were below the fixed stack flow rate; the stack velocity result obtained in 2020 was used for emission calculation purposes in 2021.

In addition to the major sources, ORNL has several minor sources that have the potential to emit radionuclides to the atmosphere. A minor source is defined as any ventilation system or component such as a vent, laboratory hood, room exhaust, or stack that does not meet the approved regulatory criteria for a major source but that is located in or vents from a radiological control area as defined by Radiological Support Services of the UT-Battelle Nuclear and Radiological Protection Division. Various methods are used to determine the emissions from the various minor sources. Methods used for calculations of minor source emissions comply with EPA criteria. The minor sources are evaluated on a 1- to 5-year basis. Major and minor emissions are compiled annually to determine the overall ORNL source term and associated dose.

The charcoal cartridges/canisters, particulate filters, and silica-gel traps are collected weekly to biweekly. The use of charcoal cartridges (or canisters) is a standard method for capturing and quantifying radioactive iodine in airborne emissions. Gamma spectrometric analysis of the charcoal samples quantifies the adsorbable gases. Analyses are performed weekly to biweekly. Particulate filters are held for 8 days before a weekly gross alpha and gross beta analysis to minimize the contribution from short-lived isotopes such as  $^{220}\text{Rn}$  and its daughter products. At stack 7911, a weekly gamma scan is conducted to better detect short-lived gamma isotopes. The filters are then composited quarterly or semiannually and are analyzed for alpha-, beta-, and gamma-emitting isotopes. At stack 7880, the filters are collected monthly and analyzed for alpha-, beta-, and gamma-emitting isotopes. The sampling system on stack 7880 requires no other type of radionuclide collection media. Monthly sampling provides a better opportunity for quantification of the low-concentration isotopes. Silica-gel traps are used to capture water vapor

that may contain tritium. Analysis is performed weekly to biweekly. At the end of the year, the sample probes for all of the stacks are rinsed, except for the 8915 and 7880 probes, and the rinsate is collected and submitted for isotopic analysis identical to that performed on the particulate filters. A probe-cleaning program has been determined unnecessary for 8915 because the sample probe is a scintillator probe used to detect radiation and not to extract a sample of stack exhaust emissions. It is not anticipated that contaminant deposits would collect on the scintillator probe. A probe-cleaning program for 7880 has established that rinse analysis historically showed no detectable contamination. Therefore, the frequency of probe rinse collection and analysis is not more often than every 3 years unless particulate emissions increase, detectable radionuclides in the sample media increase, or process modifications occur.

The data from the charcoal cartridges or canisters, silica gel, probe wash, and filter composites are compiled to give the annual emissions for each major source and some minor sources.

#### 5.4.3.2. Results

Annual radioactive airborne emissions for ORNL in 2021 are presented in Appendix G.

Historical trends for tritium ( $^3\text{H}$ ) and  $^{131}\text{I}$  are presented in Figures 5.7 and 5.8. For 2021, tritium emissions totaled about 1,035 Ci (Figure 5.7), comparable to what was seen in 2020;  $^{131}\text{I}$  emissions totaled 0.09 Ci (Figure 5.7), comparable to what was seen in 2020. For 2021, of the 341 radionuclides (excluding radionuclides with multiple solubility type) released from ORNL operations and evaluated, the isotopes that contributed 10 percent or more to the off-site dose from ORNL included  $^{212}\text{Pb}$ , which contributed about 55 percent, and  $^{138}\text{Cs}$ , which contributed about 14 percent to the total ORNL dose.

Emissions of  $^{212}\text{Pb}$  result from research activities and from the radiation decay of legacy material stored on-site and areas containing isotopes of  $^{228}\text{Th}$ ,  $^{232}\text{Th}$ , and  $^{232}\text{U}$ . Emissions of  $^{212}\text{Pb}$  were from the following stacks: 2026, 3020, 3039,

4501, 7503, 7856, 7911, and the 4000 area laboratory hoods. Cesium-138 emissions result from Radiochemical Engineering Development Center research activities and HFIR operations. For 2021,  $^{212}\text{Pb}$  emissions totaled 23.92 Ci,  $^{138}\text{Cs}$  emissions totaled 2,500 Ci, and  $^{41}\text{Ar}$  emissions totaled 3,190 Ci (see Figure 5.9).

The calculated radiation dose to the maximally exposed individual (MEI) from all radiological airborne release points at ORR during 2021 was 0.5 mrem. The dose contribution to the MEI from all ORNL radiological airborne release points was 41 percent of the ORR dose. This dose is well below the Rad-NESHAPs standard of 10 mrem and is equal to approximately 0.20 percent of the roughly 300 mrem that the average individual receives from natural sources of radiation. (See Section 7.1.2 for an explanation of how the airborne radionuclide dose was determined.)

#### 5.4.4. Stratospheric Ozone Protection and Hydrofluorocarbon Phasedown

As required by the CAA Title VI Amendments of 1990 and in accordance with 40 CFR Part 82, actions have been implemented to comply with the prohibition against intentionally releasing ozone-depleting substances during maintenance activities performed on refrigeration equipment. In 2017, EPA enacted major revisions to the Stratospheric Ozone rules to include the regulation of substitutes for ozone-depleting substances as part of 40 CFR 82 Subpart F. The revisions were effective January 1, 2018, for disposal of small appliances and January 1, 2019, for the leak rate provisions for large appliances. Necessary changes to the Stratospheric Ozone Protection compliance program were implemented to comply with the requirements of the new rule. Service requirements for refrigeration systems (including motor vehicle air conditioners), technician certification requirements, record-keeping requirements, and labeling requirements were implemented in accordance with 40 CFR 82 Subpart F. On October 1, 2021, EPA began the implementation of the HFC phasedown requirements of the American Innovation and Manufacturing (AIM) Act of 2020

which seeks to reduce HFC consumption and production to 15 percent of a 2011–2013 baseline by 2036 (*Final Rule—Phasedown of Hydrofluorocarbons: Establishing the Allowance*

*Allocation and Trading Program under the AIM Act* [EPA 2022] [here](#)). Site wide use of HFCs is being evaluated to understand future effects of AIM Act phasedowns.

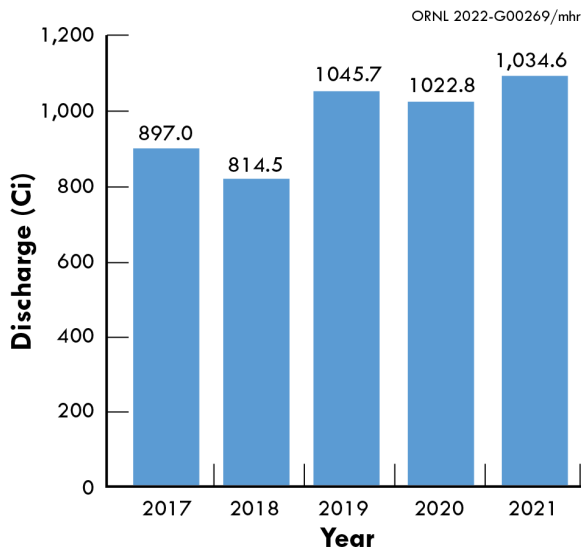


Figure 5.7. Total curies of tritium discharged from ORNL to the atmosphere, 2017–2021

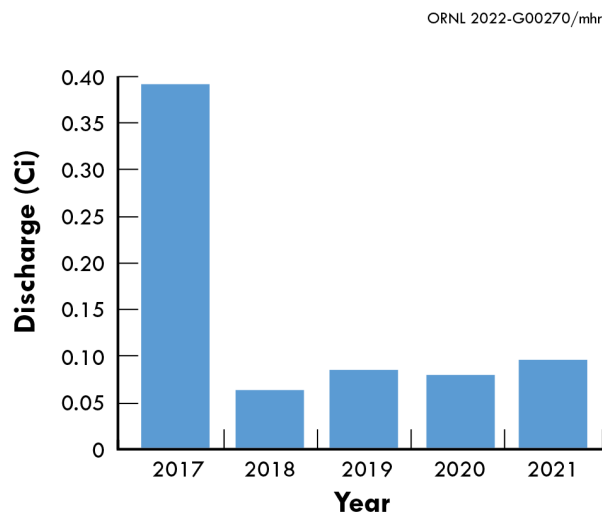


Figure 5.8. Total curies of <sup>131</sup>I discharged from ORNL to the atmosphere, 2017–2021

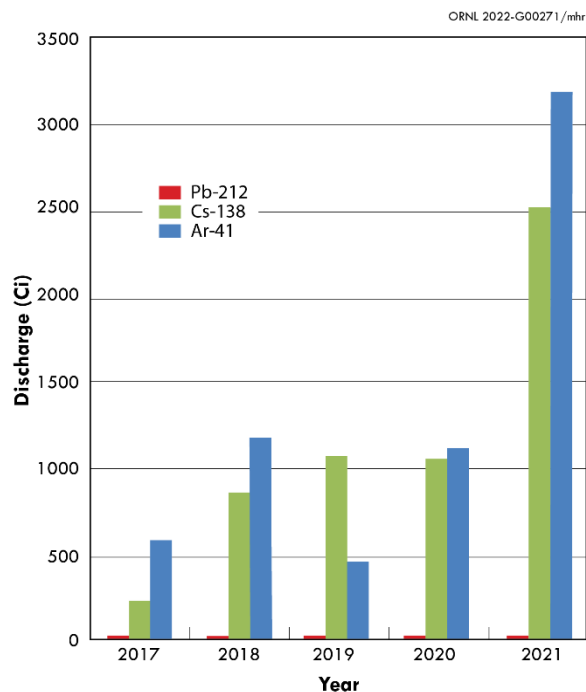


Figure 5.9. Total curies of <sup>41</sup>Ar, <sup>138</sup>Cs, and <sup>212</sup>Pb discharged from ORNL to the atmosphere, 2017–2021

#### 5.4.5. Ambient Air

Station 7 in the ORNL 7000 maintenance area is the site-specific ambient air monitoring location. During 2021, the sampling system at Station 7 was used to quantify levels of tritium; uranium; and gross alpha-, beta-, and gamma-emitting radionuclides. A low-volume air sampler was used for particulate collection. The 47 mm glass-fiber filters were collected biweekly and were composited annually for laboratory analysis. A silica-gel column was used for collection of tritium as tritiated water. The silica gel was collected biweekly or weekly, depending on ambient humidity, and was composited quarterly for tritium analysis. Station 7 sampling data (Table 5.8) are compared with derived concentration standards (DCSs) for air established by DOE as guidelines for controlling exposure to members of the public (DOE 2021a). During 2021 average radionuclide concentrations at Station 7 were less than 1 percent of the applicable DCSs in all cases.

**Table 5.8. Radionuclide concentrations measured at ORNL air monitoring Station 7, 2021**

Parameter	Concentration (pCi/mL) <sup>a</sup>
Alpha	8.7E-09
<sup>7</sup> Be	2.5E-08
Beta	2.0E-08
<sup>40</sup> K	5.7E-10
Tritium	5.1E-06
<sup>234</sup> U	1.4E-11
<sup>235</sup> U	0
<sup>238</sup> U	1.2E-11
Total U	2.6E-11

<sup>a</sup> 1 pCi = 3.7 × 10<sup>-2</sup> Bq.

## 5.5. ORNL Water Quality Program

NPDES permit TN 0002941, issued to DOE for the ORNL site and renewed by the state of Tennessee in 2019, includes requirements for discharging wastewaters from the two ORNL on-site wastewater treatment facilities and from more than 150 category outfalls (outfalls with nonprocess wastewaters such as cooling water, condensate, groundwater, and storm water), and for the development and implementation of a water quality protection plan (WQPP). The permit calls for a WQPP to “efficiently utilize the facility’s financial resources to measure its environmental impacts.” Rather than prescribing rigid monitoring schedules, the ORNL WQPP is flexible and focuses on significant findings. It is implemented utilizing an adaptive management approach (Figure 5. 10), whereby results of investigations are routinely evaluated and strategies for achieving goals are modified based on those evaluations. The goals established for the WQPP are to meet the requirements of the NPDES permit, improve the quality of aquatic resources on the ORNL site, prevent further impacts to aquatic resources from current activities, identify the stressors that contribute to impairment of aquatic resources, use available resources efficiently, and communicate outcomes with decision makers and stakeholders.

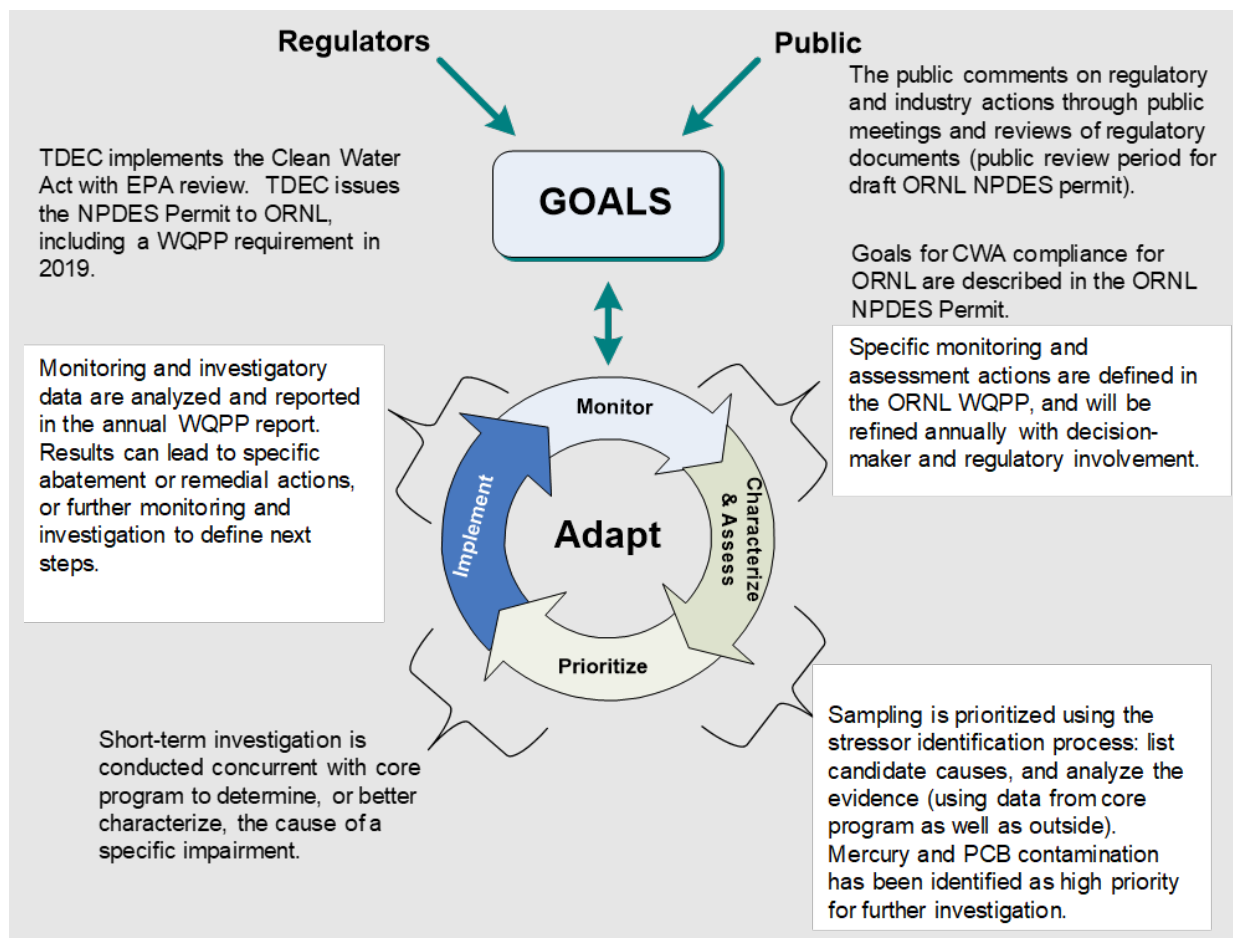
The ORNL WQPP was developed by DOE and was approved by TDEC in 2008, and the WQPP monitoring was initiated in 2009. Revisions to the WQPP are submitted to TDEC for review and comment. The WQPP incorporated several control plans that were required under the previous NPDES permit, including a biological monitoring and abatement plan, a chlorine control strategy, a storm water pollution prevention plan, a non-storm water best management practices plan, and an NPDES radiological monitoring plan.

To prioritize the stressors and/or contaminant sources that may be of greatest concern to water quality and to define conceptual models that would guide any special investigations, the WQPP strategy was defined using EPA’s *Stressor Identification Guidance Document* (EPA 2000a). Figure 5.11 summarizes that process. The process involves three major steps for identifying the cause of any impairment:

1. List candidate causes of impairment (based on historical data and a working conceptual model).
2. Analyze the evidence (using both case study and outside data).
3. Characterize the causes.

The first two steps of the stressor identification process, which were initiated in 2009, focus first on mercury impairment and then on PCB impairment because mercury and PCB concentrations in fish from WOC are at or near human health risk thresholds (e.g., EPA ambient water quality criteria [AWQCs] and TDEC fish advisory limits). Some of the major sources of mercury to biota in the WOC watershed are known, providing a good basis from which to define an appropriate conceptual model for mercury contamination in WOC. A list of potential causes of PCB contamination was also developed.

After potential causes were listed and the available evidence of mercury and PCB contamination in the WOC watershed was analyzed, it was clear that additional investigation was needed to characterize the causes.



Adapted from the US Environmental Protection Agency (EPA) stressor guidance document (*Stressor Identification Guidance Document*. EPA-822-B-00-025. US Environmental Protection Agency, Office of Water, Washington, DC.).

**Acronyms:**

- CWA = Clean Water Act
- NPDES = National Pollutant Discharge Elimination System
- PCB = polychlorinated biphenyl
- TDEC = Tennessee Department of Environment and Conservation
- WQPP = Water Quality Protection Plan

**Figure 5.10. Diagram of the adaptive management framework with stepwise planning specific to the ORNL Water Quality Protection Plan**

Special investigations were designed to identify specific source areas and to revise the conceptual model of the major causes of contamination in the WOC watershed.

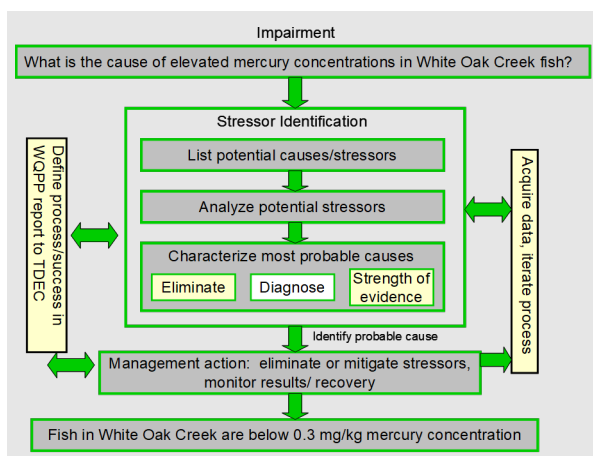
Monitoring and investigation data collected under the ORNL WQPP are analyzed, interpreted, reported, and compared with past results at least annually. The significant findings are reported in the *Annual Site Environmental Report*, and a more comprehensive report of findings is submitted to TDEC on a biannual basis. This information

provides an assessment of the status of ORNL’s receiving-stream watersheds and the impact of ongoing efforts to protect and restore those watersheds and will guide efforts to improve the water quality in the watershed.

**5.5.1. Treatment Facility Discharges**

The ORNL STP and the ORNL PWTC provide appropriate treatment of the various R&D, operational, and domestic wastewaters generated by site staff and activities. Both are permitted to

discharge treated wastewater and are monitored under NPDES Permit TN0002941, issued by TDEC to DOE for the ORNL site. The ORNL NPDES permit requirements include monitoring the two ORNL wastewater treatment facility effluents for conventional, water-quality-based, and radiological constituents and for effluent toxicity, with numeric parameter-specific compliance limits established by TDEC as determined to be necessary. TDEC last renewed the ORNL NPDES permit in May 2019. The results of field measurements and laboratory analyses to assess compliance for the parameters required by the NPDES permit and rates of compliance with numeric limits established in the permit are provided in Section 5.3.4. (Table 5.4). Compliance with permit limits for ORNL wastewater treatment facilities was greater than 99 percent in 2021.



Modified from Figure 1-1 in the US Environmental Protection Agency stressor guidance document (*Stressor Identification Guidance Document*. EPA-822-B-00-025. US Environmental Protection Agency, Office of Water, Washington, DC.).

**Acronyms:**

TDEC = Tennessee Department of Environment and Conservation

WQPP = Water Quality Protection Plan

**Figure 5.11. Application of stressor identification guidance to address mercury impairment in the White Oak Creek watershed**

Toxicity testing provides an assessment of any harmful effects that could occur from the total combined constituents in discharges from ORNL wastewater treatment facilities. The NPDES permit has required testing of effluents from the

STP for toxicity to aquatic species since 1986, and effluents from PWTC have been tested since it went into operation in 1990. Test species have been *Ceriodaphnia dubia*, an aquatic invertebrate, and fathead minnow (*Pimephales promelas*) larvae. Tests have been conducted using EPA chronic or acute test protocols at frequencies ranging from one to four times per year. The STP and PWTC have shown isolated indications of effluent toxicity, but confirmatory tests conducted as required by the permit have shown that either the result of the routine test was an anomaly or that the condition of toxicity that existed at the time of the routine test was temporary and of short duration.

Toxicity test requirements under the current NPDES permit include annual testing for chronic toxicity from the ORNL STP and PWTC. Both test species are tested on a series of four aliquots of effluent, collected at 6 h intervals over a 24 h period. An “inhibition concentration” of 25 percent was used in the testing.

### 5.5.2. Residual Bromine and Chlorine Monitoring

ORNL receives potable water from the City of Oak Ridge Department of Public Works, which uses chlorine as a final disinfectant. The City adds 2 to 3 mg/L of free chlorine prior to distribution. On the ORNL site, the water is used for drinking, sanitary, and housekeeping purposes as well as for research processes and in cooling systems. After the water is used, residual chlorine remains, and if discharged to surface water, can be toxic to fish and other aquatic life. Residual chlorine in wastewater routed to the STP is generally consumed in reactions with other substances within the collection and treatment system, and any residual chlorine in wastewater routed to the PWTC is removed by final activated carbon filtration. Air-conditioning systems that used once-through cooling water and discharged to storm outfalls have been replaced (except for one) with air-cooled systems that discharge only condensate to the ground or a storm drain. Newer buildings and complexes have been constructed to utilize cooling towers for air-conditioning and dehumidifying and to remove

heat from instrumentation and computer systems. Two main campus Outfalls (211 and 210) still receive research-generated, once-through cooling water, but flows have been reduced by water-recycling efforts.

Leaks or discharge from any of these systems to storm drains are dechlorinated and monitored via the WQPP Chlorine Control Strategy. DOE's NPDES Permit for ORNL establishes an action level of 1.2 g/day for total residual oxidant (TRO) loading at all outfalls. If that level is exceeded, ORNL is required to investigate and remove TRO sources to reduce chlorine/bromine loading to less than 1.2 g/day.

In 2021, TRO was monitored twice a month at outfalls that receive cooling tower discharges and once-through cooling water. Less frequent monitoring was conducted at other outfalls (semimonthly, monthly, quarterly, or semiannually if flow was present). A total of 342 TRO measurements were taken at 21 outfall locations, in addition to 288 semimonthly instream measurements. TRO was detected at or above action levels at outfalls in 7 instances during 2021, but TRO was not detected at any of the 12 instream monitoring points (Table 5.9).

#### **5.5.2.1. Monitoring Results and Corrective Actions**

Activities in response to TRO monitoring included emergency repairs, source investigation and elimination, and dechlorination system adjustments. Outfalls 211 and 210 are the only outfalls that still receive once-through cooling water discharges. Outfall 211 receives cooling water from multiple small sources. Two dechlorinator boxes are mounted in a weir located at the point where the outfall discharges to WOC. Each box is designed to treat chlorinated discharges at flow rates up to 50 gpm. Flows ranged from 30 to 65 gpm above the dechlorinator; TRO levels above the dechlorinator ranged from 0.3 to 1.2 mg/L TRO. No TRO exceedances occurred

at Outfall 211 (downstream of the dechlorinator) in 2021. A liquid sodium bisulfite dechlorinator, located inside Building 4508, is used to treat discharges from Outfall 210. The dechlorinator treats cooling water from instrumentation that cannot use the recycled cooling water system. On December 27, 2021, TRO was found at Outfall 210 as a result of a pump failure. This source is being dechlorinated with tablets until the pump can be repaired.

In past years, Outfall 231 received blowdown from multiple Building 5800 cooling towers; however, the cooling towers were taken off-line in 2020. Additional Oak Ridge Leadership Computing Facility towers were installed on the west end of Building 5800 during 2020 and became operational in 2021. Previous TRO exceedances have occurred at Outfall 231 from unidentified sources, unrelated to cooling tower discharges. When an exceedance occurred in May 2020, sodium sulfite tablets were placed at the outfall, and a survey of laboratory drains and discharges from Building 5800 was conducted. The source was determined to be a leaking fire hydrant weep valve. In 2021, TRO was detected again, and tablets were placed at the outfall. Operators confirmed that the source was not cooling tower operations. Investigation into the outfall drainage network identified an irrigation line break, and sources were valved off. This outfall will continue to be monitored under the Chlorine Control Strategy.

Outfall 082, located on a tributary to Melton Branch, receives seasonal cooling water from the only remaining water-cooled air-conditioning system at ORNL's Molten Salt Reactor Experiment facility. During the summer, TRO was detected three times, but loads did not exceed 1.2 g/d. (See Table 5.10.)

Emergency repairs carried out in 2021 in response to the results of TRO monitoring are listed in Table 5.10.

**Table 5.9. Overview of 2021 chlorine control strategy**

Total residual oxidant (TRO) sampling events	630
Number of TRO non-detects	578
instream TRO exceedances	0
Outfall TRO detects	10
Outfall action level TRO exceedances	7
Number of outfalls with action level TRO detects	3

**Table 5.10. Total residual oxidant mitigation summary: Emergency repairs, 2021**

Location	Date	TRO (mg/L)	Flow (gpm)	Load (g/day)	Receiving stream	Downstream water kilometer	Downstream instream monitoring point	TRO Source	Notes/actions
210	12/27/2021	0.6	2	6.54	WOC	WCK 4.1	X18	Once-through cooling	Sodium bisulfite pump failure. Dechlorination tables are being used until pump is repaired.
231	7/16/2021	0.3	50	81.8	WOC	WCK 4.4	X25	Irrigation line break	Source valved off.
231	7/22/2021	0.2	13	14.2	WOC	WCK 4.4	X25	Irrigation line break	Source valved off.
014 (4510Box)	6/17/2021	0.2	60	65.4	WOC	WCK 4.4	X23	4510/4521 cooling towers	Potassium sulfite pretreatment added to system on 7/1/21.
014 (4510Box)	6/25/2021	0.3	75	123	WOC	WCK 4.4	X23	4510/4521 cooling towers	Same as above
014 (4521Box)	6/17/2021	0.2	50	54.5	WOC	WCK 4.4	X23	4510/4521 cooling towers	Same as above
014 (4521Box)	6/25/2021	0.4	50	109	WOC	WCK 4.4	X23	4510/4521 cooling towers	Same as above

**Acronyms:**

TRO = total residual oxidant  
 WCK = White Oak Creek kilometer  
 WOC = White Oak Creek



### 5.5.2.2. Cooling Tower Discharge Outfalls

Chlorine- and bromine-based chemicals are added to supply water to control bacterial growth. Residuals of chlorine and bromine remain in the water in cooling towers if they do not evaporate or are not consumed by bacterial growth. As the cooling towers lose water by evaporation, higher conductivity, caused by an increase in the concentration of minerals, triggers a blowdown, resulting in a discharge that may contain chlorine and bromine residuals. The discharge must be treated to reduce residual oxidants to less than 0.05 mg/L TRO. A combination of sodium sulfite tablet feeders and/or additions of liquid sodium bisulfite solution have historically been used to neutralize TRO in cooling tower discharges at ORNL.

In 2021, potassium sulfite was used as a pretreatment in one location and is proposed for use at the new OLCF 5 cooling towers. In some cases, pretreatment enhances the effectiveness of the primary dechlorination tablet feeders. Inspections of tablet feeders are conducted multiple times a week to ensure that sodium sulfite tablets are refilled, in good condition, and that any fouled tablets are removed for disposal.

Outfall 014 discharges only cooling tower blowdown from towers 4510 and 4521. To better identify the sources of TRO detections, these towers are now monitored separately, prior to their confluence at Outfall 014. In June of 2021, four action level detections occurred in these tower discharges. Liquid potassium sulfite pretreatment was added to both tower discharges to improve dechlorination. There have been no action-level detections since pretreatment installation.

Outfall 227 receives large blowdown flows from multiple cooling towers in Building 5600 and 5511. There were no TRO exceedances in 2021. Primary dechlorination occurs in Building 5600, and a secondary dechlorination box located at WOC is used as a backup. Combined use of two dechlorination boxes enables approximately 4 mg/L TRO to be removed before cooling tower discharges enter the creek. To better understand

dechlorination needs, TRO is monitored above and below secondary dechlorination. Monitoring results indicate that, without secondary treatment, TRO discharges could have exceeded 1.2 g/day at the outfall on three instances in 2021.

Outfall 363 also receives discharges from multiple cooling towers. Data show that residual oxidants remain in discharges after primary dechlorination at the tower/building sources. Since 2017, sodium sulfite tablet bags have been placed below the Outfall 363 pipe as secondary dechlorination. Monitoring efforts upstream and downstream of secondary treatment identified eight instances when primary dichlorination would have been insufficient.

SNS Cooling Tower discharges are monitored to verify that dechlorination is adequate prior to merging with a larger wet-weather channel, above the west SNS storm water retention basin and Outfall 435. Outfall 435, which discharges to WOC several hundred feet downstream, is not monitored for TRO because it would not be expected after dichlorination at the towers and dilution from the retention pond. TRO greater than 1.2 g/day was detected on five occasions.

### 5.5.3. Radiological Monitoring

At ORNL, monitoring of liquid effluents and selected instream locations for radioactivity is conducted under the WQPP. Table 5.11 details the analyses performed on samples collected in 2021 at two treatment facility outfalls, three instream monitoring locations, and 20 category outfalls (outfalls that are categorized into groups with similar effluent characteristics for the purposes of setting monitoring and reporting requirements in the site NPDES permit). Dry-weather discharges from category outfalls are primarily cooling water, groundwater, and condensate. Low levels of radioactivity can be discharged from category outfalls in areas where groundwater contamination exists and where contaminated groundwater enters category outfall collection systems by direct infiltration and from building sumps, facility sumps, and building footer drains. In 2021, dry-weather grab samples were collected at 13 of the 20 category outfalls targeted for

sampling. Seven category outfalls (see Table 5.11) were not sampled because there was no discharge present during sampling attempts.

The two ORNL treatment facility outfalls that were monitored for radioactivity in 2021 were the STP outfall (Outfall X01) and the PWTC outfall (Outfall X12). The three instream locations that were monitored were X13 on Melton Branch, X14 on WOC, and X15 at White Oak Dam (WOD) (Figure 5.12). At each treatment facility and instream monitoring location, monthly flow-proportional composite samples were collected using dedicated automatic water samplers.

A DCS for each radioisotope is used to evaluate discharges of radioactivity from DOE facilities (DOE 2021a). DCSs were developed for evaluating effluent discharges and are not intended to be applied to instream values, but the comparisons can provide a useful frame of reference. Four percent of the DCS is used as a comparison point. Although comparisons are made, neither ORNL effluents nor ambient surface waters are direct sources of drinking water. The annual average concentration of at least one radionuclide exceeded 4 percent of the relevant DCS concentration in dry-weather discharges from Outfalls 085, 302, 304, X01, and X12 (Figure 5.13). In 2021, no dry-weather discharges from sampled outfalls had an annual mean radioactivity concentration greater than 100 percent of a DCS.

The total annual discharges (or amounts) of radioactivity measured in stream water at WOD, the final monitoring point on WOC before the stream flow leaves ORNL, were calculated from concentration and flow. Results of those calculations for each of the past 5 years are shown

in Figures 5.14 through 5.18. Because discharges of radioactivity are somewhat correlated to stream flow, annual flow volumes measured at the WOD monitoring station are given in Figure 5.19. Discharges of radioactivity at WOD in 2021 were similar to discharges during other recent years, particularly when differences in annual flow volume are taken into account and continue to be generally lower than in the years preceding completion of the waste area caps in Melton Valley (substantially complete by 2006).

Radiological monitoring at category outfalls in 2021 also included monitoring during storm runoff conditions. Nine storm water outfalls were monitored. Storm water samples were analyzed for gross alpha, gross beta,  $^{137}\text{Cs}$ ,  $^{89/90}\text{Sr}$ , and  $^3\text{H}$  activities. A gamma scan analysis was also performed. The monitoring plan calls for additional analyses to be added when sufficient gross alpha and/or beta activity is present in a sample to indicate that levels of radioactivity may exceed DCS levels and if the radionuclides contributing to the gross activities are not identified by routine analyses. In 2021, no samples from the outfalls sampled required additional analyses.

Concentrations of radioactivity in storm water discharges were compared with DCSs if a DCS existed for that parameter (no DCSs exist for gross alpha or gross beta activities) and if a concentration was greater than or equal to the minimum detectable activity for the measurement. In 2021, the radionuclide  $^{89/90}\text{Sr}$  exceeded 4 percent of the relevant DCS concentration in wet-weather discharges from Outfalls 302 and 304 (Figure 5.13).

**Table 5.11. Radiological monitoring conducted under the ORNL Water Quality Protection Plan, 2021**

Location	Frequency	Gross alpha/beta	Gamma scan	<sup>3</sup> H	<sup>14</sup> C	<sup>89/90</sup> Sr	Isotopic uranium	Isotopic plutonium	<sup>241</sup> Am	<sup>243/244</sup> Cm
Outfall 001	Annual	X								
Outfall 080 <sup>a</sup>	Monthly									
Outfall 081	Annual	X								
Outfall 085	Quarterly	X	X	X		X				
Outfall 203	Annual	X	X			X				
Outfall 204 <sup>a</sup>	Semiannual									
Outfall 205 <sup>a</sup>	Annual									
Outfall 207	Quarterly	X								
Outfall 211	Annual	X								
Outfall 234 <sup>a</sup>	Annual									
Outfall 241 <sup>a</sup>	Quarterly									
Outfall 265 <sup>a</sup>	Annual									
Outfall 281	Quarterly	X		X						
Outfall 282	Quarterly	X								
Outfall 302	Monthly	X	X	X		X	X <sup>b</sup>	X <sup>b</sup>	X <sup>b</sup>	X <sup>b</sup>
Outfall 304	Monthly	X	X	X		X	X <sup>b</sup>	X <sup>b</sup>	X <sup>b</sup>	X <sup>b</sup>
Outfall 365	Semiannual	X								
Outfall 368 <sup>a</sup>	Annual									
Outfall 383	Annual	X		X						
Outfall 484	Annual	X								
STP (X01)	Monthly	X	X	X	X	X				
PWTC (X12)	Monthly	X	X	X		X	X			
Melton Branch (X13)	Monthly	X	X	X		X				
WOC (X14)	Monthly	X	X	X		X				
WOD (X15)	Monthly	X	X	X		X				

<sup>a</sup> The outfall was included in the monitoring plan, but samples were not collected because no discharge was present during sampling attempts.

<sup>b</sup> The Water Quality Protection Plan does not require this parameter for this location, and therefore it may have been monitored on a frequency less than indicated in the table. Additional analyses are sometimes performed on samples, the most common reason being that gross alpha and gross beta activities exceeded a screening criterion (as described in the February 2020 update to the Water Quality Protection Plan).

**Acronyms:**

STP = Sewage Treatment Plan

WOC = White Oak Creek

PWTC = Process Waste Treatment Complex

WOD = White Oak Dam

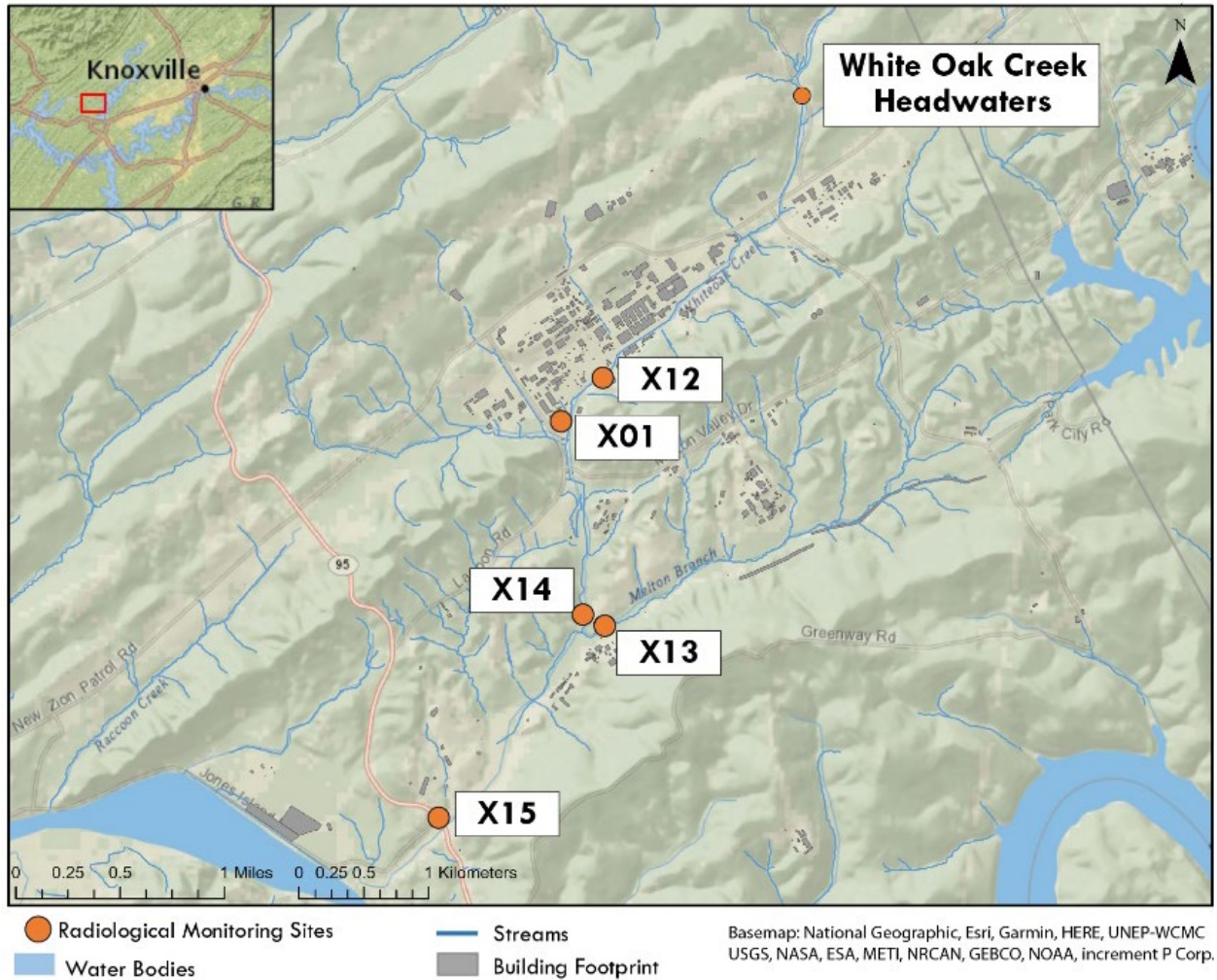
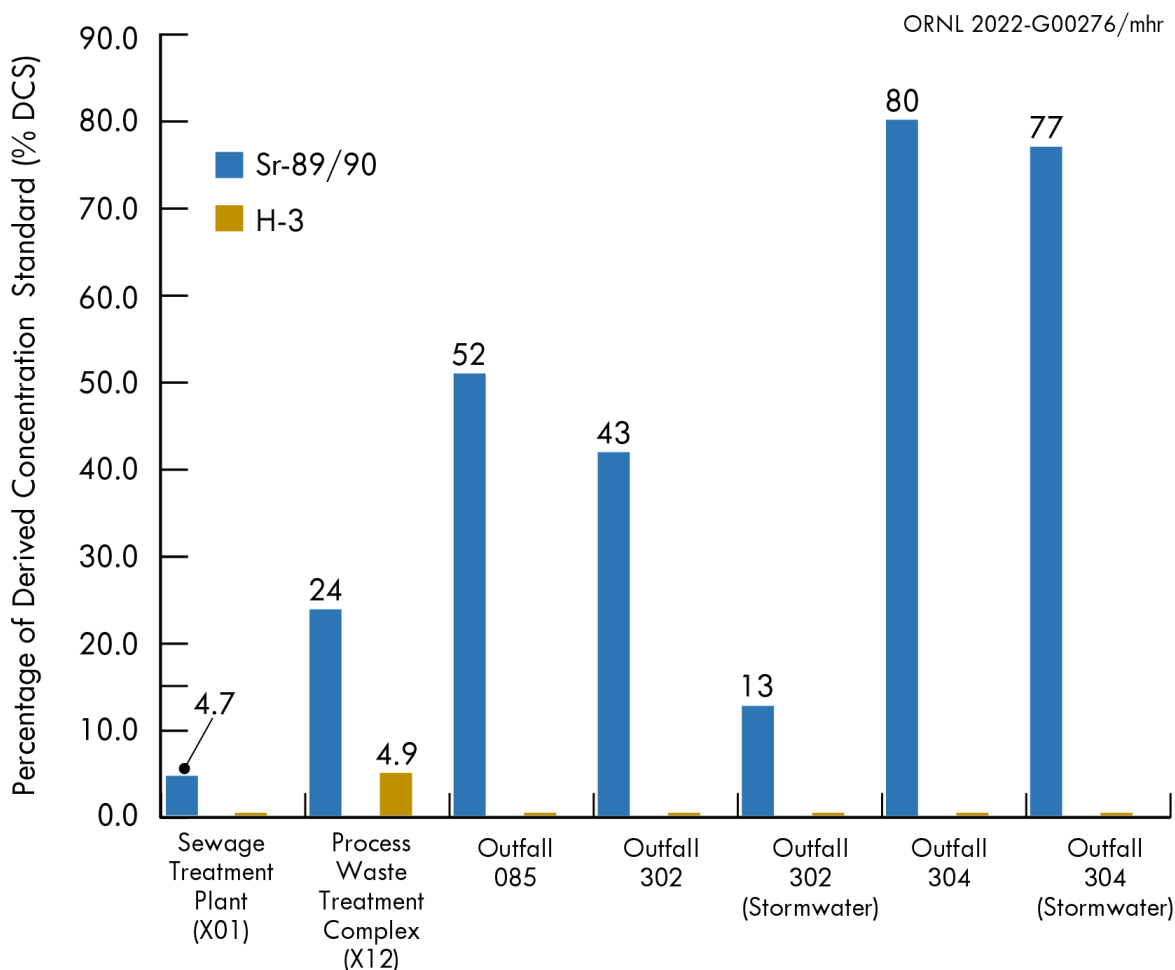


Figure 5.12. Selected surface water, National Pollutant Discharge Elimination System, and reference sampling locations at ORNL, 2021



**Acronyms:**

PWTC = Process Waste Treatment Complex

STP = Sewage Treatment Plant

WOC = White Oak Creek

WOD = White Oak Dam

**Figure 5.13. Outfalls and instream locations, including storm water outfalls at ORNL with average radionuclide concentrations greater than 4 percent of the relevant derived concentration standards in 2021**

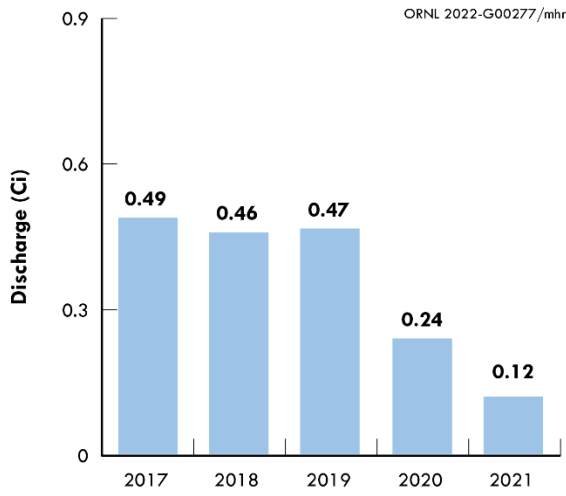


Figure 5.14. Cesium-137 discharges at White Oak Dam, 2017–2021

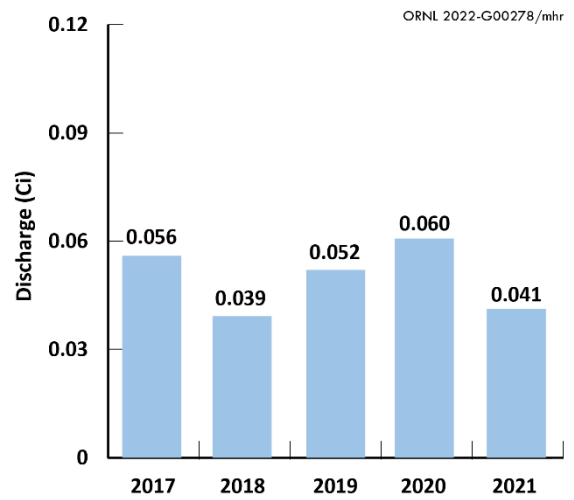


Figure 5.15. Gross alpha discharges at White Oak Dam, 2017–2021

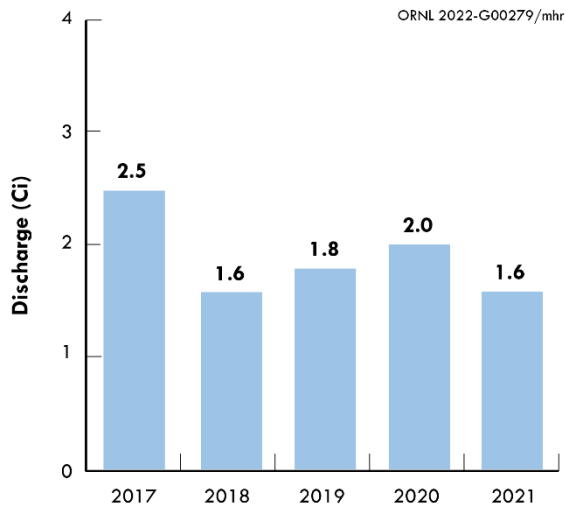


Figure 5.16. Gross beta discharges at White Oak Dam, 2017–2021

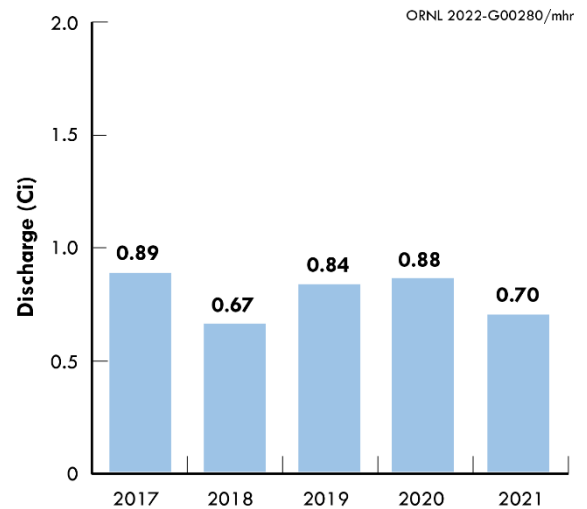


Figure 5.17. Total radioactive strontium discharges at White Oak Dam, 2017–2021

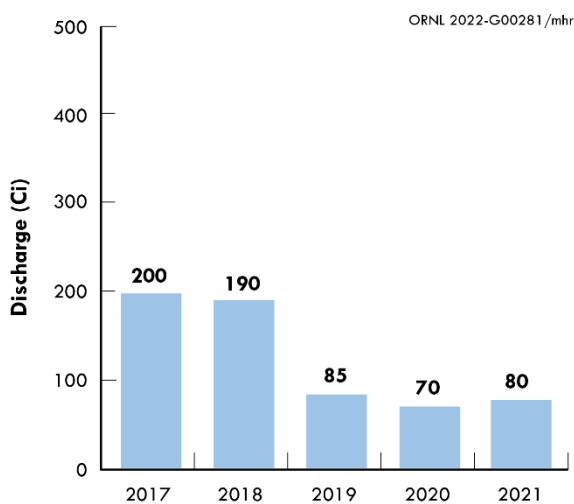


Figure 5.18. Tritium discharges at White Oak Dam, 2017–2021

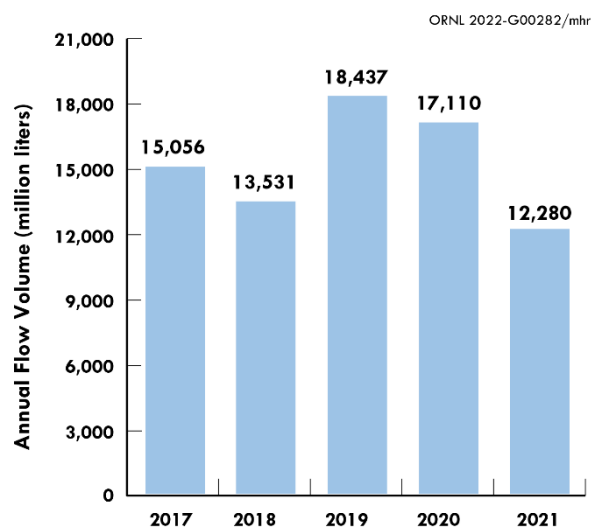


Figure 5.19. Annual flow volume at White Oak Dam 2017–2021

#### 5.5.4. Mercury in the White Oak Creek Watershed

During the mid-1950s, mercury (Hg) was used for pilot-scale isotope separation work in Buildings 4501, 4505, and 3592 and in spent-fuel reprocessing in Building 3503. By 1963 this work was transferred to Y-12.

Buildings 4501 and 4505 are active research facilities located east of Fifth Creek and north of WOC. In 1996, the Building 4501 foundation sump was found to contain legacy Hg because of its volatility and from its use and spills in the 1950s. The foundation sump discharged to storm Outfall 211 (Figure 5.20) on WOC; a smaller foundation sump in the building discharged to Outfall 263 on Fifth Creek. By 2011, an Hg pretreatment system had been installed on the larger sump. It had also been rerouted along with the smaller sump and a

4500N foundation sump to the PWTC. Outfall 211 and Outfall 363 storm piping still receive other sources of storm water, cooling water, and steam condensate discharges. Due to the persistence of elemental Hg, its volatility, and the complexity of its interactions in piping and soil, Hg continues to be monitored and assessed at these storm outfalls.

Buildings 3592 and 3503 were demolished under the CERCLA remedial process in 2011 and 2012, respectively; their footprints and associated storm water drains remain in the Outfall 207 storm water drainage system.

Mercury associated with process infrastructure has also been found in other areas, such as north of the Fifth Street and Central Avenue intersection and in the Outfall 304 drainage area. Storm water exchange with process leaks or overflows has occurred under certain situations.

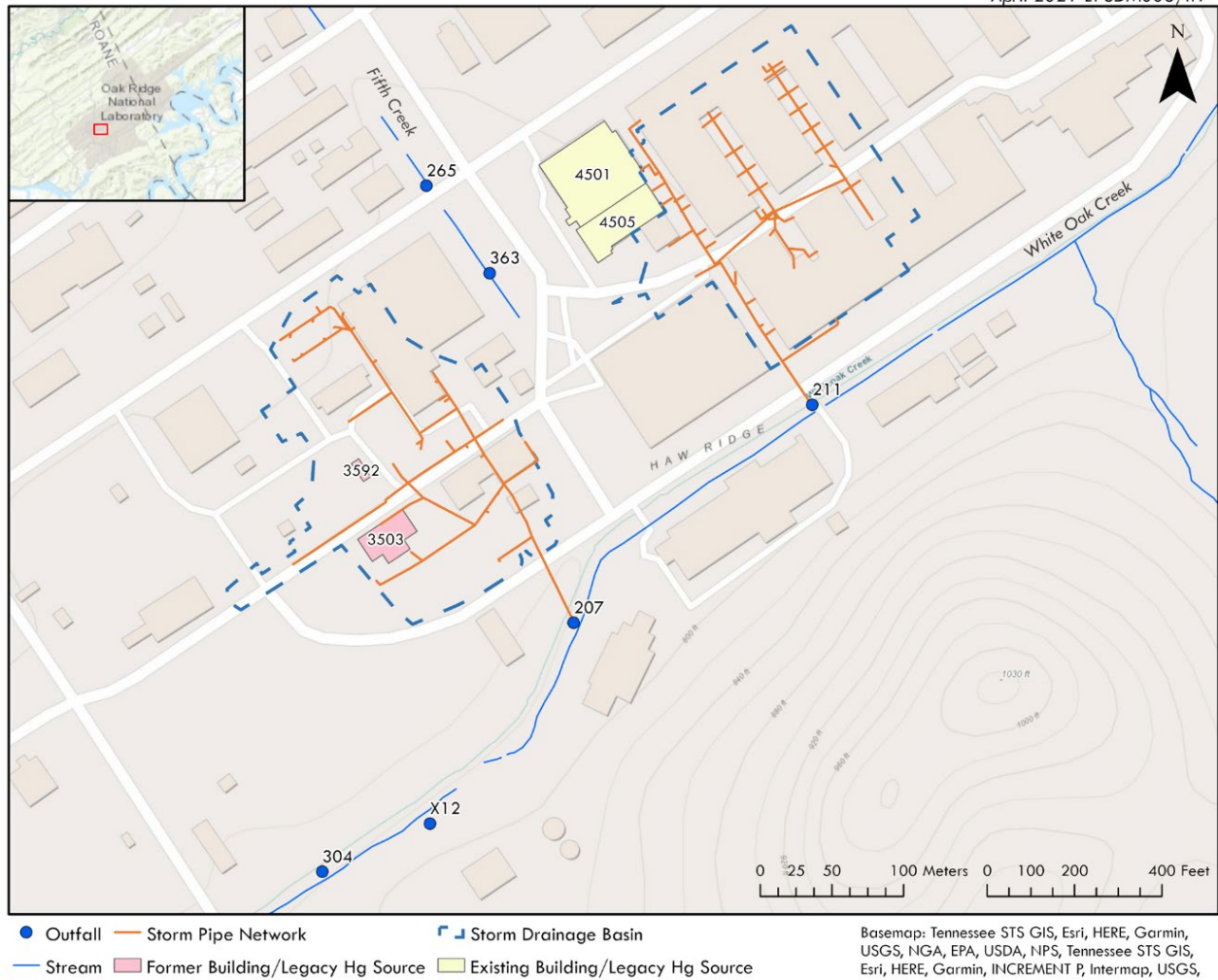


Figure 5.20. Outfalls 211 and 207 and associated storm drain connections that are potential mercury sources

#### 5.5.4.1. Mercury in Ambient Water

Aqueous Hg monitoring in WOC was initiated in 1997 and continued in 2021 with quarterly sampling at four instream sites: White Oak Creek kilometer (WCK) 1.5, WCK 3.4, WCK 4.1, and WCK 6.8 (Figure 5.21). Samples were collected to be representative of seasonal-base flow conditions (dry weather, clear flow). Historical sampling results show that Hg concentrations are typically higher under those conditions.

The concentration of Hg in WOC upstream from ORNL (WCK 6.8) was less than 2 ng/L in 2021. Waterborne Hg concentrations downstream of

ORNL (Figure 5.22) had been above Tennessee water quality criteria (WQC) from 1997 to 2007, but declined abruptly in 2008 following corrective actions and remained low through 2021 as a result of actions: (1) to lessen Hg discharges to WOC at Outfall 211 (sump reroutes to PWTC) and (2) to reduce Hg discharges from PWTC. In general, ambient concentrations have remained low since 2008, with a few exceptions. In 2021, Hg concentrations were below WQC at all of the ambient/instream sites that were monitored. The average aqueous Hg concentration at WOD (WCK 1.5) was 25.73 ng/L compared with 29.48 ng/L in 2020.



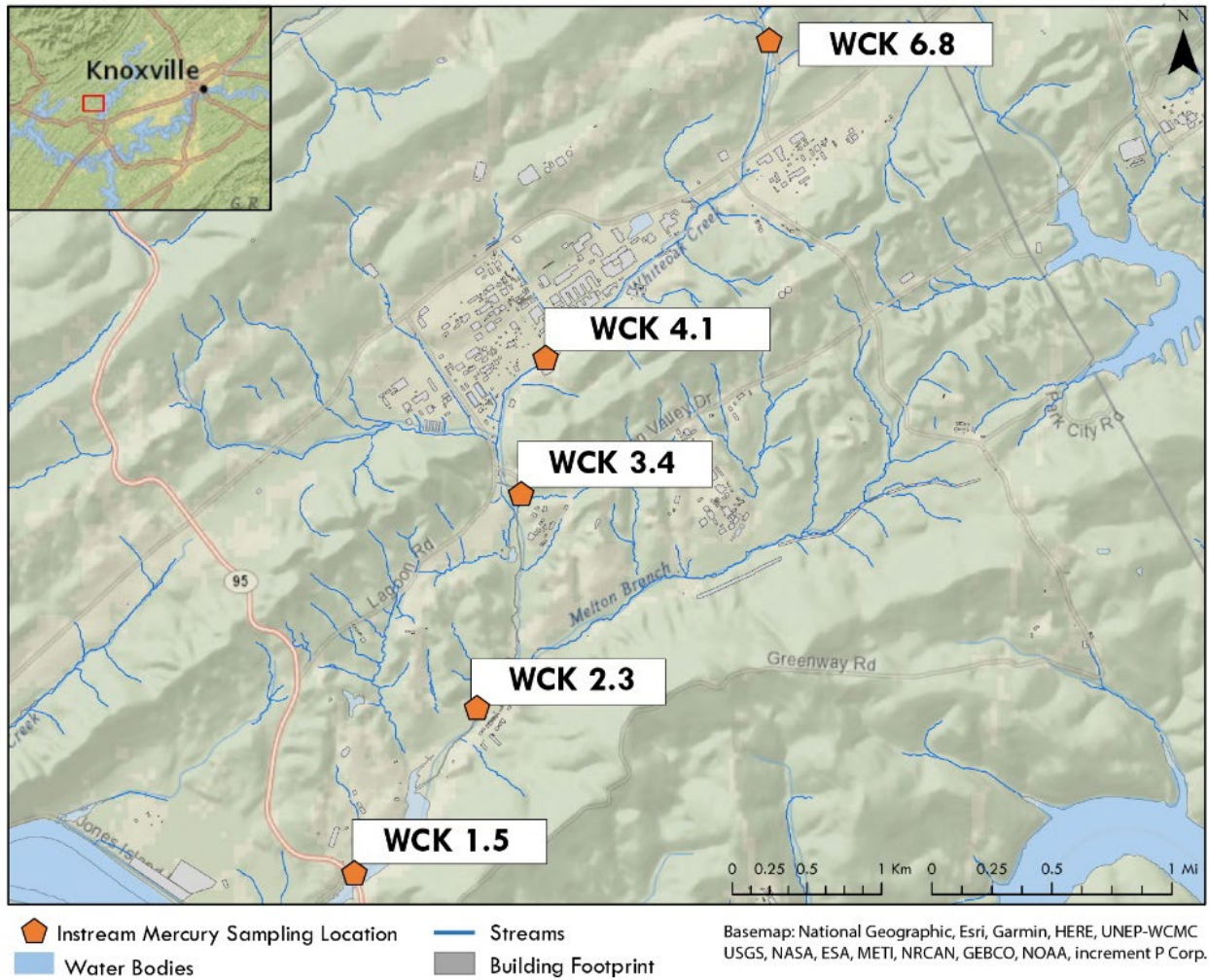
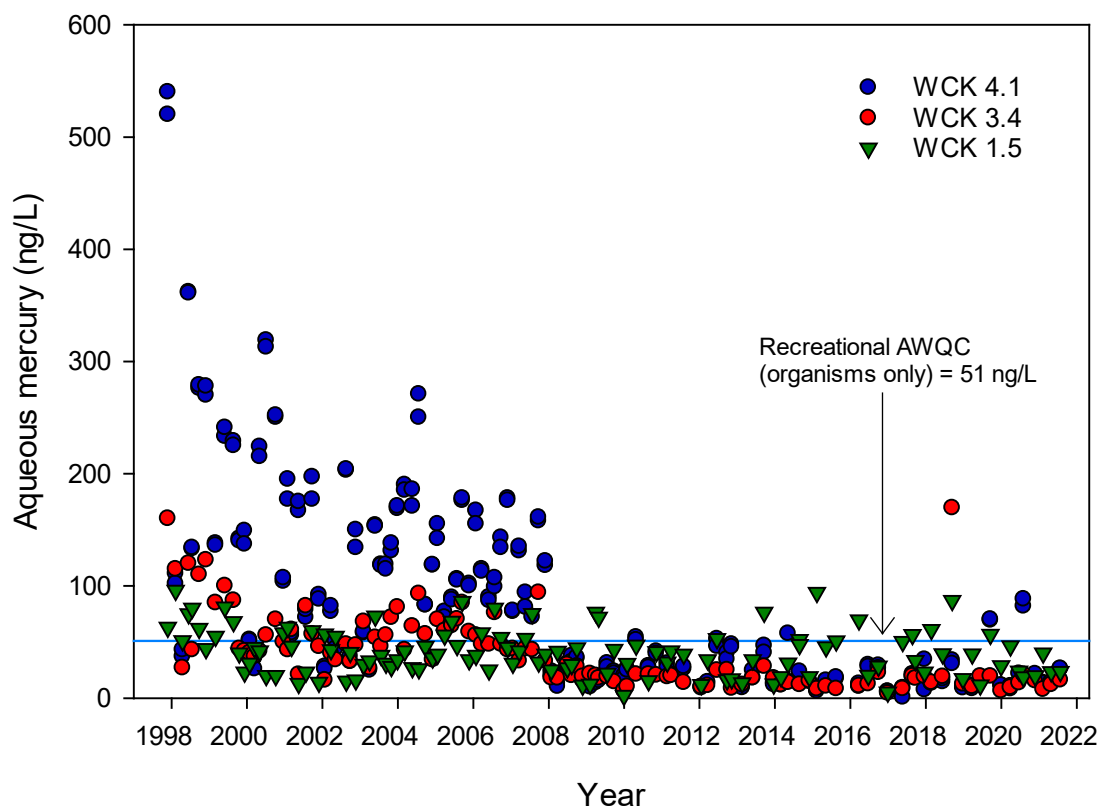


Figure 5.21. Instream mercury monitoring and data locations, 2021



**Note:** The blue line at 51 ng/L shows the Recreational Water Quality Criteria for Water and Organisms.

**Acronym:** WCK = White Oak Creek kilometer

**Figure 5.22. Aqueous mercury concentrations at sites in White Oak Creek downstream from ORNL, 1998–2021**

#### 5.5.4.2. Water Quality Protection Plan Mercury Investigation

Outfalls X01 (STP) and X12 (PWTC) are monitored for Hg quarterly. Twenty-four-hour composite samples are taken, and discharge flows are measured and recorded. Figure 5.23 shows the total Hg concentration STP discharges to Outfall X01 from 2010 to 2021. Concentrations of Hg discharged from the STP at Outfall X01 had been less than 10 ng/L since 2014 until there was an increase to 46 ng/L in May 2019. After a sand filter media change-out on July 14, 2019,

discharge concentrations dropped to 2 ng/L. In 2021, mercury concentrations in Outfall X01 effluent averaged 8.3 ng/L. Figure 5.24 shows trends in X12 total Hg concentrations and fluxes for 2009 through 2021 (worst-case loads are calculated in milligrams per day based on concentration and flow using 24-hour discharge rates). After final replacement of dual-media and Mersorb filters on July 25, 2019, mercury concentrations and fluxes declined. In 2021 the average X12 effluent Hg concentration was 34.1 ng/L.

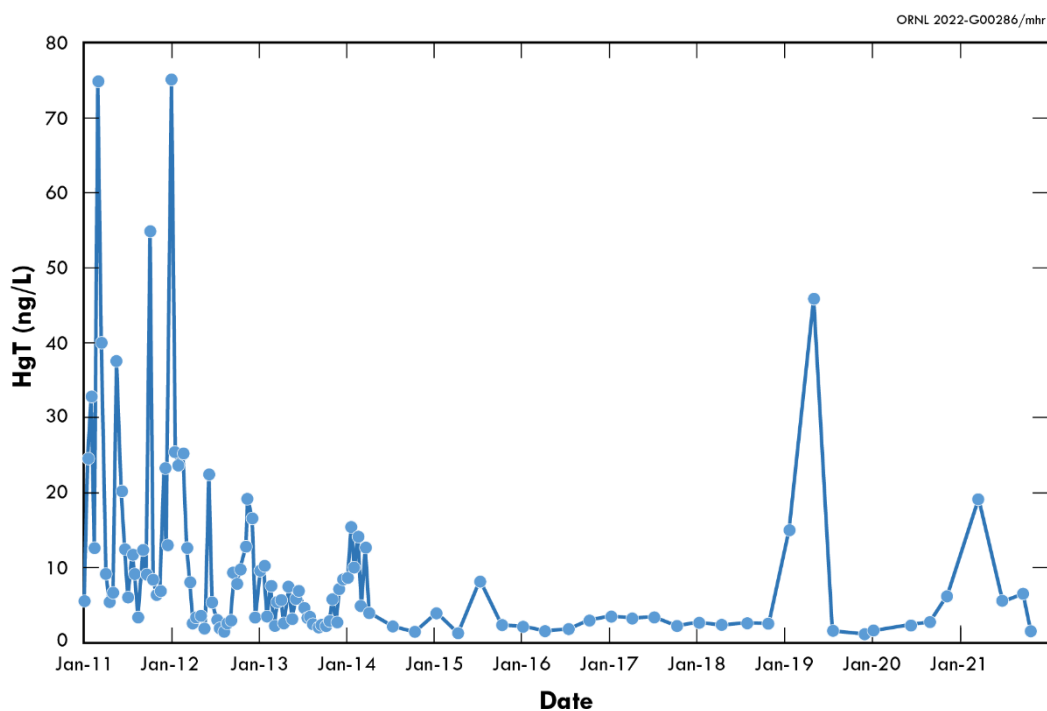
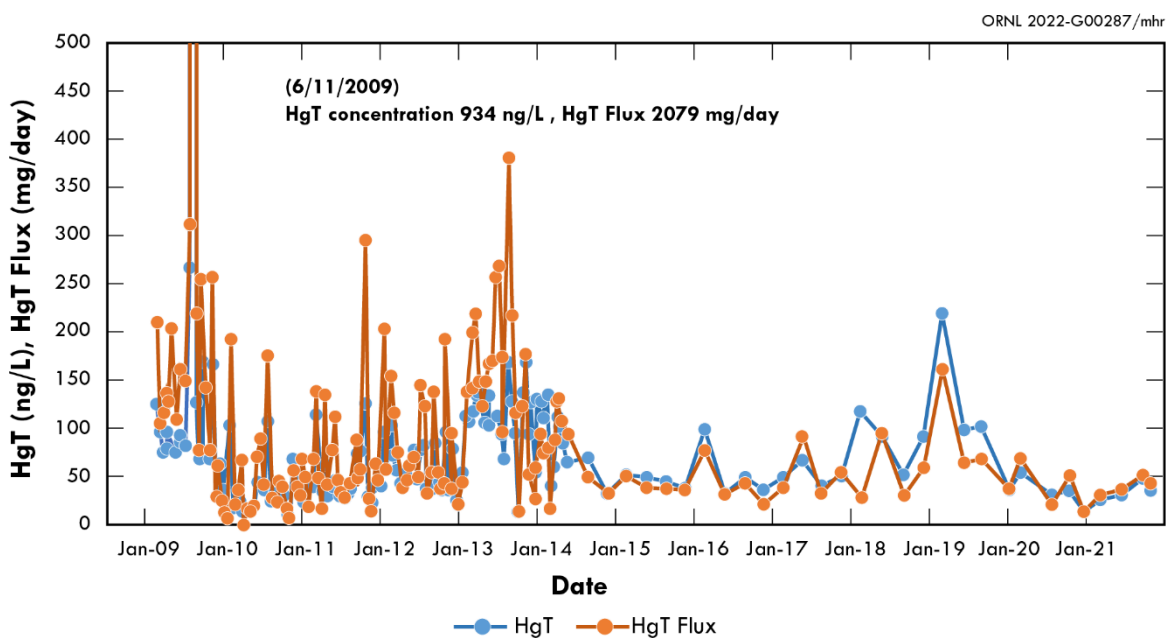


Figure 5.23. Total mercury concentration in discharges to Outfall X01 from the Sewage Treatment Plant, 2010–2021



Acronym: PWTC: Process Waste Treatment Complex

Figure 5.24. Total mercury concentrations and fluxes in Process Waste Treatment Complex discharges to Outfall X12, 2009–2021

Dry-weather sampling at Outfalls X01 and X12 was coordinated with 24-hour Hg sampling at three instream locations (Figure 5.25). Instream locations were WCK 4.4, which is upstream of the two treatment plant outfalls; WCK 3.4 at the 7500 Bridge monitoring station, downstream of the ORNL main campus and both wastewater-treatment-plant outfalls; and X15 at WOD. Flow measurements were not available to calculate

fluxes at the upstream point WCK 4.4 but were available for treatment plant discharges and for the two locations downstream of the treatment plants (see Figure 5.26). As shown in Figure 5.26, Hg flux at WOD (X15), the discharge outlet from White Oak Lake, is typically several times greater than the Hg flux at the treatment-plant outfalls X01 and X12, or that at WCK 3.4 in WOC downstream of the ORNL main campus.

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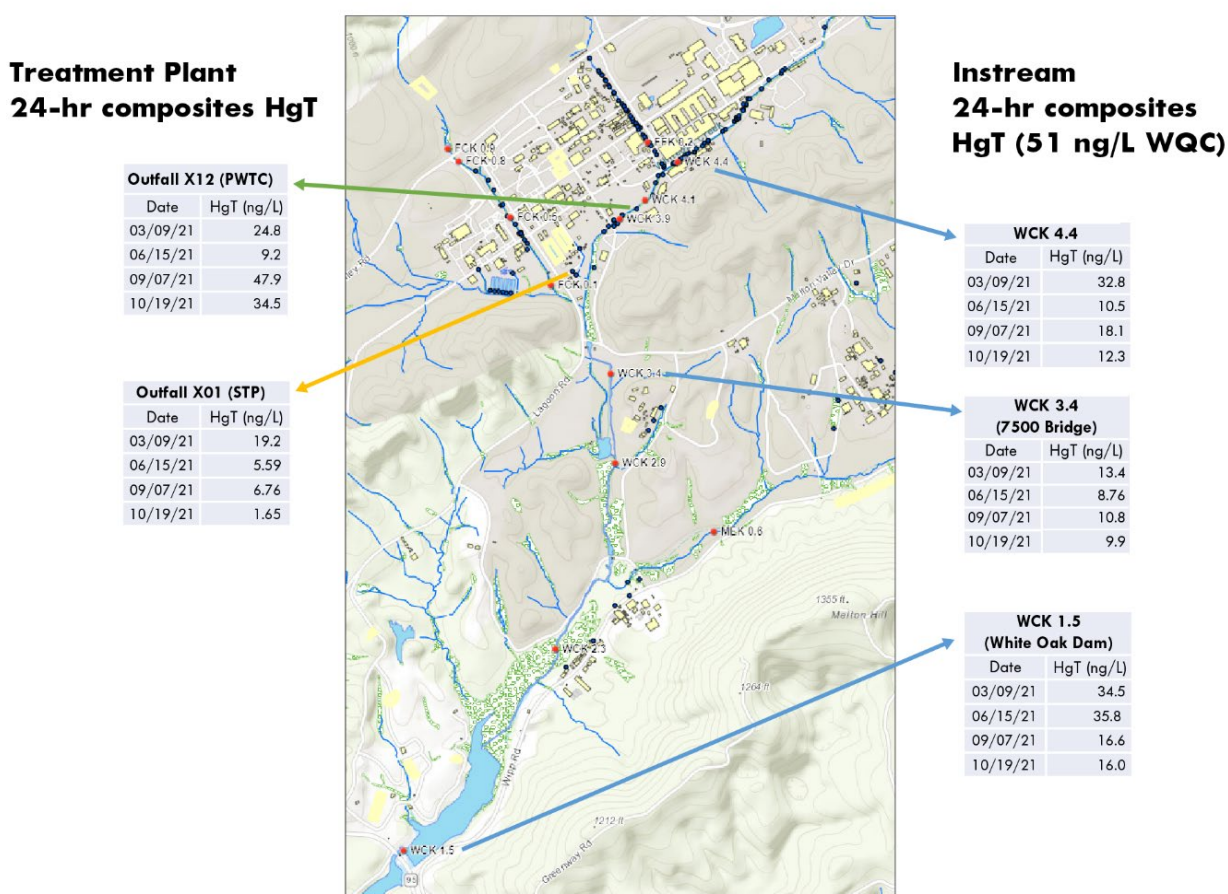
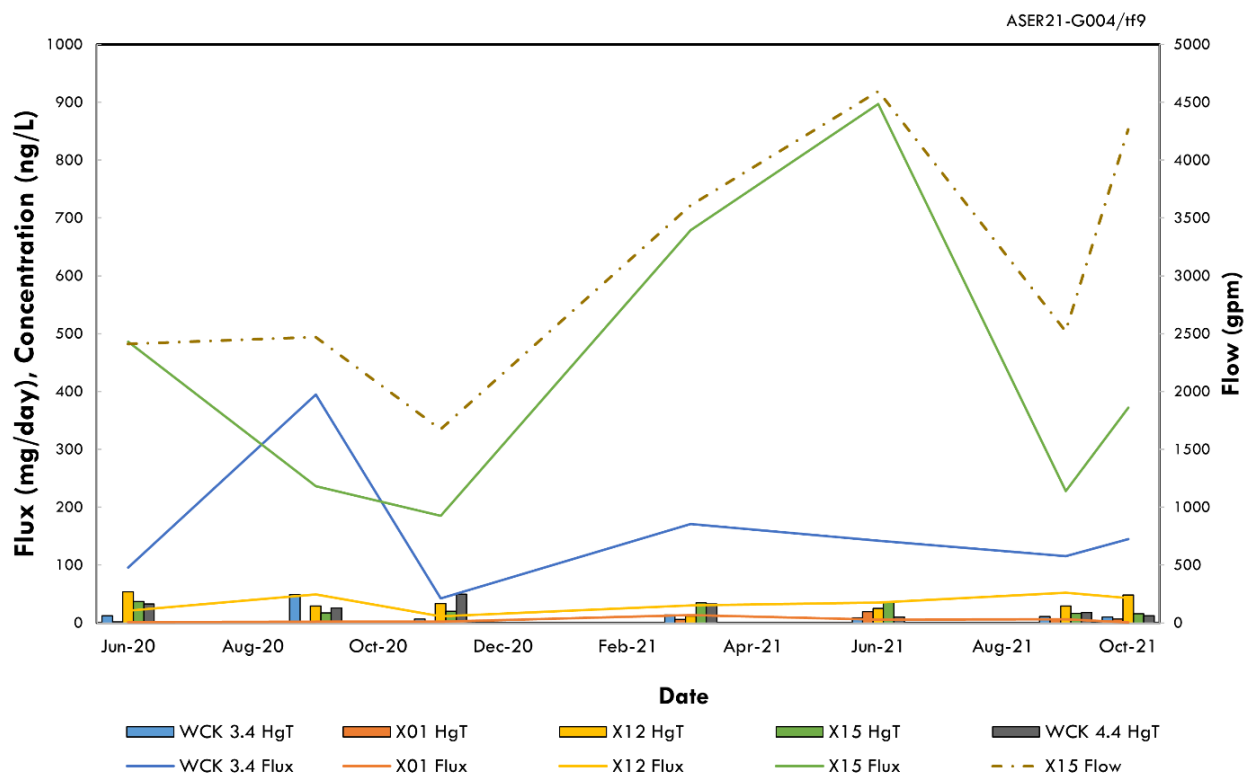


Figure 5.25. Locations and data for instream sampling sites coordinated with treatment plant sampling, 2021



Acronym: WCK = White Oak Creek kilometer

Figure 5.26. Mercury concentrations and fluxes from Sewage Treatment Plant and Process Waste Treatment Complex discharges compared with instream values from dry-weather sampling at WCK 4.4 (no flux available), WCK 3.4, and X15 (White Oak Dam), 2020–2021

### 5.5.4.3. Legacy Outfall Source Investigation

Legacy outfalls are investigated as part of the WQPP to better delineate Hg sources and to prioritize future abatement actions. In recent years, WQPP monitoring has focused on Outfalls 207 and 211, which generally show the highest Hg concentrations. Discharged water volumes (and therefore fluxes) from Outfall 211 are higher than discharges from Outfall 207. In 2021, Hg monitoring was performed at Outfalls 265 and 363, which both discharge to Fifth Creek. In the past, there have been discharges of mercury at levels of interest at these two outfalls; therefore, Hg monitoring continued at these locations in 2021. The volumes of Outfall 211 dry-weather discharges dropped after 2012, when water conservation efforts were made to recirculate once-through cooling water. Figure 5.27 shows Hg concentrations and fluxes in dry-weather discharges to Outfall 211; Hg concentrations

dropped to around 140 ng/L in 2021, while dry-weather flows have remained at about 50 gal/min. During storms, a downward trend in flux may be the result of periodic sediment removal from the Outfall 211 weir box (Figure 5.28). Plans are being made to remove accumulated sediments from the Outfall 211 weir box in 2022, and to quantify the benefit of sediment-deposit removal in the context of the overall flux of Hg from the ORNL site to the WOC watershed.

Since 2015, Outfall 207 has had dry-weather flows of 1 gpm or less, with fluxes of less than 1 mg/day total Hg. Flow rates for storm water discharged through Outfall 207 (Figure 5.29) have varied from 5 gpm to more than 100 gpm; higher fluxes occurred during storms. The average wet-weather Hg flux from Outfall 207 in 2021 was 31 mg/day. Storm water fluxes of total Hg at Outfall 207 are less than half those seen at Outfall 211.

Outfall 363 receives cooling tower blowdown, and monitoring is performed twice monthly. Dry weather flows ranged from about 3 to 15 gpm, and wet-weather flow was measured at 65 gpm. In 2021, the average dry-weather Hg flux from

Outfall 363 was 1.2 mg/day, and the wet-weather flux was 5.4 mg/day. No dry-weather flow was detected during 2021 monitoring of Outfall 265; in wet weather, the average Hg flux from Outfall 265 was 3.4 mg/day.

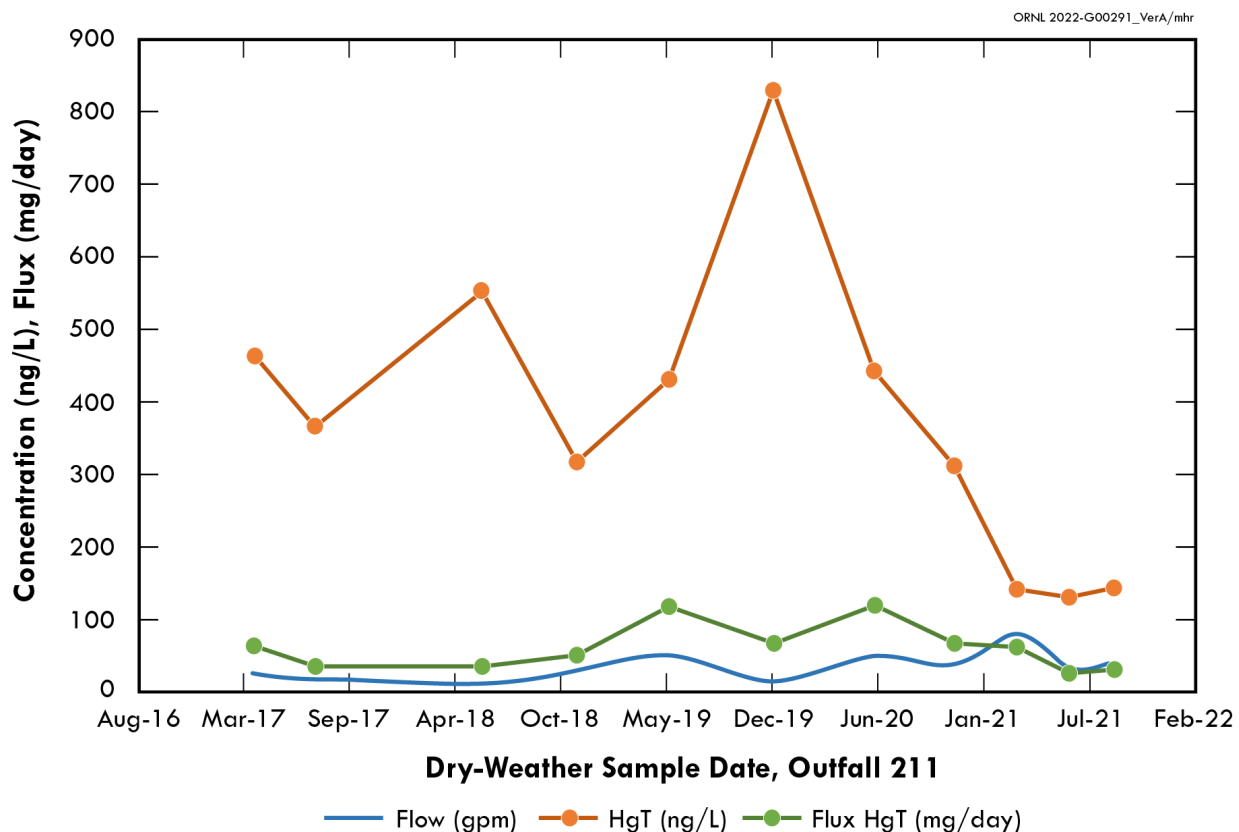


Figure 5.27. Outfall 211 dry-weather flow, concentration, and flux, 2017–2021

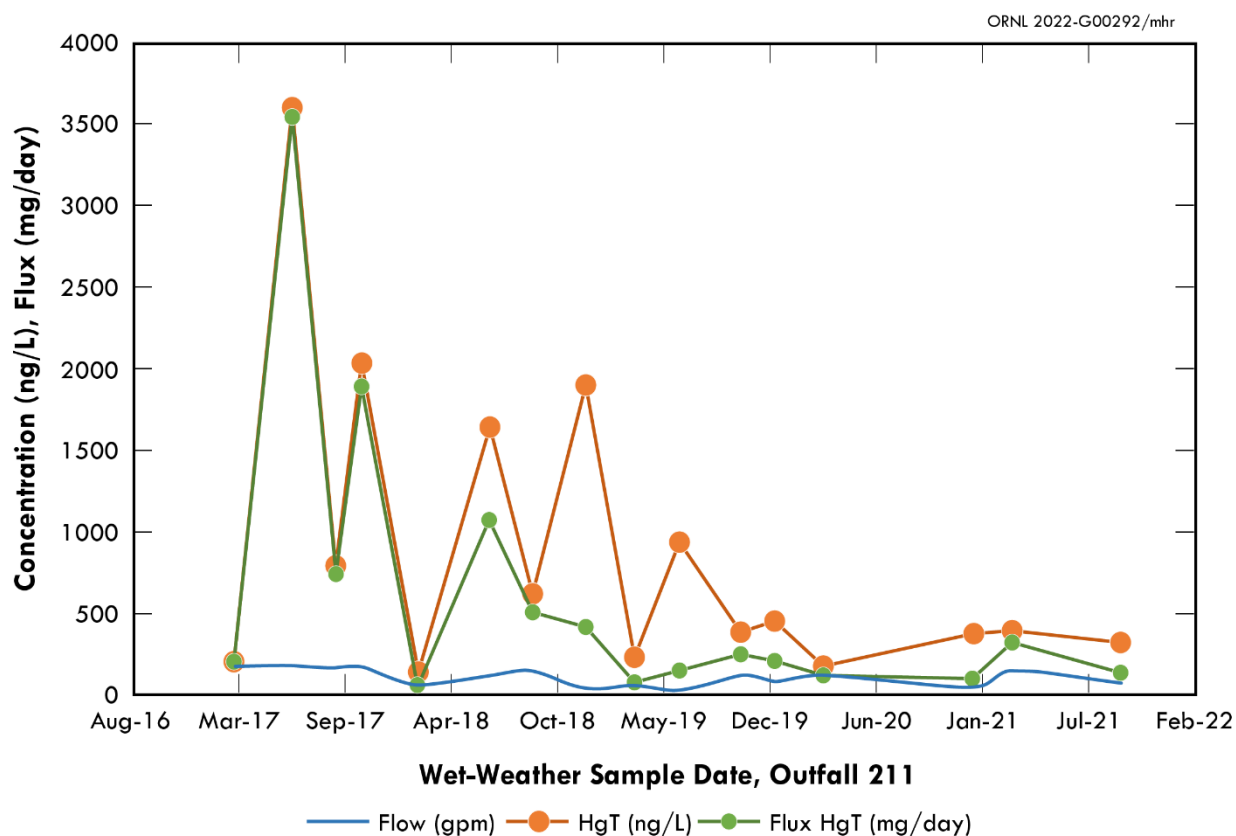


Figure 5.28. Outfall 211 storm flow, dissolved and total mercury flux, 2017–2021

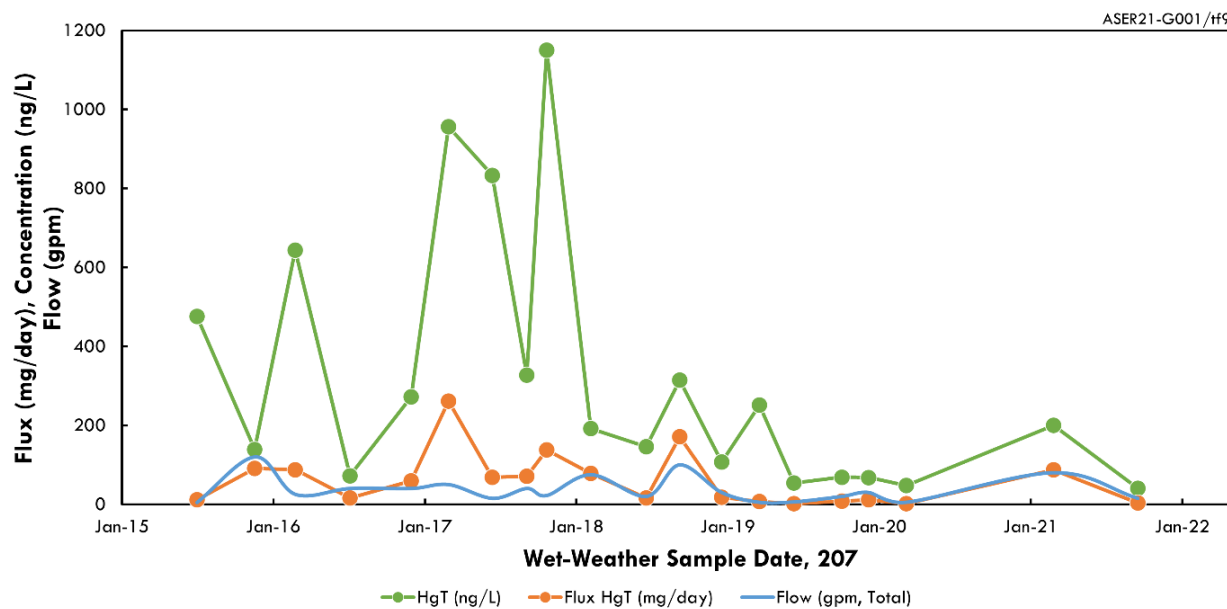


Figure 5.29. Outfall 207 storm flow, dissolved Hg flux, and total Hg flux, 2015–2021

#### 5.5.4.4. Baseline Preconstruction Investigation of 207 and 304 Storm Catch Basins

Redevelopment is planned for a central portion of the ORNL main plant area, west of Building 3500. The soil at the southeast corner of the construction site contains legacy Hg contamination. Construction of a planned new building and/or subsequent discharges from its cooling towers or storm water runoff through old storm piping might increase Hg discharges through Outfalls 207 and 304. Therefore, sampling and preconstruction investigation of storm water catch basins in the Outfall 207 and 304 drainage areas were conducted in 2020. During design of the new building, the cooling tower discharge and approximately half to three-quarters of the roof drainage are being routed to Outfall 264 on Fifth Creek. The remaining roof and storm water discharges will be routed to Outfall 207. As construction plans changed, attempts were made to sample baseline discharges from Outfall 264; however, no water was flowing through Outfall 264 during any of the attempted sampling events. Efforts to collect samples will continue.

The storm drain systems at Outfalls 304 and 207 are original and currently have no cooling water discharge inputs. However, standing water (i.e., accumulated discharges from a groundwater sump, steam condensate discharges, and unknown leakage) was found and sampled in the storm water system during dry weather. Mercury was detected (~20.5 ng/L) in Building 3500 groundwater sump discharge to the Outfall 207 storm drain network. Mercury was also found in standing water in Catch Basin 1275, southeast of Building 3500 (11.6 ng/L and duplicate result 377 ng/L). The large discrepancy between duplicate sample results is likely due to the entrainment of particulates containing Hg. Sediment removal in Catch Basin 1275 is planned for 2022. In 2020, the Outfall 304 drainage system was also sampled for Hg during dry weather (flow mainly from steam condensate discharge), and follow-up sampling was performed during rainfall. Mercury concentrations (both dry and wet weather) were less than those found in the Outfall 207 storm drainage system. During the 2020

sampling effort, the highest total Hg concentration (27 ng/L) was found during rainfall at Catch Basin 1286, just northeast of the old 3544 Radioactive Treatment Plant. Even during rainfall, samples were hard to obtain in the 304 pipe network because of storm pipe leakage and low flow rates. As was the case at Outfall 207, the Hg concentration at Outfall 304 (3.2 ng/L) was lower than the Hg concentration in the catch basins contributing to it.

#### 5.5.5. Storm Water Surveillances and Construction Activities

Storm water drainage areas at ORNL are inspected twice per year as directed in the WQPP. Land use within drainage areas is typical of office/industrial/research settings with surface features that include laboratories, support facilities, paved areas, and grassy lawns. Outdoor material is located temporarily in many places at ORNL, but most activity involving the movement and storage of outdoor material takes place in the 7000 area, which is located on the east end of the ORNL site and where most of the craft and maintenance shops are located. Smaller outdoor storage areas are located throughout the facility in and around loading docks and material delivery areas at laboratory and office buildings. The types of materials stored outside, as noted in field inspections, include finished metal items (pipes and parts); equipment awaiting use, disposal, or repair; aging (rusting) infrastructure; and construction equipment and material. While sites that are covered by a Tennessee construction general permit are considered to have more significant potential for runoff impacts, inspections and controls required by an approved storm water pollution prevention plan have proven effective at minimizing short-term and long-term impacts to nearby streams and waterways from construction sites.

Storm water outfall sampling at select outfalls was conducted in 2021 as part of a nutrient sampling plan. Initial results indicate that nutrients in receiving streams originate from dry-weather sources believed to be from cooling systems where additives used in cooling system maintenance can contain phosphorus and nitrate



components. Further evaluation of nutrients will continue under the WQPP.

Some construction activities are performed on third-party-funded construction projects on ORR under agreements with federal agencies other than DOE and with local and state agencies. There are mechanisms in place for ensuring effective storm water controls at the third-party sites, one of which includes staff from UT-Battelle acting as points of contact for communication interface on environmental conditions, erosion and sedimentation controls, spill/emergency responses, and other key issues.

### 5.5.6. Biological Monitoring

Biological monitoring programs conducted at ORNL in 2021 included bioaccumulation studies in the WOC watershed; benthic macroinvertebrate monitoring in WOC, First Creek, and Fifth Creek; and fish community monitoring in WOC and its major tributaries. The following sections summarize the biological monitoring programs at ORNL and the results for 2021.

#### 5.5.6.1. Bioaccumulation Studies

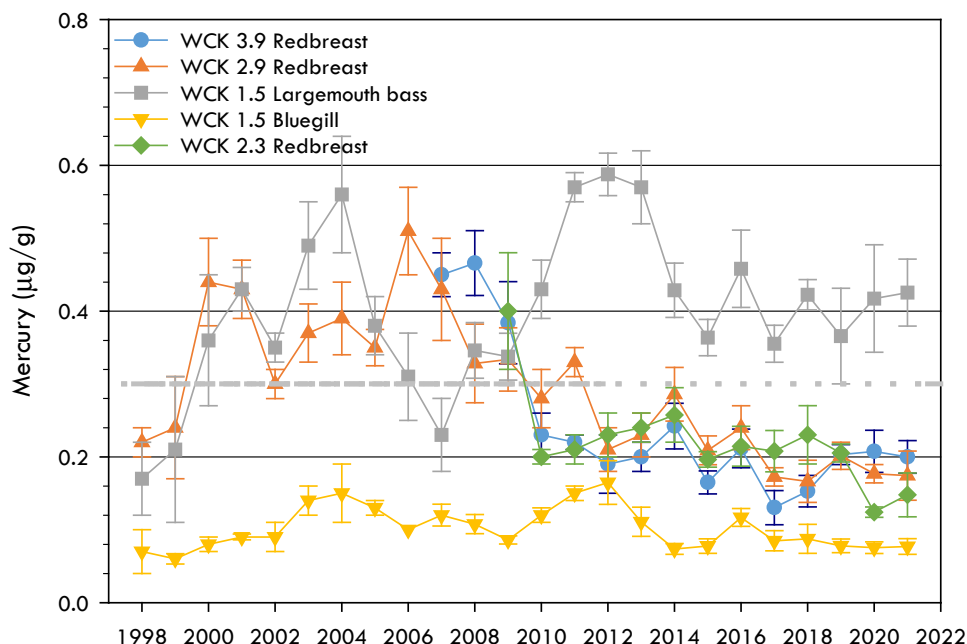
The bioaccumulation task for the biological monitoring and abatement plan addresses two NPDES permit requirements at ORNL: (1) evaluate whether mercury at the site is contributing to streams at a level that will adversely affect fish and other aquatic life or that will violate the recreational criteria and (2) monitor the status of PCB contamination in fish tissue in the WOC watershed. Concentrations of mercury in fish in the WOC watershed are monitored annually and are evaluated relative to the EPA AWQC of 0.3 µg/g in fish fillets, a concentration considered protective of human health and the environment. Concentrations of PCBs in fish fillets are also

monitored annually and are evaluated relative to the TDEC fish advisory limit of 1 µg/g.

#### ***Bioaccumulation in fish***

Mercury concentrations in fish have been below human health risk thresholds (e.g., EPA recommended fish-based AWQC [0.3 µg/g for mercury]) in the stream portions of WOC, but concentrations in fish collected in White Oak Lake continue to be above this threshold. (Figure 5.30) Actions taken in 2007 to treat a mercury-contaminated sump resulted in significant decreases in mercury concentrations in fish throughout WOC. The decreases were most apparent at upstream locations closest to the sump water reroute. Although the overall trends in the uppermost locations sampled in the creek suggest that Hg concentrations in fish tissue are decreasing overall, some interannual variability exists. Fillet concentrations of Hg for all monitored sites and species were consistent from 2020 to 2021. Concentrations in all sunfish samples remained below the AWQC for Hg in fish, and concentrations in largemouth bass collected from WCK 1.5 remained above this threshold. Largemouth bass are longer-lived, upper trophic-level fish, so the higher concentrations of bioaccumulative contaminants, such as Hg, in these fish are not surprising.

In 2021, PCB concentrations (defined as the sum of Aroclors 1248, 1254, and 1260) in fish collected throughout the WOC watershed were below human health risk thresholds (TDEC fish advisory limit of 1 µg/g for PCBs). Although PCB concentrations in fish collected in the stream portions have remained below this threshold, concentrations in fish collected in White Oak Lake, especially largemouth bass, have often been well above this threshold in recent years (Figure 5.31).

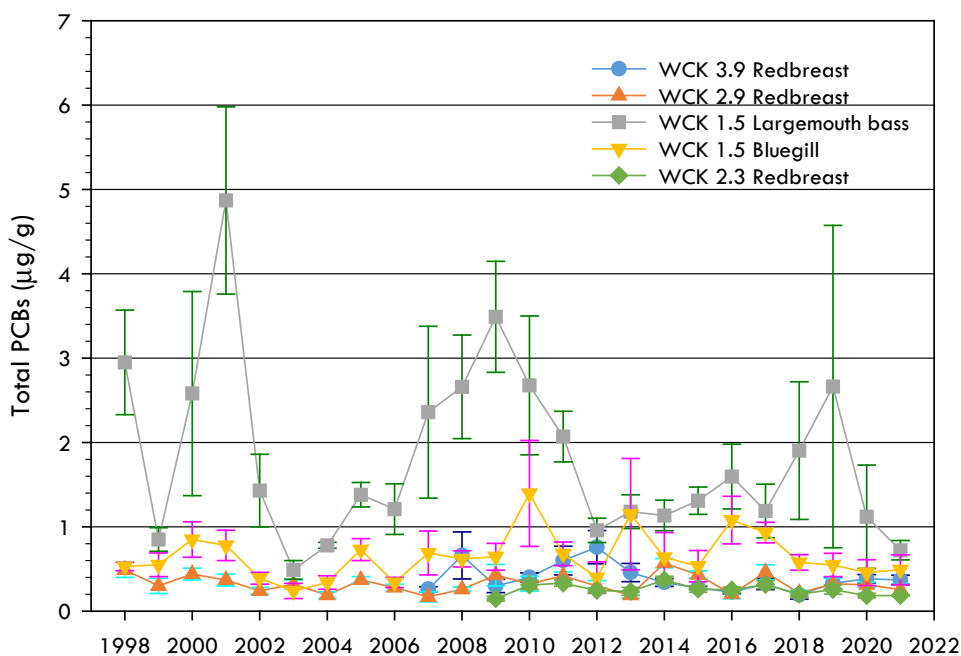


**Notes:**

1. Mean concentrations of Hg ( $\pm$  standard error,  $N = 6$ ) in tissue taken from sampled fish.
2. The dashed grey line at  $0.3 \mu\text{g/g}$  indicates the US Environmental Protection Agency ambient water quality criterion for Hg in fish tissue.

**Acronym:** WCK = White Oak Creek kilometer

**Figure 5.30. Mean mercury concentrations in muscle tissue of sunfish and bass sampled from the White Oak Creek watershed, 1998–2021**



**Note:** Mean total PCB concentrations ( $\pm$  standard error,  $N = 6$ ) found in fish fillets.

**Acronyms:** PCB = polychlorinated biphenyl    WCK = White Oak Creek kilometer

**Figure 5.31. Mean total PCB concentrations in fish sampled from the White Oak Creek watershed, 1998–2021**

### 5.5.6.2. Benthic Macroinvertebrate Communities

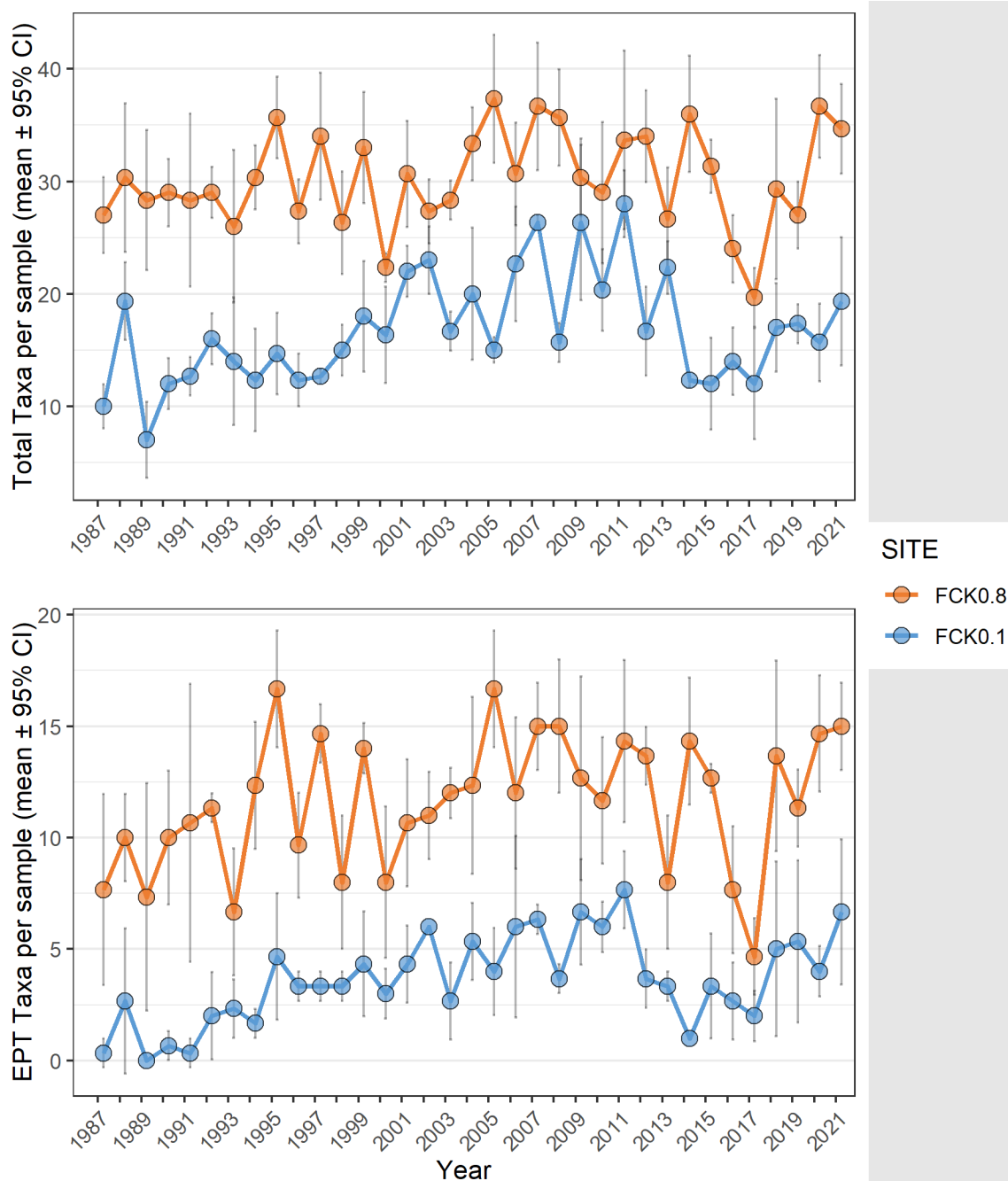
Monitoring of benthic macroinvertebrate communities in WOC, First Creek, and Fifth Creek continued in 2021. Additionally, monitoring of the macroinvertebrate community in lower Melton Branch (MEK 0.6) continued under the OREM Water Resources Restoration Program (WRRP). Benthic macroinvertebrate samples are collected annually following TDEC protocols (since 2009) and protocols developed by ORNL staff (since 1987). The protocols developed by ORNL staff provide a long-term record (35 years) of spatial and temporal trends in the invertebrate community from which the effectiveness of pollution abatement and RAs taken at ORNL can be evaluated and verified. The ORNL protocols also provide quantitative results that can be used to statistically evaluate changes in trends relative to historical conditions. The TDEC protocols provide a qualitative estimate of the condition of a macroinvertebrate community relative to a state-defined reference condition.

General trends in the results of ORNL protocols indicated significant recovery in benthic macroinvertebrate communities since 1987, but community characteristics suggest that ecological impairment remains (Figures 5.32–5.34). Relative to respective upstream reference sites, total taxonomic richness (i.e., the number of different species per sample) and richness of the pollution-intolerant taxa (i.e., the number of different mayfly, stonefly, and caddisfly species per sample or Ephemeroptera, Plecoptera, and Trichoptera [EPT] taxa richness) continued to be lower at these downstream sites.

In lower First Creek (First Creek kilometer [FCK] 0.1), total taxa richness increased gradually in the 1990s and 2000s but was then lower for 4 years beginning in 2014 (Figure 5.32). Total taxa richness has increased at FCK 0.1 in the past 4 years (2018 to 2021), reaching values that were previously observed before 2014. Similarly, the number of pollution-intolerant EPT taxa decreased in 2012, and in 2014, EPT taxa richness

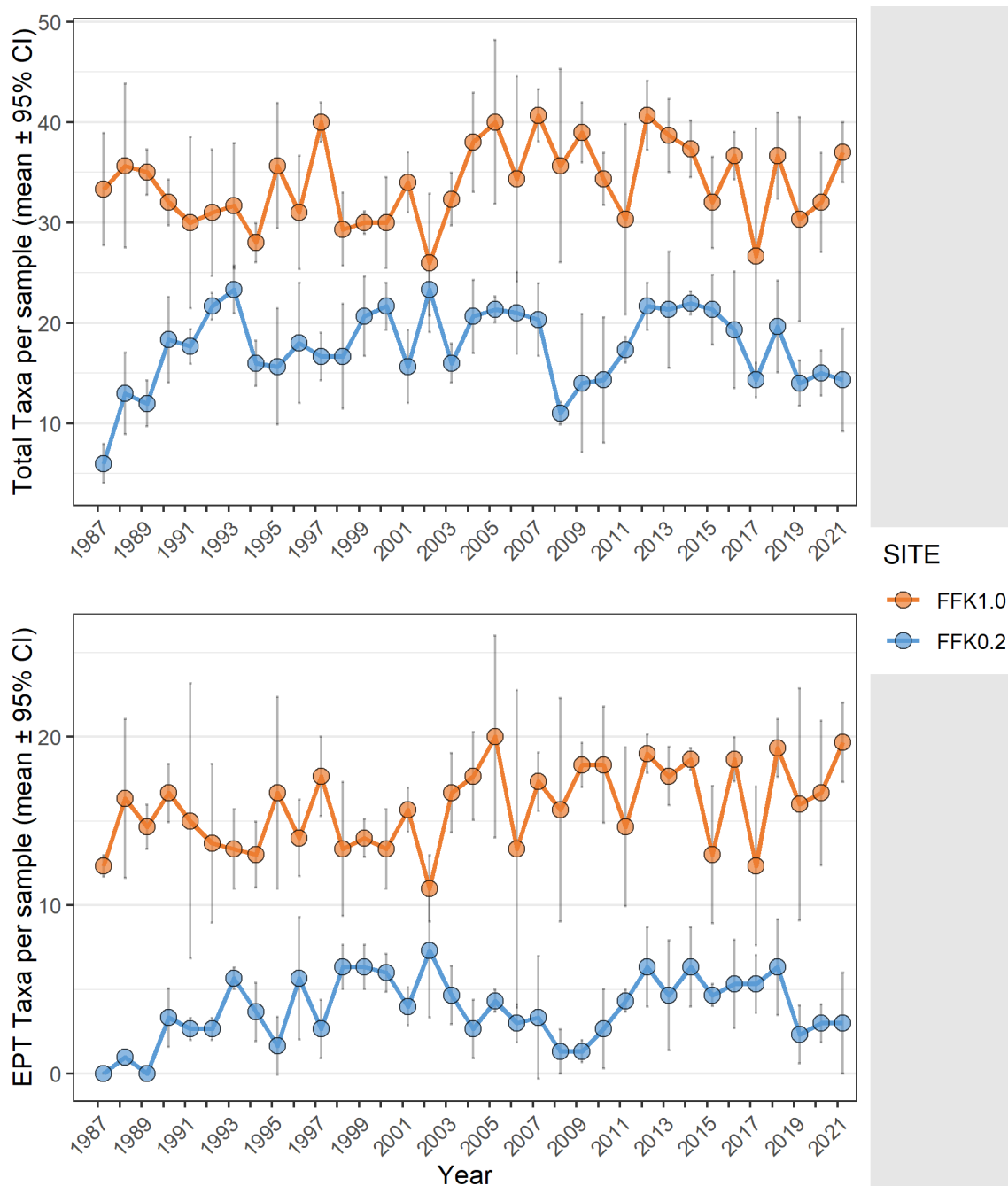
was the lowest it had been since the early 1990s. After six consecutive years of low EPT taxa richness, values have fluctuated between years but have generally increased, with 2021 values being the highest in the past 10 years. Additionally, in upper First Creek (FCK 0.8), which serves as a reference for FCK 0.1, total taxa richness and EPT taxa richness declined for three consecutive years (from 2015 to 2017), but those metrics have since returned to levels near the highest values from previous years despite a slight decrease in total taxa richness in 2021. The 6 year period of extremely low values in FCK 0.1 did not mirror those in FCK 0.8, which suggests that while climate or hydrological change may have influenced conditions within the entire stream (both FCK 0.1 and FCK 0.8), a more localized change also may have occurred in lower First Creek. If a change has occurred, it is not known whether it is related to a change in chemical conditions (e.g., change in water quality or the possible presence of a toxicant), physical conditions (e.g., unstable substrate, increased frequency of high-discharge events), or natural variation. Furthermore, it is unclear at this time whether conditions at FCK 0.1 have improved temporarily or for the long term.

Total taxa richness at Fifth Creek kilometer (FFK) 0.2 increased in the late 1980s and early 1990s, and then reached a fairly consistent level until exhibiting a large decrease between 2007 and 2008 (Figure 5.33), suggesting that a change in conditions occurred at the site during that time. Total taxa richness returned to predecline levels over a period of about 5 years. EPT taxa richness at FFK 0.2 increased slowly from the late 1980s to early 2000s before decreasing for several years (~2003–2011). More recently, EPT taxa richness remained steady at about five to six EPT taxa per sample (2011–2018). However, EPT taxa richness in 2019 decreased by four (from six EPT taxa/sample in 2018 to two EPT taxa/sample in 2019) and remained low in 2020 and 2021 (three EPT taxa/sample). It is not known whether this decrease will persist in future years or whether it instead reflects interannual variation in invertebrate community composition.



**Note:** Taxonomic richness (number of taxa per sample), 1987–2021. FCK 0.8 serves as a reference site.  
 Top: Total taxonomic richness.  
 Bottom: Taxonomic richness of the pollution-intolerant taxa Ephemeroptera, Plecoptera, and Trichoptera (EPT).  
**Acronyms:**  
 CI = confidence interval  
 FCK = First Creek kilometer

**Figure 5.32. Benthic macroinvertebrate communities in First Creek, 1987–2021**



**Note:** Taxonomic richness (number of taxa per sample), 1987–2021. FFK 1.0 serves as a reference site.

Top: Total taxonomic richness.

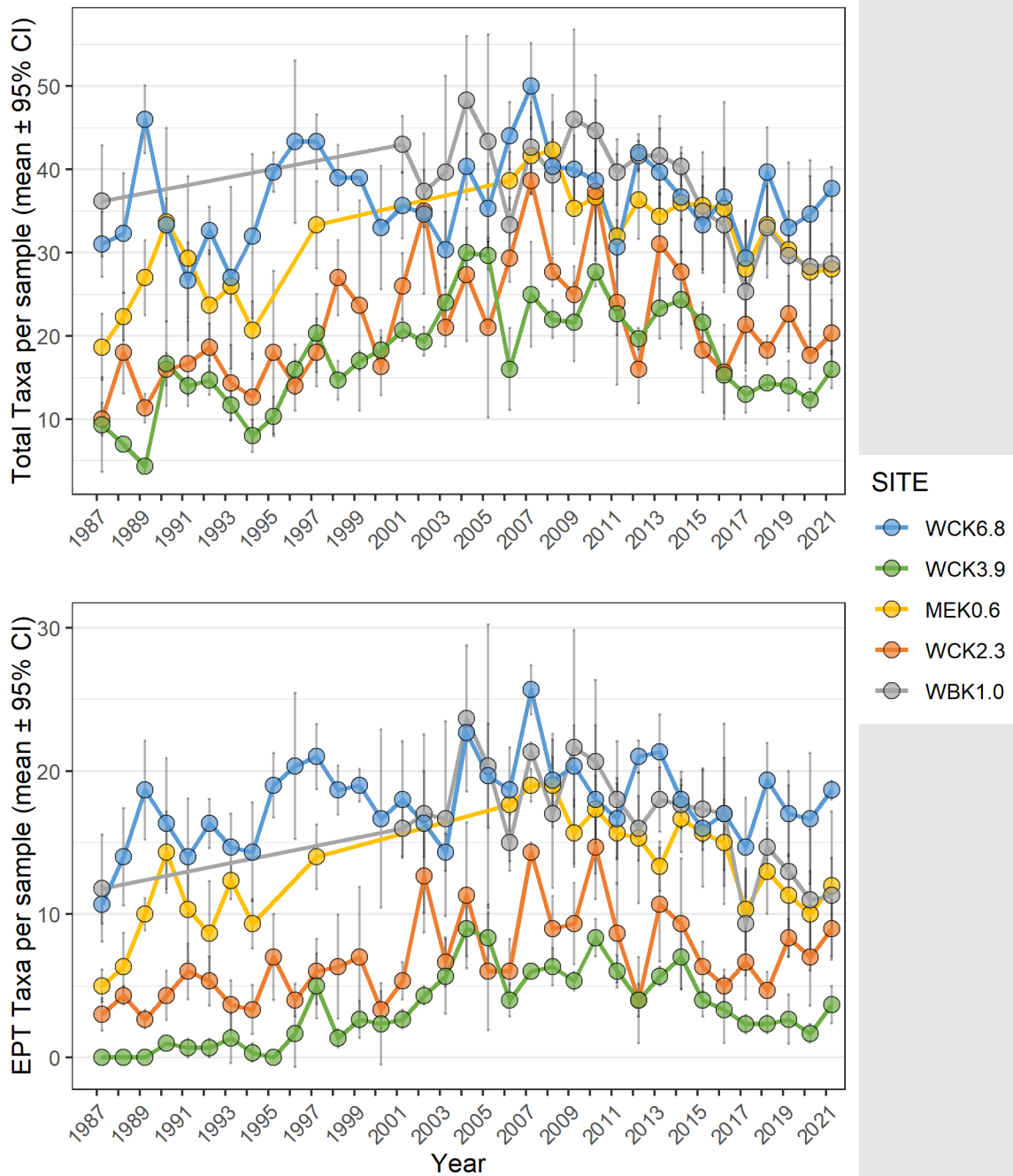
Bottom: Taxonomic richness of the pollution-intolerant taxa Ephemeroptera, Plecoptera, and Trichoptera (EPT).

**Acronyms:**

CI = confidence interval

FFK = Fifth Creek kilometer

**Figure 5.33. Benthic macroinvertebrate communities in Fifth Creek, 1987–2021**



**Note:** Taxonomic richness (number of taxa per sample), 1987–2021. WCK 6.8 and WBK 1.0 serve as reference sites.

Top: Total taxonomic richness.

Bottom: Taxonomic richness of the pollution-intolerant taxa Ephemeroptera, Plecoptera, and Trichoptera (EPT).

**Acronyms:**

CI = confidence interval

MEK = Melton Branch kilometer

WBK = Walker Branch kilometer

WCK = White Oak Creek kilometer

**Figure 5.34. Benthic macroinvertebrate communities in Walker Branch, Melton Branch, and White Oak Creek, 1987–2021**

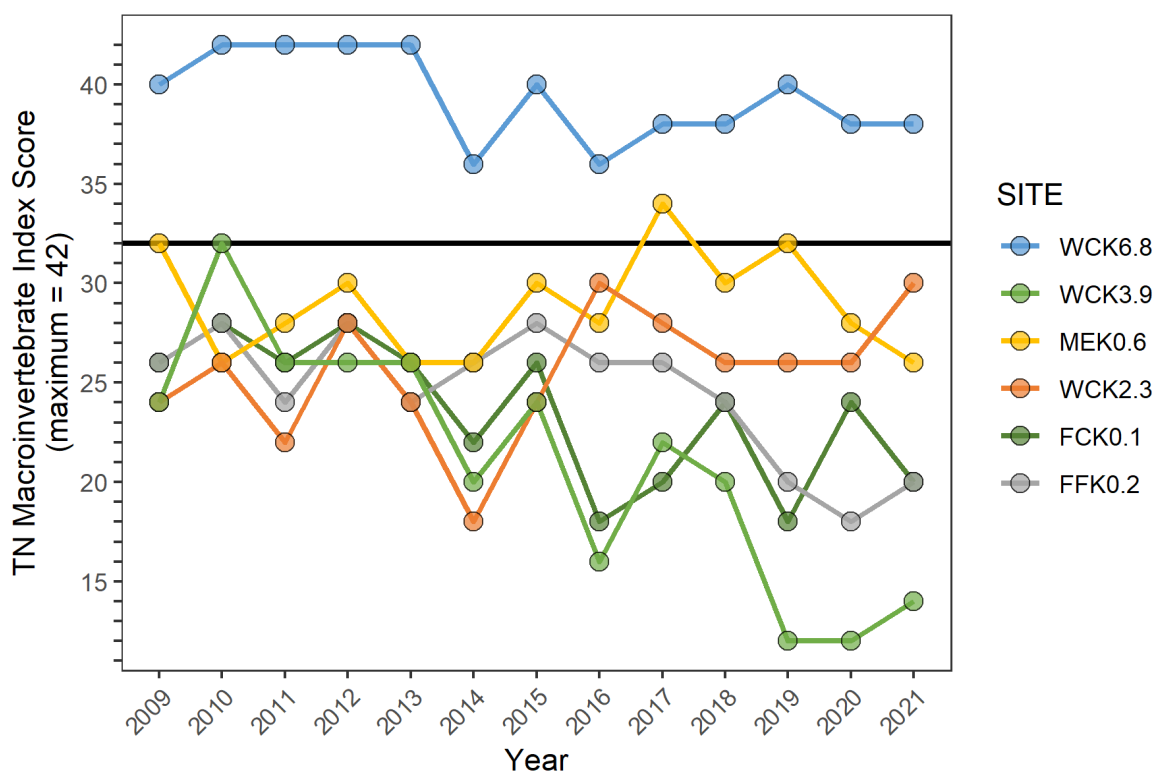
Although this recent decline was also seen at upper Fifth Creek (FFK 1.0), which serves as a reference for FFK 0.2, both total and EPT richness values have consistently remained higher than at FFK 0.2 and have steadily increased at the upstream site since 2019.

Invertebrate metric values for WCK 2.3 and WCK 3.9 continued to remain within the ranges of values found since the late 1990s and early 2000s, although total taxa richness and EPT taxa richness were lower at WCK 2.3 and WCK 3.9 over the past 6 to 7 years. As with FCK 0.1 and FFK 0.2, the total taxa richness and EPT taxa richness at WCK 2.3 and WCK 3.9 continued to be notably lower than at the reference sites. Since 2001 (except for one sampling event in 1987), Walker Branch has served as an additional reference site for WOC mainstem sites downstream of Bethel Valley Road (Figure 5.34). Comparisons of WCK 6.8 to Walker Branch kilometer (WBK) 1.0 show that communities in WCK 6.8 represent ideal reference conditions. Additionally, the comparison of Walker Branch to downstream sites in WOC show that those WOC communities remain impaired. Interestingly, a pattern similar to FCK 0.8 and FFK 1.0 occurred in both WCK 6.8 and WBK 1.0, where consecutive declines in total taxa richness and EPT taxa richness were observed in 2018 and 2019, though subsequent responses have varied with sites higher (FCK 0.8), lower (WBK 1.0), or showing little change (FFK 1.0, WCK 6.8) in 2021 relative to 2018. This suggests that similar climatological or environmental changes may be contributing to some of these patterns across the entire watershed, if not the entire ORR, but local drivers may also be present. Macroinvertebrate metrics for Melton Branch (Melton Branch

kilometer [MEK] 0.6) suggested that total taxa and EPT taxa richness continued to be similar to those in reference sites in 2021, particularly WBK 1.0 (Figure 5.34). However, other invertebrate community metrics at MEK 0.6 potentially sensitive to more specific types of pollutants, such as the density of pollution-intolerant and pollution-tolerant species (not shown), continued to fluctuate annually between comparable values and values below those of the reference sites. For the past 6 years (2016–2021), EPT density was generally lower in MEK 0.6 than WCK 6.8 and WBK 1.0 while the density of pollution-tolerant species (oligochaetes and chironomids) was higher in MEK 0.6 than in those two reference sites.

Based on 2017 TDEC protocols (TDEC 2017), scores for the TDEC Tennessee Macroinvertebrate Index (TMI) in 2021 rated the invertebrate communities at WCK 6.8 as passing biocriteria guidelines; scores from FCK 0.1, FFK 0.2, MEK 0.6, WCK 2.3, and WCK 3.9 were below these guidelines (Figure 5.35, Table 5.12). Of the five sites below the biocriteria threshold, scores improved at three sites from 2020 to 2021 (FFK 0.2, WCK 2.3, and WCK 3.9), and declined at two sites (MEK 0.6 and FCK 0.1).

Low TMI scores in FCK 0.1, FFK 0.2, MEK 0.6, WCK 2.3, and WCK 3.9 were primarily due to low values for EPT percentage and EPT taxa richness (Table 5.12). However, all of the sites had low percentages of oligochaetes and chironomids (worms and nonbiting midges) and thus received high scores for this category. WCK 6.8 received the highest attainable scores for all categories except for total taxa richness and EPT taxa richness.



**Note:** The black horizontal line shows the threshold for Tennessee Macroinvertebrate Index scores. The values above the threshold represent passing scores; those below do not.

**Acronyms:**

FCK = First Creek kilometer

MEK = Melton Branch kilometer

FFK = Fifth Creek kilometer

WCK = White Oak Creek kilometer

**Figure 5.35. Temporal trends in Tennessee Department of Environment and Conservation Tennessee Macroinvertebrate Index scores for White Oak Creek watershed streams, August sampling, 2009–2021**



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Table 5.12. Tennessee Macroinvertebrate Index metric values, metric scores, and index scores for White Oak Creek, First Creek, Fifth Creek, and Melton Branch streams, August 24 and 30, 2021<sup>a,b</sup>

Site	Metric values							Metric scores							TMI <sup>c</sup>
	Taxa rich	EPT rich	EPT (%)	OC (%)	NCBI	Cling (%)	TN Nuttol (%)	Taxa rich	EPT rich	EPT (%)	OC (%)	NCBI	Cling (%)	TN Nuttol (%)	
WCK 2.3	23	5	18.1	18.1	5.1	54.8	36.7	4	2	2	6	6	6	4	30
WCK 3.9	16	4	6.2	26.9	6.3	10.8	78.5	2	2	0	6	4	0	0	14
WCK 6.8	28	10	61.2	6.6	2.6	81.1	8.7	4	4	6	6	6	6	6	38[pass]
FCK 0.1	13	3	3.3	0.7	4.5	31.4	45.1	2	0	0	6	6	2	4	20
FFK 0.2	15	7	16.3	11	5.5	29.7	61	2	2	2	6	4	2	2	20
MEK 0.6	16	5	11.7	0.4	4.2	59.6	35.2	2	2	0	6	6	6	4	26

<sup>a</sup> TMI metric calculations and scoring and index calculations are based on TDEC protocols for Ecoregion 67f (TDEC 2017. Quality System Standard Operating Procedures for Macroinvertebrate Stream Surveys, TDEC Division of Water Pollution Control, Nashville, Tennessee. Available [here](#)).

<sup>b</sup> Taxa rich = Taxa richness; EPT rich = taxa richness of mayflies, stoneflies, and caddisflies; EPT = EPT abundance excluding Cheumatopsyche spp.; OC = percent abundance of oligochaetes (worms) and chironomids (nonbiting midges); NCBI = North Carolina Biotic Index; Cling = percent abundance of taxa that build fixed retreats or otherwise attach to substrate surfaces in flowing water; TN Nuttol = percent abundance of nutrient-tolerant organisms.

<sup>c</sup> TMI is the total index score. Higher index scores indicate higher quality conditions. A score of  $\geq 32$  is considered to pass biocriteria guidelines.

**Acronyms:**

EPT = Ephemeroptera, Plecoptera, and Trichoptera  
 FCK = First Creek kilometer  
 FFK = Fifth Creek kilometer  
 MEK = Melton Branch kilometer  
 NCBI = North Carolina Biotic Index

OC = percent abundance of oligochaetes (worms) and chironomids (nonbiting midges)  
 TDEC = Tennessee Department of Environment and Conservation  
 TMI = Tennessee Macroinvertebrate Index Score  
 TN Nuttol = nutrient-tolerant organism  
 WCK = White Oak Creek kilometer

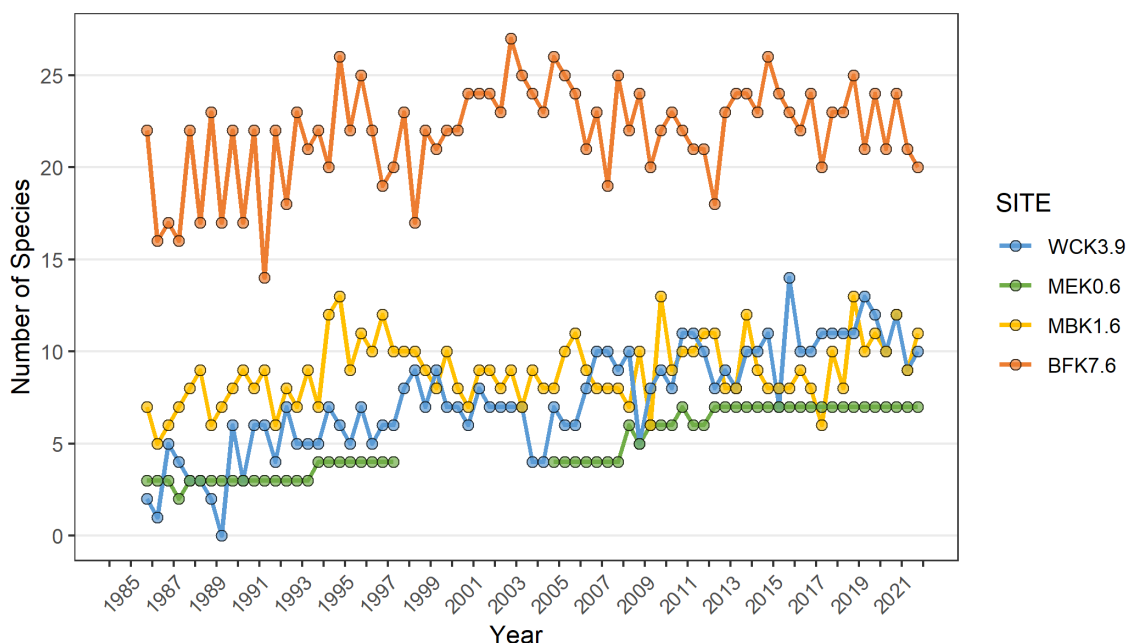
### 5.5.6.3. Fish Communities

Monitoring of the fish communities in WOC and its major tributaries continued in 2021. Fish community surveys were conducted at 11 sites in the WOC watershed, including 5 sites in the main channel, 2 sites in First Creek, 2 sites in Fifth Creek, and 2 sites in Melton Branch. Streams located near or within the city of Oak Ridge (Mill Branch and Brushy Fork) were also sampled as reference sites for comparison.

In the WOC watershed, the fish community continued to be slightly degraded in 2021 compared with communities in reference streams. Sites closest to outfalls within the ORNL campus had lower species richness (number of species) (Figure 5.36), and fewer pollution-sensitive species than a slightly larger reference site and more closely resembled values found in a smaller reference reach. WOC sites also had more pollution-tolerant species and elevated densities (number of fish per square meter) of pollution-tolerant species compared with reference streams.

Seasonal fluctuations in diversity and density are expected and may explain some of the variability seen at these sites. However, the combination of these factors indicates degraded water quality and/or habitat conditions. Overall, the fish communities in tributary sites adjacent to and downstream of ORNL outfalls continued to be negatively affected by ORNL effluent in 2021 relative to reference streams and upstream sites.

A project to introduce fish species that were not found in the WOC watershed but that exist in similar systems on ORR and that may have historically existed in WOC was initiated in 2008 with the stocking of seven such native species. Continuing reproduction has been noted for six of the species, and several species have expanded their ranges downstream and upstream from initial introduction sites to establish new reproducing populations. In general, introduced species have had more difficulty establishing populations at upstream sites in both WOC and Melton Branch.



**Acronyms:**

BFK = Brushy Fork kilometer  
 MBK = Mill Branch kilometer

MEK = Melton Branch kilometer  
 WCK = White Oak Creek kilometer

**Figure 5.36. Fish species richness (number of species) in upper White Oak Creek and lower Melton Branch compared with two reference streams, Brushy Fork and Mill Branch, 1985–2021**

This is likely due to numerous structures located within the watershed that act as barriers to upstream fish migration. As a result, introductions to supplement the small populations of those fish species were continued at sites within the watershed until 2019. One exception to the apparent difficulty of expansion is the striped shiner (*Luxilus chrysocephalus*), which has expanded into upper Melton Branch, upper WOC, and lower First Creek, although established populations have not been observed in all of those locations. The introductions have enhanced species richness at almost all sample locations within the watershed and may indicate the capacity of this watershed to support increased fish diversity, which seems to be limited by impassible barriers such as dams, weirs, and culverts, and by limited access to source populations downstream in the Clinch River below White Oak Lake.

#### **5.5.7. Polychlorinated Biphenyls in the White Oak Creek Watershed**

The initial objective of the source identification task in the WOC watershed was to identify the stream reaches, outfalls, or sediment areas that are contributing to elevated PCB levels in the watershed (Figure 5.36). Sample results for largemouth bass collected from White Oak Lake showed tissue PCB concentrations higher than those recommended by TDEC and EPA for frequent consumption, but the mobility of the fish precluded the possibility of source identification. PCBs are hydrophobic and tend not to be

dissolved in water, resulting in undetected PCB concentrations in water samples, using conventional analytical methods, even if collected from a contaminated site. Therefore, semipermeable membrane devices are used to assess the chronic low-level sources of PCBs at critical sites on the reservation. Semipermeable membrane devices are thin plastic sleeves filled with oil in which PCBs are soluble. Because semipermeable membrane devices are deployed at a given site for 4 weeks and have a high affinity for PCBs, they allow for a time-integrated semiquantitative index of the relative PCB concentrations in the water column rather than a “snapshot” value that would be obtained from a grab sample.

During the past 10 years, ORNL’s PCB monitoring efforts have identified upper parts of First Creek as a source of PCBs. In September 2019, catch basin sediment in the drainage network leading to Outfall 250 was cleaned out and disposed of as solid waste. Semipermeable membrane devices have been deployed in this piping network as well as in First Creek above and below Outfall 250 (Figure 5.37). Results from past assessments indicate that PCBs remained available in the area despite actions to remove PCB-contaminated materials from the upper part of Outfall 250 watershed, suggesting either that flows remobilized PCBs or that another source is introducing PCBs to that section of piping. Future monitoring is needed to identify the sources of the PCBs found in the Outfall 250 piping network.



**Acronym:**  
 FCK = First Creek kilometer

**Figure 5.37. Locations of monitoring points for First Creek source investigation**

**5.5.8. Oil Pollution Prevention**

CWA Section 311 regulates the discharge of oils or petroleum products to waters of the United States and requires the development and

implementation of spill prevention, control, and countermeasures (SPCC) plans to minimize the potential for oil discharges. These requirements are provided in 40 CFR 112, “Oil Pollution Prevention.” Each ORR facility implements a site-

specific SPCC plan. The HVC (home of NTRC and the Manufacturing Demonstration Facility), which is located off ORR, also has an SPCC plan covering the oil inventory at that location. CFTF is also located off ORR; however, that facility was evaluated, and a determination was made that an SPCC plan was not required. The ORNL and HVC SPCC plans were not changed in 2020. There were no regulatory actions related to oil pollution prevention at ORNL or HVC in 2020. An oil-handler training program exists to comply with training requirements in 40 CFR 112.

### 5.5.9. Surface Water Surveillance Monitoring

The ORNL surface water monitoring program is conducted in conjunction with the ORR surface water monitoring activities discussed in Section 6.4 to enable assessing the impacts of ongoing DOE operations on the quality of local surface water. The sampling locations (Figure 5.38) are used to monitor conditions upstream of ORNL main plant waste sources (WCK 6.8), within the ORNL campus (FFK 0.1), and downstream of ORNL discharge points (WCK 1.0).

Sampling frequencies and parameters vary by site and are shown in Table 5.13. Monitoring at WCK 1.0 is conducted monthly for radiological parameters and quarterly for mercury under the ORNL WQPP (Section 5.5.3) and, therefore, those parameters are not duplicated by this program. Radiological monitoring at WCK 6.8 is also conducted monthly under the ORNL WQPP and therefore is not duplicated by the surface water monitoring program.

Samples are collected and analyzed for general water quality parameters and are screened for radioactivity at all locations (either under this program or under WQPP). Samples are further analyzed for specific radionuclides when general screening levels are exceeded. Samples from WCK 1.0 are also checked for volatile organic compounds (VOCs) and PCBs. WCK 6.8 is also checked for PCBs. WCK 6.8 and WCK 1.0 are classified by the state of Tennessee for freshwater fish and aquatic life. Tennessee WQCs associated with these classifications are used as references

where applicable (TDEC 2015). The Tennessee WQCs do not include criteria for radionuclides. Four percent of the DOE DCS (DOE 2021a) is used for radionuclide comparison.

There were no radionuclides reported above 4 percent of DCS at the Fifth Creek location (FFK 0.1) in 2021. Beta activity and  $^{89/90}\text{Sr}$  were detected in samples from both sampling events at the Fifth Creek location and are related to known sources in the middle of the ORNL main campus. No  $^{89/90}\text{Sr}$  results above 4 percent of DCS were reported for samples collected at the upstream WOC sampling location (WCK 6.8). The other radionuclide results from WCK 6.8 and the radionuclide results from samples collected at WOD (before WOC empties into the Clinch River) are discussed in Section 5.5.3.

PCB-1254 and -1260 were detected at low, estimated concentrations in the June 2021 sample from WCK 1.0. PCBs were not detected in any other quarter in 2021 and have not been detected at WCK 1.0 since 2017. Two VOCs, acetone and trichloroethene (TCE), were detected at low, estimated values in one sample from WCK 1.0 in September 2021. Acetone has been detected in surface water samples from WCK 1.0 before, and acetone has occasionally been detected in at least one on-site groundwater well in past monitoring, including wells located in nearby Solid Waste Storage Area (SWSA) 6. Acetone is also a common laboratory contaminant. The September TCE result at WCK 1.0 of 0.400 ug/L is just above the lab-reported method detection level of 0.333 ug/L and below the practical quantitation limit of 1.00 ug/L and was therefore flagged as an estimated value. Known TCE plumes exist in ORNL groundwater far upstream of this sampling point.

### 5.5.10. Carbon Fiber Technology Facility Wastewater Monitoring

Facility and process wastewater from activities at CFTF are discharged to the City of Oak Ridge sanitary sewer system under conditions established in City of Oak Ridge Industrial Wastewater Discharge Permit 1-12. Permit limits, parameters, and 2021 compliance status for this permit are summarized in Table 5.14.

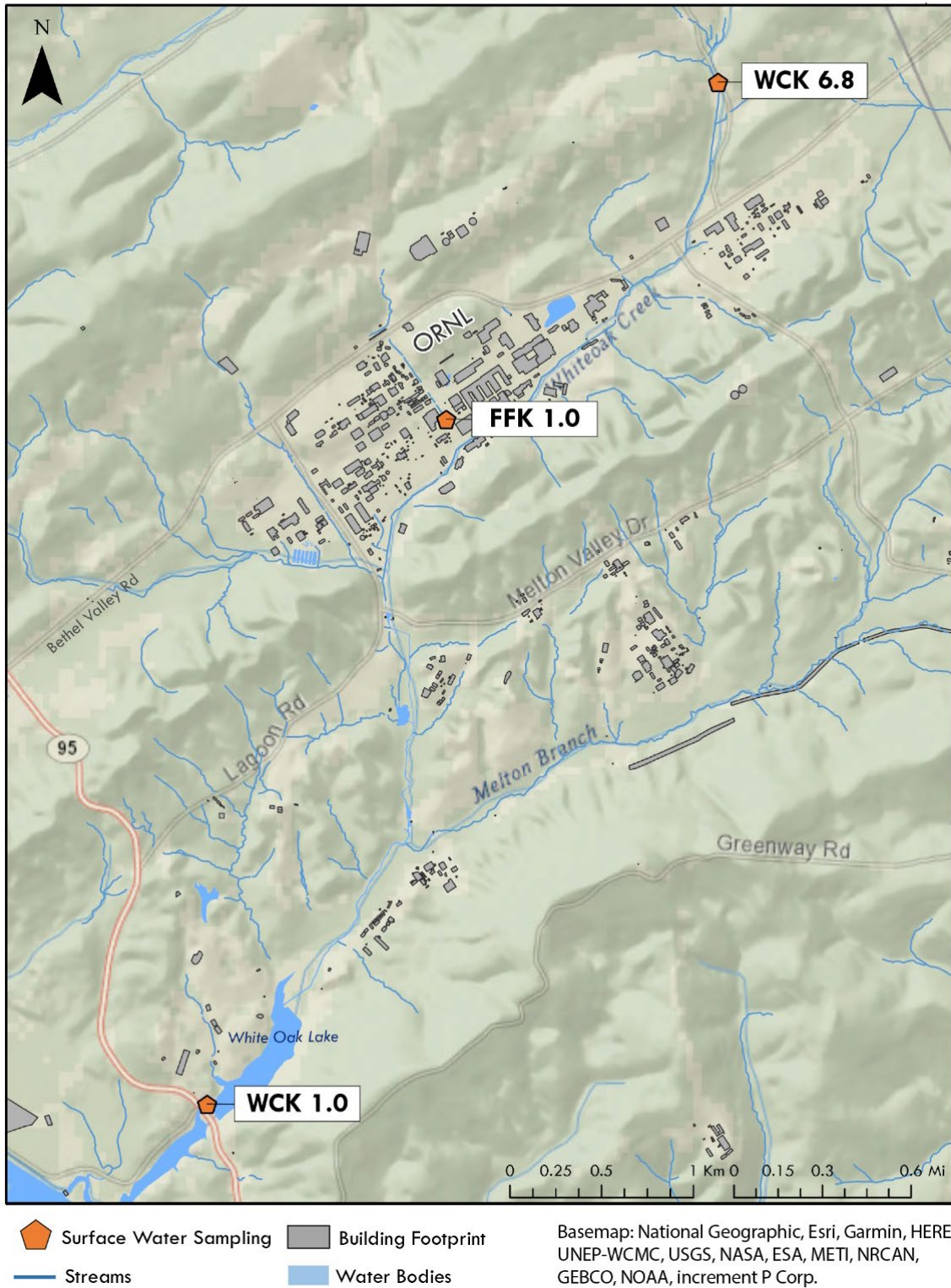


Figure 5.38. ORNL surface water sampling locations, 2021

**Table 5.13. ORNL surface water sampling locations, frequencies, and parameters, 2021**

Location <sup>a</sup>	Description	Frequency and type	Parameters
WCK 1.0 <sup>b</sup>	White Oak Lake at WOD	Quarterly, grab	Volatiles, PCBs, field measurements <sup>c</sup>
WCK 6.8 <sup>d</sup>	WOC upstream from ORNL	Quarterly, grab	PCBs, field measurements <sup>c</sup>
FFK 0.1	Fifth Creek just upstream of WOC (ORNL)	Semiannually, grab	Gross alpha, gross beta, total radioactive strontium, gamma scan, tritium, field measurements <sup>c</sup>

<sup>a</sup> Locations identify bodies of water and locations on them (e.g., WCK 1.0 is 1 km upstream from the confluence of WOC and the Clinch River).

<sup>b</sup> For this location, radiological parameters and mercury are monitored under another program (the WQPP) and therefore are not included in this plan.

<sup>c</sup> Field measurements consist of dissolved oxygen, pH, and temperature.

<sup>d</sup> Radiological monitoring is performed at this location in by the WQPP.

**Acronyms:**

FFK = Fifth Creek kilometer

ORNL = Oak Ridge National Laboratory

PCB = polychlorinated biphenyl

WCK = WOC kilometer

WOC = White Oak Creek

WOD = White Oak Dam

WQPP = Water Quality Protection Plan

**Table 5.14. Industrial and commercial user wastewater discharge permit compliance at the ORNL Carbon Fiber Technology Facility, 2021**

Effluent parameters	Permit limits		Permit compliance		
	Daily max. (mg/L)	Monthly ave. (mg/L)	Number of noncompliances	Number of samples	Percentage of compliance <sup>a</sup>
<b>Outfall 01 (Underground Quench Water Tank)</b>					
Cyanide	3.9	0.1	0	0	100
pH (standard units)	6–9		0	0	100
<b>Outfall 02 (Electrolytic Bath Tank)</b>					
pH (standard units)	6–9		0	4	100
<b>Outfall 03 (Sizing Bath Tank)</b>					
Copper	0.87	0.10	0	1	100
Zinc	1.24	0.60	0	1	100
Total phenol	4.20	-	0	1	100
pH (standard units)	6–9		0	1	100

<sup>a</sup> Percentage compliance = 100 – [(number of noncompliances/number of samples) × 100]

## 5.6. ORNL Groundwater Monitoring Program

Groundwater monitoring at ORNL was conducted under two sampling programs in 2021: DOE OREM monitoring and DOE Office of Science (SC) surveillance monitoring. The DOE OREM groundwater monitoring program was conducted by UCOR in 2021. The SC groundwater monitoring surveillance program was conducted by UT-Battelle.

### 5.6.1. Summary of US Department of Energy Office of Environmental Management Groundwater Monitoring

Monitoring was performed as part of an ongoing comprehensive CERCLA cleanup effort in Bethel and Melton Valleys, the two administrative watersheds at the ORNL site. Groundwater monitoring for baseline and trend evaluation in addition to measuring effectiveness of completed CERCLA RAs is conducted as part of the WRRP. The WRRP is managed by UCOR for the DOE OREM program. The results of CERCLA monitoring for ORR for FY 2021, including monitoring at ORNL, are evaluated and reported in the 2022 Remediation Effectiveness Report (DOE 2022a) as required by the ORR Federal Facility Agreement.

Groundwater monitoring conducted as part of the OREM program at ORNL includes routine sampling and analysis of groundwater in Bethel Valley to measure performance of several RAs and to continue contaminant and groundwater quality trend monitoring. In Melton Valley, where CERCLA RAs were completed in 2006 for the extensive waste management areas, the groundwater monitoring program includes monitoring groundwater levels to evaluate the effectiveness of hydrologic isolation of buried waste units. Additionally, groundwater is sampled and analyzed for a wide range of general chemical and contaminant parameters in 46 wells within the interior portion of the closed waste management area.

In FY 2010 DOE initiated activities on a groundwater treatability study at the Bethel Valley 7000 Area VOC plume. This plume contains trichloroethylene and its transformation products cis-1,2-dichloroethene and vinyl chloride, all at concentrations greater than EPA primary drinking water standards. The treatability study is a laboratory and field demonstration to determine whether microbes inherent to the existing subsurface microbial population can fully degrade the VOCs to nontoxic end products. Post-treatment monitoring of the 7000 Area plume continues.

During FY 2021 postremediation monitoring continued at SWSA 3 to evaluate the effectiveness of the 2011 hydrologic isolation of the area that included construction of a multilayer cap and an upgradient storm flow/shallow groundwater diversion drain. RAs and monitoring were specified in a CERCLA RA work plan that was developed by DOE and approved by EPA and TDEC before the project was started.

#### 5.6.1.1. Bethel Valley

During FY 2011 construction was completed for RAs at SWSA 1 and SWSA 3, two former waste storage sites that were used for disposal of radioactively contaminated solid wastes between 1944 and 1950. Wastes disposed of at SWSA 1 originated from the earliest operations of ORNL; those at SWSA 3 originated from ORNL, Y-12, the K-25 Site (ETTP), and off-site sources. Although most of the wastes disposed of at SWSA 3 were solids, some were containerized liquid wastes. Some wastes were encapsulated in concrete after placement in burial trenches, but most of the waste was covered with soil. The Bethel Valley Record of Decision (ROD) (DOE 2002) selected hydrologic isolation using multilayer caps and groundwater diversion trenches as the RA for the waste burial grounds and construction of soil covers over the former contractor's landfill and contaminated soil areas near SWSA 3. The baseline monitoring conducted during FY 2010 included measurement of groundwater levels to obtain baseline data to allow evaluation of postremediation groundwater-level suppression.



Sampling and analysis of groundwater quality and contaminants were also conducted.

Postremediation monitoring was specified for SWSA 3 in the *Phased Construction Completion Report for the Bethel Valley Burial Grounds at the Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE 2012). Required monitoring includes quarterly groundwater-level monitoring in 42 wells with continuous water-level monitoring in 8 wells to confirm cap performance. Groundwater samples are collected semiannually at 13 wells for laboratory analyses to evaluate groundwater contaminant concentration trends.

FY 2021 monitoring results showed that the cap was effective, although target groundwater elevations have not yet been attained at three of eight wells. Drinking water standards are used as screening water quality concentrations to evaluate the site response to remediation. Strontium-90, a signature contaminant at SWSA 3, exhibits significant decreases in groundwater and at the adjacent surface water monitoring sites at Raccoon Creek and the Northwest Tributary. Groundwater data trend evaluation shows that although within the past 10 years <sup>90</sup>Sr exceeded the 8 pCi/L maximum contaminant level derived concentration, only three wells had <sup>90</sup>Sr concentrations greater than the 8 pCi/L screening concentration during FY 2021. Mann-Kendall trends for <sup>90</sup>Sr in those three wells were decreasing for the most recent 5-year data evaluation period. Benzene, potentially from natural sources, exhibits stable to no significant trends; FY 2021 maxima were 0.007 and 0.008 mg/L in two wells, which are just slightly greater than the 0.005 mg/L maximum contaminant level. During FY 2020, as part of the DOE OREM program, three groundwater monitoring wells in Bethel Valley to the west of Tennessee Highway 95 were monitored to detect and track contamination from the SWSA 3 area. Data from those three wells supplement data being collected from a multiport well (4579) near SWSA 3 for exit pathway groundwater monitoring in western Bethel Valley. Groundwater monitoring near SWSA 3, along with the exit pathway, and groundwater and surface water monitoring at the northwest tributary of WOC and in the

headwaters of Raccoon Creek allow integration of data concerning SWSA 3 contaminant releases. The data are presented in the 2022 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Site Oak Ridge, Tennessee Data and Evaluations (DOE 2022a). To enhance exit pathway groundwater monitoring near the ORR property boundary at the Clinch River in western Bethel Valley, three deep boreholes were drilled and characterized. During FY 2021, Westbay multizone sampling systems were installed to enable discrete zone sampling in the carbonate bedrock units. The three new exit pathway multizone wells will be sampled quarterly throughout FY 2022 to assess groundwater quality conditions near the DOE property boundary at the western end of Bethel Valley.

Groundwater monitoring continued at the ORNL 7000 Area during FY 2021 to evaluate treatability of the VOC plume at that site. Site characterization testing of the endemic microbial community showed that microbes present at that site are capable of fully degrading trichloroethylene and its degradation products if sufficient electron donor compounds are present in the subsurface environment. During FY 2011, a mixture of emulsified vegetable oil and a hydrogen-releasing compound was injected into four existing monitoring wells in the 7000 area. Ongoing monitoring of VOC concentrations show that the effects of the biostimulation test continue to be apparent, although at decreasing levels.

The other principal element of the Bethel Valley ROD (DOE 2002) remedy that requires groundwater monitoring is the containment pumping to control and treat discharges from the ORNL Central Campus Core Hole 8 plume. The original action for the plume was a CERCLA removal action that was implemented in 1995 with the performance goal of reducing <sup>90</sup>Sr in WOC.

Strontium-90 is a principal CERCLA contaminant of concern in surface water in WOC. A ROD goal was established for <sup>90</sup>Sr of 37 pCi/L annual average concentration at the 7500 Bridge Weir. During FY 2021, as in FY 2020, the <sup>90</sup>Sr goal at the 7500 Bridge Weir was not attained. Over the past

several years various problems have occurred in Bethel Valley that have caused failure to meet the  $^{90}\text{Sr}$  concentration goal. Below-ground infrastructure deterioration related to process liquid wastewater handling in the aging ORNL Central Campus area allowed contaminant releases. Furthermore, treatment facility upset conditions during startup of new treatment processes reduced the effectiveness of  $^{90}\text{Sr}$  removal during part of FY 2021. The DOE EM program is investigating sources of groundwater  $^{90}\text{Sr}$  contamination that seep directly into WOC as nonpoint discharges to the stream.

### 5.6.1.2. Melton Valley

The Melton Valley ROD (DOE 2000) established goals for a reduction of contaminant levels in surface water, groundwater-level fluctuation reduction goals within hydrologically isolated areas, and mitigation of impacts to groundwater. Groundwater monitoring to determine the effectiveness of the remedy in Melton Valley includes groundwater-level monitoring in wells within and adjacent to hydrologically isolated shallow waste burial areas and groundwater quality monitoring in selected wells adjacent to buried waste areas.

Groundwater-level monitoring shows that the hydrologic isolation component of the Melton Valley remedy is effectively minimizing the amount of percolation water contacting buried waste and is reducing contaminated leachate formation. The total amount of rainfall at ORNL during FY 2021 was about 62 in., which is about 8 in. more than the long-term annual average for ORR. In a few areas, groundwater levels within capped areas continue to respond to groundwater fluctuations imposed from areas outside the caps, but contact of groundwater with buried waste is minimal. Overall, the hydrologic isolation systems are performing as designed.

Groundwater quality monitoring in the interior of Melton Valley shows that in general groundwater contaminant concentrations are declining or are stable following RAs. At SWSA 6, groundwater

quality monitoring that is substantively equivalent to the former RCRA monitoring continues. Several VOCs continue to be detected in wells along the eastern edge of the site at essentially stable concentrations.

During the past 10 years of groundwater monitoring in the Melton Valley exit pathway, several site-related contaminants have been detected in groundwater near the Clinch River. Low concentrations of strontium, tritium, uranium, and VOCs have been detected intermittently in a number of the multizone sampling locations. Groundwater in the exit pathway wells has high alkalinity and sodium and exhibits elevated pH. During FY 2020 an off-site groundwater monitoring well array west of the Clinch River and adjacent to Melton Valley was monitored as part of the OREM program. Monitoring included groundwater-level monitoring to evaluate potential flowpaths near the river and sampling and analysis for a wide array of metals, anions, radionuclides, and VOCs. Groundwater-level monitoring showed that natural head gradient conditions cause groundwater seepage to converge toward the Clinch River from both the DOE (eastern) and off-site (western) sides of the river. Monitoring results are summarized in the *Phased Groundwater Remedial Investigation Work Plan for the Bethel Valley Final Groundwater Record of Decision* (DOE 2021b).

### 5.6.2. DOE Office of Science Groundwater Surveillance Monitoring

DOE Order 458.1 (DOE 2020) is the primary requirement for a site-wide groundwater protection program at ORNL. As part of the groundwater protection program, and to be consistent with UT-Battelle management objectives, groundwater surveillance monitoring was performed to monitor ORNL groundwater exit pathways and UT-Battelle facilities (“active sites”) potentially posing a risk to groundwater resources at ORNL. Results of the DOE SC groundwater surveillance monitoring are reported in the following sections.

Exit pathway and active-sites groundwater surveillance monitoring points sampled during 2021 included seep/spring and surface-water monitoring locations in addition to groundwater surveillance monitoring wells. Seep/spring and surface-water monitoring points located in appropriate groundwater discharge areas were used in the absence of monitoring wells.

Groundwater pollutants monitored under the exit pathway groundwater surveillance and active-sites monitoring programs are not regulated by federal or state rules. Consequently, no permit-required or other applicable standards exist for evaluating results. To assess groundwater quality at these monitoring locations, and to facilitate comparison of results between locations, results were compared to selected federal and state standards even though those standards are not directly applicable. For radionuclide parameters for which alternative standards were not identified, results were compared to 4 percent of the DCSs (DOE 2021a). Regardless of the standards selected for comparison, it is important to note that no members of the public consume groundwater from ORNL wells, nor do any groundwater wells furnish drinking water to personnel at ORNL.

#### 5.6.2.1. Exit Pathway Monitoring

During 2021, exit pathway groundwater surveillance monitoring was performed in accordance with the exit pathway sampling and analysis plan (Bonine 2013). Groundwater exit pathways at ORNL include areas from watersheds or sub-watersheds where groundwater discharges to the Clinch River–Melton Hill Reservoir to the west, south, and east of the ORNL main campus. The exit pathway monitoring points were chosen based on hydrologic features, screened interval depths (for wells), and locations relative to discharge areas proximate to DOE facilities operated by, or under the control of, UT-Battelle. The groundwater exit pathways at ORNL include four discharge zones identified by a data quality objectives process. One of the original exit pathway zones was split into two zones for geographic expediency. The Southern Discharge

Area Exit Pathway was carved from the East End Discharge Area Exit Pathway. The five zones are listed below. Figure 5.39 shows the locations of the exit pathway monitoring points targeted for sampling in 2021:

- The 7000/Bearden Creek Discharge Area Exit Pathway
- The East End Discharge Area Exit Pathway
- The Northwestern Discharge Area Exit Pathway
- The Southern Discharge Area Exit Pathway
- The WOC Discharge Area Exit Pathway

The efficacy of the exit pathway monitoring program was reviewed in late 2011. As a result, the groundwater monitoring program was modified through an optimization approach that included frequency analysis of parameters and their concentrations based on an exhaustive review of historical groundwater sampling data. The modification resulted in a 10-year staggered groundwater monitoring schedule and analytical suite selection. This approach was initiated in 2012. A summary of the groundwater monitoring that was conducted in 2021 is outlined in Table 5.15.

Unfiltered samples were collected. The organic suite was composed of VOCs and semivolatile organic compounds; the metallic suite included heavy and non-heavy metals; and the radionuclide suite was composed of gross alpha/gross beta activity, gamma emitters, <sup>89/90</sup>Sr, and tritium. In 2021, wet season samples were collected in March, April, and May and dry season samples were collected in September.

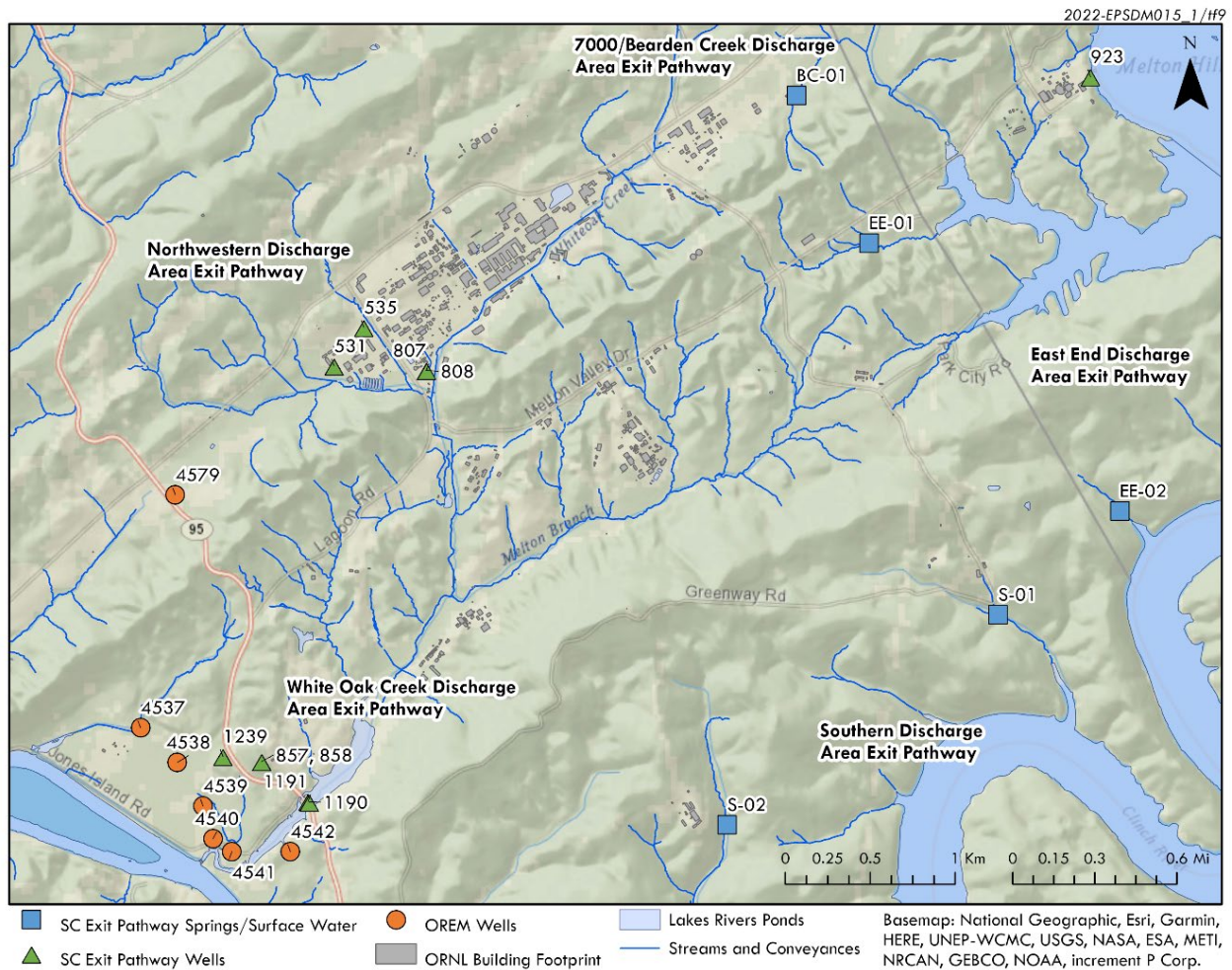
#### **Exit pathway monitoring results**

Table 5.16 provides a summary of radiological parameters detected in samples collected from exit pathway monitoring points during 2021. Metals are ubiquitous in groundwater exit pathways and so are not summarized in the table.

**Exit pathway groundwater surveillance summary**

Concentrations of metals and man-made radionuclides observed in groundwater exit pathway discharge areas in 2021 at ORNL were generally consistent with observations reported in past annual site environmental reports for ORR.

Based on the results of the 2021 monitoring effort, there is no indication that current SC operations are significantly introducing contaminants to the groundwater at ORNL.



**Acronyms:**

OREM = DOE Oak Ridge Office of Environmental Management  
 SC = DOE Office of Science

**Figure 5.39. UT-Battelle exit pathway groundwater monitoring locations at ORNL, 2021**

Table 5.15. Exit pathway groundwater monitoring conducted in 2021

Monitoring point	Season	
	Wet	Dry
<b>7000 Bearden Creek Discharge Area</b>		
BC-01	Radiological	Radiological, organics, and metals
<b>East End Discharge Area</b>		
923	Radiological	Radiological
EE-01	Radiological	Radiological
EE-02	Not sampled <sup>a</sup>	Not sampled <sup>a</sup>
<b>Northwestern Discharge Area</b>		
531	Radiological	Radiological
535	Radiological	Radiological
807	Radiological, organics, and metals	Radiological
808	Radiological	Radiological
<b>Southern Discharge Area</b>		
S-01	Radiological	Not Sampled <sup>a</sup>
S-02	Radiological	Radiological
<b>White Oak Creek Discharge Area</b>		
857	Radiological	Radiological
858	Radiological, organics, and metals	Radiological
1190	Radiological, organics, and metals	Radiological, organics, and metals
1191	Radiological, organics, and metals	Radiological, organics, and metals
1239	Radiological	Radiological

<sup>a</sup> Locations EE-02 and S-01 (stream locations) were not sampled in the 2021 dry season and location EE-02 was not sampled in the wet season due to lack of water flow.

Table 5.16. Radiological parameters detected in 2021 exit pathway groundwater monitoring

Monitoring location	Parameter	Concentration (pCi/L)		
		Wet season <sup>a</sup>	Dry season <sup>a</sup>	Reference value <sup>b</sup>
<b>7000 Bearden Creek Discharge Area</b>				
Spring BC-01	<sup>214</sup> Bi	ND	36.6	40,000
Spring BC-01	<sup>214</sup> Pb	ND	40.9	23,600
<b>East End Discharge Area</b>				
Well 923	Beta activity	4.61	4.24	50
Stream EE-01	<sup>214</sup> Bi	ND	12.8	40,000
Stream EE-01	<sup>214</sup> Pb	6.33	13.7	23,600
<b>Northwestern Discharge Area</b>				
Well 531	Beta activity	2.21	4.76	50
Well 531	Tritium	U172	208	20,000
Well 535	Beta activity	3.59	1.25	50
Well 535	<sup>214</sup> Bi	ND	29.2	40,000
Well 535	<sup>40</sup> K	ND	56.7	640
Well 535	<sup>214</sup> Pb	ND	16.2	23,600
Well 807	Beta activity	4.44	10.4	50
Well 807	<sup>214</sup> Bi	31.6	15.3	40,000
Well 807	<sup>214</sup> Pb	28.3	17.6	23,600
Well 807	Tritium	U169	274	20,000
Well 808	Beta activity	2.91	6.12	50
Well 808	<sup>212</sup> Pb	ND	12.5	292
<b>Southern Discharge Area</b>				
Stream S-01	<sup>214</sup> Bi	41.2	NF	40,000
Stream S-01	<sup>212</sup> Pb	4.94	NF	292
Stream S-01	<sup>214</sup> Pb	49.8	NF	23,600
Stream S-02	Beta activity	2.79	U2.73	50
Stream S-02	<sup>214</sup> Bi	11.4	13.9	40,000
Stream S-02	<sup>214</sup> Pb	14.2	6.55	23,600
<b>White Oak Creek Discharge Area</b>				
Well 857	Alpha activity	U1.60	1.2	15
Well 857	Beta activity	U2.88	2.64	50
Well 857	<sup>214</sup> Bi	11.5	21.4	40,000
Well 857	<sup>214</sup> Pb	14.1	27.3	23,600
Well 858	<sup>214</sup> Bi	7.53	ND	40,000
Well 1190	Alpha activity	3.12	U2.87	15
Well 1190	<sup>214</sup> Bi	73.4	46.9	40,000
Well 1190	<sup>212</sup> Pb	ND	7.21	292
Well 1190	<sup>214</sup> Pb	83.7	49	23,600
Well 1190	Tritium	11,300	18,400	20,000

Table 5.16. Radiological parameters detected in 2021 exit pathway groundwater monitoring (continued)

Monitoring location	Parameter	Concentration (pCi/L)		
		Wet season <sup>a</sup>	Dry season <sup>a</sup>	Reference value <sup>b</sup>
Well 1191	Beta activity	230	213	50
Well 1191	<sup>214</sup> Bi	46.9	40.7	40,000
Well 1191	<sup>212</sup> Pb	ND	3.43	292
Well 1191	<sup>214</sup> Pb	52.5	40.3	23,600
Well 1191	<sup>89/90</sup> Sr	138	124	8
Well 1191	Tritium	4,910	4,970	20,000
Well 1239	Alpha activity	U2.91	2.82	15
Well 1239	Beta activity	U1.99	3.20	50

<sup>a</sup> NF = there was no flow at the spring or stream sampling location during sampling attempts

ND = the analyte was not detected in the gamma scan that was performed

U = the analyte was measured but not detected above the practical quantitation limit/contractor-required detection limit

<sup>b</sup> Current federal and state standards were used as reference values. If no federal or state standard exists for the analyte, 4 percent of the DOE derived concentration standard is used as the reference value.

Eight radiological contaminants were detected in exit pathway groundwater samples collected in 2021. Gross beta and <sup>89/90</sup>Sr were the only radiological parameters exceeding reference values at any of the discharge areas. Consistent with previous monitoring, these parameters were observed at concentrations above their respective reference values in the WOC discharge area.

A new maximum concentration was measured for one parameter at one monitoring location in the 7000 Bearden Creek discharge area—surface water location BC-01—in the dry-season sampling event. The concentration of <sup>214</sup>Pb activity was measured at 40.9 pCi/L (compared to a previous maximum of 39.1 pCi/L). Lead-214 is a short-lived radioisotope in the decay chain of <sup>226</sup>Ra (NIST 2020). Radium is a naturally occurring radioactive metal and the <sup>226</sup>Ra isotope is part of the uranium decay series (EPA 2019). Although this newest concentration is the highest measured to date at the BC-01 location, the concentration is similar to the previous maximum for the location when taking the analytical counting uncertainty into account.

First detections of <sup>212</sup>Pb occurred at well number 808 (12.5 pCi/L) in the northwestern discharge area and at surface water location S-01

(4.94 pCi/L) in the southern discharge area in 2021. Lead-212 is a short-lived radioisotope in the decay chain of naturally occurring <sup>232</sup>Th (EPA 2021) and is occasionally encountered at similar concentrations in groundwater from the ORNL area.

Thirty-four metallic parameters were detected in exit pathway groundwater samples collected in 2021. Only three metals, aluminum, iron, and manganese, were detected at concentrations exceeding reference values. Each of these metals are commonly found in groundwater at ORNL.

No organic compounds were detected at concentrations above the analytical method practical quantitation limit in exit pathway groundwater monitoring in 2021. Five organic compounds were detected at estimated concentrations (concentrations between the method analytical detection level and the practical quantitation limit). Acetone was detected during dry-season monitoring in the samples from well 1191 and surface water location BC-01. Bis(2-ethylhexyl) phthalate was detected in the sample from well 807 in wet-season monitoring, and in the samples from wells 1190 and 1191 during dry-season monitoring. Methylene chloride was detected in samples from wells 807, 858,

1190, and 1191 during wet-season monitoring and in samples from wells 1190 and 1191 and surface water location BC-01 during dry-season monitoring. Toluene was detected in samples from well 858 during wet-season monitoring and in samples from wells 1190 and 1191 and surface water location BC-01 during dry-season monitoring. Di-n-butyl phthalate was detected in samples from wells 1190 and 1191 during dry-season monitoring. Acetone, methylene chloride, toluene and some phthalate compounds are common laboratory contaminants (EPA 2014).

#### **5.6.2.2. Active Sites Monitoring—High Flux Isotope Reactor**

Two storm water outfall collection systems (Outfalls 281 and 383) intercept groundwater in the HFIR area and are routinely monitored under a monitoring plan associated with the ORNL NPDES permit. (See Section 5.5.3 for a discussion of results.)

#### **5.6.2.3. Active Sites Monitoring—Spallation Neutron Source**

Active sites groundwater surveillance monitoring was performed in 2021 at the SNS site under the SNS operational monitoring plan (Bonine, Ketelle, and Trotter 2007) due to the potential for adverse impact on groundwater resources at ORNL should a release occur. Operational monitoring was initiated following a 2-year (2004–2006) baseline monitoring program and will continue throughout the duration of SNS operations.

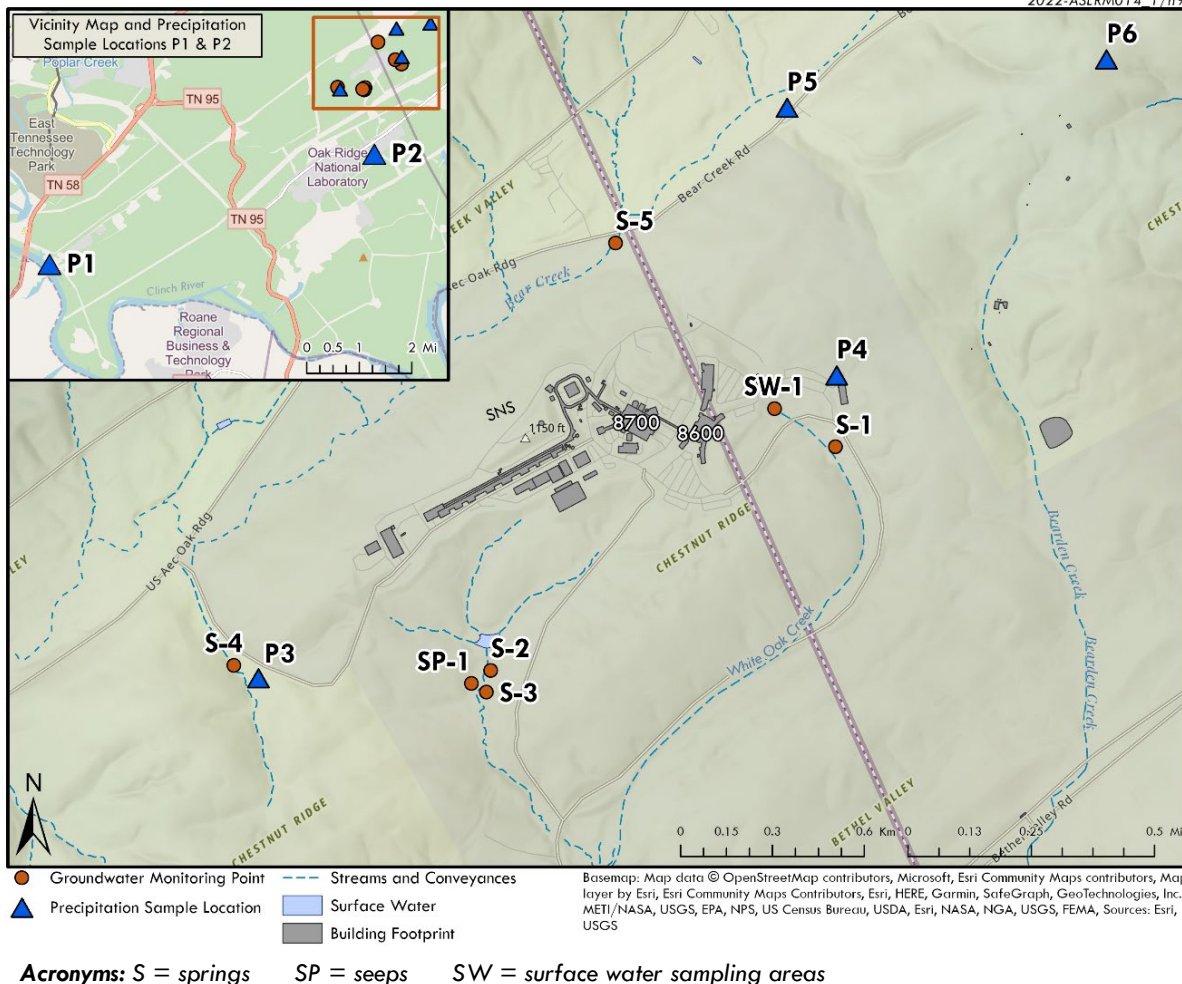
The SNS site is located atop Chestnut Ridge, northeast of the main ORNL facilities. The site slopes to the north and south, and small stream valleys, populated by springs and seeps, lie on the ridge flanks. Surface water drainage from the site flows into Bear Creek to the north and WOC to the south.

The SNS site is a hydrologic recharge area underlain by geologic formations that form karst geologic features. Groundwater flow directions at the site are based on the generally observed

tendency for groundwater to flow parallel to geologic strike (parallel to the orientation of the rock beds) and via karst conduits that break out at the surface in springs and seeps located downgradient of the SNS site. A sizable fraction of infiltrating precipitation (groundwater recharge) flows to springs and seeps via the karst conduits. SNS operations have the potential for introducing radioactivity (via neutron activation) in the shielding berm surrounding the SNS linac, accumulator ring, and/or beam transport lines. A principal concern is the potential for water infiltrating the berm soils to transport radionuclide contamination generated by neutron activation to saturated groundwater zones. The ability to accurately model the fate and transport of neutron activation products generated by beam interactions with the engineered soil berm is complicated by multiple uncertainties resulting from a variety of factors, including hydraulic conductivity differences in earth materials found at depth, the distribution of water-bearing zones, the fate and transport characteristics of neutron activation products produced, diffusion and advection, and the presence of karst geomorphic features found on the SNS site. These uncertainties led to the initiation of the groundwater surveillance monitoring program at the SNS site. Objectives of the groundwater monitoring program outlined in the operational monitoring plan include the following: (1) maintain compliance with applicable DOE contract requirements and environmental quality standards and (2) provide uninterrupted monitoring of the SNS site.

A total of seven springs, seeps, and surface water sampling points were routinely monitored as analogues to, and in lieu of, groundwater monitoring wells. Locations were chosen based on hydrogeological factors and proximity to the beam line. Since 2016, precipitation samples have also been collected for tritium analysis at six of the springs, seeps, and surface water locations. Figure 5.40 shows the locations of the specific monitoring points sampled during 2021.





**Figure 5.40. Groundwater and precipitation monitoring locations at the Spallation Neutron Source, 2021**

In November 2011 the SNS historical tritium data were evaluated to determine whether sampling could be optimized. The influence of flow condition on the proportion of tritium detects and nondetects in water samples collected at SNS from April 2004 through September 2011 was examined. In addition, the effect of seasonality on the proportion of detects and nondetects was examined for the same data set. The results of the analysis indicated that the proportion of detects to nondetects is not related to flow conditions or seasonality. This implies that samples could be collected during any flow condition and season with the expectation that there would be no statistical difference in the proportion of tritium detects to nondetects. The results of the statistical analysis of the April 2004–September 2011 data

set were the basis for the modified operational plan monitoring scheme implemented in 2012.

Quarterly sampling at each monitoring point continued in 2021, allowing the opportunity for monitoring in wet and dry seasons. All sampling performed in 2021 was performed in conjunction with rainfall events, with samples being collected during rising or falling (recession) limb flow conditions. Table 5.17 shows the sampling and parameter analysis schedule followed in 2021.

**Spallation Neutron Source site results**

Sampling at the SNS site occurred during each quarter in 2021. Low concentrations of several radionuclides were detected numerous times during 2021. At sample location S-1 <sup>14</sup>C was

detected (54.5 pCi/L) in December. This is the first detection of <sup>14</sup>C at S-1. Previous <sup>14</sup>C detections occurred in 2005, 2008, and 2009 at several other locations. The maximum previous <sup>14</sup>C detection was 13.7 pCi/L at sample location S-5 in February 2008. The <sup>214</sup>Bi and <sup>214</sup>Pb are daughter radionuclides in the uranium decay series and are considered to be of natural origin in the SNS water samples because no man-made uranium sources are present at the site. The low values of alpha and beta activity detected at the S-5 monitoring location are attributed to CERCLA contaminants in Bear Creek Valley associated with legacy waste management practices at the Y-12 facility. Table 5.18 provides a summary of the locations and results for radionuclide detections observed during 2021. Sampling results were compared with reference values. Reference values used for comparison are current federal or state standards or 4 percent of the DCS. No detected radionuclide exceeded its reference value at SNS monitoring locations in 2021.

In addition to SNS surface water sampling, precipitation monitoring for tritium has been

conducted at six locations since 2016. The precipitation sampling is conducted contemporaneous with the surface water sampling. Tritium can be an airborne constituent that is released from a number of DOE facilities at ORNL, from Tennessee Valley Authority reactor sites, and from commercial radiological waste processing facilities in the area. The precipitation sampling locations are shown in Figure 5.40, and the results are summarized in Table 5.19. Twenty-four sampling events have been conducted at each of the precipitation monitoring locations. The highest tritium concentrations and frequencies of detection were at sample location P1, approximately 6 miles southwest of the SNS site. The second highest concentrations and detection frequency occurred at location P4, which is located within 2,000 ft northeast of the SNS target facility. Tritium rainout from atmospheric tritium releases from sources, including DOE facilities, Tennessee Valley Authority facilities, and commercial radiological waste handling and processing facilities creates a regional background of tritium in some surface water and groundwater samples.

**Table 5.17. 2021 Spallation Neutron Source monitoring program schedule**

Monitoring location	Quarter 1 January–March	Quarter 2 April–June	Quarter 3 July–September	Quarter 4 October–December
SW-1	Tritium	Tritium	Tritium and expanded suite <sup>a</sup>	Tritium
S-1	Tritium and expanded suite <sup>a</sup>	Tritium	Tritium	Tritium and expanded suite <sup>a</sup>
S-2	Tritium and expanded suite <sup>a</sup>	Tritium	Tritium	Tritium
S-3	Tritium	Tritium and expanded suite <sup>a</sup>	Tritium	Tritium
S-4	Tritium	Tritium and expanded suite <sup>a</sup>	Tritium	Tritium
S-5	Tritium	Tritium	Tritium and expanded suite <sup>a</sup>	Tritium
SP-1	Tritium	Tritium	Tritium	Tritium and expanded suite <sup>a</sup>

<sup>a</sup> The expanded suite includes gross alpha and gross beta activity, <sup>14</sup>C, and gamma emitters.

Table 5.18. Radiological concentrations detected in samples collected at the Spallation Neutron Source, 2021<sup>a</sup>

Parameter	Concentrations (pCi/L)				Reference value <sup>b</sup>
	March	June	August	December	
<b>SW-1<sup>c</sup></b>					
Tritium	3,590	2,480	2,410	2,610	20,000
<b>S-1<sup>d</sup></b>					
<sup>14</sup> C				54.5	13,200
Tritium	1,580	1,060	311	2,230	20,000
<b>S-2<sup>e</sup></b>					
<sup>214</sup> Bi	26.7				40,000
Tritium	1,090	910	878	1,020	20,000
<b>S-3<sup>f</sup></b>					
<sup>214</sup> Bi		52.8			40,000
<sup>214</sup> Pb		38.1			23,600
Tritium	676	733	265	335	20,000
<b>S-4<sup>g</sup></b>					
Bi-214		18		31.5	40,000
Pb-214		39.4			23,600
Tritium	736	485	316	517	20,000
<b>S-5<sup>c</sup></b>					
Alpha			19		15
Beta			22.1		50
<sup>214</sup> Bi			31.5		40,000
Tritium	U204	U159	U231	U233	20,000
<b>SP-1<sup>g</sup></b>					
Tritium	437	404	361	439	20,000

<sup>a</sup> In addition to tritium analyses, analysis of an extended suite of parameters was completed at each location during one 2021 sampling event. The extended suite includes gross alpha, gross beta, gamma scan, and <sup>14</sup>C. Tritium results and detected concentrations from the extended suite are listed in the table.

<sup>b</sup> Current federal and state standards are used as reference values. If no federal or state standard exists for a particular radionuclide, 4 percent of the derived concentration standard for a radionuclide is used.

<sup>c</sup> Analysis of extended suite completed in August.

<sup>d</sup> Analysis of extended suite completed in March and December.

<sup>e</sup> Analysis of extended suite completed in March.

<sup>f</sup> Analysis of extended suite completed in June.

<sup>g</sup> Analysis of extended suite completed in December.

Table 5.19. Summary of precipitation tritium monitoring results, 2016–2021

Sample Location	Total Samples	Total Detects	Maximum Detect (pCi/L)	Date of Maximum Detect	Date of Most Recent Detect
P1	24	6	4,930	05/21/2016	10/28/2020
P2	24	2	1,070	05/21/2016	02/07/2018
P3	24	3	1,230	05/21/2016	10/28/2020
P4	24	5	2,010	10/22/2019	12/11/2021
P5	24	4	908	05/21/2016	08/29/2020
P6	24	2	1,240	02/07/2018	02/07/2018

#### 5.6.2.4. Emerging Contaminant Assessment—Potential for Per- and Polyfluoroalkyl Substances in ORNL Area Groundwater

A group of fluorinated organic chemical compounds collectively referred to as per- and polyfluoroalkyl substances (PFAS) are contaminants of emerging concern. PFAS compounds are persistent in the environment, and some are known to bioaccumulate in humans and/or wildlife. They have been widely used in both consumer and industrial products, and traces have been detected in environmental media in many parts of the world.

Perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) are the two PFAS compounds that have been produced in the largest amounts in the United States and that have received the most study. In May 2017, EPA established a drinking water health advisory of 70 ng/L of combined PFOA and PFOS, but EPA has not established a maximum contaminant level for drinking water. Through 2001, PFOS and other PFAS compounds were used in the manufacture of aqueous film-forming foams (AFFFs), and use of such foams, including firefighting training activities, may have contributed to environmental releases. The information contained in this and the previous paragraph was summarized from EPA's *Technical Fact Sheet—Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA)* (EPA 2017).

Historically, firefighter training at ORNL included training in the use of AFFFs, and the foams that were used in past training activities may have

contained PFAS compounds. The discharges of these foams are suspected to be the most significant potential source of PFAS in environmental media at ORNL. Most of the training was conducted at four locations: adjacent to the ORNL Fire Station (Building 2500), at the Fire Training and Test Facility (Building 2648), on the southeast corner of First Street and Bethel Valley Road (near where Building 2040 was later constructed), and at a location on the north side of Old Bethel Valley Road in the Bearden Creek watershed. A sampling and analysis plan (SAP) has been developed to assess these areas for the presence of PFAS compounds in groundwater and in surface water bodies draining these areas. The plan also includes monitoring of surface water locations draining other parts of the ORNL campus, including former waste storage areas, to determine if PFAS compounds from sources other than the use of AFFFs are present and are reaching surface water bodies. Surface water monitoring will include the use of passive sampling devices, which are deployed in stream environments for long periods of time (typically 4-week deployment periods) and which can accumulate PFAS compounds and allow the detection of trace concentrations that might not be detectable with traditional water sampling techniques. The sampling and analysis plan will be implemented in 2022.

Neither groundwater nor surface water at ORNL is a direct source of drinking water; ORNL's water supply is municipal water from the City of Oak Ridge.

## 5.7. Quality Assurance Program

The UT-Battelle Quality Management System (QMS) has been developed to implement the requirements defined in DOE Order 414.1D, Quality Assurance (DOE 2011c). The methods used for successful implementation of the QMS rely on the integration and implementation of quality elements/criteria flowed down through multiple management systems and daily operating processes. These management systems and processes are described in SBMS, where basic requirements are communicated to UT-Battelle staff. Additional or specific customer requirements are addressed at the project or work activity level. The QMS provides a graded approach to implementation based upon risk. The application of quality assurance (QA) and quality control (QC) programs specifically focused on environmental monitoring activities on ORR is essential for generating data of known and defensible quality. Each aspect of an environmental monitoring program from sample collection to data management and record keeping must address and meet applicable quality standards. The activities associated with administration, sampling, data management, and reporting for ORNL environmental programs are performed by the UT-Battelle Environmental Protection Services Division (EPSD).

UT-Battelle uses SBMS to provide a systematic approach for integrating QA, environmental, and safety considerations into every aspect of environmental monitoring at ORNL. SBMS is a web-based system that provides a single point of access to all the requirements for staff to safely and effectively perform work. SBMS translates laws, orders, directives, policies, and best-management practices into laboratory-wide subject areas and procedures.

### 5.7.1. Work/Project Planning and Control

UT-Battelle's work/project planning and control directives establish the processes and requirements for executing work activities at ORNL. All environmental sampling tasks are

performed following the four steps required in the work control subject areas:

- Define scope of work.
- Perform work planning—analyze hazards and define controls.
- Execute work.
- Provide feedback.

In addition, EPSD has approved project-specific standard operating procedures for all activities controlled and maintained through the Integrated Document Management System.

Environmental sampling standard operating procedures developed for UT-Battelle environmental sampling programs provide detailed instructions on maintaining chain of custody; identifying, collecting, handling, and preserving samples; decontaminating equipment; and collecting QC samples such as field and trip blanks, duplicates, and equipment rinses.

### 5.7.2. Personnel Training and Qualifications

The UT-Battelle Training and Qualification Management System provides staff with the knowledge and skills necessary to perform their jobs safely, effectively, and efficiently with minimal supervision. This capability is accomplished by establishing site-level procedures and guidance for training program implementation with an infrastructure of supporting systems, services, and processes.

EPSD team leaders are responsible for identifying the training needs, qualifications, and requirements for staff who conduct sampling, data management, and reporting tasks associated with ORNL and ORR-wide environmental surveillance programs. Training status is routinely monitored by the division training officer, and notices of training needs or deficiencies are automatically sent to individual employees. The training program is supplemented by a division-wide required reading program. This program ensures that staff members have reviewed new/revised documents (e.g., procedures, lessons learned) that are applicable to their jobs. Likewise, the NWSol

Training and Qualification program provides employees with the knowledge and skills necessary to perform their jobs safely, effectively, and efficiently with minimal supervision. This capability is accomplished by establishing site-level procedures and guidance for training program implementation with an infrastructure of supporting systems, services, and processes.

### 5.7.3. Equipment and Instrumentation

The UT-Battelle QMS includes subject area directives that require all UT-Battelle staff to use equipment of known accuracy based on appropriate calibration requirements and traceable standards to ensure measurement quality and traceability. The UT-Battelle Facilities and Operations Instrumentation and Control Services team tracks all equipment used in EPSD environmental monitoring programs through a maintenance recall program to ensure that equipment is functioning properly and within defined tolerance ranges.

#### 5.7.3.1. Calibration

The determination of calibration schedules and frequencies is based on a graded approach at the activity planning level. EPSD environmental monitoring programs follow rigorous calibration schedules to eliminate gross drift and the need for data adjustments. Instrument tolerances, functions, ranges, and calibration frequencies are established based on manufacturer specifications, program requirements, actual operating environment and conditions, and budget considerations.

In addition, a continuous monitor used for CAA compliance monitoring at ORNL Boiler 6 is subject to rigorous QA protocols as specified by EPA methods. A relative accuracy test audit is performed annually to certify the Predictive Emissions Monitoring System for nitrogen oxides and oxygen. The purpose of a relative accuracy test audit is to provide a rigorous QA assessment in accordance with *Performance Specification 16* (40 CFR Parts 60 and 63.). The accuracy of Predictive Emissions Monitoring System is also

evaluated by performing relative accuracy audits in accordance with *Performance Specification 16*. The results of the QA tests are provided to TDEC quarterly, semiannually, or annually as applicable.

#### 5.7.3.2. Standardization

EPSD sampling procedures are maintained in Integrated Document Management System and include requirements and instructions for the proper standardization and use of monitoring equipment. Requirements include the use of traceable standards and measurements; performance of routine, before-use equipment standardizations; and actions to follow when standardization steps do not produce required values. Standard operating procedures for sampling also include instructions for designating nonconforming instruments as “out-of-service” and initiating requests for maintenance.

#### 5.7.3.3. Visual Inspection, Housekeeping, and Grounds Maintenance

EPSD environmental sampling personnel conduct routine visual inspections of all sampling instrumentation and sampling locations. These inspections identify and address any safety, grounds keeping, general maintenance, and housekeeping issues or needs.

#### 5.7.4. Assessment

Independent audits, surveillance, and internal management assessments are performed to verify that requirements have been accurately specified and that activities that have been performed conform to expectations and requirements. External assessments are scheduled based on requests from auditing agencies. Table 5.1 presents a list of environmental audits and assessments performed at ORNL in 2021 and information on the number of findings identified. EPSD also conducts internal assessments of UT-Battelle environmental monitoring activities. Surveillance results, recommendations, and completion of corrective actions, if required, are also documented and tracked in the UT-Battelle Assessment and Commitment Tracking System.

NWSol and Isotek perform independent audits, surveillances, and internal management assessments to verify that requirements have been accurately specified and that activities that have been performed conform to expectations and requirements. NWSol corrective actions, if required, are documented and tracked in an issues management database or a deficiency reporting database, and Isotek corrective actions are tracked in its Assessment and Commitment Tracking System.

### 5.7.5. Analytical Quality Assurance

Laboratories that perform analyses of environmental samples collected for EPSD environmental sampling programs are required to have documented QA/QC programs, trained and qualified staff, appropriately maintained equipment and facilities, and applicable certifications. As applicable, the laboratories also participate in accreditation, certification, and performance evaluation programs, such as the National Environmental Laboratory Accreditation Program (NELAP), Mixed Analyte Performance Evaluation Program (MAPEP), Discharge Monitoring Report Quality Assurance Study (DMRQA), and DOE Environmental Management Consolidated Audit Program (DOECAP). Any issues identified through accreditation/certification programs or performance evaluation testing are addressed with analytical laboratories and are considered when determinations are made on data integrity. Blank and duplicate samples are submitted along with environmental samples to provide an additional check on analytical laboratory performance.

Analysis of environmental samples collected in support of EPSD environmental monitoring programs in 2021 were performed by either one of the three contracted commercial laboratories discussed below or by the UT-Battelle Radiochemical Materials Analytical Laboratory (RMAL) or the UT-Battelle Environmental Toxicology Laboratory. Contracts with analytical laboratories include statements of work that specify the scope of work, data deliverables, turnaround times, required methods, and

detection limits. The laboratories are required to participate in third-party accreditation, certification, and approval programs, which evaluate laboratories according to stringent and widely accepted criteria for quality, accuracy, reliability, and efficiency.

GEL Laboratories, a contracted commercial radiochemistry and environmental laboratory in Charleston, South Carolina, holds more than 40 federal and state certifications, accreditations, and approvals, including ISO 17025 (general requirements for the competence of testing and calibration laboratories), Department of Defense Environmental Laboratory Accreditation Program (DOD-ELAP), DOECAP, and NELAP. External audits were performed on-site at GEL and virtually in 2021 because of social-distancing precautions implemented in response to COVID-19 concerns. Ten internal audits focusing on analytical and support service activities were conducted to verify compliance with the requirements of the GEL QA/QC program and with client-specified terms. No issues were identified that would affect analytical data reported to clients. In 2021, GEL reported results from 5,746 performance test analyses (including DMRQA, MAPEP, DOECAP, and NELAP). Of these, 5,553 (96.6 percent) fell within acceptance ranges. Those that did not meet acceptance criteria were found to have no effect on data reported to clients.

ALS, a radiochemistry and environmental laboratory in Fort Collins, Colorado, is accredited, certified, or approved by 22 third-party programs including ISO 17025 (ISO 2017), NELAP, DOD-ELAP, DOECAP, and several state accrediting and licensing programs. In 2021, ALS was audited by the state of Utah, by Exxon Mobile, an ALS client, and by a third party for DOECAP and DOD-ELAP certification. Several internal audits on adherence to methods and recordkeeping were also performed. There were no audit findings related to analyses or recordkeeping in support of EPSD environmental monitoring programs. ALS participated in 12 performance studies during 2021 as well as any supplemental performance tests needed to address any out-of-range values

from the initial studies. All applicable test results were in acceptable ranges.

Eurofins, a contracted environmental laboratory in Tacoma, Washington, is accredited, licensed, or approved by 11 third-party programs, including ISO 17025, DOD-ELAP, DOECAP, NELAP, and several state licensing or accrediting programs. In November 2021, Eurofins was audited by the American National Standards Institute's National Accreditation Auditing Board and was recertified by DOECAP, DOD-ELAP and ISO 17025 (ISO 2017). Furthermore, multiple internal system and method audits were conducted during the year. No audit findings required data corrections or repeated analyses of samples. In 2021, Eurofins participated in MAPEP and DMRQA, and all applicable test results were within acceptable ranges.

RMAL does not hold any outside accreditations. However, the laboratory operates in compliance with ISO 17025 (ISO 2017), *DOD/DOE Consolidated Quality Systems Manual* (DOD/DOE 2018), and requirements from DOE 414.1D (DOE 2011c) and 10 CFR 830 Subpart A, *Quality Assurance Requirements*. The UT-Battelle Chemical Sciences Division's quality assurance plan also meets applicable requirements of the American Society of Mechanical Engineers' Nuclear Quality Assurance Program. Two external audits of RMAL activities were conducted in 2021. In March, RMAL participated in the biennial NPDES permit inspection with TDEC; no findings or issues were noted. In December 2021, RMAL was assessed by the Nuclear Waste Partnership for projects in support of Waste Isolation Pilot Plan shipments. That audit was paused because of Nuclear Waste Partnership miscommunication concerning the scope and will be restarted the summer of 2022. Furthermore, 11 internal assessments that focused on adherence to approved analytical methods, waste management, and recordkeeping were performed. No issues that would require reanalysis or data corrections related to environmental sampling results were identified. In 2021, RMAL participated in MAPEP and DMRQA, and all test results for analyses that RMAL performs in support in EPSD environmental

monitoring programs were within acceptable ranges.

The Environmental Toxicology Laboratory does not hold any outside accreditations, but it operates in compliance with all EPA, TDEC, and NPDES required methods and the UT-Battelle Environmental Sciences Division's Quality Assurance Management Program. One external audit of the Environmental Toxicology Laboratory was conducted in March 2021 by a representative from TDEC one suggested opportunity for improvement. In 2021, five internal assessments focused on adherence to approved analytical methods and data analysis were performed. No issues that would require reanalysis or data corrections related to standard toxicity testing results were identified. In addition, updates of all standard operating procedures, reference toxicity control charts, and training requirements in were completed in 2021. All standard operating procedures and lab methods comply with EPA's acute and chronic testing requirements for freshwater species (EPA 2002a and EPA 2002b, respectively). In 2021 the Environmental Toxicology Laboratory participated in the DMRQA program for whole effluent toxicity testing of *Pimephales promelas* (fathead minnow, a freshwater fish) and *Ceriodaphnia dubia* (water flea, a freshwater invertebrate). All results were in acceptable ranges.

#### 5.7.6. Data Management and Reporting

Management of data collected by UT-Battelle in conjunction with ORR and ORNL environmental surveillance programs and with CWA activities at ORNL is accomplished using the Environmental Surveillance System (ESS), a web interface data management tool. A software QA plan for ESS has been developed to document ESS user access rules; verification and validation methods; configuration and change management rules; release history; software registration information; and the employed methods, standards, practices, and tools.

Field measurements and sample information are entered into ESS, and an independent verification is performed on all records to ensure accurate



data entry. Sample results and associated information are loaded into ESS from electronic files provided by analytical laboratories. An automated screening is performed to ensure that all required analyses were performed, appropriate analytical methods were used, holding times were met, and specified detection levels were achieved.

Following the screening, a series of checks is performed to determine whether results are consistent with expected outcomes and historical data. QC sample results (i.e., blanks and duplicates) are reviewed to check for potential sample contamination and to confirm repeatability of analytical methods within required limits. More in-depth investigations are conducted to explain results that are questionable or problematic.

ORNL radiological airborne effluent monitoring data are managed using the Rad-NESHAPs Inventory Web Application and the Rad-NESHAPs Source Data Application. Field measurements, analytical data inputs, and emission calculations results are independently verified.

#### 5.7.7. Records Management

The UT-Battelle Requirements, Documents, and Records Management System provides the requirements for managing all UT-Battelle records. Requirements include creating, maintaining and using records; scheduling, protecting, and storing records; and destroying records.

NWSol and Isotek maintain all records specific to their projects at ORNL, and associated records management programs include the requirements for creating and identifying record material, protecting and storing records in applicable areas, and destroying records.

## 5.8. Environmental Management and Waste Management Activities at ORNL

The three campuses on ORR have a rich history of research, innovation, and scientific discovery that

shaped the course of the world. Unfortunately, today, despite their vitally important missions, they are hindered by environmental legacies remaining from past operations. The contaminated portions of ORR are on the EPA National Priorities List, which includes hazardous waste sites across the nation that are to be cleaned up under CERCLA. Areas that require cleanup or further action on ORR have been clearly defined, and OREM is working to clean those areas under the Federal Facility Agreement with the EPA and TDEC. The *Cleanup Progress: Annual Report on Oak Ridge Reservation Cleanup* (UCOR 2021) provides detailed information on DOE OREM's 2021 cleanup activities ([here](#)).

### 5.8.1. Wastewater Treatment

At ORNL, DOE OREM operates PWTC and the Liquid Low-Level Waste Treatment Facility. In 2021, 376.4 million L of wastewater were treated and released at PWTC. In addition, the liquid LLW system at ORNL received 554,037 L of waste. The waste treatment activities of these facilities support both DOE OREM and DOE SC mission activities, ensuring that wastewaters from activities associated with projects of both offices are managed in a safe and compliant manner.

### 5.8.2. Newly Generated Waste Management

ORNL is the largest, most diverse DOE SC laboratory in the DOE complex. Although much effort is expended to prevent pollution and to eliminate waste generation, some waste streams are generated as a by-product of performing research and operational activities and must be managed to ensure that the environment is protected from associated hazards. As the prime contractor for the management of ORNL, UT-Battelle is responsible for management of most of the wastes generated from R&D activities and wastes generated from operation of the R&D facilities. Waste streams that can be treated by on-site liquid and/or gaseous waste treatment facilities operated by OREM are treated via these systems. Other R&D waste streams are generally packaged by UT-Battelle in appropriate shipping containers for off-site transport to commercial

waste-processing facilities. In 2021, ORNL performed 79 waste and recycle shipments to off-site hazardous/radiological/mixed waste treatment and/or disposal vendors with zero shipment rejections or violations.

### 5.8.3. Transuranic Waste Processing Center

TRU waste-processing activities carried out for DOE in 2021 by NWSol addressed contact-handled solids/debris and remotely handled solids/debris, which involved processing, treating, and repackaging of waste. In 2021, LLW/mixed LLW was transported to the Nevada National Security Site or to another approved offsite facility for disposal. In 2021, NWSol shipped 151.4 m<sup>3</sup> of contact-handled TRU waste from TWPC in 21 shipments (721 containers).

During 2021, 5.2 m<sup>3</sup> of contact-handled waste and 0.4 m<sup>3</sup> of remotely handled waste were processed, and 97.3 m<sup>3</sup> of mixed LLW (TRU waste that was recharacterized as LLW) were shipped off-site.

## 5.9. References

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