Chapter 5 - Oak Ridge National Laboratory

Oak Ridge National Laboratory (ORNL) is the largest US Department of Energy (DOE) science and energy laboratory, conducting basic and applied research to deliver transformative solutions to compelling problems in energy and security.

Diverse capabilities at ORNL span a broad range of scientific and engineering disciplines, enabling the exploration of fundamental science challenges and the research needed to accelerate the delivery of solutions to the marketplace. ORNL supports DOE's national missions of scientific discovery, clean energy, and security through four major areas:

- **Neutrons**—The Spallation Neutron Source and the High Flux Isotope Reactor, two of the world's leading neutron sources, are operated at ORNL, enabling scientists and engineers to gain new insights into materials and biological systems.

- **Computing**—ORNL programs accelerate scientific discovery through modeling and simulation on powerful supercomputers and advance data-intensive science and US leadership in high-performance computing.

- **Materials**—Basic research and applied research are integrated at ORNL to develop advanced materials for energy applications.

- **Nuclear**—ORNL programs advance the scientific basis for 21st century nuclear fission and fusion technologies and systems and produce isotopes for research, industry, and medicine.

In addition, nine world-class facilities that support ORNL's research and development 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 2016 included North Wind Solutions, LLC; URS | CH2M Oak Ridge LLC; and Isotek Systems LLC. During 2016 activities of these contractors were conducted to comply with contractual and regulatory environmental requirements.

Because of differing permit-reporting requirements and instrument capabilities, various units of measurement are used in this report. The information found in "Units of Measure and Conversion Factors" is intended to help readers convert numeric values presented here as needed for specific calculations and comparisons.

5.1 Description of Site, Missions, and Operations

Oak Ridge National Laboratory (ORNL), which is managed for the US Department of Energy (DOE) by UT-Battelle, LLC, a partnership of the University of Tennessee and Battelle Memorial Institute, lies in the southwest corner of the DOE Oak Ridge Reservation (ORR) (Fig. 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.

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Fig. 5.1. Location of Oak Ridge National Laboratory (ORNL) within the Oak Ridge Reservation and its relationship to other local US Department of Energy facilities. *[ETTP: East Tennessee Technology Park; ORISE: Oak Ridge Institute for Science and Education; Y-12: Y-12 National Security Complex.]*

In March 2007, Isotek Systems LLC assumed responsibility for the Building 3019 Complex at ORNL, where the national repository of ^{233}U has been kept since 1962. In 2010, an “alternatives analysis” was conducted to evaluate methods available for ^{233}U disposition, and in 2011, the recommendations in the *Final Draft ^{233}U Alternatives Analysis Phase I Report* (DOE 2011) were endorsed. The Phase I recommendations included (1) transfer of Zero-Power Reactor (ZPR) plate canisters to the National Nuclear Security Administration and disposal of Consolidated Edison Uranium Solidification Project (CEUSP) material canisters, and (2) completing a Phase II alternatives analysis for processing the remaining 50% of the inventory. The transfer of the ZPR plate canisters was completed in 2012. Disposal of the CEUSP material canisters began in 2015 and continued through 2016. Plans and preparations for the disposition of the remaining ^{233}U inventory are under way.

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.

URS | CH2M Oak Ridge LLC (UCOR) is the DOE ORR cleanup contractor. The scope of UCOR activities at ORNL includes long-term surveillance, maintenance, and management of inactive waste disposal sites, structures, and buildings such as former reactors and isotope production facilities. Other activities include groundwater monitoring, transuranic (TRU) waste storage, and operation of the waste-processing facility for liquid low-level radioactive waste (LLW).

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 TRU wastes for processing, treatment, repackaging, and 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 (CH) debris waste in December 2005 and remotely handled (RH) 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) and the Manufacturing Demonstration Facility (MDF). HVC is located on a 6 acre site owned by Pellissippi Investors, LLC, and is leased to UT-Battelle and the University of Tennessee. Approximately 152 industry partners work at the HVC to shape America's mobility future. NTRC is DOE's only user facility dedicated to transportation and serves as the gateway to UT-Battelle's comprehensive capabilities for transportation research and development (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.

MDF 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. Research achievements in 2016 included (1) collaboration with Boeing to print the 777-X drill and trim tool (Fig. 5.2); (2) collaboration in developing the first 100% digitally manufactured autoclaveable tool for vacuum-assisted-transfer manufacturing; (3) production of a mold with built-in convection heat for a 13 m wind turbine blade; and (4) partnership with teams from the Office of Naval Research to design, 3D-print, and assemble a SEAL delivery vehicle.

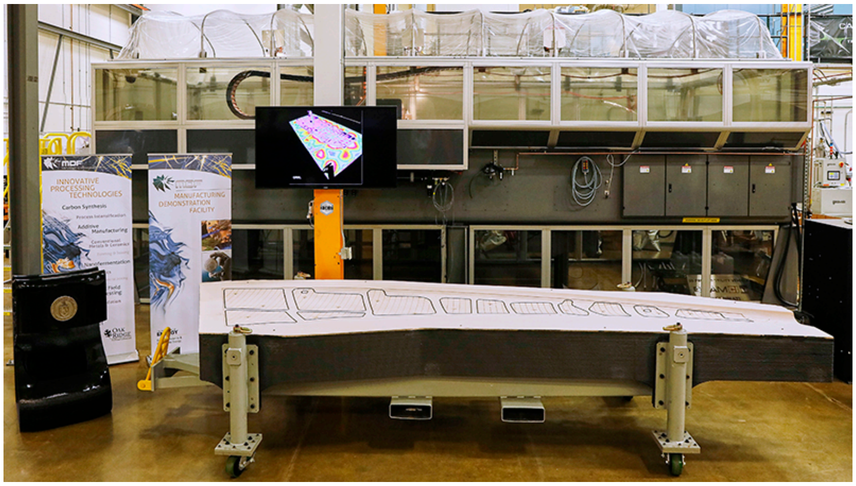

Fig. 5.2. Boeing 777-X drill and trim tool at the *Guinness World Records* ceremony.

The Carbon Fiber Technology Facility (CFTF), a leased 42,000 ft^2 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 carbon fibers (Fig. 5.3). 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.

Fig. 5.3. Production of lower-cost carbon fiber at the Carbon Fiber Technology Facility.
[Photo by Jason Richards.]

UT-Battelle also manages several buildings and trailers located at the Y-12 National Security Complex (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, to measure, manage, and control environmental impacts. 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. UT-Battelle's EMS was first registered in July 2013 and was successfully registered, by National Quality Assurance, U.S.A., in July 2016 to the new ISO 14001:2015 standard.

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 policy and translates environmental laws, applicable DOE orders, and other requirements into laboratory-wide subject area documents (procedures and guidelines). Through environmental protection officers, environmental compliance representatives, and waste services representatives (WSRs), the UT-Battelle EMS assists the line organizations in identifying and addressing environmental issues in accordance with SBMS 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 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 environmental safety and health (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. Figure 5.4 depicts the relationship between the EMS and the ISMS. The UT-Battelle EMS is consistent with the ISMS and includes all the elements in the ISO 14001:2015 standard.

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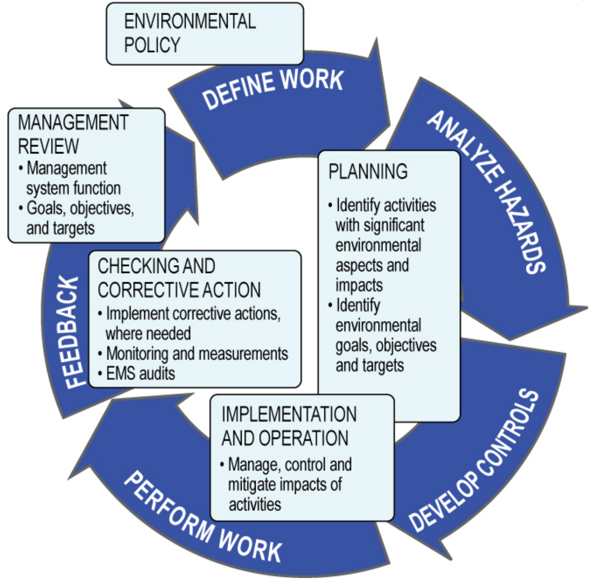

Fig. 5.4. The relationship between the UT-Battelle Environmental Management System and the Integrated Safety Management System.

5.2.1.2 UT-Battelle Policy for Oak Ridge National Laboratory

UT-Battelle's Environmental Policy for ORNL clearly states expectations and provides the framework for setting and reviewing environmental objectives.

5.2.1.3 Planning

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 project and activity level. Activities that are relative to any of the aspects are carefully controlled to minimize or eliminate impacts to the environment. Nine environmental aspects 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 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 has established and implemented objectives and performance indicators for appropriate functions and activities. In all cases, the objectives and performance indicators are consistent with the UT-Battelle Policy for ORNL and are supportive of the laboratory mission, and where practical, they are measurable. The objectives are entered into a commitment tracking system and are tracked to completion.

UT-Battelle Programs

UT-Battelle has established an organizational structure to ensure that environmental stewardship practices are integrated into all facets of UT-Battelle's 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 2016 compliance status, activities, and accomplishments is presented in Section 5.3.

The environmental protection staff provide critical support services in the following areas:

- waste management;
- National Environmental Policy Act (NEPA) compliance;
- air quality compliance;
- water quality compliance;
- US Department of Agriculture (USDA) compliance;
- transportation safety;
- environmental sampling and data evaluation; and
- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) interface.

UT-Battelle's staff also include subject matter experts who provide critical waste management, transportation, and disposition support services to research, operations, and support divisions:

- pollution prevention staff, who manage recycling programs, work with staff to reduce waste generation and to promote sustainable acquisition;
- radiological engineering staff, who provide radiological characterization support to generators and WSRs, develop tools to help ensure compliance with facility safety and transportation, and provide packaging support;
- waste acceptance and disposition staff, who 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, and certify waste packages, and coordinate off-site disposition of UT-Battelle's newly generated waste;
- WSRs, who 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, which performs waste-packing operations and conducts inspections of waste items, areas, and containers;
- the transportation management team, which ensures that both the on-site and off-site packaging and transportation activities are performed in an efficient and compliant manner; and
- the hazardous material spill response team, which 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 UT-Battelle Sustainable Campus Initiative

The UT-Battelle Sustainable Campus Initiative (SCI) for ORNL is a holistic approach to sustainability based on DOE guidance and on Executive Order (EO) 13693 (2015). In 2016 the SCI addressed a number of sustainability issues at ORNL, such as water and energy use, waste management, and greenhouse gas emissions.

Avoided Costs: Energy, Water, and Waste

SCI efforts to reduce energy use intensity (EUI) and water use intensity (WUI), and to divert municipal solid waste and construction and demolition (C&D) debris have resulted in an accumulated cost (Fig. 5.5).

Energy Use Intensity Reduction. UT-Battelle reduced EUI by 5.4% in FY 2016, exceeding the 2.5% annual goal established in EO 13693 (Fig. 5.6).

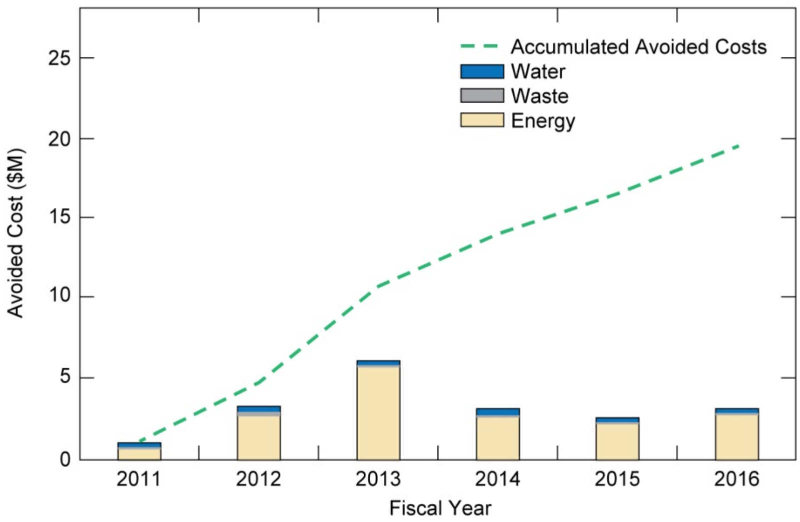
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Fig. 5.5. Avoided costs.

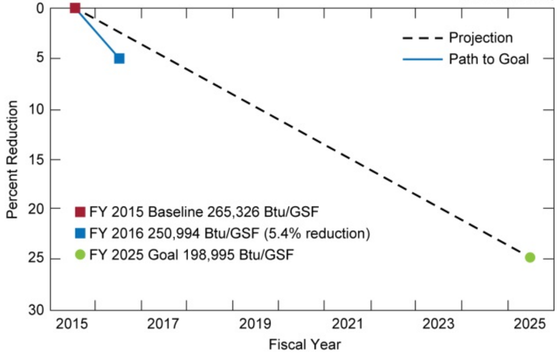
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Fig. 5.6. ORNL energy use intensity reduction summary.

Water Use Intensity Reduction. EO 13693 established a potable water consumption reduction goal of 36% by 2025 through reductions of 2% annually relative to baseline consumption in 2007, and DOE O 230.2B established a reduction goal of 15% between 2007 and 2015. A cumulative reduction in WUI of 21.8% has been realized at ORNL between 2007 and 2016 by means of an aggressive approach that includes repairing leaks and replacing old lines in the site water distribution system and eliminating once-through cooling where possible. Water reduction at ORNL has exceeded both of these goals (Fig. 5.7).

Waste Diversion. The diversion rate for municipal solid waste at ORNL was 46% in FY 2016, slightly less than the DOE goal of 50%. The diversion rate for C&D materials and debris (66%) exceeded the DOE goal of 50%.

Pollution Prevention. UT-Battelle implemented 38 new pollution prevention projects at ORNL during 2016, eliminating more than 3.7 million kg of waste. In total, these projects and ongoing reuse/recycle projects led to cost savings/avoidance of more than $2.5 million. Source reduction actions pursued in 2016 included moving toward paperless work processes; resource-efficient computing; and recycling efforts for paper, scrap metal, pallets, carpet, drums, electronics, and C&D debris (Fig. 5.8).

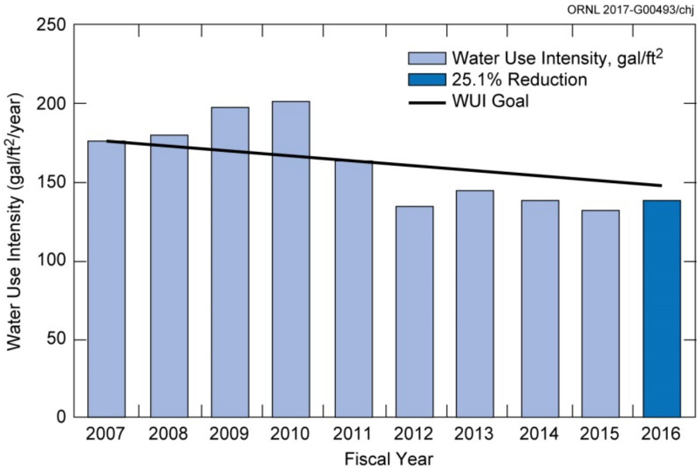


Fig. 5.7. ORNL water use intensity reduction summary.
(EO 13693 reduction goal between 2007 and 2025: 36%.
DOE O 430.2B reduction goal between 2007 and 2016: 15%.)

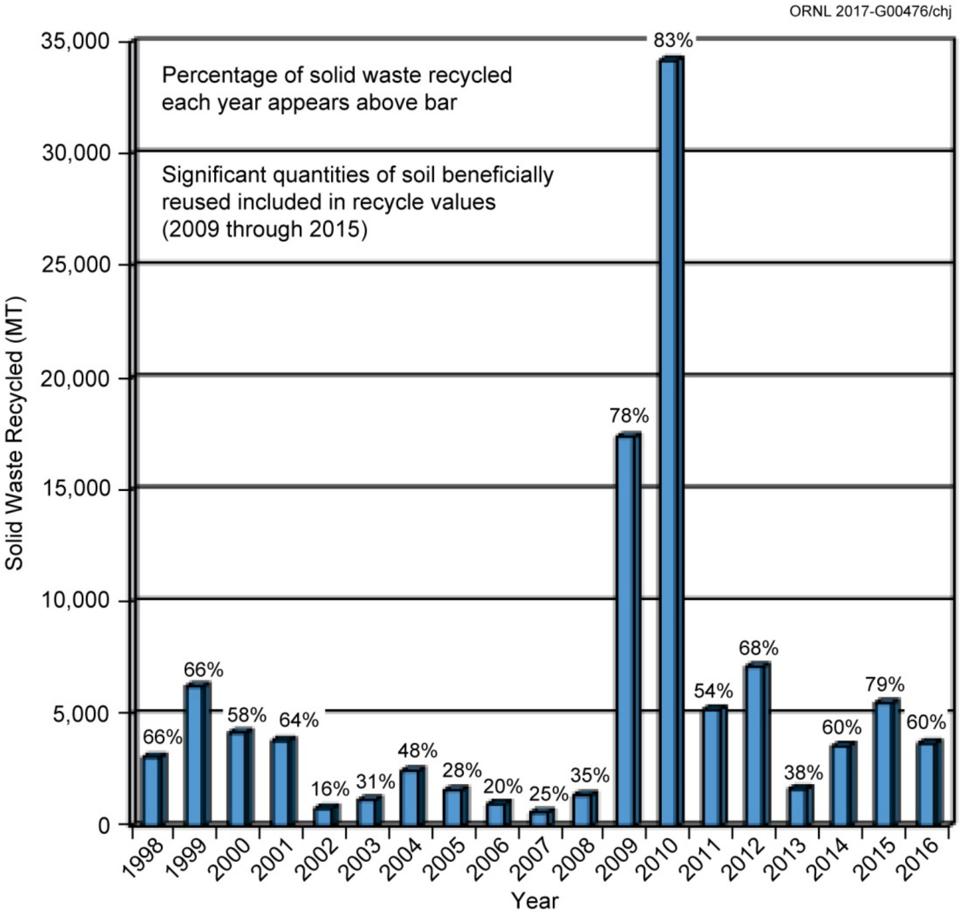


Fig. 5.8. Solid waste recycled at Oak Ridge National Laboratory as a result of recycling programs through 2016.

Sustainable Vehicle Fleet

Fleet Fuel Savings. The vehicle fleet at ORNL includes 63 flexible fuel vehicles and 5 plug-in hybrid sedans, which also use alternative fuels. Fuel data for FY 2016 show a 54.6% decrease in petroleum consumption at ORNL since the 2005, the baseline year established by DOE. This decrease exceeds the DOE cumulative target of a 20% reduction. In addition, ORNL alternative fuel use has increased from the 2005 baseline by 331%, far exceeding the 160% target.

Electric Vehicle Drivers Club. Over the past 5 years, 47 electric vehicle (EV) charging stations have been installed on the ORNL campus. The stations are available for charging of both personal and government fleet vehicles. Most of the EV chargers were installed under the EV Research Project, which bore the associated costs until the end of FY 2016. An EV Owners Club was formed at ORNL to continue operating the non-fleet EV charging stations; annual club dues cover the costs of charging personal vehicles.

Sustainable Buildings: Battle of the Buildings

The Battle of the Buildings, a competition started at ORNL to encourage the reduction of electricity use in buildings, was held between July and September 2016. Electricity use in 2016 at eight buildings with similar missions and similar square footage was compared to use for the previous year. The occupants of the winning building achieved accumulated energy savings of 23%; savings for the second- and third-place buildings were 14% and 8%, respectively.

Regional and Local Planning: The Shuttle Bus System

A bus route between ORNL, the University of Tennessee, and Pellissippi State Community College continued operations for a second year in 2016. The average daily ridership was 27 people. (Fig. 5.9)

Fig. 5.9. ORNL-UT-Pellissippi shuttle bus.

Employee, Family, and Community Engagement: The Science of Earth Day

ORNL’s Earth Day celebration spanned 1 week in 2016. Activities included a tour of the Additive Manufacturing Integrated Energy demonstration project, where a natural-gas-powered hybrid electric vehicle was on display; multiple seminars; a bike ride and a 5k walk; and the opportunity to speak to SCI representatives about various projects and displays.

Awards for Sustainability Efforts

Efforts at ORNL that are related to sustainability were recognized with the following awards in 2016.

- DOE Presidential Migratory Bird Federal Stewardship Award, honorable mention for four species of warblers benefitting from wetlands on the ORR

- DOE Sustainability Award for Green IT Stewardship for team efforts related to “Programming Future Sustainability”

- DOE Sustainability Award for ORNL’s Green Transportation Team efforts related to “Driving Future Sustainability”

- *Facility Maintenance Decisions Magazine* Achievement in Sustainability Award for recognizing “the essential role maintenance and engineering departments play in the safe, sustainable and efficient operation of the nation's institutional and commercial facilities”

- *R&D Magazine* R&D 100 Awards:

    - The Roof Savings Calculator Suite, a Web-based tool for simulating energy flow and loss developed by a team from ORNL, Jacksonville State University, and White Box Technologies

    - The U-Grabber, an adsorbent material designed to extract uranium and other metals from water inexpensively and efficiently

    - Waste Tire Derived Carbon technology, which enables the economic use of waste tires in a green, value-added product and results in lower-cost, higher-performance lithium-ion batteries and a significant reduction in carbon emissions, awarded to ORNL and RJ Lee Group Inc.

    - Wireless Power Transfer Based Electric and Plug-In Vehicle Charging System, awarded to Toyota Engineering and Manufacturing North America with co-developers at ORNL and the Cisco Systems International Transportation Innovation Center

    - Open Port Sampling Interfaces for Mass Spectrometry, which solved a major bottleneck in the expansion of mass spectrometry, an important measurement technique for chemically characterizing materials (Fig. 5.10)

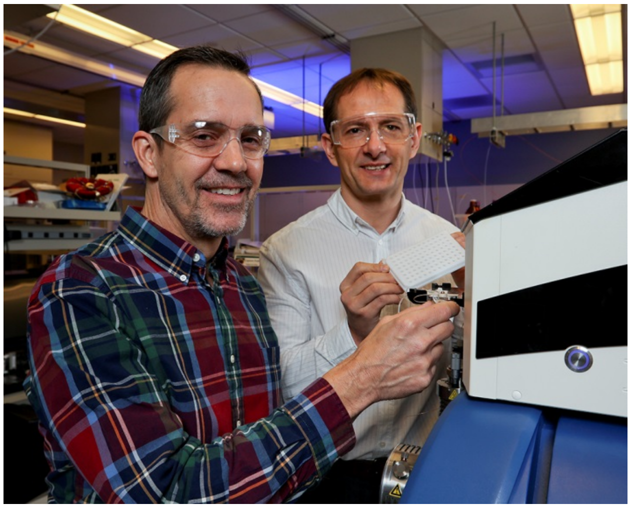


Fig. 5.10. The Open Port Sampling Interfaces for Mass Spectrometry, invented by Gary Van Berkel (left) and Vilmos Kertes, ORNL. *(ORNL photo by Carlos Jones.)*

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 2007) 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.

For the purposes of this provision, "development or redevelopment" is defined as

> 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).

Strategic plans for demolition and renovation of old facilities and construction of new facilities at ORNL incorporate green infrastructure and low-impact development (GI/LID) practices to infiltrate, evapotranspire, and/or harvest and use storm water on site to the maximum extent feasible. GI/LID approaches and technologies have been used to mimic the natural processes of the hydrologic cycle (infiltration, evapotranspiration, and use). GI/LID practices that have been incorporated at ORNL include

- trees and tree boxes,
- rain gardens,
- vegetated swales,
- pocket wetlands,
- infiltration planters,
- porous and permeable pavements,
- vegetated median strips,
- reforestation and revegetation,
- protection of riparian buffers and floodplains,
- retention ponds, and
- water reuse (e.g., tanks in restrooms to collect water for reuse in irrigation).

At ORNL, a three-step approach is used to evaluate and satisfy the requirements of EISA Section 438. Evaluation occurs

1. within the project boundaries. If the necessary volume of runoff cannot be infiltrated or retained on site, then

2. on land immediately adjacent to the project boundaries. If the necessary volume of runoff cannot be infiltrated or retained on land immediately adjacent to the project boundaries, then

3. within the same valley or ridge area (e.g., within Bethel Valley if the project is within Bethel Valley; within Melton Valley if the project is within Melton Valley).

In addition to GI/LID practices, the projects may remove impervious areas and reestablish pervious areas to allow infiltration or evapotranspiration 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 services and, in the event of an accident, emergency response services. Emergency preparedness 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 performance of the procedures and plans. An environmental subject matter expert is a member of the emergency response team and participates in drills and exercises to ensure that environmental requirements are met and that environmental impacts from an event and the response are mitigated.

5.2.1.7 Checking

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. Several SBMS subject areas include requirements for managers 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 are a part of 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, internal and external EMS assessments are performed annually to ensure that the UT-Battelle EMS continues to conform to ISO requirements. An internal audit and an external registration audit conducted in 2016 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 Other Environmental Management System Assessments

5.2.2.1 Environmental Management System for the Transuranic Waste Processing Center

The National Sanitation Foundation, International Strategic Registrations, Ltd (NSF-ISR) registered the TWPC EMS for activities to the ISO 14001:2004 standard (ISO 2004) in May 2008. 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.

The NSF-ISR registered the TWPC EMS for activities to the ISO 14001:2004 standard in May 2008. NSF-ISR conducted a recertification audit in April 2014 and a surveillance audit in April 2016. No nonconformances or issues were identified, and several significant practices were noted.

The TWPC EMS incorporates applicable environmental laws, DOE orders, and other requirements (i.e., DOE directives and federal, state, and local laws) through NWSol's *Regulatory Management Plan* (NWSol 2015), which dictates 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 contamination, pollution prevention, habitat alteration, and energy consumption as potentially having significant environmental impacts. Activities that are relative 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 NWSol 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, construction debris, and batteries. NWSol has established a "single stream" recycling program that allows the mixing of multiple types of recyclables that increases the amount of recyclable items and improves compliance. A construction debris recycling program began in September 2011 and has resulted in about 172 tons being diverted from the landfill to date.

"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 biobased materials and other environmentally friendly products. NWSol ensures that environmentally preferable products are purchased by incorporating the "green" procurement requirements in NWSol procurement procedures.

Several methods are used by NWSol 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.

5.2.2.2 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 ISO14001:2004 standard and that satisfies the applicable requirements of DOE O 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 facilities and includes Buildings 3017 and 3019 at ORNL and an off-site administrative office in Oak Ridge. 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 2016 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 2016.

The following discussions summarize the major environmental programs and activities carried out at ORNL during 2016 and provide an overview of the compliance status for the year.

Table 5.1. Summary of regulatory environmental audits, evaluations, inspections, and assessments conducted at Oak Ridge National Laboratory, 2016

Date	Reviewer	Subject	Issues
March 7	City of Oak Ridge	CFTF Wastewater Inspection	0
April 12–13	TDEC	Annual RCRA Inspection for ORNL (including TWPC)	0
April 12	City of Oak Ridge	CFTF Wastewater Monitoring	0
September 7	City of Oak Ridge	CFTF Wastewater Inspection	0
October 24	TDEC	Annual CAA Inspection for ORNL and CFTF	0
November 17	TDEC	UST Compliance Inspection	2[a]

[a] Three active tanks were identified as not being registered correctly (one violation, rescinded), and two electronic line leak detectors had not been third-party tested in the preceding 12 months.

Acronyms

CAA = Clean Air Act
CFTF = Carbon Fiber Technology Facility
ORNL = Oak Ridge National Laboratory
RCRA = Resource Conservation and Recovery Act
TDEC = Tennessee Department of Environment and Conservation
TWPC = Transuranic Waste Processing Center
UST = Underground storage tank

5.3.1 Environmental Permits

Table 5.2 contains a list of environmental permits that were in effect in 2016 at ORNL.

Table 5.2. Environmental permits in effect at ORNL in 2016

Regulatory driver	Permit title/description	Permit number	Owner	Operator	Responsible contractor
CAA	Title V Major Source Operating Permit, ORNL	562765	DOE	UT-B	UT-B
CAA	Construction Permit, CFTF facility (located near ETTP)	965013P	DOE	UT-B	UT-B
CAA	Construction Permit, CFTF emergency generator	967180P	DOE	UT-B	UT-B
CAA	Construction Permit, Steam Plant boilers 7–9	969317F	DOE	UT-B	UT-B
CAA	Construction Permit, 4501/4505 Area Off Gas System	971441P	DOE	UT-B	UT-B
CAA	Operating Permit, NTRC	0941-05	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	Title V Major Source Operating Permit, Isotek	568276	DOE	Isotek	Isotek
CWA	ORNL NPDES Permit (ORNL sitewide wastewater discharge permit)	TN0002941	DOE	DOE	UT-B, UCOR, NWSol
CWA	Tennessee General NPDES Permit TNR10-0000, Storm Water Discharges from Construction Activities—Spallation Neutron Source	TNR139975	DOE	DOE	UT-B
CWA	Tennessee General NPDES Permit TNR10-0000, Storm Water Discharges from Construction Activities—7018 Renovations/Additions (2.81 acres)	TNR134552	DOE	DOE	UT-B
CWA	Industrial and Commercial User Waste Water Discharge Permit (CFTF)	1-12	UT-B	UT-B	UT-B
CWA	Tennessee General NPDES Permit TNR10-0000, Storm Water Discharges from Construction Activities—Pro2Serve National Security Engineering Center		DOE	DOE	CROET

Table 5.2 (continued)

Regulatory driver	Permit title/description	Permit number	Owner	Operator	Responsible contractor
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	Tennessee General NPDES Permit TNR10-0000, Storm Water Discharges from Construction Activity—Site Expansion Project	TNR 133560	DOE	NWSol	NWSol
CWA	ARAP for ORNL East Campus Pond Replacement	ARAP NR1403.060	DOE	UT-B	UT-B
RCRA	Hazardous Waste Transporter Permit	TN1890090003	DOE	DOE	UT-B, UCOR
RCRA	Hazardous Waste Corrective Action Permit	TNHW-164	DOE	DOE/all	DOE/all
RCRA	Hazardous Waste Container Storage and Treatment Units	TNHW-134	DOE	DOE/UT-B	UT-B
RCRA	Hazardous Waste Container Storage and Treatment Units	TNHW-145	DOE	DOE/ UCOR/ NWSol	UCOR/ NWSol

Acronyms

ARAP = Aquatic Resource Alteration Permit
CAA = Clean Air Act
CFTF = Carbon Fiber Technology Facility
CROET = Community Reuse Organization of East Tennessee
CWA = Clean Water Act
DOE = US Department of Energy
ETTP = East Tennessee Technology Park
Isotek = Isotek Systems LLC
NPDES = National Pollutant Discharge Elimination System
NTRC = National Transportation Research Center
NWSol = North Wind Solutions, LLC
ORNL = Oak Ridge National Laboratory
RCRA = Resource Conservation and Recovery Act
UCOR = URS | CH2M Oak Ridge LLC
UT-B = UT-Battelle

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 2016.

Table 5.3. National Environmental Policy Act activities, 2016

Types of NEPA documentation	Number of instances
Oak Ridge National Laboratory	
Approved under general actions or generic CX determinations[a]	103
Project-specific CX determinations[b]	3
North Wind Solutions	
Approved under general actions[a] or generic CX determinations	1

[a] Projects that were reviewed and documented through the site NEPA compliance coordinator.

[b] 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

During 2016, 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 Oak Ridge Office has approved generic categorical exclusion (CX) determinations that cover proposed bench- and pilot-scale research activities and generic CXs that cover proposed nonresearch activities (e.g., maintenance activities, facilities upgrades, personnel safety enhancements). A CX 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 Protection Act at ORNL is achieved and maintained 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), 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. It includes four major regulatory programs: the national ambient air quality standards, state implementation plans, new source performance standards, and 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 sitewide UT-Battelle Title V Major Source Operating Permit, which was issued in 2011, was sent in for renewal in February 2016. Three minor modification requests were submitted to TDEC in 2016 and will likely be finalized in a minor modification in 2017. TDEC issued two additional construction permits, one for the new off-gas system radionuclide emission source at Building 3525 and one for the new off-gas system radionuclide emission source at Buildings 4501 and 4505.

The Title V Major Source Operating Permit for the 3039 stack, operated by UCOR, was renewed in 2015. 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 (NO_x), 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 9 major radionuclide sources and periodically from 15 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. A permit was issued by Knox County for an emergency generator located at NTRC in April 2016. The CFTF operates under two construction permits issued by TDEC. A permit application to convert them to a true minor operating air permit was submitted in 2015 and was still pending issuance at the end of 2016.

In summary, there were no UT-Battelle CAA violations and no Isotek, UCOR, or NWSol CAA violations or exceedances in 2016. Section 5.4 provides detailed information on 2016 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) is to restore, maintain, and protect the integrity of the nation’s waters. The CAA 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.

In 2016, compliance with the ORNL NPDES permit was determined by about 2,300 laboratory analyses and field measurements. The NPDES permit limit compliance rate for all discharge points for 2016 was greater than 99%, with no measurements exceeding numeric NPDES permit limits. One laboratory sampling error occurred during February 2016 when the contents of the sample bottle containing the composited effluent from the week of February 8–12, 2016, was mistakenly discarded before being analyzed for the total suspended solids (TSS). A replacement sample was unable to be obtained, and so the required analysis for the weekly TSS concentration could not be measured or reported.

5.3.5 Safe Drinking Water Act Compliance Status

ORNL's water distribution system is designated as a "nontransient, noncommunity" water system by the TDEC Division of Water Supply. TDEC's Water Supply rules, Chapter 0400-45-01, Public Water Systems (TDEC 2012), 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), and
- 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 2016, 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 will not be required again until 2018.

5.3.6 Resource Conservation and Recovery Act Compliance Status

The Hazardous Waste Program under the Resource Conservation and Recovery Act (RCRA) 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 2016, 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 2016. 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 5.4. In 2016, UT-Battelle and UCOR were permitted to transport hazardous wastes under an EPA ID number issued for ORNL activities. On September 15, 2015, the ORR Hazardous Waste Corrective Action Permit TNHW-121 was reissued as TNHW-164. TNHW-164 is a set of conditions pertaining to the current status of all solid waste management units (SWMUs) and areas of concern (AOCs) at East Tennessee Technology Park (ETTP), ORNL, and the Y-12 National Security Complex. The corrective action conditions require that the SWMUs and AOCs be investigated and, as necessary, remediated.

Reporting is required for hazardous waste activities on 42 active waste streams at ORNL, some of which are mixed wastes. The quantity of hazardous/mixed waste generated at ORNL in 2016 was 540,600 kg, with mixed wastewater accounting for 387,637 kg. ORNL generators treated 5,773 kg of hazardous/mixed waste by elementary neutralization, silver recovery, and deactivation. Four hundred forty-seven kg of hazardous waste from ETTP was treated at Process Waste Treatment Complex (PWTC). The quantity of hazardous/mixed waste treated in RCRA-permitted treatment facilities at ORNL in 2016 was 6,191 kg. This included waste treated by macroencapsulation, size reduction, stabilization/solidification, and wastewater treatment at the PWTC. In addition, 387,637 kg of liquid mixed waste was treated at the Liquid Low Level Waste Treatment Facility. The amount of hazardous/mixed waste shipped off site to commercial treatment, storage, and disposal facilities was 118,186 kg in 2016.

Table 5.4. Oak Ridge National Laboratory Resource Conservation and Recovery Act operating permits, 2016

Permit number	Storage and treatment units/description
	Oak Ridge National Laboratory
TNHW-134	Building 7651 Container Storage Unit
	Building 7652 Container Storage Unit
	Building 7653 Container Storage Unit
	Building 7654 Container Storage Unit
	Portable Unit 2 Storage and Treatment Unit
TNHW-145	Portable Unit 1 Storage Unit and Treatment Unit
	Building 7572 Container Storage Unit
	Building 7574 Container Storage Unit
	Building 7823 Container Storage Unit
	Building 7855 Container Storage Unit
	Building 7860A Container Storage Unit
	Building 7879 Container Storage Unit
	Building 7883 Container Storage Unit
	TWPC-1 (Contact-Handled Storage Area) Container Storage Unit
	TWPC-2 (Second Floor WPB) Container Storage Unit
	TWPC-3 (Drum Aging Criteria) Container Storage Unit
	TWPC-4 (First Floor WPB) Container Storage Unit
	TWPC-5 (Container Storage Area) Container Storage Unit
	TWPC-6 (Contact-Handled Marshaling Building) Container Storage Unit, Building 7880BB
	TWPC-7 (Drum-Venting Building) Container Storage Unit, Building 7880AA
	TWPC-8 (Multipurpose Building) Container Storage Unit, Building 7880QQ
	T-1[a] Macroencapsulation Treatment
	T-2[a] Amalgamation Treatment
	T-3[a] Solidification/Stabilization Treatment
	T-4[a] Groundwater Absorption Treatment
	T-5[a] Size Reduction T-5a Treatment
	T-6[a] Groundwater Filtration Treatment
	Oak Ridge Reservation
TNHW-121[b]	Hazardous Waste Corrective Action Permit

[a] Treatment operating units within TWPC facilities.

[b] On September 15, 2015, the ORR Hazardous Waste Corrective Action Permit TNHW-121 was reissued as TNHW-164.

Acronyms

TWPC = Transuranic Waste Processing Center
WPB = Waste Processing Building

In April 2016, TDEC conducted an annual RCRA inspection of ORNL generator areas; battery collection areas; RCRA-permitted treatment, storage, and disposal facilities; and RCRA records. TDEC also reviewed the Hazardous Waste Transporter Permit; US Department of Transportation (DOT) inspection records for tractors, trailers, and tankers; commercial driver's licenses; and DOT training records. All records and areas were found to be in compliance with RCRA regulations and the RCRA permits.

DOE and UT-Battelle operations at NTRC and CFTF were regulated as "conditionally exempt small-quantity generators" in 2016, meaning that less than 100 kg of hazardous waste per month was generated.

In 2016, no hazardous/mixed wastes were generated, accumulated, or shipped by DOE or UT-Battelle at the DOE Office of Scientific and Technical Information, the 1916-T2 warehouse, or the 0800 Area. The 0800 Area is a location on ORR adjacent to ORNL that has been assigned EPA identification number TNR000019760.

5.3.7 Oak Ridge National Laboratory RCRA-CERCLA Coordination

The Federal Facility Agreement for the Oak Ridge Reservation (FFA) (DOE 2014) 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 2015 for ORNL's SWMUs and AOCs 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 2016.

Periodic updates of proposed C&D activities and 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 C&D 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 Resource Conservation and Recovery Act 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 three USTs registered with TDEC under Facility ID 0-730089. Two are in service (petroleum) and meet the current UST standards. One (formerly storing petroleum) is undergoing permanent closure activities and is expected to be closed in the first quarter of 2017.

TDEC performed a compliance inspection in November 2016, and two findings were cited by TDEC as a result of the inspection. Both findings were resolved within 60 days, as required by TDEC.

5.3.8 Comprehensive Environmental Response, Compensation, and Liability Act Compliance Status

CERCLA, also known as Superfund, was passed in 1980 and was amended in 1986 by the Superfund Amendments and Reauthorization Act (SARA). Under CERCLA, a site is investigated and remediated if it poses significant risk to health or the environment. The EPA National Priorities List (NPL) 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 EPA NPL. In 1992, the ORR FFA among EPA, TDEC, and DOE became effective and established the framework and schedule for developing, implementing, and monitoring remedial actions (RAs) on ORR. The on-site CERCLA Environmental Management Waste

Management Facility (EMWMF) is operated by UCOR 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 2016, UT-Battelle operated 12 PCB waste storage areas. When longer-term storage was necessary, PCB/radioactive wastes were stored in RCRA-permitted storage buildings at ORNL. One PCB waste storage area 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 disposed of. 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) 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.

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

The Emergency Planning and Community Right-to-Know Act (EPCRA) and Title III of SARA require that facilities report inventories and releases of certain chemicals that exceed specific release thresholds. The report is submitted to the University of Texas at Dallas (UT-Dallas) Emergency Response Information System (E-Plan) E-Plan is an electronic database managed by UT-Dallas and funded by the U.S. Department of Homeland Security. The State of Tennessee Emergency Response Commission has access to ORNL EPCRA data via the E-Plan system.

Table 5.5 describes the main elements of EPCRA. UT-Battelle complied with these requirements in 2016 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 2016. Releases of toxic chemicals that were greater than the Section 313 designated reportable threshold quantities are discussed in Section 5.3.10.2.

Table 5.5. 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, Material 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 Material 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 2016, there were 25 hazardous and/or extremely hazardous substances at ORNL that met EPCRA reporting criteria.

Private-sector lessees were not included in the 2016 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.

For 2016, ORNL exceeded the reporting threshold and reported on the otherwise use of nitric acid and the manufacture of nitrate compounds. Most of the nitric acid was used in wastewater treatment operations at the PWTC. Nitrate compounds were coincidentally manufactured as by-products of neutralizing the nitric acid waste and 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 2016, UT-Battelle personnel had 39 permits and agreements for the receipt, movement, or controlled release of regulated articles.

5.3.12 Wetlands

In 2016, the fifth and final year of postmitigation monitoring and reporting was completed on compensatory mitigation sites for the ORNL Parking Structure, which was constructed in 2011. The monitored mitigation sites included the expansion of Wetland P2 and the enhanced sections of White Oak Creek and First Creek riparian zones. All requirements of TDEC's wetland-mitigation Aquatic Resource Alteration Permits stipulated by Section 401 of the CWA are fulfilled. Wetland monitoring included surveys of vegetation and fauna. Creek monitoring included riparian-zone vegetation surveys, fish and benthic community surveys, and stream habitat assessments (Fig. 5.11).

Fig. 5.11. Creek monitoring of wetland mitigation site.
(ORNL photo by Neil Giffen, Facilities and Operations Directorate.)

5.3.12.1 Wetland P2

Baseline data collected in 2011 showed sparse vegetation with limited habitat and lack of fauna prior to mitigation. Five years later, the wetland has good overall vegetative cover from a mix of planted and volunteer species. The plant community has shifted from herbaceous growth (e.g., rushes and sedges) to woody species (e.g., willows) over time. The improved wildlife habitat is evident by the increased presence of birds, frogs, and benthic macroinvertebrates in and around the wetland.

5.3.12.2 First Creek

Riparian zone planting was conducted prior to the completion of the ORNL Parking Structure, resulting in more than the required 5 years of monitoring. Plantings on the east side of the creek have improved habitat quality in that area over original habitat conditions, which included large mowed turf grass areas and a high number of invasive plant species. Results of habitat measurements conducted in 2016 along this reach of First Creek showed that the creek provided good overall habitat and was in a nonimpaired state. Fish community monitoring showed fish population densities similar to certain reference streams, although the number of fish species was generally lower than the numbers found in reference streams.

5.3.12.3 White Oak Creek

Vegetation surveys have shown improved riparian buffer habitat quality compared to the premitigation mowed turf. Although there have been records of dying shrubs over the years, plant cover remains good due to replacement shrub plantings and volunteer plants. Results of habitat measurements conducted in 2016 along the mitigated section of White Oak Creek showed that the creek provided average overall habitat and was in a nonimpaired state. A moderately diverse benthic macroinvertebrate population was recorded at the site in 2016. Fish population density and biomass were lower in this reach of White Oak Creek than were found in certain reference streams on the ORR. The number of fish species was comparable to or lower than the numbers found in the reference streams.

5.3.13 Radiological Clearance of Property at Oak Ridge National Laboratory

DOE O 458.1, *Radiation Protection of the Public and the Environment* (DOE 2011b), 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 O 458.1 established requirements for clearance of property from DOE control and for public notification of clearance of property.

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; and
- other items with an approved release plan.

Items that are not in the listed categories and that originate from nonradiological areas within the site'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 O 458.1 (DOE 2011b) 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 O 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.

UT-Battelle continues to use the preapproved authorized limits for surface contamination 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 2016, UT-Battelle cleared more than 17,000 items through the excess items and property sales processes. A summary of items requested for release through these processes (including donations, transfers, landfill, reutilization, and sales) is shown in Table 5.6.

Table 5.6. Excess items requested for release and/or recycling, 2016

Item	Process knowledge	Radiologically surveyed
Release request totals for 2016		
Computers-for-Learning	0	0
DOE donations	0	0
Other donations	613	129
LEDP (donations to colleges/universities)	77	0
DOE transfers	524	100
Other federal agency transfers	159	61
Landfill	67	12
Reuse at ORNL	390	29
Sales	12,477	2,522
Totals	14,307	2,853
Recycling request totals for 2016		
Cardboard (tons)	125.45	
Scrap metal (nonradiological areas) (tons)	583.32	
Pallets (each)	4,000	

Acronyms

DOE = US Department of Energy
LEDP = Laboratory Equipment Donation Program
ORNL = Oak Ridge National Laboratory

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

The Spallation Neutron Source (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 O 458.1 (DOE 2011b) 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., NRC 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.

The approved revised process for notification was continued in 2016. In 2016 ORNL cleared 184 samples from neutron scattering experiments using the SNS and HFIR sample authorized limits process.

5.4 Air Quality Program

5.4.1 Construction and Operating Permits

Permits issued by the State of Tennessee convey the clean air requirements that are applicable to ORNL. 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 ambient air criteria pollutants, and requirements applicable to sources of other hazardous (nonradiological) air pollutants. In September 2011, the State of Tennessee issued Title V Major Source Operating Permit 562765 to DOE and UT-Battelle operations at ORNL. This permit was renewed in 2016 and was issued on August 2, 2017. In January 2015, TDEC also issued two construction permits for the Building 3525 and the 4501/4505 Off Gas System new radionuclide emission sources. DOE and UT-Battelle also maintained a valid minor source operating permit with the Knox County Air Quality Management Division for NTRC facilities located in Knox County.

In 2012 UT-Battelle applied for and received construction permit number 965103P for the construction of CFTF, located off site at the Horizon Center Business Park in Oak Ridge, Tennessee. The initial start-up of CFTF occurred in March 2013. A True Minor Source Operating Permit for the facility and its emergency generator is anticipated to be issued in 2017.

DOE /NWSol has two Title V Major Source Operating Permits for one emission source and two emergency generators at TWPC. Isotek has a Title V Major Source Operating Permit for the Radiochemical Development Facility (Building 3019 complex). During 2016 no permit limits were exceeded. UCOR has a Title V Major Source Operating Permit for the 3039 stack. No permit limits were exceeded for these sources in 2016.

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 (ACM). UT-Battelle's Asbestos Management Program manages the compliance of work activities involving the removal and disposal of ACM, 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 2016 there were no deviations or releases of reportable quantities of ACM.

5.4.3 Oak Ridge National Laboratory Radiological Airborne Effluent Monitoring

Radioactive airborne discharges at ORNL 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 seven stacks. Six are located in Bethel and Melton Valleys, and one, the SNS Central Exhaust Facility stack, is located on Chestnut Ridge (Fig. 5.12).

- 2026 Radioactive Materials Analytical Laboratory
- 3020 Radiochemical Development Facility
- 3039 central off-gas and scrubber system, which includes the 3500 cell ventilation system, isotope solid-state ventilation system, 3025 area cell ventilation system, 3042 ventilation system, and 3092 central 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 2016 there were 14 minor point/group sources, and emission calculations/estimates were made for each of them.

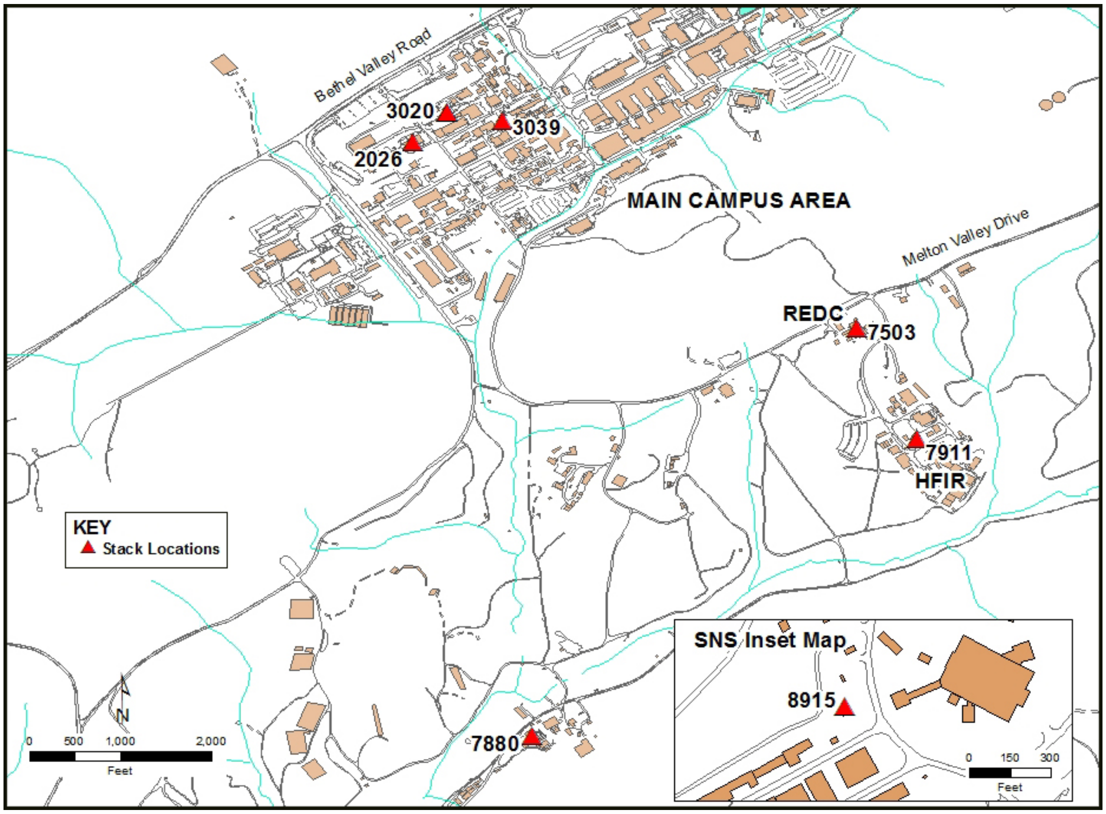


Fig. 5.12. Locations of major radiological emission points at Oak Ridge National Laboratory.*(HFIR = High Flux Isotope Reactor, REDC = Radiochemical Engineering Development Center, and SNS = Spallation Neutron Source.)*

5.4.3.1 Sample Collection and Analytical Procedure

Four of the major point sources (stacks 2026, 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). The sampling systems generally consist of a multipoint in-stack sampling probe, a sample transport line, a particulate filter, activated charcoal cartridges, a silica gel cartridge (if required), flow-measurement and totalizing instruments, a sampling pump, and a return line to the stack. The 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 7911 sampling system has the same components as the ANSI 1969 sampling systems but uses a stainless-steel-shrouded probe instead of a multipoint in-stack sampling probe. The 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., ^{41}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. 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 and some minor sources; the criteria in EPA Method 2 (EPA 2010) 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.

In addition to the major sources, ORNL has a number of 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, particulate filters, and silica-gel traps are collected weekly to biweekly. The use of charcoal cartridges 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}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 composited monthly and analyzed for alpha-, beta-, and gamma-emitting isotopes. The sampling system on stack 7880 requires no other type of radionuclide collection media. Compositing 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 no more often than every 3 years unless there is an increase in particulate emissions, an increase in detectable radionuclides in the sample media, or process modifications.

The data from the charcoal cartridges, 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 2016 are presented in Table 5.7. All data presented were determined to be statistically different from zero at the 95% confidence level. Any number not statistically different from zero was not included in the emission calculation. Because measuring a radionuclide requires counting random radioactive emissions from a sample, the same result may not be obtained if the sample is analyzed repeatedly. This deviation is referred to as the “counting uncertainty.” Statistical significance at the 95% confidence level means that there is a 5% chance that the results could be erroneous.

Historical trends for tritium (^{3}H) and ^{131}I are presented in Figs. 5.13 and 5.14. For 2016, tritium emissions totaled about 1,086.9 Ci (Fig. 5.13), over twice the emissions seen in 2015; ^{131}I emissions totaled 0.03 Ci (Fig. 5.11), a 65% reduction from 2015. For 2016, of the 278 radionuclides released from ORNL operations and evaluated (see Table 5.7), the isotopes that contributed 10% or more to the off-site dose from ORNL were ^{11}C, ^{234}U, and ^{212}Pb, with dose contributions of about 34%, 21%, and 18%, respectively. The increase in tritium and ^{11}C emissions results from SNS operations and research activities (Fig. 5.15). Emissions of ^{234}U are associated with a number of sources at ORNL, including 1000, 3000, 4000 and 7000 area laboratory hoods. Emissions of ^{212}Pb result from the radiation decay of legacy material stored on site, and areas containing isotopes of ^{228}Th, ^{232}Th, and ^{232}U. Emissions of ^{212}Pb were from the following stacks: 2026, 3020, 3039, 7503, 7856, 7911, 7935 Glove Box, the STP Sludge Drier and the 4000 area laboratory hoods. For 2016, ^{11}C emissions totaled 40,000 Ci, double that of 2015; ^{234}U emissions totaled 0.0243 Ci; and ^{212}Pb emissions totaled 2.02 Ci.

The calculated radiation dose to the maximally exposed individual (MEI) from all radiological airborne release points at ORR during 2016 was 0.2 mrem. The dose contribution to the MEI from all ORNL radiological airborne release points was 97.8% of the ORR dose. This dose is well below the NESHAPs standard of 10 mrem and is less than 0.07% 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.)

Table 5.7. Radiological airborne emissions from all sources at ORNL, 2016 (Ci)[a]

Isotope	Inhalation form[b]	Chemical form	Stack								
			X-2026	X-3020	X-3039	X-7503	X-7880	X-7911	X-8915	Total minor Source	ORNL total
^{225}Ac	M	Particulate								3.04E-04	3.04E-04
^{226}Ac	M	Particulate								5.63E-08	5.63E-08
^{227}Ac	M	Particulate								6.48E-09	6.48E-09
^{228}Ac	M	Particulate								2.34E-05	2.34E-05
^{109m}Ag	B	Unspecified								1.25E-14	1.25E-14
^{110m}Ag	M	Particulate								1.15E-09	1.15E-09
^{111}Ag	M	Particulate								8.52E-06	8.52E-06
^{112}Ag	M	Particulate								2.45E-08	2.45E-08
^{26}Al	M	Particulate								6.85E-14	6.85E-14
^{241}Am	M	Particulate	4.78E-08	3.01E-07				3.06E-08		9.76E-06	1.01E-05
^{241}Am	F	Particulate			1.23E-07	1.08E-08	1.02E-06			1.69E-08	1.17E-06
^{243}Am	M	Particulate								8.74E-09	8.74E-09
^{37}Ar	B	Unspecified								9.75E-11	9.75E-11
^{39}Ar	B	Unspecified								7.25E-10	7.25E-10
^{41}Ar	B	Unspecified						4.44E+02	7.80E+01		5.22E+02
^{42}Ar	B	Unspecified								2.04E-14	2.04E-14
^{133}Ba	M	Particulate								2.14E-09	2.14E-09
^{137m}Ba	B	Unspecified								3.13E-11	3.13E-11
^{139}Ba	M	Particulate						1.99E-01			1.99E-01
^{140}Ba	M	Particulate						3.80E-04		3.80E-06	3.84E-04
^{7}Be	M[b]	Particulate	1.99E-07							7.74E-06	7.94E-06
^{7}Be	S	Particulate			6.56E-06	3.47E-07				5.19E-07	7.43E-06
^{206}Bi	M	Particulate								3.80E-07	3.80E-07
^{211}Bi	B	Unspecified								5.82E-11	5.82E-11
^{212}Bi	M	Particulate								1.70E-07	1.70E-07
^{213}Bi	M	Particulate								2.76E-04	2.76E-04

Table 5.7 (continued)

Isotope	Inhalation form	Chemical Form	Stack X-2026	X-3020	X-3039	X-7503	X-7880	X-7911	X-8915	Total minor Source	ORNL total
^{249}Bk	M	Particulate								7.00E-11	7.00E-11
^{82}Br	M	Particulate								8.99E-08	8.99E-08
^{11}C	G	Dioxide							4.00E+04		4.00E+04
^{14}C	M	Particulate								7.11E-08	7.11E-08
^{14}C	G	Dioxide								3.00E-02	3.00E-02
^{41}Ca	M	Particulate								1.13E-10	1.13E-10
^{45}Ca	M	Particulate								9.70E-08	9.70E-08
^{47}Ca	M	Particulate								1.10E-10	1.10E-10
^{109}Cd	M	Particulate								1.25E-14	1.25E-14
^{113m}Cd	M	Particulate								2.66E-14	2.66E-14
^{115}Cd	M	Particulate								3.55E-06	3.55E-06
^{139}Ce	M	Particulate								3.69E-08	3.69E-08
^{141}Ce	M	Particulate						8.18E-07		1.24E-06	2.06E-06
^{143}Ce	M	Particulate								4.36E-07	4.36E-07
^{144}Ce	M	Particulate								5.17E-07	5.17E-07
^{249}Cf	M	Particulate								1.06E-08	1.06E-08
^{250}Cf	M	Particulate								2.91E-07	2.91E-07
^{251}Cf	M	Particulate								2.50E-09	2.50E-09
^{252}Cf	M	Particulate						1.56E-08		2.31E-06	2.33E-06
^{36}Cl	M	Particulate								3.90E-10	3.90E-10
^{242}Cm	F	Particulate					6.61E-07				6.61E-07
^{242}Cm	M	Particulate								4.32E-13	4.32E-13
^{243}Cm	M	Particulate	1.19E-07							7.66E-09	1.26E-07
^{243}Cm	F	Particulate			1.01E-08	2.04E-08	4.29E-07			2.81E-09	4.62E-07
^{244}Cm	M	Particulate	1.19E-07	2.93E-08						3.56E-06	3.71E-06
^{244}Cm	F	Particulate			1.01E-08	2.04E-08	4.29E-07			2.81E-09	4.62E-07
^{245}Cm	M	Particulate								3.74E-10	3.74E-10

Table 5.7 (continued)

Isotope	Inhalation form	Chemical Form	Stack								
			X-2026	X-3020	X-3039	X-7503	X-7880	X-7911	X-8915	Total minor Source	ORNL total
^{246}Cm	M	Particulate								2.26E-14	2.26E-14
^{248}Cm	M	Particulate								6.80E-14	6.80E-14
^{56}Co	M	Particulate								1.58E-13	1.58E-13
^{57}Co	M	Particulate								4.13E-09	4.13E-09
^{57}Co	S	Particulate			1.79E-07		6.06E-07				7.85E-07
^{58}Co	M	Particulate								9.91E-09	9.91E-09
^{60}Co	M	Particulate								2.79E-05	2.79E-05
^{60}Co	S	Particulate			1.04E-07		1.96E-06				2.06E-06
^{60m}Co	M	Particulate								1.05E-13	1.05E-13
^{51}Cr	S	Particulate								1.99E-05	1.99E-05
^{51}Cr	M	Particulate								2.18E-04	2.18E-04
^{134}Cs	F	Particulate								3.61E-07	3.61E-07
^{136}Cs	F	Particulate								1.02E-06	1.02E-06
^{137}Cs	F	Particulate	2.45E-06	1.59E-06				4.02E-06		4.85E-04	4.93E-04
^{137}Cs	S	Particulate			5.72E-05	4.58E-07	1.79E-06			5.30E-05	1.12E-04
^{138}Cs	F	Particulate						2.05E+02			2.05E+02
^{64}Cu	M	Particulate								3.70E-07	3.70E-07
^{66}Cu	B	Unspecified								1.93E-13	1.93E-13
^{67}Cu	M	Particulate								4.35E-09	4.35E-09
^{169}Er	M	Particulate								2.41E-19	2.41E-19
^{152}Eu	M	Particulate			4.34E-07					2.57E-04	2.58E-04
^{154}Eu	M	Particulate								4.86E-05	4.86E-05
^{155}Eu	M	Particulate								5.09E-06	5.09E-06
^{156}Eu	M	Particulate								6.58E-15	6.58E-15
^{55}Fe	M	Particulate								1.91E-05	1.91E-05
^{59}Fe	M	Particulate								1.93E-06	1.93E-06
^{60}Fe	M	Particulate								1.05E-13	1.05E-13

Table 5.7 (continued)

Isotope	Inhalation form	Chemical Form	Stack								
			X-2026	X-3020	X-3039	X-7503	X-7880	X-7911	X-8915	Total minor Source	ORNL total
^{221}Fr	B	Unspecified								3.00E-04	3.00E-04
^{72}Ga	M	Particulate								4.69E-12	4.69E-12
^{151}Gd	M	Particulate								2.64E-14	2.64E-14
^{153}Gd	M	Particulate								2.19E-08	2.19E-08
^{71}Ge	M	Particulate								6.53E-09	6.53E-09
^{3}H	V	Vapor	1.94E-02		4.77E+00	6.77E-01		1.21E+02	9.60E+02	3.98E-01	1.09E+03
^{175}Hf	M	Particulate								1.45E-08	1.45E-08
^{178m}Hf	M	Particulate								4.01E-11	4.01E-11
^{181}Hf	M	Particulate								3.23E-07	3.23E-07
^{203}Hg	M	Inorganic								3.66E-11	3.66E-11
^{166m}Ho	M	Particulate								1.90E-12	1.90E-12
^{124}I	F	Particulate								2.73E-07	2.73E-07
^{124}I	V	Vapor								5.08E-16	5.08E-16
^{125}I	V	Vapor								7.96E-10	7.96E-10
^{126}I	F	Particulate								2.48E-07	2.48E-07
^{126}I	V	Vapor								5.82E-10	5.82E-10
^{129}I	F	Particulate								1.86E-05	1.86E-05
^{129}I	V	Vapor					1.94E-06			1.27E-12	1.94E-06
^{131}I	F	Particulate			1.31E-05			3.24E-02		2.72E-06	3.24E-02
^{131}I	V	Vapor					8.41E-06			4.48E-07	8.86E-06
^{132}I	F	Particulate						4.09E-01			4.09E-01
^{133}I	F	Particulate			9.39E-06			1.82E-01		1.53E-08	1.82E-01
^{134}I	F	Particulate						8.25E-01			8.25E-01
^{135}I	F	Particulate						6.18E-01			6.18E-01
^{113m}In	M	Particulate								7.11E-10	7.11E-10
^{114}In	B	Unspecified								8.67E-12	8.67E-12
^{114m}In	M	Particulate								1.37E-10	1.37E-10

Table 5.7 (continued)

Isotope	Inhalation form	Chemical Form	Stack X-2026	X-3020	X-3039	X-7503	X-7880	X-7911	X-8915	Total minor Source	ORNL total
^{192}Ir	M	Particulate								1.82E-13	1.82E-13
^{40}K	M	Particulate								7.99E-05	7.99E-05
^{42}K	M	Particulate								2.04E-14	2.04E-14
^{81}Kr	B	Unspecified								5.82E-12	5.82E-12
^{85}Kr	B	Unspecified						6.63E+02		2.74E-01	6.63E+02
^{85m}Kr	B	Unspecified						5.06E+00			5.06E+00
^{87}Kr	B	Unspecified						3.21E+01			3.21E+01
^{88}Kr	B	Unspecified						4.45E+01	4.10E+01		8.55E+01
^{89}Kr	B	Unspecified						2.91E+01			2.91E+01
^{140}La	M	Particulate						3.61E-04		1.22E-06	3.62E-04
^{177}Lu	M	Particulate								9.28E-11	9.28E-11
^{177m}Lu	M	Particulate								2.20E-12	2.20E-12
^{54}Mn	M	Particulate								4.23E-07	4.23E-07
^{56}Mn	M	Particulate								2.04E-21	2.04E-21
^{93}Mo	M	Particulate								2.96E-12	2.96E-12
^{99}Mo	M	Particulate								3.97E-06	3.97E-06
^{13}N	B	Unspecified							8.80E+02		8.80E+02
^{22}Na	M	Particulate								4.27E-11	4.27E-11
^{24}Na	M	Particulate								9.52E-08	9.52E-08
^{91m}Nb	B	Unspecified								1.62E-11	1.62E-11
^{92m}Nb	B	Unspecified								1.83E-17	1.83E-17
^{93m}Nb	M	Particulate								1.63E-13	1.63E-13
^{94}Nb	M	Particulate								1.37E-12	1.37E-12
^{95}Nb	M	Particulate								4.20E-07	4.20E-07
^{95m}Nb	M	Particulate								1.76E-13	1.76E-13
^{96}Nb	M	Particulate								4.59E-09	4.59E-09
^{97}Nb	M	Particulate								2.15E-09	2.15E-09

Table 5.7 (continued)

Isotope	Inhalation form	Chemical Form	Stack								
			X-2026	X-3020	X-3039	X-7503	X-7880	X-7911	X-8915	Total minor Source	ORNL total
^{147}Nd	M	Particulate								6.37E-07	6.37E-07
^{59}Ni	M	Particulate								4.94E-09	4.94E-09
^{63}Ni	M	Particulate								6.58E-03	6.58E-03
^{65}Ni	M	Particulate								2.81E-24	2.81E-24
^{66}Ni	M	Particulate								1.92E-13	1.92E-13
^{237}Np	M	Particulate								8.94E-08	8.94E-08
^{239}Np	M	Particulate								1.90E-09	1.90E-09
^{191}Os	M	Particulate								7.03E-10	7.03E-10
^{32}P	M	Particulate								6.38E-09	6.38E-09
^{33}P	M	Particulate								3.85E-12	3.85E-12
^{228}Pa	M	Particulate								2.48E-09	2.48E-09
^{230}Pa	M	Particulate								6.62E-07	6.62E-07
^{232}Pa	M	Particulate								8.44E-09	8.44E-09
^{233}Pa	M	Particulate								1.53E-07	1.53E-07
^{234m}Pa	B	Unspecified								2.11E-09	2.11E-09
^{210}Pb	M	Particulate								4.06E-12	4.06E-12
^{212}Pb	M	Particulate	3.80E-01	3.86E-01				1.95E-02		1.08E-05	7.86E-01
^{212}Pb	S	Particulate			1.10E+00	1.15E-01				2.12E-02	1.24E+00
^{214}Pb	M	Particulate								6.08E-14	6.08E-14
^{147}Pm	M	Particulate								7.80E-11	7.80E-11
^{148m}Pm	M	Particulate								1.53E-07	1.53E-07
^{210}Po	B	Inorganic								5.17E-12	5.17E-12
^{143}Pr	M	Particulate								2.86E-15	2.86E-15
^{144}Pr	M	Particulate								6.32E-11	6.32E-11
^{193}Pt	M	Particulate								5.40E-10	5.40E-10
^{238}Pu	M	Particulate	2.88E-08	6.68E-08				8.02E-08		2.32E-05	2.33E-05
^{238}Pu	F	Particulate			3.18E-08	7.58E-09	9.81E-07			1.00E-08	1.03E-06

Table 5.7 (continued)

Isotope	Inhalation form	Chemical Form	Stack X-2026	X-3020	X-3039	X-7503	X-7880	X-7911	X-8915	Total minor Source	ORNL total
^{239}Pu	M	Particulate	3.95E-08	3.38E-07				3.36E-08		1.97E-07	6.08E-07
^{239}Pu	F	Particulate			2.84E-07	5.30E-09	4.48E-07			3.13E-09	7.40E-07
^{240}Pu	M	Particulate	3.95E-08					3.36E-08		8.94E-08	1.62E-07
^{240}Pu	F	Particulate			2.84E-07	5.30E-09	4.48E-07			3.13E-09	7.40E-07
^{241}Pu	M	Particulate								2.16E-06	2.16E-06
^{242}Pu	M	Particulate								3.96E-09	3.96E-09
^{223}Ra	M	Particulate								3.17E-06	3.17E-06
^{224}Ra	M	Particulate								9.54E-07	9.54E-07
^{225}Ra	M	Particulate								2.34E-12	2.34E-12
^{226}Ra	M	Particulate								1.20E-07	1.20E-07
^{228}Ra	M	Particulate								2.34E-05	2.34E-05
^{88}Rb	M	Particulate								2.56E-15	2.56E-15
^{186}Re	M	Particulate								3.58E-10	3.58E-10
^{188}Re	M	Particulate								6.21E+01	6.21E+01
^{189}Re	M	Particulate								3.04E-11	3.04E-11
^{105}Rh	M	Particulate								2.17E-06	2.17E-06
^{106}Rh	B	Unspecified								1.09E-11	1.09E-11
^{219}Rn	B	Unspecified								3.80E-11	3.80E-11
^{220}Rn	B	Unspecified								1.70E-07	1.70E-07
^{103}Ru	M	Particulate						4.78E-08		3.12E-06	3.17E-06
^{106}Ru	M	Particulate								1.20E-06	1.20E-06
^{35}S	M	Particulate								1.21E-07	1.21E-07
^{120m}Sb	M	Particulate								1.50E-07	1.50E-07
^{122}Sb	M	Particulate								5.59E-07	5.59E-07
^{124}Sb	M	Particulate								4.94E-07	4.94E-07
^{125}Sb	M	Particulate								1.26E-07	1.26E-07
^{126}Sb	M	Particulate								1.19E-06	1.19E-06

Table 5.7 (continued)

Isotope	Inhalation form	Chemical Form	Stack								
			X-2026	X-3020	X-3039	X-7503	X-7880	X-7911	X-8915	Total minor Source	ORNL total
^{127}Sb	M	Particulate								4.14E-07	4.14E-07
^{44}Sc	M	Particulate								3.75E-22	3.75E-22
^{46}Sc	M	Particulate								3.46E-08	3.46E-08
^{47}Sc	M	Particulate								5.01E-08	5.01E-08
^{48}Sc	M	Particulate								2.93E-08	2.93E-08
^{75}Se	S	Particulate			3.75E-03					5.83E-09	3.75E-03
^{75}Se	F	Particulate								1.39E-11	1.39E-11
^{31}Si	M	Particulate								1.51E-23	1.51E-23
^{32}Si	M	Particulate								1.17E-13	1.17E-13
^{145}Sm	M	Particulate								2.91E-10	2.91E-10
^{151}Sm	M	Particulate								2.54E-12	2.54E-12
^{113}Sn	M	Particulate								1.60E-09	1.60E-09
^{117m}Sn	M	Particulate								1.44E-07	1.44E-07
^{119m}Sn	M	Particulate								4.58E-10	4.58E-10
^{121}Sn	M	Particulate								3.42E-10	3.42E-10
^{121m}Sn	M	Particulate								7.24E-12	7.24E-12
^{123}Sn	M	Particulate								5.94E-12	5.94E-12
^{125}Sn	M	Particulate								1.08E-06	1.08E-06
^{85}Sr	M	Particulate								5.17E-11	5.17E-11
^{89}Sr	M	Particulate	1.72E-07	1.01E-06				5.90E-06		3.14E-04	3.21E-04
^{89}Sr	S	Particulate			1.06E-05	3.43E-08				1.77E-05	2.83E-05
^{90}Sr	M	Particulate	1.72E-07	1.01E-06				5.90E-06		4.16E-04	4.23E-04
^{90}Sr	S	Particulate			1.06E-05	3.43E-08	5.97E-06			1.77E-05	3.43E-05
^{182}Ta	M	Particulate								2.49E-08	2.49E-08
^{183}Ta	M	Particulate								2.96E-06	2.96E-06
^{184}Ta	M	Particulate								4.08E-14	4.08E-14
^{160}Tb	M	Particulate								1.06E-10	1.06E-10

Table 5.7 (continued)

Isotope	Inhalation form	Chemical Form	Stack								
			X-2026	X-3020	X-3039	X-7503	X-7880	X-7911	X-8915	Total minor Source	ORNL total
^{161}Tb	M	Particulate								9.36E-22	9.36E-22
^{96}Tc	M	Particulate								1.84E-08	1.84E-08
^{99}Tc	M	Particulate								3.47E-06	3.47E-06
^{99}Tc	S	Particulate					6.88E-06				6.88E-06
^{121}Te	M	Particulate						1.17E-07		7.84E-08	1.95E-07
^{121m}Te	M	Particulate								7.64E-09	7.64E-09
^{123m}Te	M	Particulate								4.90E-09	4.90E-09
^{125m}Te	M	Particulate								2.12E-08	2.12E-08
^{127}Te	M	Particulate								3.60E-13	3.60E-13
^{127m}Te	M	Particulate								3.68E-13	3.68E-13
^{131m}Te	M	Particulate								2.74E-07	2.74E-07
^{132}Te	M	Particulate								1.24E-06	1.24E-06
^{227}Th	S	Particulate								4.03E-06	4.03E-06
^{228}Th	S	Particulate	8.72E-09	7.85E-09	1.34E-08	2.37E-09		7.97E-09		4.16E-07	4.56E-07
^{229}Th	S	Particulate								7.61E-09	7.61E-09
^{230}Th	S	Particulate	1.43E-09	4.80E-09				7.37E-09		7.06E-08	8.42E-08
^{230}Th	F	Particulate			1.39E-08	1.25E-09				2.94E-09	1.81E-08
^{232}Th	S	Particulate	1.72E-09	2.90E-09				4.52E-09		8.48E-06	8.49E-06
^{232}Th	F	Particulate			8.31E-09	9.52E-10				1.74E-09	1.10E-08
^{45}Ti	M	Particulate								2.06E-24	2.06E-24
^{202}Tl	M	Particulate								3.98E-12	3.98E-12
^{204}Tl	M	Particulate								3.46E-13	3.46E-13
^{208}Tl	B	Unspecified								3.17E-06	3.17E-06
^{170}Tm	M	Particulate								1.25E-09	1.25E-09
^{171}Tm	M	Particulate								5.66E-10	5.66E-10
^{232}U	M	Particulate								1.70E-07	1.70E-07
^{233}U	M	Particulate	5.40E-08					2.29E-08		1.78E-04	1.78E-04

Table 5.7 (continued)

Isotope	Inhalation form	Chemical Form	Stack								
			X-2026	X-3020	X-3039	X-7503	X-7880	X-7911	X-8915	Total minor Source	ORNL total
^{233}U	S	Particulate			1.07E-07	1.52E-08	1.53E-06			2.16E-06	3.81E-06
^{234}U	M	Particulate	5.40E-08	1.57E-07				2.29E-08		2.43E-02	2.43E-02
^{234}U	S	Particulate			1.07E-07	1.52E-08	1.53E-06			2.16E-06	3.81E-06
^{235}U	M	Particulate	1.54E-08	1.40E-08				1.54E-08		1.20E-03	1.20E-03
^{235}U	S	Particulate			6.08E-08	6.59E-09	1.36E-06			1.29E-07	1.56E-06
^{236}U	S	Particulate								2.37E-07	2.37E-07
^{236}U	M	Particulate								8.17E-05	8.17E-05
^{238}U	M	Particulate	7.11E-09	1.45E-08				1.35E-08		4.89E-03	4.89E-03
^{238}U	S	Particulate			5.69E-08	4.78E-09	1.83E-06			1.66E-07	2.06E-06
^{49}V	M	Particulate								2.08E-09	2.08E-09
^{181}W	M	Particulate								1.27E-11	1.27E-11
^{185}W	M	Particulate								6.06E-09	6.06E-09
^{187}W	M	Particulate								5.29E-03	5.29E-03
^{188}W	M	Particulate								6.18E-04	6.18E-04
^{127}Xe	B	Unspecified							8.11E+02	6.18E-11	8.11E+02
^{129m}Xe	B	Unspecified								1.31E-10	1.31E-10
^{131m}Xe	B	Unspecified						1.46E+02		8.52E-08	1.46E+02
^{133}Xe	B	Unspecified						5.13E+00		8.02E-09	5.13E+00
^{133m}Xe	B	Unspecified						2.13E+01		4.88E-16	2.13E+01
^{135}Xe	B	Unspecified						1.53E+01			1.53E+01
^{135m} Xe	B	Unspecified						6.73E+00			6.73E+00
^{137}Xe	B	Unspecified						3.16E+01			3.16E+01
^{138}Xe	B	Unspecified						4.31E+01			4.31E+01
^{87}Y	M	Particulate								1.18E-08	1.18E-08
^{88}Y	M	Particulate								6.23E-11	6.23E-11
^{88}Y	F	Particulate					1.35E-06				1.35E-06
^{90}Y	M	Particulate								1.36E-10	1.36E-10

Table 5.7 (continued)

Isotope	Inhalation form	Chemical Form	Stack								
			X-2026	X-3020	X-3039	X-7503	X-7880	X-7911	X-8915	Total minor Source	ORNL total
^{91}Y	M	Particulate								4.00E-11	4.00E-11
^{65}Zn	M	Particulate								1.96E-05	1.96E-05
^{69}Zn	M	Particulate								2.76E-09	2.76E-09
^{69m}Zn	M	Particulate								1.84E-09	1.84E-09
^{95}Zr	M	Particulate								1.00E-06	1.00E-06
^{97}Zr	M	Particulate								1.14E-07	1.14E-07
Totals			**3.99E-01**	**3.86E-01**	**5.87E+00**	**7.92E-01**	**3.96E-05**	**1.82E+03**	**4.28E+04**	**6.29E+01**	**4.47E+04**

[a] Emissions given in curies (Ci). 1 Ci = 3.7E+10 Bq

[b] The designations of F, M, and S refer to the lung clearance type—fast (F), moderate (M), and slow (S) for the given radionuclide. G stands for gaseous, V stands for vapor, and B stands for blank, unspecified form.

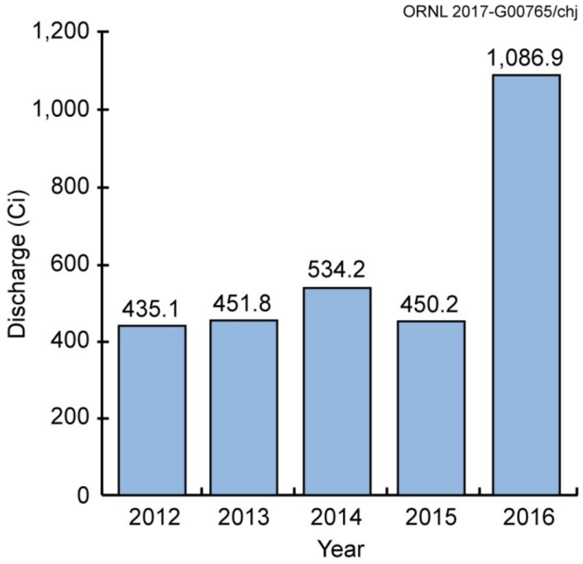


Fig. 5.13. Total curies of tritium discharged from Oak Ridge National Laboratory to the atmosphere, 2012–2016.

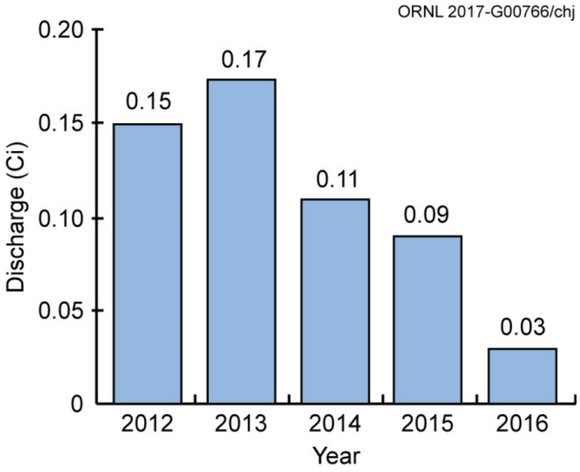


Fig. 5.14. Total curies of ^{131}I discharged from Oak Ridge National Laboratory to the atmosphere, 2012–2016.

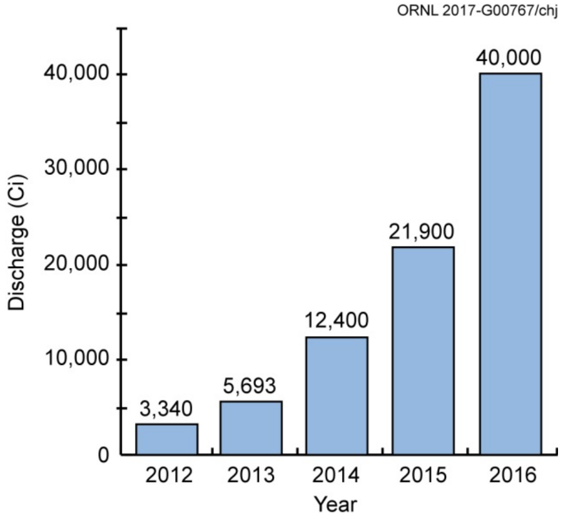


Fig. 5.15. Total curies of ^{11}C discharged from Oak Ridge National Laboratory to the atmosphere, 2012–2016.

5.4.4 Stratospheric Ozone Protection

As required by the CAA Title VI Amendments of 1990, actions have been implemented to comply with the prohibition against intentionally releasing ozone-depleting substances (ODSs) during maintenance activities performed on refrigeration equipment. In addition, service requirements for refrigeration systems (including motor vehicle air conditioners), technician certification requirements, and labeling requirements have been implemented. ORNL has implemented a plan to phase out the use of all Class I

ODSs. (Class I includes the fully halogenated chlorofluorocarbons, halons, and the ODSs that are the most threatening to the ozone layer.) All critical applications of Class I ODSs have been eliminated, replaced, or retrofitted with other materials. Work is progressing as funding becomes available for noncritical applications.

5.4.5 Ambient Air

During 2016 two of the three ORNL perimeter air monitoring stations were upgraded and incorporated into the ORR perimeter monitoring network, leaving Station 7 in the ORNL 7000 maintenance area as the only site-specific ambient air monitoring location. (Monitoring results from Stations 2 and 3, which have previously been included as part of ORNL site-monitoring activities, are now discussed in Chapter 6.) 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) were compared with derived concentration standards (DCSs) for air established by DOE as guidelines for controlling exposure to members of the public. During 2016 average radionuclide concentrations at Station 7 were less than 1% of the applicable DCS in all cases.

Table 5.8. Radionuclide concentrations (pCi/mL)[a] measured at Oak Ridge National Laboratory air monitoring Station 7, 2016

Parameter	Concentration
Alpha	7.33E-09
Be-7	2.29E-08
Beta	1.57E-08
K-40	−1.8E-09[b]
U-234	5.93E-12
U-235	1.04E-12
U-238	4.23E-12
U-TOT	1.12E-11

[a] 1 pCi = 3.7 × 10^{-2} Bq.

[b] At very low sample activity levels, close to the instrument background, it is possible to obtain a sample result that is less than the background. When the background activity is subtracted from the sample activity to obtain a net value, a negative value results.

5.4.5.1 Results

Station 7 sampling data (Table 5.8) are compared with DCSs for air established by DOE as guidelines for controlling exposure to members of the public. During 2016 average radionuclide concentrations at Station 7 were less than1% of the applicable DCS in all cases.

5.5 Oak Ridge National Laboratory Water Quality Program

NPDES permit TN 0002941, issued to DOE for the ORNL site, was renewed by the State of Tennessee in 2014 and includes requirements for discharging wastewaters from the two ORNL on-site wastewater treatment facilities and for the development and implementation of a water quality protection plan

(WQPP). The permit calls for a WQPP to "establish better linkages between water quality monitoring and detecting and abating water quality and ecological impact." Rather than prescribing rigid monitoring schedules, the ORNL WQPP is flexible, allows an annual assessment of all outfalls, and focuses on significant findings. The WQPP goals 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 UT-Battelle and was approved by TDEC in 2008, and the WQPP monitoring was initiated in 2009. The WQPP incorporated several control plans that were required under the previous NPDES permit, including a biological monitoring and abatement plan (BMAP), a chlorine control strategy, a storm water pollution prevention plan, a non-storm water best management practices plan, and an NPDES radiological monitoring plan. The WQPP has been reviewed and revised annually and submitted to TDEC for review and comment.

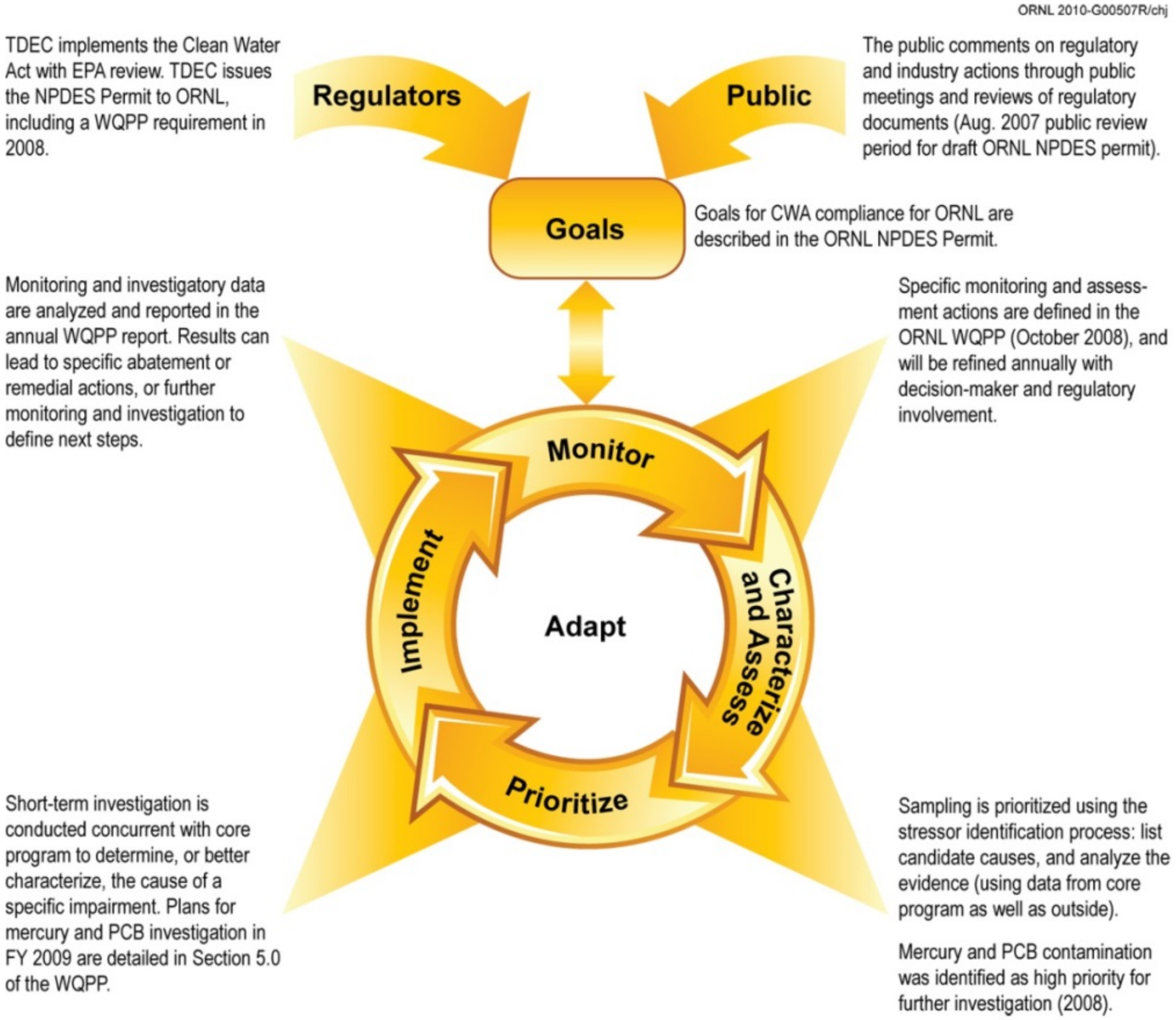
To prioritize the stressors and/or contaminant sources that may be of greatest concern to water quality and to define conceptual models that would guide any special investigations, the WQPP strategy was defined using EPA's *Stressor Identification Guidance Document* (EPA 2000). Figure 5.16 summarizes 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), and
3. characterize the causes.

The first two steps of the stressor identification process were initiated in 2009, focusing first on mercury impairment (Fig. 5.17) and then on PCBs because mercury and PCB concentrations in fish from White Oak Creek (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. 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.

At the end of each year, monitoring and investigation data collected under the ORNL WQPP are analyzed, interpreted, reported, and compared with past results in the WQPP annual report. 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.



TDEC implements the Clean Water Act with EPA review. TDEC issues the NPDES Permit to ORNL, including a WQPP requirement in 2008.

The public comments on regulatory and industry actions through public meetings and reviews of regulatory documents (Aug. 2007 public review period for draft ORNL NPDES permit).

Goals for CWA compliance for ORNL are described in the ORNL NPDES Permit.

Monitoring and investigatory data are analyzed and reported in the annual WQPP report. Results can lead to specific abatement or remedial actions, or further monitoring and investigation to define next steps.

Specific monitoring and assessment actions are defined in the ORNL WQPP (October 2008), and will be refined annually with decision-maker and regulatory involvement.

Short-term investigation is conducted concurrent with core program to determine, or better characterize, the cause of a specific impairment. Plans for mercury and PCB investigation in FY 2009 are detailed in Section 5.0 of the WQPP.

Sampling is prioritized using the stressor identification process: list candidate causes, and analyze the evidence (using data from core program as well as outside).

Mercury and PCB contamination was identified as high priority for further investigation (2008).

Fig. 5.16. Diagram of the adaptive management framework with step-wise planning specific to the Oak Ridge National Laboratory Water Quality Protection Plan (WQPP). *[Adapted from the US Environmental Protection Agency (EPA) stressor guidance document (EPA 2000). CWA = Clean Water Act, NPDES = National Pollutant Discharge Elimination System, ORNL = Oak Ridge National Laboratory, PCB = polychlorinated biphenyl, TDEC = Tennessee Department of Environment and Conservation.]*

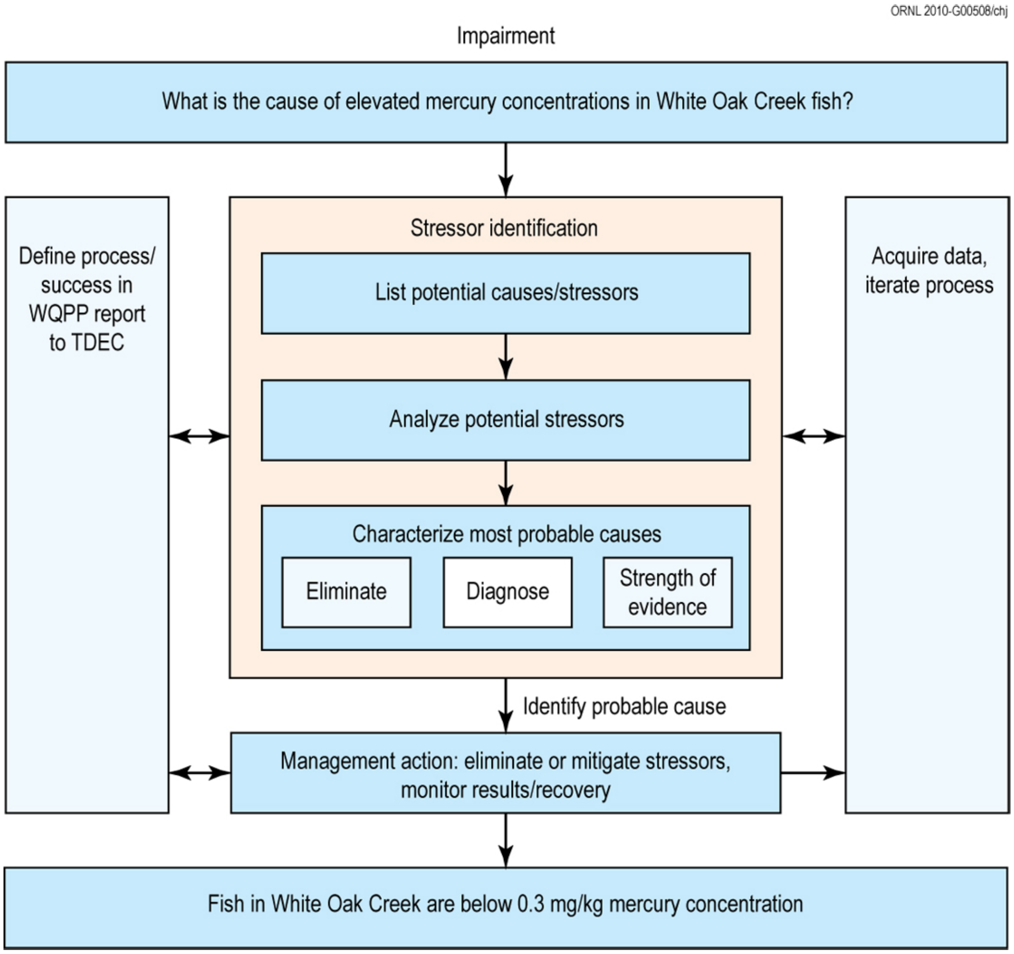


Fig. 5.17. Application of stressor identification guidance to address mercury impairment in the White Oak Creek watershed. *[Modified from Fig. 1-1 in the US Environmental Protection Agency stressor guidance document (EPA 2000). TDEC = Tennessee Department of Environment and Conservation, WQPP = water quality protection plan.]*

5.5.1 Treatment Facility Discharges

Two on-site wastewater treatment systems were operated at ORNL in 2016 to provide appropriate treatment of the various R&D, operational, and domestic wastewaters generated by site staff and activities. Both were permitted to discharge treated wastewater and were monitored under NPDES Permit TN0002941, issued by TDEC to DOE for the ORNL site. These are the ORNL STP (outfall X01) and the ORNL PWTC (outfall X12). 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. The ORNL NPDES permit was last renewed by TDEC in March 2014. 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 Table 5.9. ORNL wastewater treatment facilities achieved 99% compliance with permit limits and conditions in 2016. On infrequent occasions, the plant has gone into partial-treatment mode (disinfection) when the influent-handling capacity was exceeded due to heavy rain storms. A project to upgrade the ORNL STP is in design, including increased influent-handling capacity. The project is planned to be completed in 2017.

Table 5.9. National Pollutant Discharge Elimination System compliance at Oak Ridge National Laboratory, January through December 2016

	Permit limits					Permit compliance		
Effluent parameters	**Monthly average (lb/day)**	**Daily max. (lb/day)**	**Monthly average (mg/L)**	**Daily max. (mg/L)**	**Daily min. (mg/L)**	**Number of noncompliances**	**Number of samples**	**Percentage of compliance**[a]
				X01 (ORNL Sewage Treatment Plant)				
LC_{50} for *Ceriodaphnia* (%)					100	0	4	100
LC_{50} for fathead minnows (%)					100	0	4	100
Ammonia, as N (summer)	6.26	9.39	2.5	3.75		0	26	100
Ammonia, as N (winter)	13.14	19.78	5.25	7.9		0	26	100
Carbonaceous biological oxygen demand	19.2	28.8	10	15		0	52	100
Dissolved oxygen					6	0	52	100
Escherichia coliform (col/100 mL)			941	126		0	52	100
Oil and grease				15		0	1	100
pH (standard units)				9	6	0	52	100
Total suspended solids	57.5	86.3	30	45		1	51[b]	98
				X12 (Process Waste Treatment Complex)				
LC_{50} for *Ceriodaphnia* (%)					100	0	4	100
LC_{50} for fathead minnows (%)					100	0	4	100
Arsenic, total				0.014		0	4	100
Chromium, total				0.44		0	4	100
Copper, total				0.11		0	4	100
Cyanide, total				0.046		0	2	100
Lead, total				0.69		0	4	100
Oil and grease				15		0	12	100
pH (standard units)				9.0	6.0	0	52	100
Temperature (°C)				30.5		0	52	100
				Instream chlorine monitoring points				
Total residual oxidant			0.011	0.019		0	288	100

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

[b] The suspended solids sample taken February 16, 2016, was mistakenly disposed of by the lab before the analysis was performed. By the time of disposal, the weekly period in which a replacement sample could be collected had passed.

Abbreviated terms

LC_{50} = lethal concentration; the concentration (as a percentage of full-strength wastewater) that kills 50% of the test species in 48 h.

ORNL = Oak Ridge National Laboratory

Toxicity testing provides an assessment of any harmful effects that could occur from the total combined constituents in discharges from ORNL wastewater treatment facilities. Effluents from the STP have been required to be tested for toxicity to aquatic species under the NPDES permit every year since 1986, and effluents from PWTC have been tested since it went into operation in 1990. Test species have been *Ceriodaphnia dubia* (*C. 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. Test results have been excellent. PWTC effluent has always been shown to be nontoxic. The STP has shown isolated indications of effluent toxicity, none recent, 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 acute toxicity of four effluent samples each from the ORNL STP and PWTC collected at 6 h intervals over a 24 h period, using both test species. In 2016, toxicity test results for the ORNL wastewater treatment facilities were once again favorable, with no indication of toxicity in any of the tests that were conducted (Table 5.9).

5.5.2 Residual Bromine and Chlorine Monitoring

Chlorine is added to drinking water as a disinfectant prior to consumption. Chlorine and bromine are added to cooling system water to prevent bacterial growth in the system. When waters are discharged to streams, residual chlorine and bromine can be toxic to fish and other aquatic life. The ORNL NPDES permit controls the discharge of chlorinated and brominated waters, reported as “total residual oxidant” (TRO), by limiting the TRO mass loading from outfalls. TRO is monitored to ensure effective dechlorination of cooling tower blowdown systems, once-through cooling water systems, and any infrastructure leaks from water lines. When the permit action level of 1.2 g/day TRO is exceeded at an outfall, the staff investigate and implement treatment and reduction measures. NPDES permit outfalls that contain TRO are monitored and are dechlorinated until chlorine sources are removed or until the data show that the source is gone. The most frequent monitoring, which is performed to check the effectiveness of the dechlorination systems, takes place twice a month at outfalls where dechlorination of cooling tower blowdown or large cooling water discharges occur. TRO is also monitored at instream points twice per month to verify that releases are not creating adverse conditions for fish and other aquatic life.

In 2016, TRO measurements were required at 27 outfalls on a semiannual, quarterly, monthly, or semimonthly basis if flow was present. A total of 245 TRO measurements were made at the 27 outfalls during 2016. Table 5.10 summarizes those that exceeded the TRO permit action level. The action level was exceeded twice in 2015 at Outfall 267 because a carbon filter had been valved off, but 2016 semimonthly monitoring showed no recurring problems.

During 2016 TRO from outfall 231 exceeded the permit action level of 1.2 g/day in one monitoring event. The outfall receives cooling tower blowdown from Building 5800 that is dechlorinated inside the building using a sodium sulfite tablet feeder; the cause of this exceedance is not known.

Outfall 082 receives discharge from an old hose-fed once-through air-conditioning unit in Building 7509, which is dechlorinated using a tablet feeder. Operational problems such as old and stuck tablets accounted for its ineffectiveness. Outfall 082 was removed from the NPDES permit when the permit was reissued in 2008 because the area is associated with CERCLA activities. However, it continues to be monitored because there is a preexisting source of TRO.

Table 5.10. Outfalls exceeding total residual oxidant NPDES permit action level in 2016

Sample date	Outfall	TRO[a] concentration (mg/L)	Flow (gpm)	Load (g/day)	Receiving stream	Downstream integration point	Instream TRO point
9/23/2016	231	1.68	30	274.7	White Oak Creek	WCK 4.4	X25
5/16/2016	082[b]	0.7	1.5	5.7	Melton Branch	MEK 0.6	X27
7/11/2016	082[b]	0.82	12	53.6	Melton Branch	MEK 0.6	X27
8/15/2016	082[b]	1.1	5	30	Melton Branch	MEK 0.6	X27

[a] The NPDES action level is 1.2 g/day.

[b] Outfall 082 was removed from ORNL's NPDES Permit when it was reissued in 2008 and was not included in the 2014 NPDES Permit or the 2015 modification because all effluents discharged were associated with CERCLA activities.

Acronyms

CERCLA= Comprehensive Environmental Response Compensation & Liability Act
MEK = Melton Valley Creek kilometer
NPDES = National Pollutant Discharge Elimination System
ORNL = Oak Ridge National Laboratory
TRO = total residual oxidant
WCK = White Oak Creek kilometer

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 2016 at 2 treatment facility outfalls, 3 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 from building and facility sumps, building footer drains, and direct infiltration. In 2016, dry-weather grab samples were collected at 16 of the 20 category outfalls targeted for sampling. Four category outfalls (205, 241, 265, and 368) were not sampled because there was no discharge present during sampling attempts.

The two ORNL treatment facility outfalls that were monitored for radioactivity in 2016 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) (Fig. 5.18). At each treatment facility and instream monitoring location, monthly flow-proportional composite samples were collected using dedicated automatic water samplers.

For each radioisotope, a DCS is published in DOE directives and is used to evaluate discharges of radioactivity from DOE facilities. 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 roughly equivalent to the 4 mrem dose limit on which the EPA radionuclide drinking water standards are based and is a convenient 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% of the relevant DCS concentration in dry-weather discharges from NPDES outfalls 085, 204, 207, 302, 304, X01, and X12 and at instream sampling locations on WOC (X14) and at WOD (X15) (Fig. 5.19).

Table 5.11. Radiological monitoring conducted under the Oak Ridge National Laboratory Water Quality Protection Plan, 2016

Location	Frequency	Gross alpha/beta	Gamma scan	^{3}H	^{14}C	$^{89/90}$Sr	Isotopic uranium	Isotopic plutonium	^{241}Am	$^{243/244}$Cm
Outfall 001	Annual	X								
Outfall 080	Monthly	X	X	X		X			X[a]	X
Outfall 081	Annual	X								
Outfall 085	Quarterly	X	X	X		X	X[a]	X[a]		
Outfall 203	Annual	X	X			X				
Outfall 204	Semiannual	X	X			X				
Outfall 205 [b]	Annual									
Outfall 207	Quarterly	X	X[a]			X[a]	X[a]			
Outfall 211	Annual	X								
Outfall 234	Annual	X								
Outfall 241 [b]	Quarterly									
Outfall 265 [b]	Annual									
Outfall 281	Quarterly	X		X						
Outfall 282	Quarterly	X								
Outfall 284	Annual	X								
Outfall 302	Monthly	X	X	X		X	X[a]	X[a]	X[a]	X[a]
Outfall 304	Monthly	X	X	X		X	X[a]	X[a]	X[a]	X[a]
Outfall 365	Semiannual	X								
Outfall 368 [b]	Annual									
Outfall 383	Annual	X		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				

[a] 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 criteria (as described in the May 2012 update to the Water Quality Protection Plan).

[b] The outfall was included in the monitoring plan, but samples were not collected because no discharge was present during sampling attempts.

Acronyms

PWTC = Process Waste Treatment Complex
STP = Sewage Treatment Plant
WOC = White Oak Creek
WOD = White Oak Dam

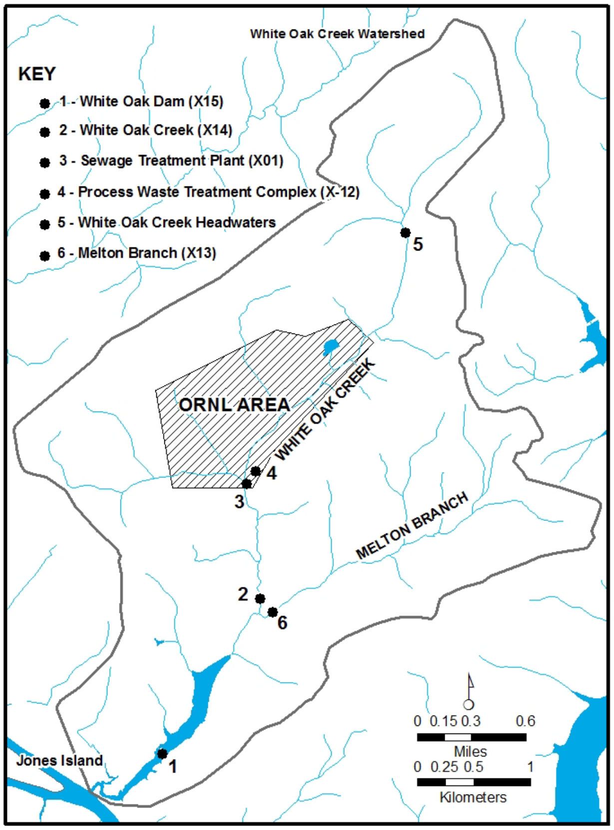


Fig. 5.18. Selected surface water, National Pollutant Discharge Elimination System, and reference sampling locations at Oak Ridge National Laboratory.

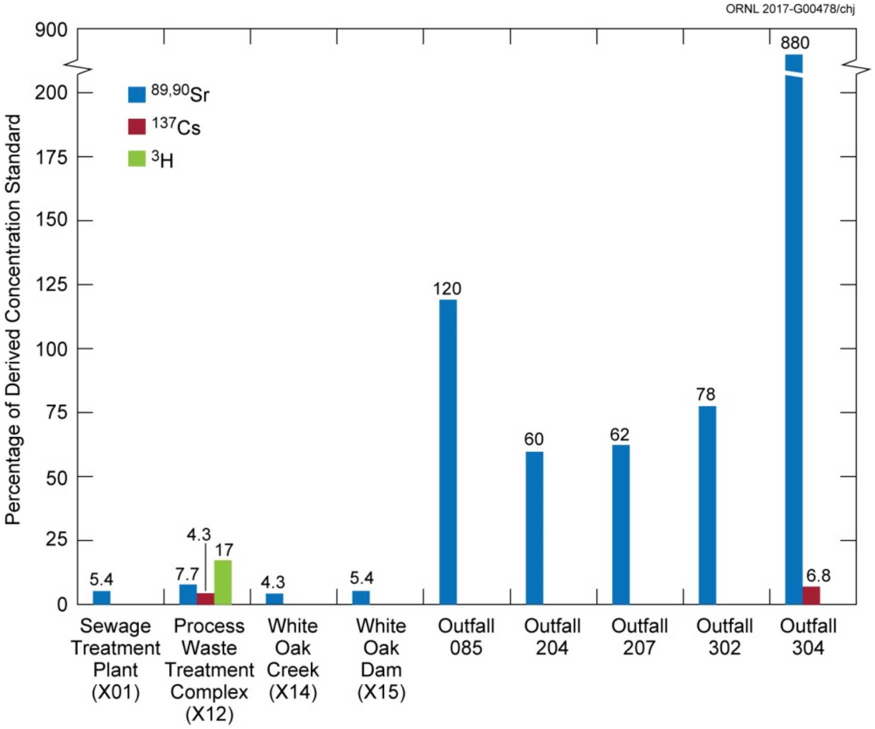


Fig. 5.19. Outfalls and instream locations at Oak Ridge National Laboratory with average radionuclide concentrations greater than 4% of the relevant derived concentration standards in 2016.

In 2016, two outfalls had an annual mean radioactivity concentration greater than 100% of a DCS. Outfalls 085 and 304 had average total radioactive strontium (^{89,90}Sr) concentrations that exceeded the DCS for ^{90}Sr (it is reasonable, for an ORNL environmental sample, to assume that ^{89,90}Sr activity is comparable to ^{90}Sr activity due to the relatively short half-life of ^{89}Sr—50.55 days). The concentrations of ^{89,90}Sr were 120% and 880% of the DCS at outfalls 085 and 304, respectively. Consequently, concentrations of radioactivity in discharges from both outfalls were also greater than DCS levels on a sum-of-fractions basis (i.e., the summation of DCS percentages of multiple radiological parameters); the sums of the fractions were 124% and 896%, respectively.

Concentrations of radioactivity at outfall 085 have been elevated since early 2015, when a water leak occurred in Building 7830A. The foundation drain for that building is connected to Outfall 085. The leak resulted from a ruptured pipe in the building’s fire suppression system that occurred when the pipe froze in the early morning hours of February 23, 2015. It is believed that leaked water mobilized existing underground contamination to a location where it could enter the building foundation drain. Concentrations have been declining since April 2015, although the rate of decline slowed in the latter part of 2016 and concentrations have not yet returned to levels that existed prior to 2015.

Levels of radioactivity in discharges from Outfall 304 have been elevated since 2014 because of two unrelated infrastructure issues. In 2014, a pump failed in a groundwater suppression sump at the EM WOC-9 (WC-9) Low Level Liquid Waste Tank Farm, a CERCLA soil and groundwater contamination area. Without groundwater suppression in the tank farm area, contaminated groundwater enters the Outfall 304 storm drain system. A second infrastructure issue, which had an even greater influence on Outfall 304 radiological concentrations, occurred in 2015. A leak developed in a pipe leading from Pump Station #2 in the Process Waste Collection System to a downstream diversion box. A dye tracer test confirmed a hydraulic connection between the pipe and the storm water collection system that discharges through Outfall 304, and the pipe was subsequently bypassed and taken out of service. Before the leaky pipe was bypassed, the ^{89,90}Sr concentration at Outfall 304 peaked at 29,000 pCi/L (August and September 2015). Since the bypass was implemented, ^{89,90}Sr levels in the outfall effluent have trended downward but have remained above DCS levels in 2016. No additional infrastructure issues affecting outfall 304 have been discovered, and it is believed that concentrations of radioactivity at the outfall will slowly decline as concentrations of radioactivity in the groundwater surrounding the outfall pipe decline by means of normal hydrologic processes.

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 Figs. 5.20 through 5.24. Because discharges of radioactivity are somewhat correlated to stream flow, annual flow volumes measured at the WOD monitoring station are given in Fig. 5.25. Discharges of radioactivity at WOD in 2016 are 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 2016 also included monitoring during storm runoff conditions. Three storm water outfalls were monitored. Storm water samples were analyzed for gross alpha, gross beta, Sr-89/90, and tritium 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, but in 2016 no additional analyses were required for storm water samples.

Concentrations of radioactivity in storm water discharges were compared with DCSs if a DCS existed for that parameter (there are no DCSs 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 2016, none of the outfalls had a radionuclide concentration in storm water that was greater than 4% of a DCS level.

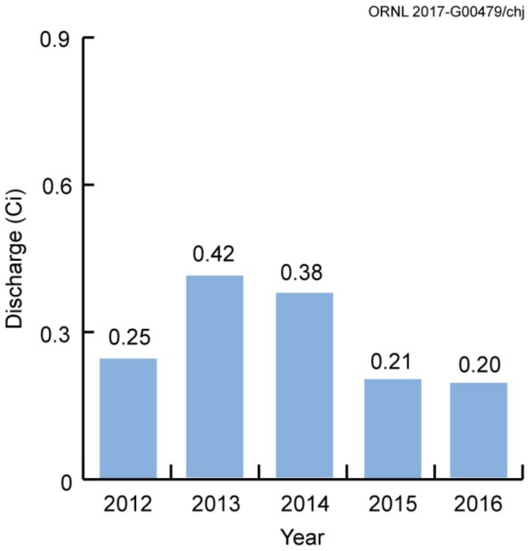


Fig. 5.20. Cesium-137 discharges at White Oak Dam, 2012–2016.

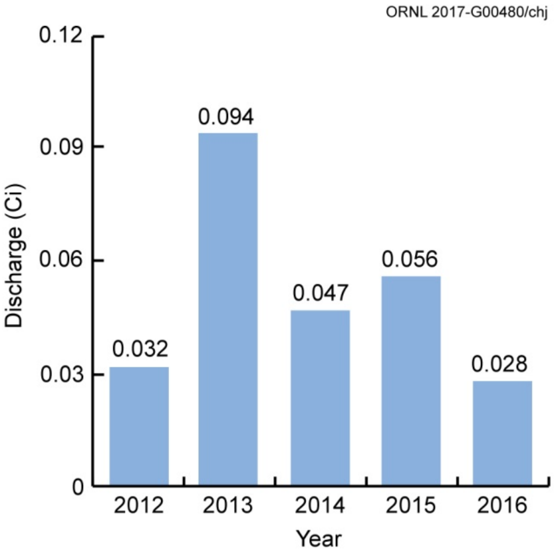


Fig. 5.21. Gross alpha discharges at White Oak Dam, 2012–2016.

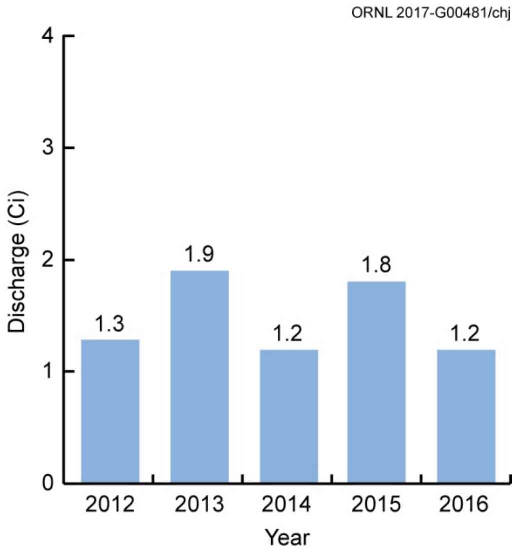


Fig. 5.22. Gross beta discharges at White Oak Dam, 2012–2016.

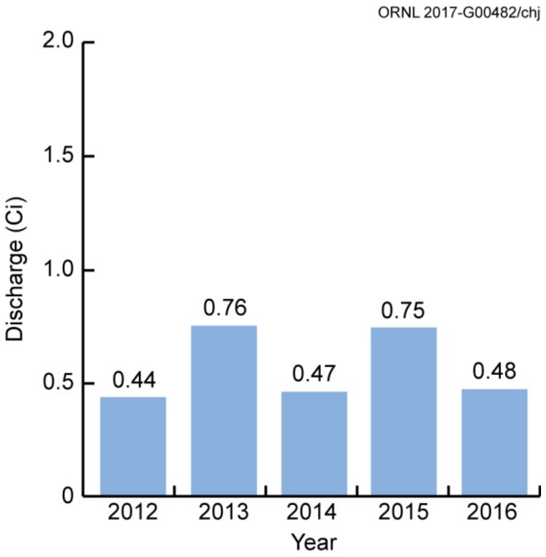


Fig. 5.23. Total radioactive strontium discharges at White Oak Dam, 2012–2016.

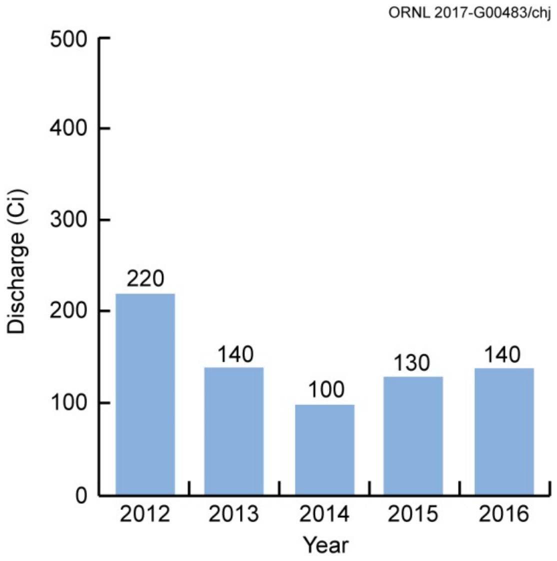


Fig. 5.24. Tritium discharges at White Oak Dam, 2012–2016.

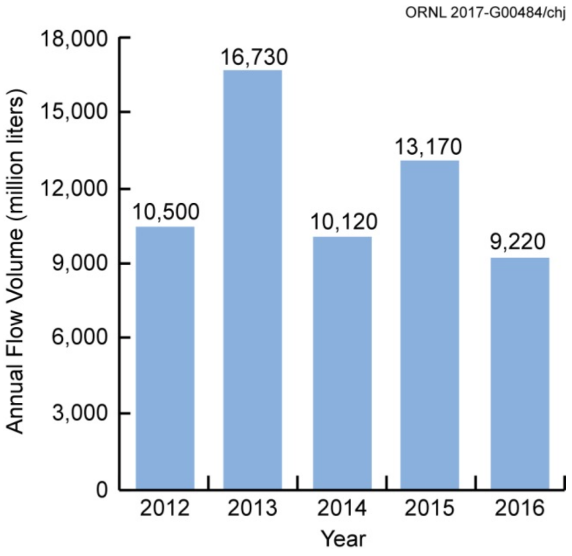


Fig. 5.25. Annual flow volume at White Oak Dam, 2012–2016.

5.5.4 Mercury in the White Oak Creek Watershed

Legacy mercury environmental contamination exists at ORNL, largely as a result of spills and releases that occurred in the 1950s during pilot-scale isotope separation work in Buildings 3503, 3592, 4501, and 4505. As a result, the mercury that is present in piping and soil can also be found in groundwater and storm water runoff in and around the four facilities. Buildings 4501 and 4505 are located adjacent to Fifth Creek, but most of the storm water from that area is routed to Outfall 211. Buildings 3592 and 3503 were removed under the CERCLA remedial process in 2011 and 2012; their footprints are in the Outfall 207 storm water drainage area.

Process wastewater drains and building sumps from Buildings 4501 and 4505 are routed via underground collection system piping to the ORNL PWTC for treatment to remove constituents, including mercury, before discharge to WOC. Between 2007 and 2011, three sumps that receive foundation groundwater from around 4501/4505 and the area between 4501 and 4500N were redirected to PWTC treatment for mercury removal, and in 2009 a mercury pretreatment system was installed on the main sump in Building 4501. The PWTC treatment units include granular activated carbon filter columns, one of which was upgraded in 2014 to a sulfur-impregnated carbon that is optimized for mercury removal. These actions have significantly diminished the release of legacy mercury (Fig. 5.26) by redirecting foundation water away from the storm drain system and by improving treatment plant removal capabilities.

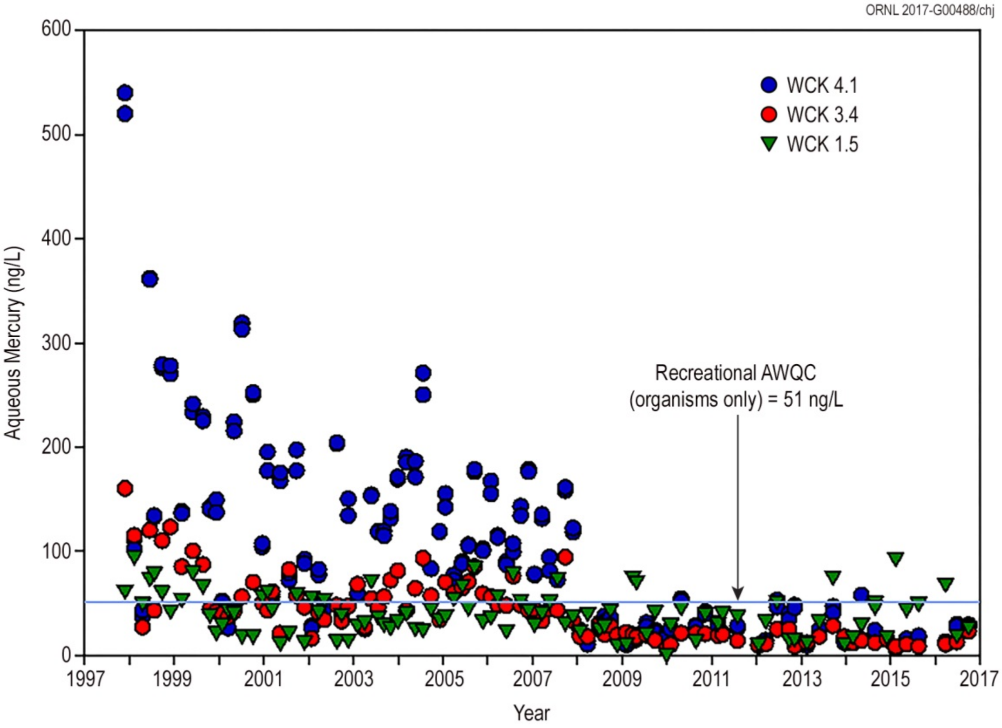


Fig. 5.26. Total aqueous mercury concentrations at sites in White Oak Creek downstream from Oak Ridge National Laboratory, 1998–2016. *(AWQC = ambient water quality criterion; WCK = White Oak Creek kilometer.)*

5.5.4.1 Ambient Mercury in Water

In continuation of a monitoring effort initiated in 1997, bimonthly water samples were collected from WOC at four sites in 2016. Stream conditions were selected to be representative of seasonal base-flow conditions (dry weather, clear flow) based on historical results that indicate higher mercury concentrations under those conditions.

The concentration of mercury in WOC (see Fig. 5.27) upstream from ORNL [White Oak Creek kilometer (WCK) 6.8] was less than 5 ng/L in 2016. Long-term trends in waterborne mercury in the WOC system downstream of ORNL are shown in Fig. 5.26. Waterborne mercury downstream of ORNL declined abruptly in 2008 and remained low through 2016 as a result of rerouting highly contaminated sump water in Building 4501 to PWTC in December 2007. The mean total mercury concentration at WCK 4.1 was

22.76 ± 6.7 ng/L in 2016 compared with 108 ± 33 ng/L in 2007. The decrease was also apparent but less pronounced at WCK 3.4, with mercury averaging 15.46 ± 6.6 ng/L in 2016 vs. 49 ± 23 ng/L in 2007. Mercury concentrations at these two sites were significantly lower than levels in 2007. A pretreatment system for the sump water, which started operation on October 22, 2009, removes almost all of the mercury before sending the water to PWTC. The system reduces the mercury concentration in the PWTC influent and effluent. The average aqueous mercury concentration at WOD (WCK 1.5) was 30.66 ± 27.7 ng/L in 2016, higher than concentrations at other sites.

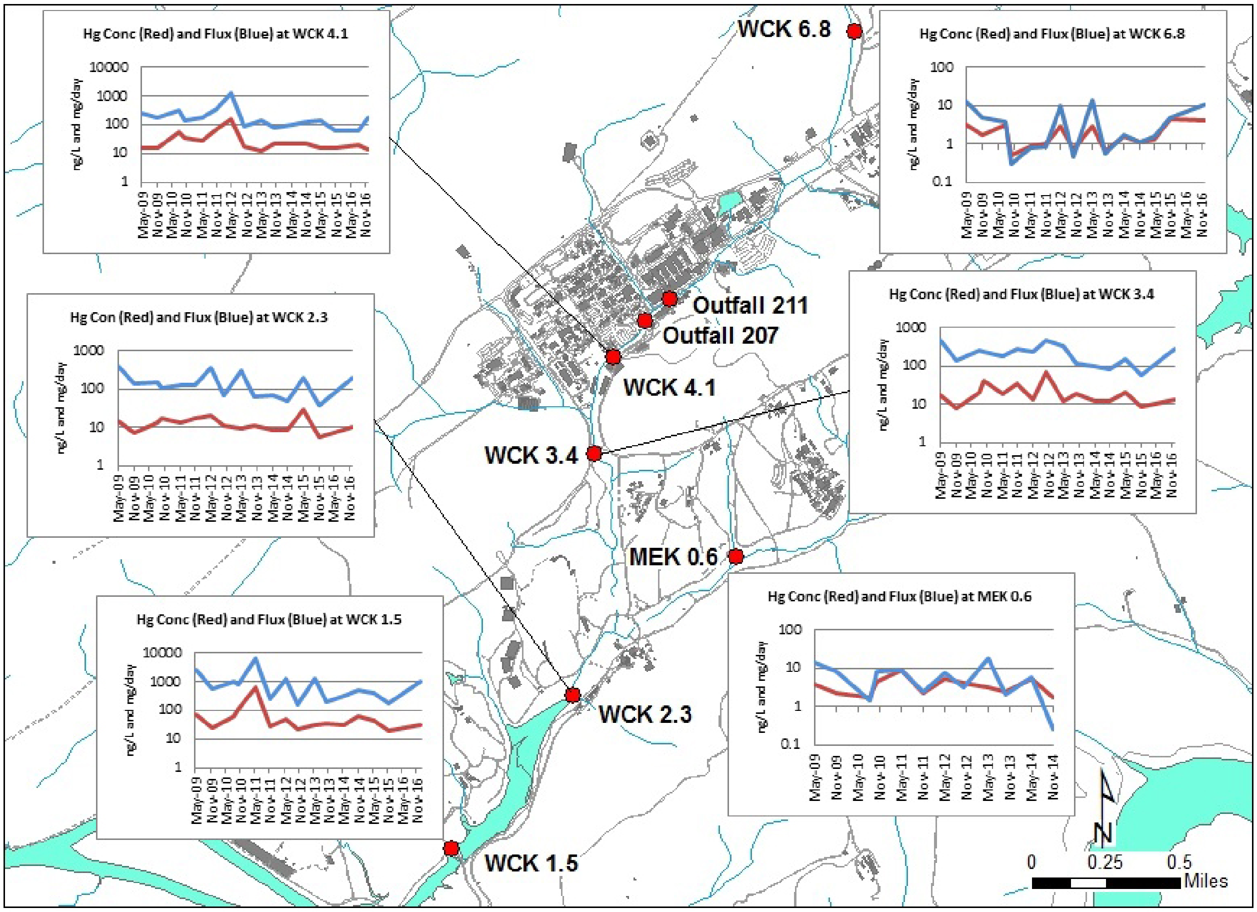


Fig. 5.27. Total mercury concentration and flux at selected Oak Ridge National Laboratory instream locations, 2009 through 2016.

Water Quality Protection Plan Mercury Investigation

The mercury-investigation component of the WQPP includes outfalls that are key mercury contributors to help delineate mercury sources and prioritize future abatement actions. In addition to the bimonthly instream samples taken in 2016, a dry-weather sample was taken at the five WOC instream points shown in Fig. 5.27; no samples were collected in May. The additional monitoring at Melton Branch kilometer (MEK) 0.6 was discontinued in 2015 due to the consistently low mercury levels found there from 2009 to 2014. Mercury concentration and flow measurements were used to calculate flux (the amount of a substance detected per unit time in flowing water). Results indicated that Tennessee mercury water-quality criteria (WQCs) were met at these instream locations. Complete mercury monitoring results are available in the Oak Ridge Environmental Information System (OREIS). Access to OREIS can be requested via email (oreis@ettp.doe.gov) or by telephone (865-574-3257).

Monitoring in 2016 included dry-weather monitoring of Outfalls 211, 207, 304, and 302; wet-weather monitoring of Outfalls 211 and 207; and a study that targeted the WOC reach below Fifth Creek starting above Outfall 207 downstream to the Third Street Bridge. Data collected in 2015 had shown mercury flux increases occurring in the lower (downstream) ends of both Fifth Creek and this section of WOC above the Third Street Bridge that were not completely explained by flux data from individual outfalls. The 2016 study was coordinated to occur while there was no discharge from the PWTC at Outfall X12. The 2016 dye-calibrated flow study implies that the instream concentration and flux varied more upstream of Outfall 207 than below; mercury concentrations at WCK 4.1 and the Third Street Bridge remaining relatively constant (below 20 ng/L).

Dry- and wet-weather sampling of Outfalls 211 and 207 during 2016 confirm these outfalls as significant sources of mercury. Dry-weather flows from Outfall 207 may contain elevated mercury (35 and 856 ng/L were measured), but the flows are very small (estimated at 0.1 gpm); the larger concentration generated a flux of only 0.467 mg/day. A storm concentration of 272 ng/L was estimated at a flow rate of 40 gpm in November 2016, yielding a flux of 59 mg/day.

In contrast, the 2016 measurements of Outfall 211 storm flows show the major importance of storm flows from that outfall. A February storm flow of 180 gpm had a concentration of 9,670 ng/L total mercury, delivering a total flux of 9,490 mg/day, and in July a 175 gpm flow had a concentration of 2,150 ng/L, delivering a flux of 2,050 mg/day to WOC. Outfall 211 remains the major contributor of mercury to WOC.

5.5.5 Storm Water Surveillances and Construction Activities

In 2016, two construction sites were inspected to evaluate the overall effectiveness of the best management practices in use. Sites are considered significant if they occupy an area of nearly 1 acre or more and/or because of the requirements of a Tennessee construction general permit. In general, while some short-term impacts to receiving streams, such as increased sedimentation in runoff, were noted, no long-term adverse impacts were observed.

Land use within drainage areas is typical of office/industrial settings with surface features that include laboratories, support facilities, paved areas, and grassy lawns. Outdoor material storage is most prevalent in the 7000 area on the east end of the main ORNL facility (where most of the craft and maintenance shops are located); other 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 include metal items (sheeting, pipes, and parts); equipment awaiting use, disposal, or repair; construction material; and deicer product.

Some construction activities are performed on third-party-funded construction projects on the 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, spill/emergency responses, and other key issues.

5.5.6 Biological Monitoring

5.5.6.1 Bioaccumulation Studies

The bioaccumulation task for BMAP addresses two NPDES permit requirements at ORNL: (1) evaluate whether mercury at the site is contributing to a stream 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 mg/g in fish fillets, a concentration considered to be 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

In WOC, mercury and PCB concentrations in fish have been at or near human health risk thresholds (e.g., EPA recommended fish-based AWQC [0.3 µg/g for mercury], TDEC fish advisory limits for PCBs). 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 (Fig. 5.28). Mean fillet concentrations increased slightly from 0.16 µg/g in 2015 to 0.21 µg/g in 2016 at WCK 3.9 and from 0.21 µg/g in 2015 to 0.24 µg/g in 2016 at WCK 2.9 (Fig. 5.28). These concentrations are below the AWQC for mercury in fish. Mercury concentrations in largemouth bass collected from WCK 1.5 (White Oak Lake) had been decreasing in recent years but remained above the guideline in 2016. Concentrations increased to 0.46 µg/g from 0.36 µg/g in 2015. Mercury concentrations in bluegill collected from WCK 1.5 showed the same increase as largemouth bass but remained below the recommended guideline. Mean PCB concentrations in redbreast sunfish at WCK 3.9 and WCK 2.9 (0.22 and 0.20 µg/g, respectively) were comparable to values recorded in recent years and are continuing their decreasing trend. Mean PCB concentrations in largemouth bass from WCK 1.5 have been increasing since 2012, with concentrations remaining above the TDEC fish advisory limit of 1 µg/g in 2016 (Fig. 5.29).

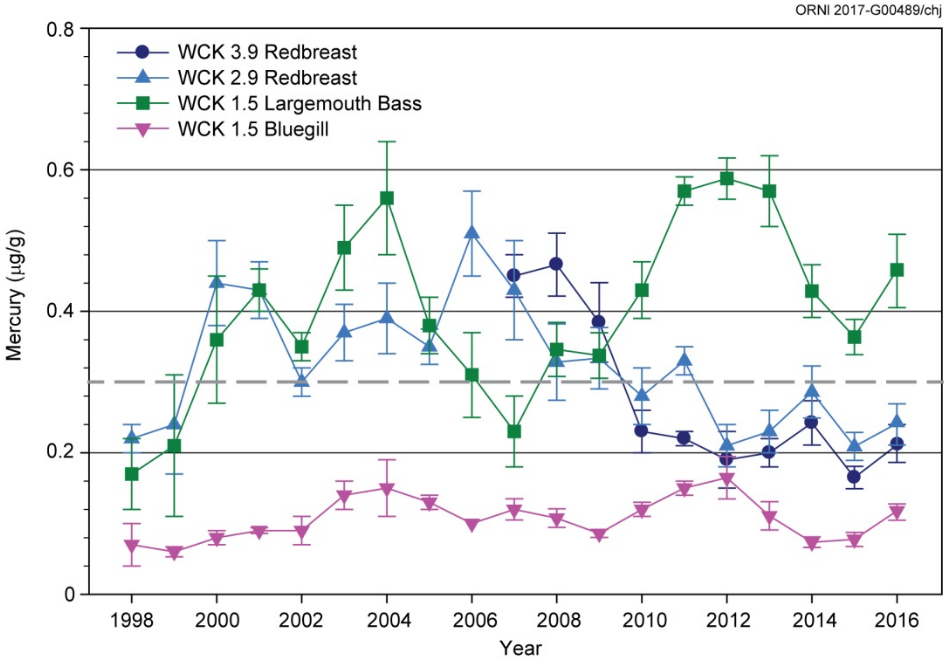


Fig. 5.28. Mean concentrations of mercury (± standard error, N = 6) in muscle tissue of sunfish and bass from White Oak Creek (White Oak Creek kilometers [WCKs] 3.9 and 2.9) and White Oak Lake (WCK 1.5), 1998–2016. *[Dashed grey line indicates the US Environmental Protection Agency ambient water quality criterion for mercury (0.3 µg/g in fish tissue).]*

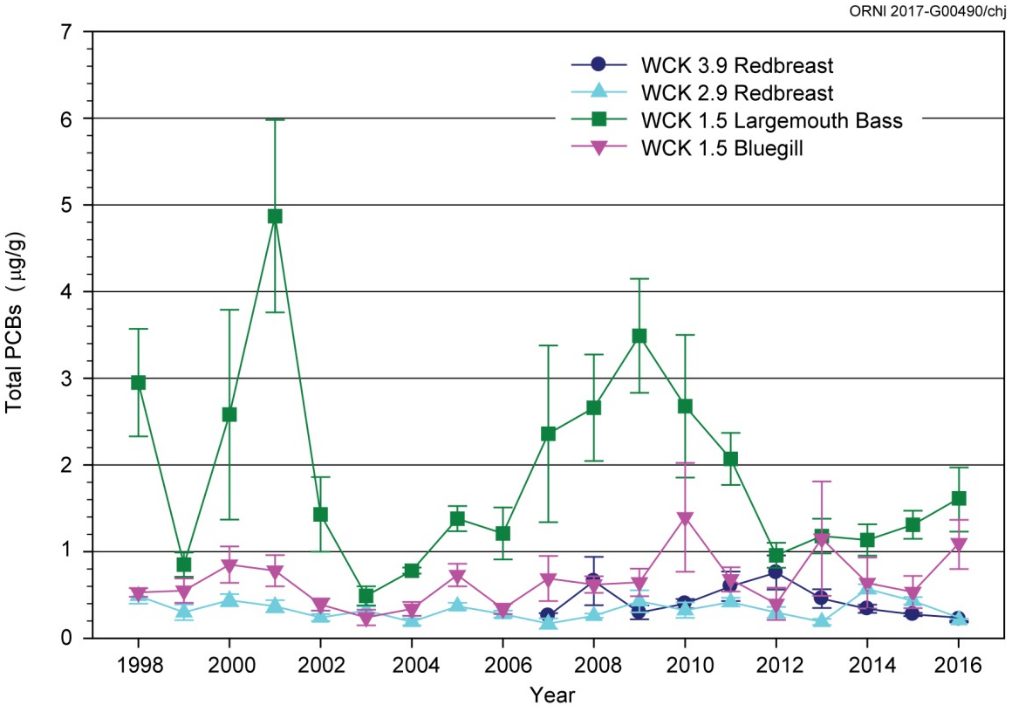


Fig. 5.29. Mean total polychlorinated biphenyl (PCB) concentrations (± standard error, N = 6) in fish fillets collected from the White Oak Creek watershed, 1998–2016. *(WCK = White Oak Creek kilometer.)*

5.5.6.2 Benthic Macroinvertebrate Communities

Monitoring of benthic macroinvertebrate communities in WOC, First Creek, and Fifth Creek continued in 2016. Additionally, monitoring of the macroinvertebrate community in lower Melton Branch (Melton Branch kilometer [MEK] 0.6) continued under the DOE Office of Environmental Management (EM) Water Resources Restoration Program (WRRP). Benthic macroinvertebrate samples are collected annually following TDEC protocols and protocols developed by ORNL staff and used since 1986. The protocols developed by ORNL staff provide a continuous long-term record (29 years) of spatial and temporal trends in the invertebrate community from which the effectiveness of pollution abatement and remedial actions 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. At the time of publication, 2016 sample results for benthic macroinvertebrate communities in First Creek, Fifth Creek, and WOC downstream of effluent discharges were not available. These results will be reported in the 2017 annual report. The 2015 results, which were not available in time for inclusion in the 2015 annual site environmental report (DOE 2016) are included in this report (see Fig. 5.30).

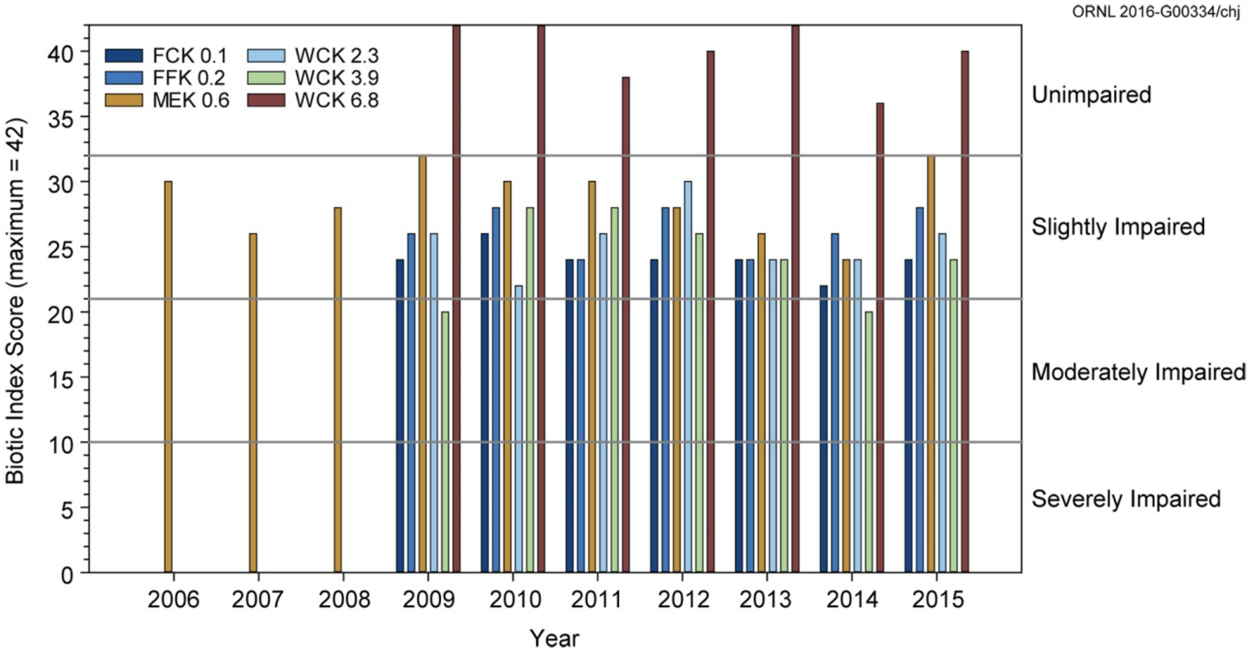


Fig. 5.30. Temporal trends in Tennessee Department of Environment and Conservation Biotic Index Scores for White Oak Creek watershed, August 2006–August 2015. *Results for 2016 were not available at the time of publication. Horizontal lines show the lower thresholds for biotic condition ratings for index scores; respective narrative ratings for each threshold are shown at right of graph. (FCK = First Creek kilometer, FFK = Fifth Creek kilometer, MEK = Melton Branch kilometer, and WCK = White Oak Creek kilometer.)*

The 2015 results indicated significant recovery in these communities since 1987, but community characteristics indicated that ecological impairment remains (Figs. 5.31–5.33). Relative to respective upstream reference sites, total taxonomic richness (i.e., the mean number of different species per sample) and richness of the pollution-intolerant taxa (i.e., the mean 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. After modest increases in the mid-1990s, total taxa richness appeared to have generally decreased at First Creek kilometer (FCK) 0.1, and in 2014 the total number of taxa was the lowest it had been since 1989. Similarly, the number of pollution-intolerant EPT taxa decreased in 3 consecutive years, and in 2014 EPT taxa richness was the lowest it had been since the early 1990s. These results suggest a change may have occurred in conditions in lower First Creek. Total taxa richness remained low in 2015; however, a slight increase in EPT taxa richness was observed, although values remain low relative to the mid-1990s. 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. Trends in metrics at Fifth Creek kilometer (FFK) 0.2 since the mid-1990s suggest that a change in conditions at that site occurred between 2007 and 2008. More recent results, however, suggest that improvements have occurred, and the condition of the invertebrate community is now comparable to what it was from the late 1990s through the early 2000s. Metric values for WCK 2.3 and WCK 3.9 continued to remain within the ranges of values found since the early 2000s, although they also continued to be notably lower than those for the reference sites, suggesting that no additional major changes had occurred at those sites for roughly 13 years.

Macroinvertebrate community metrics for lower Melton Branch (MEK 0.6, Fig. 5.34) suggested that in 2015 taxa richness metrics continued to be similar to reference conditions. However, like the results from the TDEC protocols, other invertebrate community metrics potentially sensitive to more specific types of pollutants, such as the percent 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. Thus, while the condition of the invertebrate community at MEK 0.6 was generally at or near reference conditions, annual changes in some characteristics of the community suggested that annual fluctuations in environmental conditions at the site appear to have some minor negative influence on the condition of the community.

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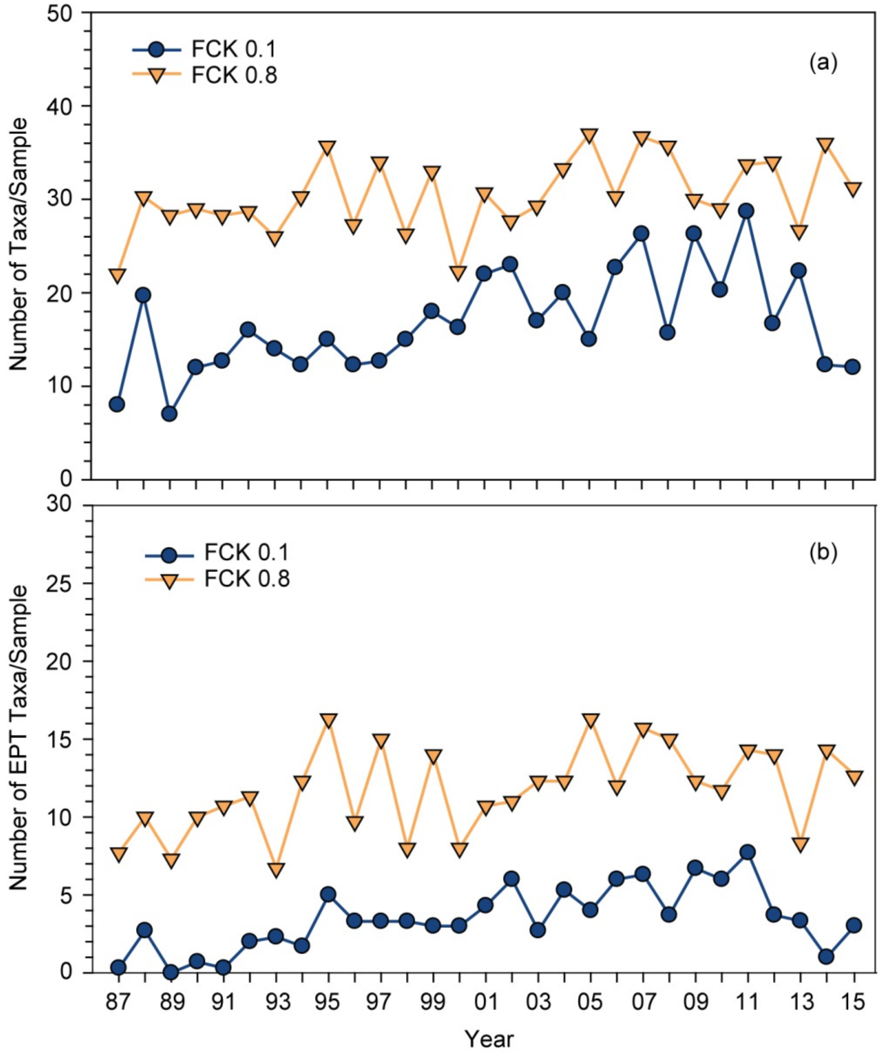

Fig. 5.31. Benthic macroinvertebrate communities in First Creek: (a) total taxonomic richness (mean number of all taxa/sample) and (b) taxonomic richness of the pollution-intolerant taxa, Ephemeroptera, Plecoptera, and Trichoptera (EPT); mean number of EPT taxa/sample, April sampling periods, 1987−2015. *Results for 2016 were not available at the time of publication. (FCK = First Creek kilometer; FCK 0.8 = reference site.)*

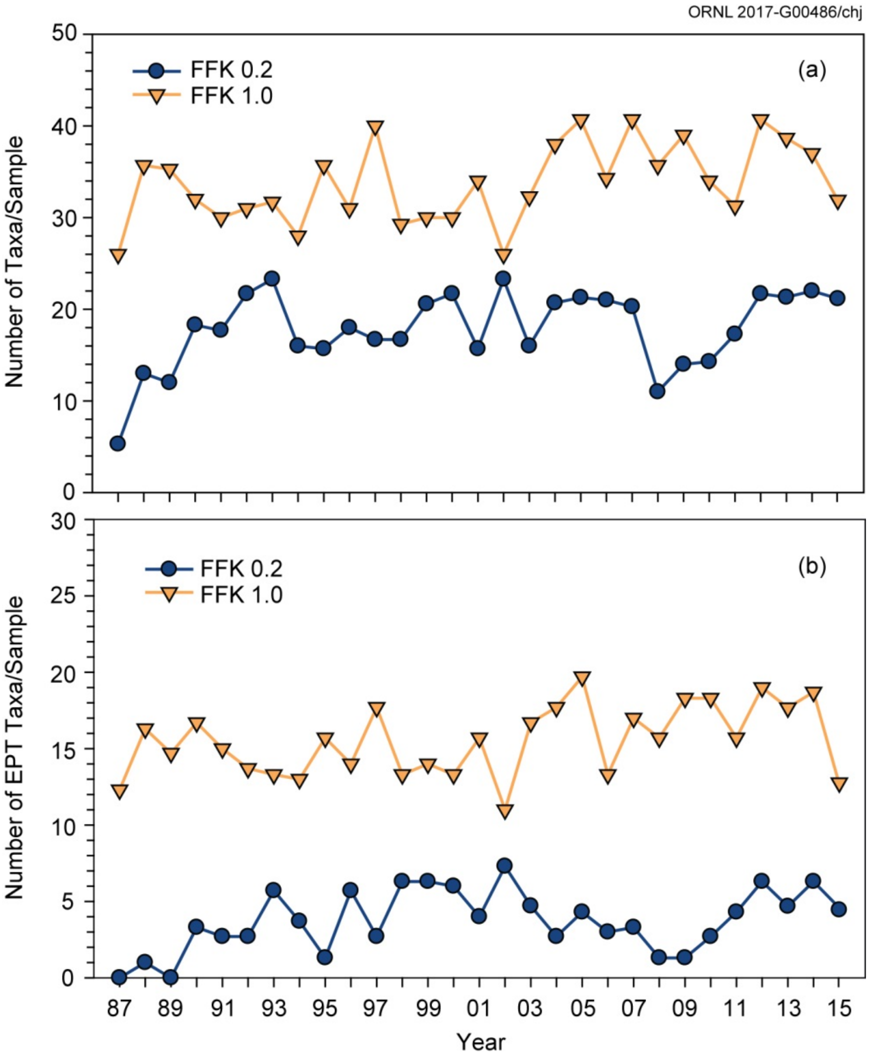

Fig. 5.32. Benthic macroinvertebrate communities in Fifth Creek: (a) total taxonomic richness (mean number of all taxa/sample) and (b) taxonomic richness of the pollution-intolerant taxa, Ephemeroptera, Plecoptera, and Trichoptera (EPT); mean number of EPT taxa/sample), April sampling periods, 1987−2015. *Results for 2016 were not available at the time of publication. (FFK = Fifth Creek kilometer; FFK 1. 0 = reference site.)*

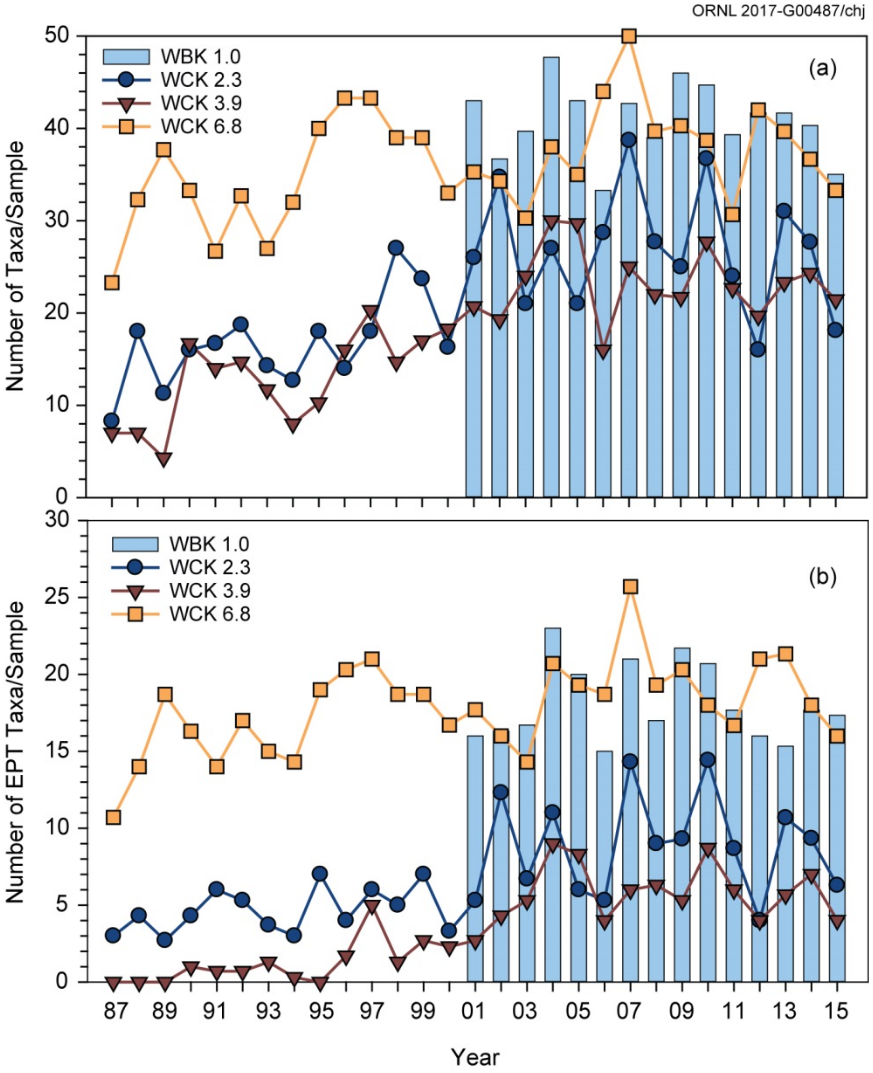

Fig. 5.33. Benthic macroinvertebrate communities in White Oak Creek: (a) total taxonomic richness (mean number of all taxa/ sample) and (b) taxonomic richness of the pollution-intolerant taxa, Ephemeroptera, Plecoptera, and Trichoptera (EPT); mean number of EPT taxa/sample), April sampling periods, 1987−2015. *Results for 2016 were not available at the time of publication. (WCK = White Oak Creek kilometer and WBK = Walker Branch kilometer; WBK 1.0 = reference site.)*

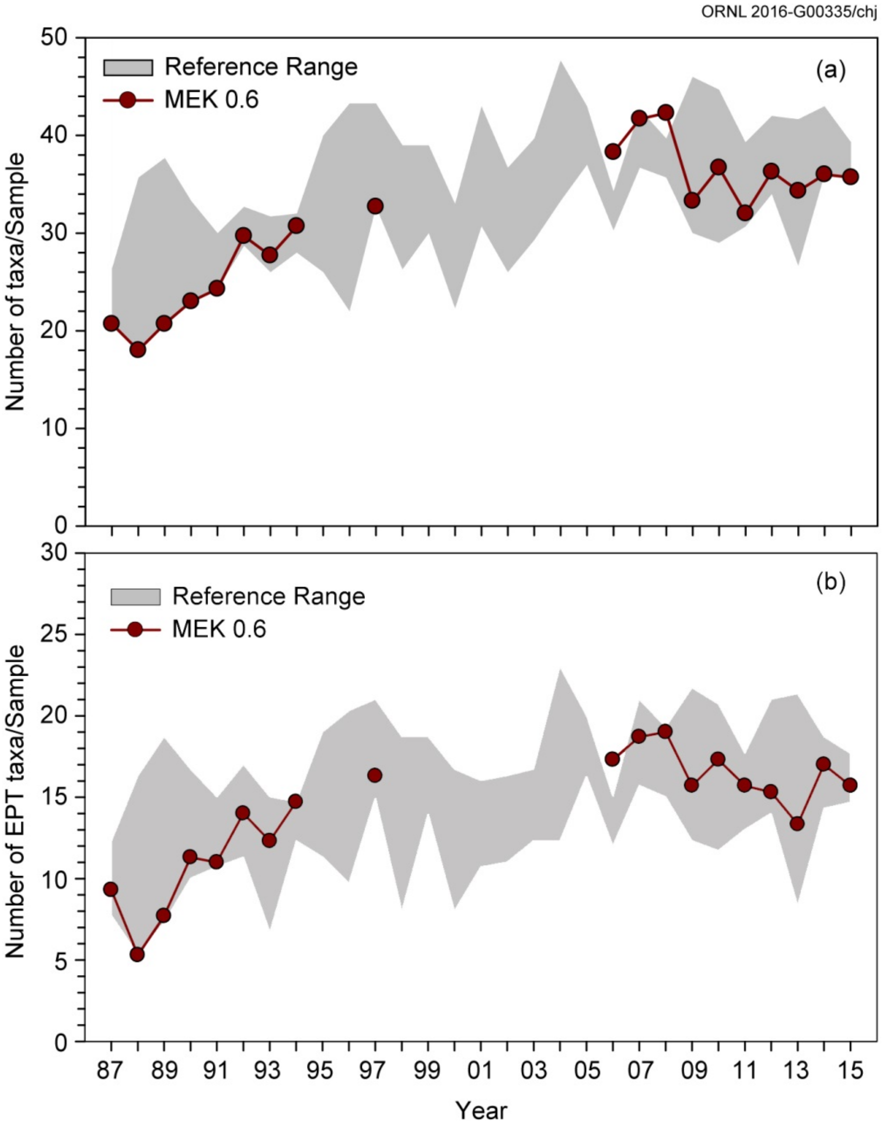

Fig. 5.34. Benthic macroinvertebrate communities in lower Melton Branch: (a) total taxonomic richness (mean number of all taxa/sample) and (b) taxonomic richness of the pollution-intolerant taxa, Ephemeroptera, Plecoptera, and Trichoptera (EPT); mean number of EPT taxa/sample, April sampling periods, 1987−2015. *Results for 2016 were not available at the time of publication. (MEK = Melton Branch kilometer; reference range = minimum and maximum values for Oak Ridge National Laboratory Biological Monitoring and Abatement Program reference sites on upper Melton Branch [1987–1997], First Creek and Fifth Creek [1987–2014], Walker Branch [2001–2014], and White Oak Creek [1987–2000, 2007–2014], and other Oak Ridge Reservation reference sites.)*

5.5.6.3 Fish Communities

Monitoring fish communities in WOC and major tributaries continued in 2016. 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 2016 compared with communities in reference streams. Sites closest to outfalls within the ORNL campus had lower species richness (number of species) (Fig. 5.35), fewer pollution-sensitive species, more pollution-tolerant species, and elevated density (number of fish per square meter) of pollution-tolerant species compared with similar-sized reference streams. Seasonal fluctuations in diversity and density are expected and explain some of the variability seen at these sites as well as recent fish introduction work. Overall, the fish communities in tributary sites adjacent to and downstream of ORNL outfalls also remained negatively affected by ORNL effluent in 2016 relative to reference streams and upstream sites.

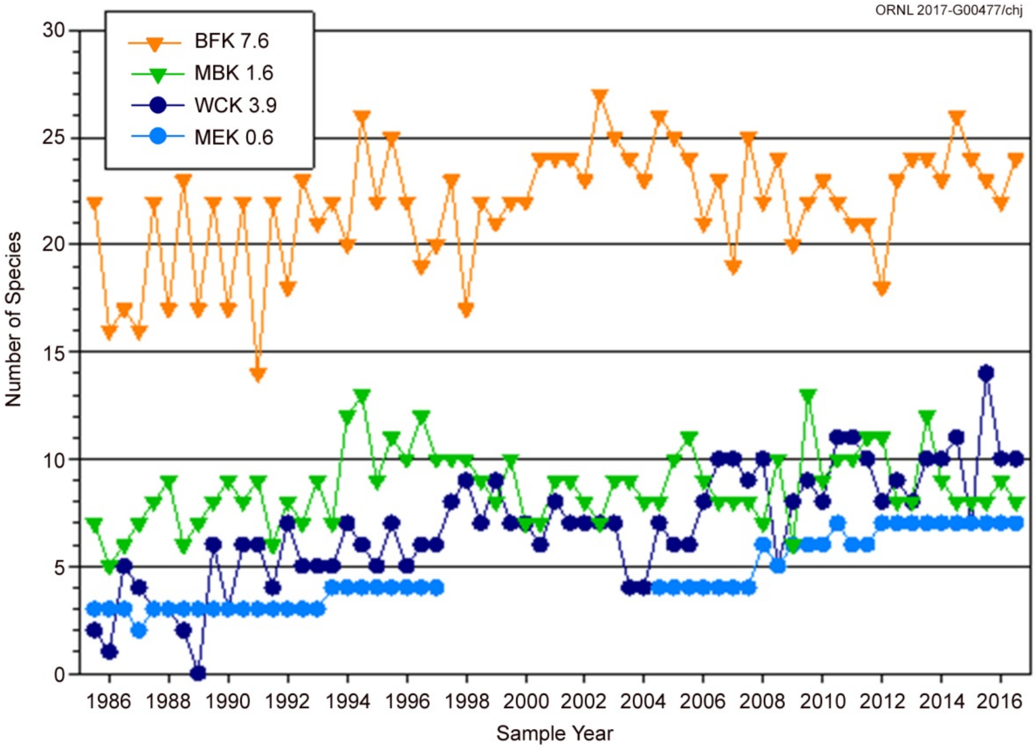

Fig. 5.35. Fish species richness (number of species) in upper White Oak Creek and lower Melton Branch compared with two reference streams (Brushy Fork and Mill Branch) 1985–2016 *(BFK = Brushy Fork kilometer; MBK = Mill Branch kilometer; MEK = Melton Branch kilometer; and WCK = White Oak Creek kilometer.)*

A project to introduce fish species that were not found in the WOC watershed but that exist in similar systems on the ORR and that may have historically existed in WOC was initiated in 2008 with the stocking of six such native species. Reproduction has been noted for five 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, and as a result, introductions to supplement the small populations of these fish species have continued at sites within the watershed. One exception to this is the striped shiner (*Luxilus chrysocephalus*), which has expanded into upper Melton Branch, upper WOC, and lower First Creek. The introductions have enhanced species richness at almost all sample locations within the watershed and illustrate 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.

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. 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 (Figure 5.29), 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, even if collected from a contaminated site. Therefore, semipermeable membrane devices (SPMDs) are used to assess the chronic low-level sources of PCBs at critical sites on the reservation. SPMDs are thin plastic sleeves filled with oil in which PCBs are soluble. Because SPMDs are in contact with water at a given site for 4 weeks and have a high affinity for PCBs, a time-integrated semiquantitative index of the mean PCB concentration in the water column during the deployment period is obtained. SPMDs also have advantages over “snapshot” water concentration analyses. The long deployment period enables distinction between the relative PCB inputs at sites whose aqueous PCB concentrations are below detection limits in water.

While past monitoring efforts were instrumental in establishing a baseline for PCBs, the focus has historically been on relating PCB levels in fish to safe levels for consumption. These studies were not designed to identify specific stream reaches or sources contributing to PCB bioaccumulation.

In 2016, ORNL’s PCB monitoring efforts continued focusing on the First Creek watershed, which has been identified as a source of PCBs. Sampling sites on WOC included at kilometers 3.9, 4.1, and 3.4. SPMDs were also deployed on First Creek at outfalls 249, 250, 341, 341-1 (sampling port), and the piping network of outfall 250, which contributes to First Creek (Fig. 5.36). SPMDs deployed at manholes 250-19 and 341-1 were partially chewed/torn by an unidentified source, but some PCB data were recovered. The results are summarized in Table 5.12.

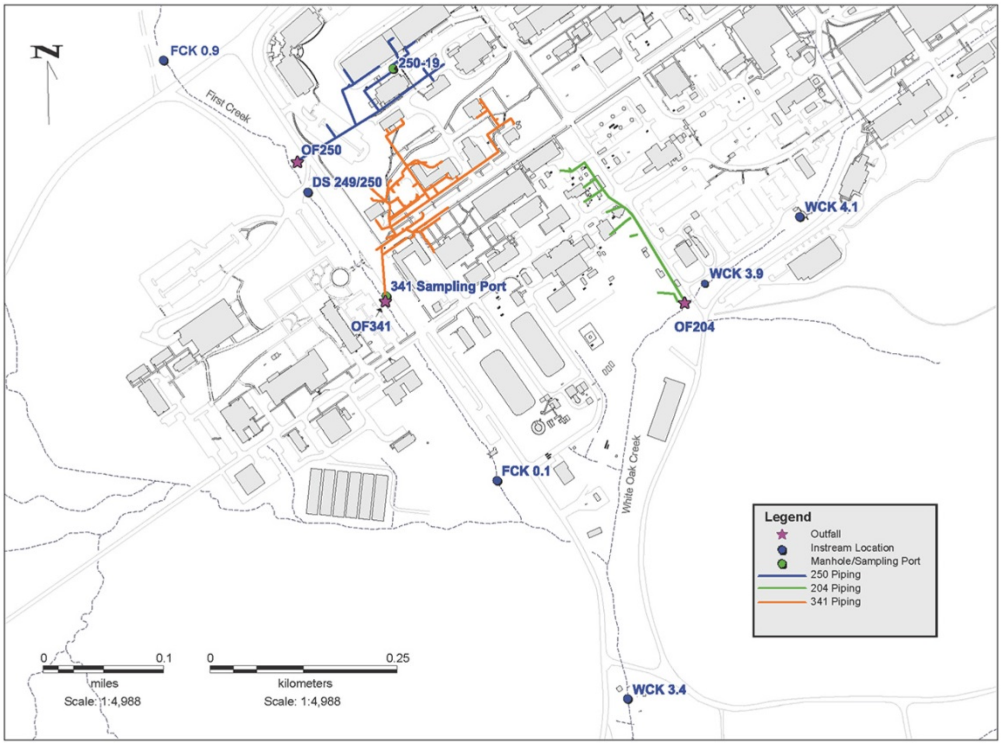

Fig. 5.36. Locations of monitoring points for First Creek source investigation.
(FCK = First Creek kilometer, WCK = White Oak Creek kilometer, OF = outfall.)

Table 5.12. First Creek and WOC PCB source assessment, September 2016 (Total PCBs [parts per billion])

Sample location	Location Type	SPMD (ppb)
OF 250	Outfall	1,000
250-19	Inlet/Outlet	12,077
FCK0.9	Instream	438
DS 249/250	Instream	4,804
OF 341 manhole/sampling port	Manhole/sampling port for outfall	400
OF 341	Outfall	767
FCK0.1	Instream	8,614
OF 204	Outfall	439
WCK3.9	Instream	863
WCK4.1	Instream	1,064
WCK3.4	Instream	2,405

Acronyms
FCK = First Creek kilometer
OF = outfall
PCB = polychlorinated biphenyl
SPMD = semipermeable membrane device
WCK = White Oak Creek kilometer
WOC = White Oak Creek

Results from the 2016 assessment confirm that upper parts of outfalls 249 and 250 pipe networks continue to be of primary interest for investigation of legacy PCB sources in the First Creek watershed. The results from sample location 250-19 (Table 5.12) indicate that PCBs remain available in that area despite recent actions to remove PCB-contaminated building materials from the upper part of the 250 watershed. In WOC, sample location 3.4, downstream of confluence with First Creek, contained the highest PCB concentration (Table 5.12). Therefore, First Creek remains the greatest area of concern for sources of PCBs and future remediation efforts. Results were within the ranges of past monitoring, giving no indication that the nature of PCB movement is significantly changing in those networks.

5.5.7.1 Biota sampling in First Creek

Over the past 8 years, the major sources of PCBs to the WOC watershed have been traced to two storm drains leading to First Creek (Outfalls 250 and 341). In 2016, fish and invertebrates were sampled at three sites that had not previously been monitored in First Creek to establish baseline PCB concentrations for biota in this stream. The sites included First Creek kilometer (FCK) 0.9 (above outfall 250), FCK 0.5 (below outfalls 250 and 341), and FCK 0.1 (just above the confluence with Northwest Tributary). Total PCB concentrations in both whole body black nose dace (*Rhinichthys obtusus*) and crayfish (*Cambarus sp.*) increased at each downstream location. At FCK 0.9, concentrations in fish were low, and concentrations in crayfish were below detection limits. At FCK 0.1, mean PCB concentrations in fish were higher (6.7 μg/g) than in crayfish (0.77 μg/g). Future monitoring will tell whether actions taken to clean out storm drains affect PCB bioaccumulation within the creek.

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. NTRC, which is located off ORR, also has an SPCC plan covering the oil inventory at its location. CFTF is also located off ORR; however, that facility was evaluated, and a determination was made that it did not require an SPCC plan. There were no regulatory or permitting actions related to oil pollution prevention at ORNL or NTRC in 2016. 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 (Fig. 5.37) 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. Radiological monitoring at the discharge point downstream of ORNL (White Oak Lake at WOD) is conducted monthly under the ORNL WQPP (Section 5.5.3) and, therefore, is not duplicated by this program. Radiological monitoring at a point upstream of ORNL is conducted monthly under the ORNL WQPP (Section 5.5.3) and therefore is not duplicated by the surface water monitoring program. Total radioactive strontium is monitored quarterly by this surveillance 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 White Oak Lake at WOD are also checked for volatile organic compounds (VOCs), PCBs, and mercury. 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. The Tennessee WQCs do not include criteria for radionuclides. Four percent of the DOE DCS is used for radionuclide comparison because that value is roughly equivalent to the 4 mrem dose limit from ingestion of drinking water on which the EPA radionuclide drinking water standards are based.

There were no radionuclides reported above 4% of DCS at the Fifth Creek location (FFK 0.1). Also, no strontium-89/90 results above 4% of DCS were reported for samples collected at the upstream White Oak Creek sampling location (WCK 6.8). The other radionuclide results from WCK 6.8 and the radionuclide results from samples collected at WOD (immediately before WOC empties into the Clinch River) are discussed in Section 5.5.3.

Neither PCBs nor VOCs were detected during 2016 in WOC at WOD. Mercury was detected once in the September sample.

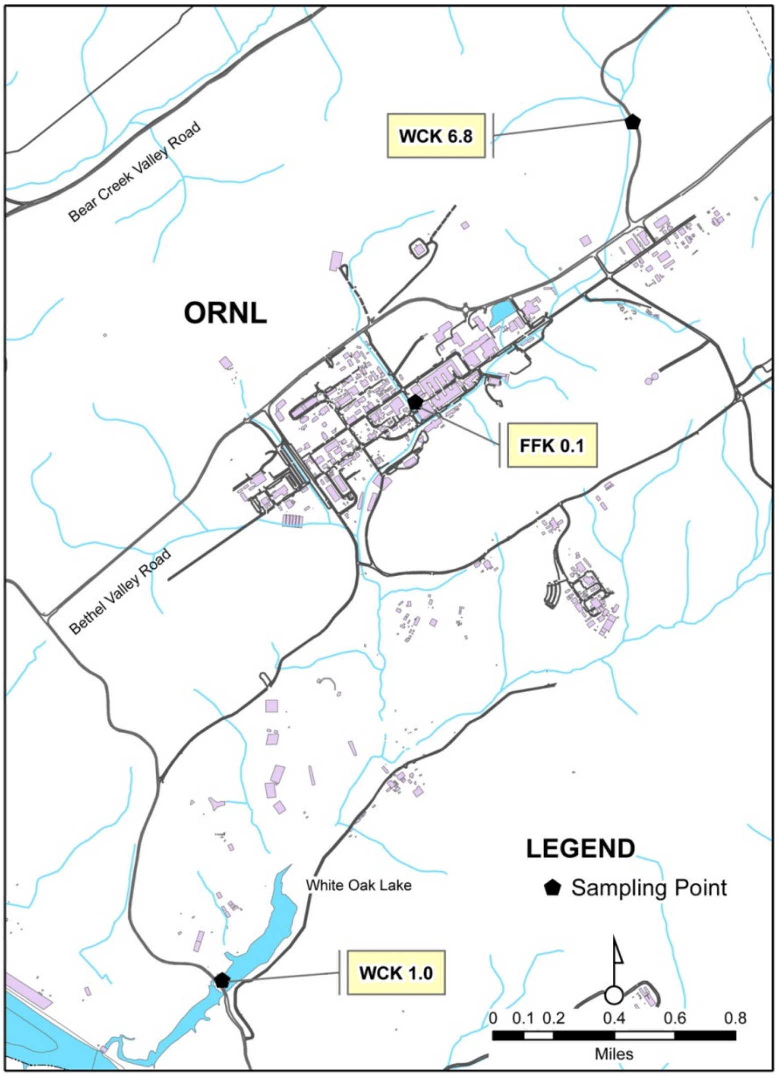

Fig. 5.37. Oak Ridge National Laboratory surface water sampling locations. *(FFK = Fifth Creek kilometer; WCK = White Oak Creek kilometer.)*

Table 5.13. Oak Ridge National Laboratory surface water sampling locations, frequencies, and parameters, 2016

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

[a] Locations identify bodies of water and locations on them (e.g., WCK 1.0 is 1 km upstream from the confluence of White Oak Lake and the Clinch River).

[b] Field measurements consist of dissolved oxygen, pH, and temperature.

Acronyms

FFK = Fifth Creek kilometer
ORNL = Oak Ridge National Laboratory
PCB = polychlorinated biphenyl
WCK = WOC kilometer
WOC = White Oak Creek
WOD = White Oak Dam

5.5.10 Carbon Fiber Technology Facility Waste Water Monitoring

Facility and process waste water from activities at CFTF are discharged to the City of Oak Ridge sanitary sewer system under conditions established in City of Oak Ridge Industrial Waste Water Discharge Permit 1-12. Permit limits, parameters, and 2016 compliance status for this permit are summarized in Table 5.14.

Table 5.14. Industrial and Commercial User Waste Water Discharge Permit compliance at the Oak Ridge National Laboratory Carbon Fiber Technology Facility, 2016

Effluent parameters	Permit limits		Permit compliance		
	Daily max. (mg/L)	Daily min. (mg/L)	Number of noncompliances	Number of samples	Percentage of compliance[a]
			Outfall 01 (Underground Quench Water Tank)		
Cyanide		4.2	0	1	100
pH (standard units)	9.0	6.0	0	1	100
			Outfall 02 (Electrolytic Bath Tank)		
pH (standard units)	9.0	6.0	0	17	100
			Outfall 03 (Sizing Bath Tank)		
Copper		0.87	0	5	100
Zinc		1.24	0	5	100
Total phenol		4.20	0	5	100
pH (standard units)	9.0	6.0	0	5	100

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

5.6 Groundwater Monitoring Program

Groundwater monitoring at ORNL was conducted under two sampling programs in 2016: DOE EM monitoring and DOE Office of Science (SC) surveillance monitoring. The DOE EM groundwater monitoring program was conducted by UCOR in 2016. The SC groundwater monitoring surveillance program was conducted by UT-Battelle.

5.6.1 DOE 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 EM program. The results of CERCLA monitoring for ORR for FY 2016, including monitoring at ORNL, are evaluated and reported in the 2017 remediation effectiveness report (DOE 2017) as required by the ORR FFA. The monitoring results and remedial effectiveness evaluations for Bethel and Melton Valley are reported in Sections 2 and 3, respectively, in that report.

Groundwater monitoring conducted as part of the EM 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 Services Area VOC plume. This plume contains trichloroethylene (TCE) 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.

During FY 2016 postremediation monitoring continued at Solid Waste Storage Area (SWSA) 3 following completion of hydrologic isolation of the area by construction of a multilayer cap and upgradient stormflow/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.

During FY 2016 EM continued to collect and analyze samples from the off-site groundwater monitoring well array west of the Clinch River adjacent to Melton Valley. In addition, exit pathway groundwater monitoring in Melton Valley is conducted as part of the EM program, including sampling at six multiport monitoring wells in western Melton Valley (wells 4537, 4538, 4539, 4540, 4541, and 4542).

During FY 2014 the EM Groundwater Program staff conducted planning for an ORR off-site groundwater quality assessment and started development of an ORR regional groundwater flow model. The off-site groundwater assessment project is aimed at documenting water quality in selected residential water supply wells and at springs to the west and southwest of the ORR. General water chemistry, metals, organic compounds, and radionuclides are included in the suite of analytes to be assessed. The Offsite Groundwater Assessment project to evaluate off-site groundwater quality and movement continued in FY 2016. The project is a cooperative DOE, EPA, and TDEC effort. Two sampling events were completed in FY 2015 in accordance with an approved work plan. A confirmatory sampling event was completed in FY 2016, and a report of results was prepared and issued in November 2016 (DOE 2016a).

Construction and calibration of a regional-scale flow model was completed in FY 2016. The regional flow model will serve as an underlying framework to support future cleanup decisions and actions. A technical advisory group composed of members from DOE, EPA, TDEC, and industry has met several times annually since 2014. Members of the group reviewed progress and made recommendations for development and future use of the model.

5.6.1.1 Summary of DOE Office of Environmental Management Groundwater Monitoring

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 2016 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. Groundwater quality monitoring at SWSA 3 showed decreasing or stable concentrations of beta emitters, ^{90}Sr, and vinyl chloride. Benzene, potentially from natural sources, showed stable concentrations in one well with increasing concentrations at a second location.

During FY 2016, as part of the DOE EM 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 2016 remediation effectiveness report (DOE 2017).

Groundwater monitoring continued at the ORNL 7000 Area during FY 2016 to evaluate treatability of the VOC plume at that site. Site characterization testing of the endemic microbial community showed that microbes were present that are capable of fully degrading TCE 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. A future full-scale bioremediation project will be designed to complete remediation of the plume.

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. The remedy had performed well until the latter portion of FY 2008 when conditions changed and ^{90}Sr and $^{233/234}$U concentrations in monitoring wells and the groundwater collection system began increasing. The increase of contaminants feeding the plume was likely the result of leaking utility lines mobilizing contaminants near the source area. That has allowed increased contaminant flux to First Creek, a tributary of WOC. During FY 2009 the remedy did not meet its performance goal, which is a reduction of ^{90}Sr in WOC. In March 2012 DOE completed refurbishment and enhancement of the groundwater collection system to increase the effectiveness of the plume containment. Since FY 2013 the remedy has met its performance goal of reducing ^{90}Sr levels in WOC as measured at the 7500 bridge.

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 minimization of the spread of groundwater contamination. 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 during FY 2016 was several inches below 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. Groundwater quality monitoring substantively equivalent to the former RCRA monitoring continues at SWSA 6. Several VOC substances continue to be detected in wells along the eastern edge of the site.

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 ^{90}Sr, 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 2016 an off-site groundwater monitoring well array west of the Clinch River and adjacent to Melton Valley was monitored as part of the EM 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. The maximum concentrations of ^{90}Sr and ^{3}H for the on-site exit pathway groundwater monitoring network during FY 2016 were estimated by the analytical laboratory. The estimated values were very low in comparison with the maximum contaminant levels (MCLs) specified in EPA regulations:

- Sr-90: 0.37 J pCi/L (8 pCi/L MCL-derived concentration)
- H-3: 209 J pCi/L (20,000 pCi/L MCL-derived concentration)

The “J” flags on the reported results indicate estimates of concentrations below contract required quantitation limits but greater than zero. Monitoring results are summarized in the 2017 remediation effectiveness report (DOE 2017).

Off-Site Groundwater Monitoring

During FY 2014 the EM Groundwater Program staff conducted planning for an ORR off-site groundwater quality assessment and started development of an ORR regional groundwater flow model. The off-site groundwater assessment project is aimed at documenting water quality in selected residential water supply wells and at springs to the west and southwest of the ORR. General water chemistry, metals, organic compounds, and radionuclides are included in the suite of analytes to be assessed. An off-site groundwater assessment project to evaluate off-site groundwater quality and movement continued in FY 2016. The project is a cooperative DOE, EPA, and TDEC effort. Two sampling events were completed in FY 2015 in accordance with an approved work plan. A confirmatory sampling event was completed in FY 2016, and a report of results was prepared and issued in November 2016 (DOE 2016a). Construction and calibration of a regional-scale flow model was completed in FY 2016. The regional flow model will serve as an underlying framework to support future cleanup decisions and actions. A technical advisory group composed of DOE, EPA, and TDEC members as well as industry experts has met several times annually since 2014. Members of the group reviewed progress and made recommendations for development and future use of the model.

5.6.2 DOE Office of Science Groundwater Monitoring

DOE O 458.1 (DOE 2011b) 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 program are reported in the following sections.

Exit pathway and active-sites groundwater surveillance monitoring points sampled during 2016 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 monitoring performed under the exit pathway groundwater surveillance and active-sites monitoring programs are not regulated by federal or state rules. Consequently, no permit or standards exist for evaluating sampling results. To provide a basis for evaluating analytical results and to assess groundwater quality at locations monitored by UT-Battelle, current federal drinking water standards and/or Tennessee WQCs for radiological and nonradiological contaminants were used as reference standards. If no federal or state standard had been established for a particular radionuclide, 4% of the DCSs for radionuclides found in DOE O 458.1 were used to evaluate sampling results. Although drinking water standards and DOE DCSs were used for comparative purposes, 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 2016, exit pathway groundwater surveillance monitoring was performed in accordance with the exit pathway sampling and analysis plan (Bonine 2012). 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 as follows:

- the WOC Discharge Area Exit Pathway,
- the 7000–Bearden Creek Watershed Discharge Area Exit Pathway,
- the East End Discharge Area Exit Pathway,
- the Northwestern Discharge Area Exit Pathway, and
- the Southern Discharge Area Exit Pathway.

Figure 5.38 shows the locations of the exit pathway monitoring points sampled in 2016.

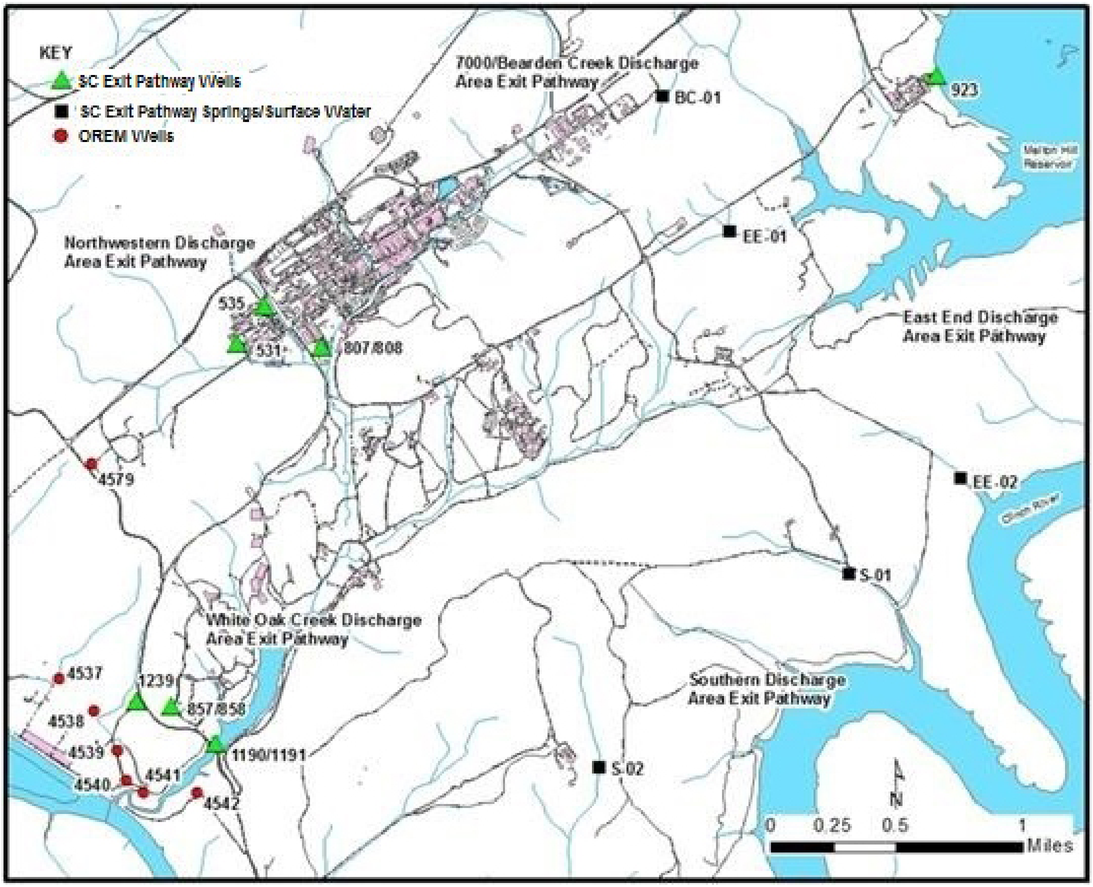

Fig. 5.38. UT-Battelle exit pathway groundwater monitoring locations at Oak Ridge National Laboratory, 2016. *(EM = DOE Environmental Management; OS = DOE Office of Science).*

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. The groundwater monitoring program implemented in 2016 is outlined in Table 5.15.

Unfiltered samples were collected from the exit pathway groundwater surveillance monitoring points in 2016. The organic suite was composed of VOCs and semivolatile organic compounds (SVOCs); the metallic suite included heavy and non-heavy metals; and the radionuclide suite was composed of gross alpha/gross beta activity, gamma emitters, total radioactive strontium, and tritium. Under the monitoring strategy outlined in the exit pathway sampling and analysis plan (Bonine 2012), samples were collected semiannually during the wet (April/May) and dry (August/September/October) seasons.

Table 5.15. Scheduled 2016 exit pathway groundwater monitoring

Discharge area	Monitoring point	Wet season	Dry season
White Oak Creek	857	Radiological	Radiological
	858	Radiological	Radiological
	1190	Radiological, organic, and metals	Radiological, organic, and metals
	1191	Radiological, organic, and metals	Radiological, organic, and metals
	1239	Radiological, organic, and metals	Radiological
Northwestern	531	Radiological, organic, and metals	Radiological
	535	Radiological	Radiological
	807	Radiological	Radiological
	808	Radiological, organic, and metals	Radiological
7000–Bearden Creek	BC-01	Radiological	Radiological
East End	923	Radiological, organic, and metals	Radiological
	EE-01	Radiological, organic, and metals	Radiological
	EE-02	Radiological	Radiological
Southern	S-01	Radiological	Radiological
	S-02	Radiological	Radiological

Exit Pathway Monitoring Results

Statistical trend analyses were performed on 2016 exit pathway monitoring data sets containing data exceeding reference standards. The bases used for the trend analyses were the historical data collected from the late 1980s through 2016. Trend analyses were not performed on data sets where minimum detection limits exceeded reference standards (i.e., the SVOCs atrazine, benzo(a)pyrene, hexachlorobenzene, and pentachlorophenol) and were not performed on parameters for which there are no reference standards or where data densities were insufficient. Parameters that exhibited statistically significant (80% to 99% confidence levels) upward or downward trends are reported. Trend analysis results are summarized in Table 5.16.

Samples were not collected at S-01during the wet season in 2016. Additionally, no samples were collected from BC-01, S-01, or EE-02 during the dry season. Samples were not collected due to a lack of water flow at the locations. Samples were collected at all other monitoring points during both the wet and dry seasons. Monitoring results are available in OREIS. Access to this system can be requested via email (oreis@ettp.doe.gov) or by telephone (865-574-3257).

Table 5.17 provides a summary of radiological parameters detected in samples collected from exit pathway monitoring points during 2016. Metals are ubiquitous in groundwater exit pathways and so are not summarized in the table.

Table 5.16. 2016 exit pathway groundwater monitoring—results of trend analyses for parameters exceeding reference standards

Discharge area	Monitoring point	Parameter	Trend
White Oak Creek	1190	H-3	Downward
		Fe	Downward
		Mn	Downward
	1191	H-3	Downward
		Sr-89/90	No trend
		Gross beta	Downward
		Fe	Downward
		Mn	No trend
	1239	Al	Downward
East End	EE-01	Al	Downward
		Mn	No trend
	923	Fe	No trend

Table 5.17. 2016 exit pathway groundwater monitoring results—detected radiological parameters

Discharge area	Monitoring location	Parameter	Result	Wet or dry season
Northwest	531	Beta	15	Wet
		Cs-137	4.4	Wet
		K-40	140	Wet
		Sr-89/90	4.9	Wet
		Beta	7	Dry
		K-40	150	Dry
	535	Cs-137	110	Wet
		K-40	110	Wet
		Sr-89/90	5	Wet
		Beta	24	Dry
		Cs-137	11	Dry
		K-40	190	Dry
		Sr-89/90	3.5	Dry
	807	Beta	12	Wet
		K-40	83	Wet
		Sr-89/90	6.5	Wet
		Tritium	490	Wet
		Alpha	4.5	Dry
		Beta	13	Dry
		Cs-137	53	Dry
		K-40	110	Dry
		Sr-89/90	5.1	Dry
	808	Beta	10	Wet
		Sr-89/90	3.1	Wet
		Beta	7.2	Dry
		K-40	170	Dry

Table 5.17 (continued)

Discharge area	Monitoring location	Parameter	Result	Wet or dry season
White Oak Creek	857	K-40	110	Wet
		Sr-89/90	4.3	Wet
		K-40	150	Dry
		Sr-89/90	11	Dry
	858	Cs-137	7.6	Wet
		Sr-89/90	3.7	Wet
		K-40	97	Dry
	1190	Alpha	11	Wet
		Beta	7.6	Wet
		Cs-137	79	Wet
		K-40	180	Wet
		Sr-89/90*	9.5	Wet
		Tritium	21,000	Wet
		Alpha	5.7	Dry
		Beta	8.9	Dry
		Tritium	26,000	Dry
	1191	Alpha	4.2	Wet
		Beta	200	Wet
		Cs-137	54	Wet
		K-40	120	Wet
		Sr-89/90	110	Wet
		Tritium	23,000	Wet
		Alpha	4.3	Dry
		Beta	260	Dry
		K-40	190	Dry
		Sr-89/90	140	Dry
		Tritium	29,000	Dry
	1239	Beta	6.6	Wet
		Cs-137	38	Wet
		K-40	150	Wet
		K-40	210	Dry
7000/Bearden Creek	BC-01	Alpha	2.5	Wet
		K-40	120	Wet
East End	EE-01	K-40	85	Wet
		Beta	6.4	Dry
		K-40	180	Dry
	EE-02	Sr-89/90	14	Dry
		Cs-137	8.2	Wet
		K-40	130	Wet
	923	K-40	120	Wet
		Sr-89/90	14	Dry
Southern	S-02	Alpha	2.9	Dry
		Beta	5.6	Dry
		K-40	130	Dry
		Sr-89/90	4.1	Dry

*The reported result is thought to be a laboratory error. The laboratory aliquot for the collected sample was discarded by the laboratory prior to a request for reanalysis to confirm the result.

Summary

The following bullets summarize the exit pathway groundwater surveillance program monitoring efforts for 2016 at ORNL:

- Seven radiological contaminants were detected in exit pathway groundwater samples collected in 2016. Tritium, total radioactive strontium, and gross beta activity were the only radiological contaminants exceeding reference standards at any of the discharge areas, and, as in past years, those three contaminants were observed at the WOC discharge area in 2016. Statistical trend analyses show that the concentration trends for those parameters continue downward (no statistically significant trend was detected for $^{89/90}$Sr in Well 1191). No other radiological contaminants exceed reference standards at other discharge areas.

- Thirty-one metallic contaminants were detected in exit pathway groundwater samples collected in 2016; however, only three metals (iron, manganese, and aluminum) were detected at concentrations exceeding reference standards. These metals are commonly found in groundwater at ORNL

- Two VOCs (acetone and methylene chloride) were detected in exit pathway groundwater at ORNL during 2016. Both are common laboratory contaminants and are thought to be present due to contamination of the samples by the laboratory.

Radiological and metal contaminant concentrations observed in groundwater exit pathway discharge areas were generally consistent with observations reported in past annual site environmental reports for the ORR. Based on the results of the 2016 monitoring effort, there is no indication that current SC operations are significantly introducing contaminants to the groundwater at ORNL.

Active Sites Monitoring—High Flux Isotope Reactor

Outfall pipelines intercepting groundwater are routinely monitored under the ORNL NPDES permit. (See Section 5.5 for a discussion of results.)

Active Sites Monitoring—Spallation Neutron Source

Active sites groundwater surveillance monitoring was performed in 2016 at the SNS site under the SNS operational monitoring plan (OMP) (Bonine et al. 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 OMP 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. Figure 5.39 shows the locations of the specific monitoring points sampled during 2016.

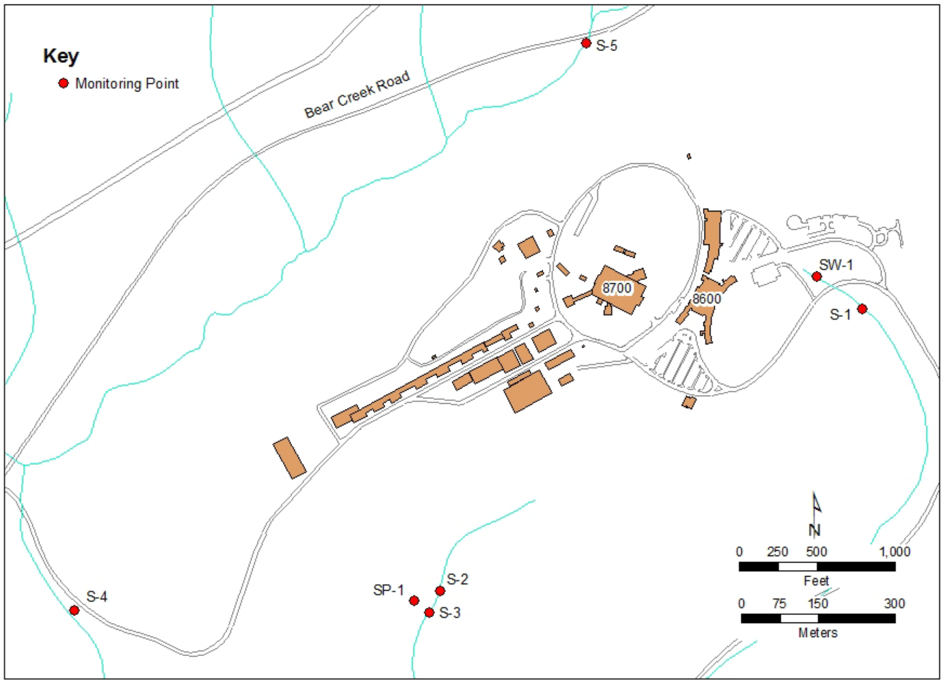

Fig. 5.39. Groundwater monitoring locations at the Spallation Neutron Source, 2016. *Springs are labeled with an S, seeps are labeled with SP, and surface water sampling areas are labeled with SW.*

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 this statistical analysis of the April 2004–September 2011 data set were the basis for the modified OMP monitoring scheme implemented in 2016.

Quarterly sampling at each monitoring point continued in 2016, allowing the opportunity for monitoring in wet and dry seasons. All sampling performed in 2016 was performed in conjunction with rainfall events, with samples being collected during rising or falling (recession) limb flow conditions (see Fig. 5.40). In Fig. 5.40, the curves represent spring or seep flow (base flow, through flow, overland flow, peak flow); the bars represent rainfall amounts. Table 5.18 shows the sampling and parameter analysis schedule followed in 2016.

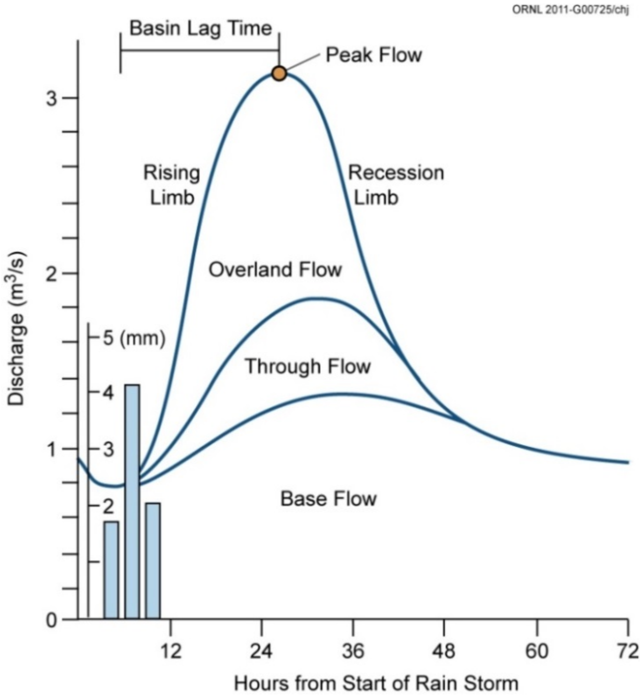

Fig. 5.40. Simple hydrograph of spring discharge vs. time after initiation of rainfall.

Spallation Neutron Source Site Results. In 2016 sampling at the SNS site occurred during March (quarter 1), May (quarter 2), August (quarter 3), and November (quarter 4). Low concentrations of several radionuclides were detected numerous times during 2016. Table 5.18 provides a summary of the locations for radionuclide detections observed during 2016.

Sampling results were compared against reference standards. Reference standards used for comparison are either 4% of the DOE O 458.1 DCSs or the National Primary Drinking Water Standards (40 CRF Part 141). Gross alpha activity was detected in S-5 at a concentration exceeding its reference standard of 15 pCi/L during the fourth-quarter sampling event. Additionally, uranium isotopes were detected in samples collected from S-5 during the fourth-quarter event. The source of these radionuclides is most likely the S-3 Ponds at Y-12. The S-3 Ponds are located up-gradient of S-5 and are interconnected via karst features to S-5. No other radionuclide exceeded its reference standard at SNS monitoring locations in 2016.

Table 5.18. Analytical results for parameters detected in samples collected at the Spallation Neutron Source during 2016 (pCi/L)

Quarter	Sampling station[a]	Parameter	Result	Reference standard
1	S-1	Tritium	452	20,000
	S-2	Tritium	418	20,000
	S-3	Tritium	311	20,000
	S-4	Tritium	570	20,000
	SP-1	Beta	4.29	50
	SW-1	Tritium	739	20,000
2	S-1	Alpha	4.67	15
	S-1	Tritium	4950	20,000
	S-2	Tritium	521	20,000
	S-4	Tritium	478	20,000
	SP-1	Tritium	334	20,000
	SW-1	Alpha	6.33	15
	SW-1	Beta	4.56	50
	SW-1	Bi-214	24.2	10,400
	SW-1	Tritium	2,350	20,000
3	S-1	Tritium	498	20,000
	S-2	Beta	5.01	50
	S-2	Bi-214	9.25	10,400
	S-2	Tl-208	4.27	No standard
	S-2	Tritium	564	20,000
	S-3	Bi-214	13.2	10,400
	SP-1	Tritium	304	20,000
	SW-1	Tritium	945	20,000
4	S-1	Tritium	261	20,000
	S-2	Tritium	263	20,000
	S-5	Alpha	19.7	15
	S-5	Beta	12	50
	S-5	Th-232	0.373	6
	S-5	U-233/234	5.31	No standard
	S-5	U-235/236	0.274	No standard
	S-5	U-238	9.18	30
	SP-1	Tritium	413	20,000
	SW-1	Tritium	204	20,000

[a] Springs are labeled with an S, seeps are labeled with SP, and surface water sampling areas are labeled with SW.

5.7 Quality Assurance Program

The UT-Battelle Quality Management System (QMS) has been developed to implement the requirements defined in DOE O 414.1D (DOE 2011c). The methods used for successful implementation of the QMS rely on the integration and implementation of quality elements/criterion 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; and
- provide feedback.

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

Environmental sampling standard operating procedures developed for UT-Battelle environmental sampling programs provide detailed instructions on maintaining chain of custody; sample identification; sample collection and handling; sample preservation; equipment decontamination; and collection of 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 employees and nonemployee staff of UT-Battelle 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.

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

5.7.3.1 Calibration

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 that are traceable to an authority standard. The UT-Battelle Facilities and Operations Instrumentation and Control Services team tracks all equipment used in the environmental monitoring programs conducted by UT-Battelle for the ORNL site and ORR through a maintenance recall program to ensure that equipment is functioning properly and within defined tolerance ranges. 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 (RATA) is performed annually to certify the Predictive Emissions Monitoring System (PEMS) for nitrogen oxides and oxygen. The purpose of a RATA is to provide a rigorous QA assessment in accordance with EPA 40 CFR, Performance Specification 16. The accuracy of PEMS is determined three times per year by performing a RATA on a second, calibrated system. The results of these QA tests are provided to TDEC quarterly, semiannually, or annually as applicable.

5.7.3.2 Standardization

The UT-Battelle IDMS provides the necessary functionality and controls to ensure that controlled documents are managed, distributed, revised, and maintained in accordance with ORNL document control requirements. EPSD sampling procedures are maintained in IDMS 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 2016 and information on the number of findings identified, if any. EPSD also conducts internal management assessments of UT-Battelle environmental monitoring procedural compliance, safety performance, and work planning and control. 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

The contract laboratories that perform analyses of environmental samples from the UT-Battelle environmental monitoring programs at ORNL and on ORR are required to have documented QA/QC programs, trained and qualified staff, appropriately maintained equipment and facilities, and applicable certifications. Several laboratories are contracted under basic ordering agreements to perform analytical work to characterize UT-Battelle environmental samples. As applicable, the laboratories participate in accreditation, certification, and performance evaluation programs, including the National Environmental Laboratory Accreditation Program, Mixed Analyte Performance Evaluation Program, Discharge Monitoring Report Quality Assurance Study, and DOE Environmental Management Consolidated Audit Program. Any issues of concern identified through accreditation/certification programs or performance evaluation testing are addressed with analytical laboratories and are considered when determinations are made on data integrity.

A statement of work for each project specifies any additional QA/QC requirements and includes detailed information on data deliverables, turnaround times, and required methods and detection limits. Blank and duplicate samples are routinely submitted along with ORR environmental samples to provide an additional check on analytical laboratory performance.

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 Records Management System provides the requirements for managing all UT-Battelle records. Requirements include creating and identifying record material; scheduling, protecting, and storing records in office areas and in the UT-Battelle Inactive Records Center; 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 Oak Ridge National Laboratory

The three campuses on the 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 the ORR are on the EPA NPL, which includes hazardous waste sites across the nation that are to be cleaned up under CERCLA. Areas that require cleanup or further action on the ORR have been clearly defined, and EM is working to clean those areas under the Federal Facility Agreement with the EPA and TDEC. The *2016 Cleanup Progress Annual Report to the Oak Ridge Regional Community* (UCOR 2016) provides detailed information on DOE EM's 2016 cleanup activities.

5.8.1 Oak Ridge National Laboratory Wastewater Treatment

At ORNL, DOE EM operates PWTC and the Liquid Low-Level Waste Treatment Facility. In 2016 313 million L of wastewater was treated and released at PWTC. In addition, the liquid LLW evaporator at ORNL treated 388,360 L of waste. The waste treatment activities of these facilities support both DOE EM 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 Oak Ridge National Laboratory 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. UT-Battelle, as the prime contractor for the management of ORNL, is responsible for management of most of the wastes generated from R&D activities and wastes generated from operation of the R&D facilities. TRU wastes and waste streams that can be treated by on-site liquid and/or gaseous waste treatment facilities operated by EM 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 2016, ORNL performed 96 waste shipments to off-site hazardous/radiological/mixed waste treatment and/or disposal vendors with no shipment rejections or violations.

5.8.3 Transuranic Waste Processing Center

TRU waste-processing activities carried out for DOE in 2016 by NWSol addressed CH solids/debris and RH solids/debris, which involved processing, treating, and repackaging of waste. Off-site transportation and disposal of LLW at the Nevada National Security Site or other approved off-site facilities was also performed in 2016. TRU waste disposal at the Waste Isolation Pilot Plant will resume once the facility is reopened to receive TRU waste.

During 2016, 26.21 m^3 of CH waste and 73.75 m^3 of RH waste were processed, and 11.96 m^3 of mixed LLW (TRU waste that was recharacterized as low level waste) was shipped off the site.

5.9 References

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