

Oak Ridge Reservation

Annual Site Environmental Report

2024



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Acronyms and Abbreviations

A	ACM	asbestos-containing material
	AFFF	aqueous film-forming foams
	AFV	alternative fuel vehicle
	AIM	American Innovation and Manufacturing Act
	ANSI	American National Standards Institute
	AOEC	Agent Operations Eastern Command
	ASER	*Oak Ridge Reservation Annual Site Environmental Report*
	AWQC	ambient water quality criterion
B	BCG	biota concentration guide
	BCK	Bear Creek kilometer
	BFK	Brushy Fork kilometer
	BMAP	Biological Monitoring and Abatement Program
	BMP	best management practice
C	CAA	Clean Air Act
	CAP-88 PC	Clean Air Act Assessment Package-1988 (software)
	CEDS	Central Energy Data System
	CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
	CFR	*Code of Federal Regulations*
	CFTF	Carbon Fiber Technology Facility
	CNS	Consolidated Nuclear Security, LLC
	COVID-19	Coronavirus Disease 2019
	CRK	Clinch River kilometer
	CROET	Community Reuse Organization of East Tennessee
	CWA	Clean Water Act
	CWTS	Chromium Water Treatment System
	CX	categorical exclusion
	CY	calendar year
D	D&D	decontamination and decommissioning
	DCE	dichloroethene/dichloroethylene
	DCS	derived concentration standard
	DMRQA	Discharge Monitoring Report Quality Assurance Study
	DOD-ELAP	US Department of Defense Environmental Laboratory Accreditation Program
	DOE	US Department of Energy
	DOECAP	DOE Consolidated Audit Program

E	EC	environmental compliance
	ECM	energy conservation measure
	ED	effective dose
	EFK	East Fork Poplar Creek kilometer
	EFPC	East Fork Poplar Creek
	EIS	environmental impact statement
	EISA	Energy Independence and Security Act of 2007
	EM	DOE Office of Environmental Management
	EMDF	Environmental Disposal Facility
	EMP	Environmental Monitoring Program
	EMS	environmental management system
	EMWMF	Environmental Management Waste Management Facility
	EO	executive order
	EPA	US Environmental Protection Agency
	EPCRA	Emergency Planning and Community Right-to-Know Act
	EPSD	UT-Battelle Environmental Protection Services Division
	EPT	ephemeroptera, plecoptera, and trichoptera (taxa)
	e-RICE	emergency reciprocating internal combustion engine
	ES&H	environment, safety, and health
	ESH&Q	environment, safety, health, and quality
	ESPC	Energy Savings and Performance Contract
	ESS	ORNL Environmental Surveillance System
	ETTP	East Tennessee Technology Park
	EU	exposure unit
F	FCK	First Creek kilometer
	FFK	Fifth Creek kilometer
	FMD	ORNL Facilities Management Division
	FWS	US Fish and Wildlife Service
	FY	fiscal year
G	GHG	greenhouse gas
	GSA	General Services Administration
H	HAP	hazardous air pollutant
	HCK	Hinds Creek kilometer
	HFIR	High Flux Isotope Reactor
	Hg^{2+}	inorganic mercury
	Hg_T	total mercury
	HQ	hazard quotient
	HVC	ORNL Hardin Valley Campus

I	IC	inhibition concentration
	ISMS	integrated safety management system
	ISO	International Organization for Standardization
	Isotek	Isotek Systems, LLC
J	JCI	Johnson Controls Inc.
L		
	LLW	low-level radioactive waste
	LPF	Lithium Processing Facility
M	M&E	material and equipment
	M&V	measurement and verification
	MAPEP	Mixed Analyte Performance Evaluation Program
	MARSAME	*Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual*
	MARSSIM	*Multi-Agency Radiation Survey and Site Investigation Manual*
	MBK	Mill Branch kilometer
	MCK	McCoy Branch kilometer
	MCL	maximum contaminant level
	MCL-DCs	maximum contaminant level-derived concentrations
	MEI	maximally exposed individual
	MEK	Melton Branch kilometer
	MeHg	methylmercury
	MIK	Mitchell Branch kilometer
	MOA	memorandum of agreement
	MPNHP	Manhattan Project National Historical Park
	MT	meteorological tower
N	NAAQS	National Ambient Air Quality Standards
	NELAP	National Environmental Laboratory Accreditation Program
	NEPA	National Environmental Policy Act
	NESHAPs	National Emission Standards for Hazardous Air Pollutants
	NFPA	National Fire Protection Association
	NHPA	National Historic Preservation Act
	NNSA	National Nuclear Security Administration
	NPDES	National Pollutant Discharge Elimination System
	NPO	NNSA Production Office
	NRC	US Nuclear Regulatory Commission
	NRHP	National Register of Historic Places
	NTRC	National Transportation Research Center

O	ODS	ozone-depleting substance
	ORAU	Oak Ridge Associated Universities
	OREM	DOE Oak Ridge Office of Environmental Management
	ORGDP	Oak Ridge Gaseous Diffusion Plant
	ORISE	Oak Ridge Institute for Science and Education
	ORNL	Oak Ridge National Laboratory
	ORO	DOE Oak Ridge Office
	ORR	Oak Ridge Reservation
	ORRL	Oak Ridge Reservation Landfills
	ORSSAB	Oak Ridge Site Specific Advisory Board
	OST	Office of Secure Transportation
P	PCB	polychlorinated biphenyl
	PCBADL	Polychlorinated Biphenyl Annual Document Log
	PCCR	phased construction completion report
	PCE	tetrachloroethene
	PFAS	per- and polyfluoroalkyl substances
	PFOA	perfluorooctanoic acid
	PFOS	perfluorooctane sulfonate
	PM_{10}	particulate matter with an aerodynamic diameter ≤ 10 µm
	$PM_{2.5}$	fine particulate matter with an aerodynamic diameter ≤ 2.5 µm
	PWTC	Process Waste Treatment Complex
Q	QA	quality assurance
	QC	quality control
	QMS	quality management system
R	R&D	research and development
	RA	remedial action
	Rad-NESHAPs	National Emission Standards for Hazardous Air Pollutants for Radionuclides
	RCRA	Resource Conservation and Recovery Act
	RECs	renewable energy credits
	RMAL	Radiochemical Materials Analytical Laboratory
	ROD	record of decision
S	SARA	Superfund Amendments and Reauthorization Act
	SBMS	UT-Battelle Standards-Based Management System
	SC	DOE Office of Science
	SD	storm water outfall/storm drain
	SHPO	State Historic Preservation Office
	SME	subject matter expert
	SNS	Spallation Neutron Source
	SODAR	sonic detection and ranging

	SOF	sum of fractions
	SPCC	spill prevention, control, and countermeasures
	SPMD	semipermeable membrane device
	STP	sewage treatment plant
	SWPP	storm water pollution prevention
	SWPPP	storm water pollution prevention plan
	SWSA	solid waste storage area
T	Tc	technetium
	TCA	trichloroethane
	TCE	trichloroethene/trichloroethylene
	TDEC	Tennessee Department of Environment and Conservation
	TEMA	Tennessee Emergency Management Agency
	TMDL	total maximum daily load
	TMI	Tennessee Macroinvertebrate Index
	TRI	toxic chemical release inventory
	TRO	total residue oxidant
	TRU	transuranic
	TSCA	Toxic Substances Control Act
	TSS	total suspended solids
	TVA	Tennessee Valley Authority
	TWPC	Transuranic Waste Processing Center
	TWRA	Tennessee Wildlife Resources Agency
U	UCOR	United Cleanup Oak Ridge LLC
	UEFPC	Upper East Fork Poplar Creek
	UPF	Uranium Processing Facility
	USDA	US Department of Agriculture
	UST	underground storage tank
	UT	University of Tennessee
	UT-Battelle	UT-Battelle, LLC
V	VC	vinyl chloride
	VOC	volatile organic compound
	VOHAP	volatile organic hazardous air pollutant
W	WBK	Walker Branch kilometer
	WCK	White Oak Creek kilometer
	WEPAR	West End Protected Area Reduction
	WFMP	*Oak Ridge Reservation Wildland Fire Management Plan*
	WM/WRM	weapon material/weapon-related material
	WOC	White Oak Creek
	WOCHW	White Oak Creek headwaters

	WOD	White Oak Dam
	WQC	water quality criterion
	WQPP	water quality protection plan
	WRRP	Water Resources Restoration Program
Y	Y-12 or Y-12 Complex	Y-12 National Security Complex

Units of Measure and Conversion Factors*

Units of measure and their abbreviations

acre	acre	miles per hour	mph
becquerel	Bq	millicurie	mCi
British thermal unit	Btu	milligram	mg
centimeter	cm	milliliter	mL
curie	Ci	millimeter	mm
day	d	million	M
degrees Celsius	°C	million gallons per day	MGD
degrees Fahrenheit	°F	millirad	mrad
disintegrations per minute	dpm	millirem	mrem
foot	ft	milliroentgen	mR
gallon	gal	millisievert	mSv
gallons per minute	gpm	minute	min
gram	g	nanogram	ng
gray	Gy	nephelometric turbidity unit	NTU
gross square feet	gsf	parts per billion	ppb
hectare	ha	parts per million	ppm
hour	h	parts per trillion	ppt
inch	in.	picocurie	pCi
joule	J	pound	lb
kilocurie	kCi	pound mass	lbm
kilogram	kg	pounds per square inch	psi
kilometer	km	pounds per square inch gauge	psig
kilowatt	kW	quart	qt
linear feet	LF	rad	rad
liter	L	roentgen	R
millibar	mb	roentgen equivalent man	rem
megajoule	MJ	second	S
megawatt	MW	sievert	Sv
megawatt-hour	MWh	standard unit (pH)	SU
meter	m	thousand cubic feet	mcf
metric tons	MT	ton, short (2,000 lb)	ton
metric tons of carbon	MTCO2e	wet weight	ww
microcurie	µCi	yard	yd
microgram	µg	year	Yr
micrometer	µm		

Quantitative prefixes

exa	$\times 10^{18}$	mega	$\times 10^{6}$	atto	$\times 10^{-18}$	micro	$\times 10^{-6}$
peta	$\times 10^{15}$	kilo	$\times 10^{3}$	femto	$\times 10^{-15}$	milli	$\times 10^{-3}$
tera	$\times 10^{12}$	hecto	$\times 10^{2}$	pico	$\times 10^{-12}$	center	$\times 10^{-2}$
giga	$\times 10^{9}$	deka	$\times 10^{1}$	nano	$\times 10^{-9}$	decic	$\times 10^{-1}$

**Due to differing permit reporting requirements and instrument capabilities, various units of measurement are used in this report. This list of units of measure and conversion factors is intended to help readers make approximate conversions to other units as needed for specific calculations and comparisons.*

Unit conversions

Unit	Conversion	Equivalent	Unit	Conversion	Equivalent
Length					
in.	× 2.54	cm	cm	× 0.394	in.
ft	× 0.305	m	m	× 3.28	ft
mile	× 1.61	km	km	× 0.621	mile
Area					
acre	× 0.405	ha	ha	× 2.47	acre
ft^2	× 0.093	m^2	m^2	× 10.764	ft^2
$mile^2$	× 2.59	km^2	km^2	× 0.386	$mile^2$
Volume					
ft^3	× 0.028	m^3	m^3	× 35.31	ft^3
qt	× 0.946	L	L	× 1.057	qt
gal	× 3.7854118	L	L	× 0.264172051	gal
Concentration					
ppb	× 1	µg/kg	µg/kg	× 1	ppb
ppm	× 1	mg/kg	mg/kg	× 1	ppm
ppb	× 1	µg/L	µg/L	× 1	ppb
ppm	× 1	mg/L	mg/L	× 1	ppm
Weight					
lb	× 0.4536	kg	kg	× 2.205	lb
lbm	× 0.45356	kg	kg	× 2.2046226	lbm
ton, short	× 907.1847	kg	kg	× 0.00110231131	ton, short
Temperature					
°C	°F = (9/5)°C + 32	°F	°F	°C = (5/9) (F–32)	°C
Activity					
Bq	$\times 2.7 \times 10^{-11}$	Ci	Ci	$\times 3.7 \times 10^{10}$	Bq
Bq	× 27	pCi	pCi	× 0.037	Bq
mSv	× 100	mrem	mrem	× 0.01	mSv
Sv	× 100	rem	rem	× 0.01	Sv
nCi	× 1,000	pCi	pCi	× 0.001	nCi
mCi/km^2	× 1	nCi/m^2	nCi/m^2	× 1	mCi/km^2
dpm/L	$\times 0.45 \times 10^9$	$\mu Ci/cm^3$	$\mu Ci/cm^3$	$\times 2.22 \times 10^9$	dpm/L
pCi/L	$\times 10^{-9}$	µCi/mL	µCi/mL	$\times 10^9$	pCi/L
pCi/m^3	$\times 10^{12}$	$\mu Ci/cm^3$	$\mu Ci/cm^3$	$\times 10^{12}$	pCi/m^3

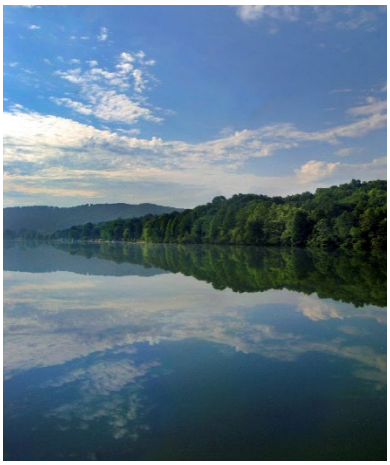
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Located on the banks of the Clinch River, the Oak Ridge Reservation comprises three major facilities involved in every mission in the DOE portfolio. DOE is committed to enhancing environmental stewardship and managing the impacts its operations may have on the environment.

Executive Summary

Overview

The Oak Ridge Reservation (ORR) is located in Roane and Anderson Counties in East Tennessee. It is about 40 km (25 mi) west of Knoxville and is managed by the US Department of Energy (DOE). Today, ORR is one of DOE's most complex sites. The site was established in the early 1940s as part of the Manhattan Project to enrich uranium and pioneer methods for producing and separating plutonium; ORR continued those activities until the mid-1980s. Today, ORR comprises three sites with thousands of employees performing every mission in the DOE portfolio: energy research, environmental restoration, national security, nuclear fuel supply, reindustrialization, science education, basic and applied research in areas important to US security, and technology transfer. Scientists at the Oak Ridge National Laboratory (ORNL), DOE's largest science and energy laboratory, conduct leading-edge research in advanced materials, neutron scattering, nuclear programs (including isotope production), and high-performance computing. The Y-12 National Security Complex (Y-12 or Y-12 Complex) is vital to maintaining the safety, security, and effectiveness of the US nuclear weapons stockpile and reducing the global threat posed by nuclear proliferation and terrorism. The Heritage Center, the former uranium enrichment complex known as East Tennessee Technology Park (ETTP), has been transitioned to a clean, revitalized industrial park.

ORR is managed by three DOE Program Secretarial Offices, their management and operating contractors, and other prime contractors. This calendar year 2024 Oak Ridge Reservation Annual Site Environmental Report (ASER) contains information furnished to the DOE ORR integrating contractor by other contractors, including UT-Battelle, LLC (UT-Battelle); Consolidated Nuclear Security, LLC; United Cleanup Oak Ridge LLC (UCOR); Oak Ridge Associated Universities; and Isotek Systems, LLC (Isotek). DOE and its contractors at ORR are committed to environmental protection and compliance, which includes the site's utmost efforts to ensure the validity and accuracy of monitoring data.

Chapter 3 of this report was prepared by UCOR, the lead cleanup contractor for DOE's Oak Ridge Office of Environmental Management (OREM). Chapter 4 was developed by Consolidated Nuclear Security, LLC, which manages and operates the Y-12 Complex. Chapters 5, 6, and 7 were written by UT-Battelle, LLC, the ORNL management and operating contractor. These contractors are responsible for independently carrying out the various DOE missions at the three major ORR sites. They manage and implement environmental protection programs through environmental management systems that adhere to International Organization for Standardization Standard 14001, Environmental Management Systems. Chapters 3, 4, and 5 include detailed information on each contractor's environmental management systems, which interface with DOE's signature integrated safety management system (ISMS) to provide unified strategies for managing resources. ISMS incorporates safety in all aspects of work and helps ensure safety at all DOE facilities. Safety, as defined in ISMS, encompasses protection of the public, the worker, and the environment and includes all safety, health, and environmental disciplines: radiation protection, fire protection, nuclear safety, environmental protection, waste management, and environmental management.

DOE operations on ORR have the potential to release various constituents to the environment via atmospheric, surface water, and groundwater pathways. Some of these constituents, such as particles from diesel engines, are common at many types of facilities. Other constituents, such as radionuclides, are unique to specialized research and production activities like those conducted on ORR. DOE is committed to enhancing environmental stewardship and managing the impacts its operations may have on the environment. To encourage the public to participate in matters related to ORR's environmental impact on the community, DOE solicits citizens' input, through multiple channels, on matters of significant public interest. DOE also offers access to information on its Oak Ridge environmental, safety, and health activities.

The ASER is prepared for DOE according to the requirements of DOE Order 231.1B, *Environment, Safety, and Health Reporting*. The ASER includes data on the environmental performance of each major DOE ORR contractor and describes significant accomplishments in pollution prevention programs that reduce many types of waste and pollutant releases to the environment. Since the mid-1970s, DOE has published an annual environmental report with consolidated data on overall ORR performance and status. The ASER is a key component of DOE's effort to keep the public informed about environmental conditions across DOE and National Nuclear Security Administration sites.

Impacts

In 2024, DOE ORR operations resulted in minimal impact to the public and the environment. Permitted discharges to air and water continued to be well below regulatory standards. In addition, potential radiation doses to the public from activities on the reservation were much less than the 100 mrem standard established for DOE sites in DOE Order 458.1, *Radiation Protection of the Public and the Environment*.

The maximum radiation dose a hypothetical off-site individual could have received from DOE activities on ORR in 2024 was estimated to be 0.6 mrem from air pathways, 0.3 mrem from water pathways (drinking water, fish consumption, swimming, recreation, and other uses), and 3 mrem from the consumption of wildlife harvested on ORR. This is under 4 percent of the DOE 100 mrem standard for all pathways and is significantly less than the 300 mrem annual average dose from background radiation to people in the United States.

Environmental Monitoring

Each year, extensive environmental monitoring is conducted across ORR. Site-specific environmental protection programs are implemented at ORNL, the Y-12 Complex, and

ETTP. ORR-wide environmental surveillance programs, which include locations and media both on and off the reservation, enhance and supplement data from site-specific efforts. In 2024, many thousands of samples and measurements of air, water, direct radiation, vegetation, fish, and wildlife were collected from across the reservation; these samples were analyzed for radioactive and nonradioactive contaminants. Sample media, locations, frequencies, and parameters were selected based on environmental regulations and standards, public and environmental exposure pathways, environmental permits, and measurement capabilities. Chapters 2 through 7 of this report summarize the environmental protection and surveillance programs on ORR. These extensive sampling and monitoring efforts demonstrate DOE's commitment to ensuring safety; protecting human health; complying with regulations, standards, DOE orders, and the "as low as (is) reasonably achievable" principle; reducing the risks associated with past, present, and future operations; and improving cost-effectiveness.

Compliance with Environmental Regulations

Federal, state, and local government agencies, including the US Environmental Protection Agency and the Tennessee Department of Environment and Conservation, monitor ORR for compliance with applicable environmental regulations. These agencies issue permits, review compliance reports, participate in monitoring programs, and inspect facilities and operations. Compliance with environmental regulations and DOE orders ensures ORR activities do not result in adverse impacts to the public or the environment.

Compliance in 2024 with applicable regulations for the three major ORR sites is summarized as follows:

- ETTP had no notices of environmental violations or penalties.
- Y-12 had 100 percent compliance with water quality permit discharge limits for 2024 and no Clean Air Act violations or exceedances. However, three Clean Water Act violations were noted. Two violations were the result of fish kills on June 20, 2024, from a potable water line break, and on October 1, 2024, from concrete mix entering East Fork Poplar Creek. A third violation, an instantaneous flow rate exceedance in the sanitary sewer, occurred on July 28, 2024, from excessive rainfall. From May 21-22, 2024, personnel from the Tennessee Department of Environment and Conservation Division of Solid Waste Management performed an unannounced Resource Conservation and Recovery Act hazardous waste compliance inspection of Y-12. One issue was identified: a 10-gal container of hazardous waste was not labeled with the accumulation start date. This was corrected immediately. The issue and its causes were reviewed to prevent recurrence.
- ORNL facilities include those on the Oak Ridge campus as well as off-campus entities, such as the National Transportation Research Center and the Carbon Fiber Technology Facility. A compliance inspection by TDEC on December 12, 2024, resulted in the issuance of a minor violation for a petroleum underground storage tank. The violation was immediately resolved and was closed by TDEC on January 14, 2025. No notices of environmental violations or penalties were received by other contractors (Isotek and UCOR) who conducted activities at ORNL in 2024. ORNL wastewater treatment facilities achieved a numeric permit compliance rate of 100 percent in 2024. The Carbon Fiber Technology Facility also achieved 100 percent compliance with the UT-Battelle City of Oak Ridge Industrial and Commercial User Discharge Pre-Treatment Permit in 2024.

Chapter 2 provides a more detailed summary of ORR environmental compliance during 2024. Chapters 3, 4, and 5 further discuss each site's compliance status for the year. All chapters discuss lessons learned, participation in work groups, and involvement with communities of practice, as applicable.

Environmental Management and Pollution Prevention

Numerous environmental management and pollution prevention programs across ORR embody efforts to achieve continuous distinction in facility operations and organizational culture. The objectives of these programs are to conserve water and energy and minimize waste. They also aim to promote energy-efficient buildings, landscaping to reduce environmental impact, green transportation, and environmentally responsible procurement. Consequently, these initiatives decrease the life cycle costs of programs and projects while also reducing risks to the environment. As described in Chapters 3, 4, and 5, ORR contractors achieved a high level of excellence in environmental management and pollution prevention programs in 2024.

Environmental Management

Since 1943, ORR has played key roles in America's defense and energy research. However, past waste disposal practices, operational and industrial practices, changing standards, and unintentional releases left some land and facilities contaminated with radioactive elements, mercury, asbestos, polychlorinated biphenyls, and industrial wastes. The DOE Environmental Management program is responsible for cleaning up these sites; as a result, numerous cleanup projects are underway at the reservation's three main facilities.

Completion of soil remediation at ETTP, referred to as Vision 2024, has been achieved 4 years after UCOR completed demolition of all unneeded facilities at the site. During this cleanup, OREM worked to transform ETTP into a multiuse industrial park. Currently, there are 25 businesses operating at the site. As part of transforming the site into a community asset, attention will now turn to the final remediation effort at ETTP: addressing final cleanup of groundwater and surface water.

Deactivation activities at three large former uranium processing facilities—Alpha-2, Alpha-4, and Beta-1— were among Y-12 achievements in 2024. (Demolition began at Alpha-2 later in the year.) Currently, there are 44 excess facilities at Y-12, and within the next 10 years, another 39 buildings and trailers will be excessed. Also in 2024, UCOR assumed construction responsibility for the Outfall 200 Mercury Treatment Facility and began construction of the treatment plant and headworks facility. In support of ongoing mercury remediation, a new Technology Demonstration Facility is being developed in the repurposed Disposal Area Remedial Action facility to carry out demonstrations of proposed mercury treatment technologies.

Accomplishments in continuing demolition and deactivation were made at ORNL in 2024. These activities included shipment of the reactor vessel from the Low-Intensity Test Reactor (Building 3005) for off-site disposal. Deactivation work is ongoing in six of the 11 buildings comprising "Isotope Row" (facilities historically used to process radioisotopes). To this end, four Krypton tanks have been removed from Building 3093; the building is now in its deactivation end state. In addition, water tanks shielding hot cells in Building 3038 have been removed. Further, through continuing work to remove the building's final hot cell, Building 3026 is being prepared for demolition in 2025. Deactivation activities also continued at the Oak Ridge Graphite Reactor support facility buildings 3002 (Filter House), 3003 (Fan House), and 3018 (Exhaust Stack); the process is nearing completion with demolition expected to begin in 2025.

The Environmental Management Waste Management Facility received 9,976 waste shipments from ORR cleanup projects in 2024. Environmental Management Waste Management Facility operations also collected, analyzed, and disposed of approximately 3.42 million gallons of leachate treated by the Liquid and Gaseous Waste Operations Facility.

In FY 2024, the Transuranic Waste Processing Center compliantly performed 12 shipments of legacy transuranic waste shipments (301 drums) to the Waste Isolation Pilot Plant in Carlsbad, New Mexico, and 12 shipments of mixed low-level waste to treatment and disposal, low-level waste,

and hazardous industrial waste resulting from the processing and certification of the transuranic legacy waste. The Transuranic Waste Processing Center team also processed and repackaged four boxes and 13 drums of Nuclear Fuel Services waste into 140 drums of compliant soil and debris for disposal.

Pollution Prevention and Resource Management

The three main ORR sites made significant strides in resource management and pollution prevention in 2024; highlights are summarized below.

In 2024, Y-12 experienced a slight decrease in energy intensity (three-quarters of a percentage below 2023). Also in 2024, Y-12 diverted 59.9 percent of municipal and 2.8 percent of construction and demolition waste from landfill disposal through reuse and recycle and certified one building as a High Performance Sustainable Building.

ORNL implemented 28 ongoing and new pollution prevention projects during 2024. These projects eliminated more than 2.6 million kg of waste. Presently, 80 percent of all ORNL vehicles are alternative fuel vehicles (AFVs), with 86 percent of all replacements since FY 2020 being alternative fuel or electric vehicles. Also, 77 percent of the light-duty vehicles operate on alternative fuels. Water use intensity increased by 5 percent between 2023 and 2024 due to increased demands for cooling tower makeup water to support growth of high-performance computing systems. Calculated energy use intensity for FY 2024 was 250,387 Btu per gross square foot, a cumulative reduction of 31.2 percent since FY 2003 but an increase of 5.42 percent from FY 2023.

During 2024 at ETTP, OREM continued to see significant momentum in the Reindustrialization Program. The former government-owned uranium enrichment complex is being turned into a multiuse industrial park that includes national historic preservation and conservation and green space areas. OREM has transferred over 1,700 acres for economic development at ETTP, including 470 acres during FY 2024. Reindustrialization efforts at ETTP are expected to generate 1,400 jobs from the $1.35 billion in investments announced by the on-site companies, which are largely focusing on clean energy technology.

OREM continued planning for capital asset projects that will further advance ORR cleanup objectives. These include completion of the following activities over the next five years: construction of the Outfall 200 Mercury Treatment Facility at Y-12; demolition activities at ORNL's Central Campus, Beta-1, and Alpha-2; processing, downblending, and disposing of the remaining inventory of ^{233}U stored at ORNL; and construction of the first phase of the new Environmental Management Disposal Facility.



Signs such as this were common in the city of Oak Ridge during the Manhattan Project era and for years afterward.

1

Introduction to the Oak Ridge Reservation

The Oak Ridge Reservation (ORR), located in East Tennessee, was part of the Manhattan Project during World War II. Construction of the reservation began in 1942 and continued during the war and beyond. Today, ORR covers a little over 50 square miles of land in Anderson and Roane counties and is home to two major US Department of Energy (DOE) operating facilities: the Oak Ridge National Laboratory (ORNL) and the Y-12 National Security Complex (Y-12).

Other ORR facilities include the following:

- East Tennessee Technology Park (ETTP), the site of the former K-25 gaseous diffusion plant that has undergone significant environmental cleanup and transitioned to a private sector business and industrial park
- The Oak Ridge Institute for Science and Education (ORISE) South Campus, which includes training, laboratory, and support facilities
- The government-owned, government-operated Agent Operations Eastern Command (AOEC) of the National Nuclear Security Administration (NNSA) Office of Secure Transportation (OST)
- The Transuranic Waste Processing Center (TWPC)
- Small government-owned, contractor-operated environmental cleanup facilities

Due to different permit reporting requirements and instrument capabilities, this report uses various units of measurement. The lists of units of measure and conversion factors on pages xxxiii and xxxiv are included to help readers convert numeric values as needed for specific calculations and comparisons.

1.1. Background

The ORR Annual Site Environmental Report (ASER) is a consolidated report that fulfills the annual reporting requirements of the NNSA and DOE's Office of Environmental Management (EM) under DOE Order 231.1B Chg.1, Environment, Safety, and Health Reporting (DOE 2011).

ORR's ASER summarizes environmental data that characterizes environmental performance, lists environmental occurrences reported during the year, confirms compliance with environmental standards and requirements, and highlights significant environmental program activities. This ASER also demonstrates the site's compliance with the radiological protection requirements of DOE O 458.1 (DOE 2020).

Summary results in this report are based on data collected before and continuing through 2024. Not all results of the environmental monitoring associated with ORR are reported here, so this is not intended to be a comprehensive monitoring report. Data collected for other site and regulatory purposes, such as environmental restoration and remedial investigation reports, waste management characterization sampling data, and environmental permit compliance data, are presented in other documents that have been prepared in accordance with applicable laws, regulations, policies, and guidance. These data are referenced in this report as appropriate.

Environmental monitoring of ORR activities consists primarily of effluent monitoring and environmental surveillance. Effluent monitoring involves the collection and analysis of samples or measurements of liquid and gaseous effluents at the points of their release to the environment. These measurements allow quantification and official reporting of contaminant levels, assessment of public exposures to radiation (see Appendix E) and chemicals (see Appendix F), and demonstration of compliance with applicable standards and permit requirements. Environmental surveillance consists of direct measurement, collection, and analysis of samples taken from the site and its environs, exclusive of effluents. These surveillance activities provide information on contaminant concentrations in air, water, groundwater, soil, foods, biota, and other media. Environmental surveillance data support environmental compliance and, when combined with data from effluent monitoring, also support chemical and radiation dose and exposure assessments of any potential effects of ORR operations on the local environment.

1.2. History of the Area around the Oak Ridge Reservation

Native Americans first inhabited the ORR area during the Woodland Period (c. 900 BC to AD 1000). Their descendants still lived in the East Tennessee region when European settlers arrived in the late 1700s. The Cherokee Nation controlled the region at this time, but the 1791 Treaty of the Holston and the 1798 Treaty of Tellico allowed for European settlement, which forever altered the landscape. As settlements continued to grow in numbers, new counties were formed, including Roane County and Anderson County in 1801. Early European settlers of the area lived on farms or in four small communities named Elza, Robertsville, Wheat, and Scarborough. These villages served primarily as gathering centers and usually had one or two churches and a general store. About one thousand families inhabited the area in the early 1940s (Souza 2001, Hogan 2021).

In 1939, President Franklin D. Roosevelt received the famous Einstein-Szilard letter informing him that German scientists were working on a nuclear weapon. In utmost secrecy, he formed the Advisory Committee on Uranium, a team of scientists and military officials tasked with researching uranium's potential role as a weapon. This committee later evolved into the Office of Scientific Research and Development. After the United States was thrust into World War II following the Japanese attack on Pearl Harbor, the Manhattan Project emerged in 1942 as a full-scale program to build an atomic bomb. Named after the location of its original headquarters at 270 Broadway in New York City's Manhattan district, the super-secret code name of the project gave no indication of the classified activities it carried out. In the summer of 1943, the project moved to East Tennessee where construction of America's first

full-scale gaseous diffusion plant was underway to fulfill the mission of isolating ^{235}U for the first atomic bomb.

The selection of the area now known as ORR for the nuclear development site was largely due to the vision of General Leslie Groves. The original 56,200-acre area was primarily located in Anderson and Roane Counties. The presence of abundant water from the Clinch River, a good source of labor in nearby Knoxville, accessible railroads, and an ample supply of electricity from the Tennessee Valley Authority were viewed as key assets. Moreover, the parallel northeast-to-southwest valleys separated by 200- to 300-foot ridges were seen as useful to segregate the production areas and to provide protection in case of a catastrophe within any one of these areas.

The site's wartime name was Clinton Engineer Works, and the area now known as Oak Ridge was the workers' city on the reservation's northern edge. Although Oak Ridge did not appear on any map until 1949, the city quickly grew to a population of 75,000 to become the fifth largest city in Tennessee. To the south of the residential area at the Y-12 Complex, an electromagnetic method separated ^{235}U from natural uranium. The K-25 gaseous diffusion plant (now ETTP) was built on the reservation's western edge. Near the reservation's southwest corner, about 16 km (10 mi) from the Y-12 Complex, a third facility—known as X-10 or Clinton Laboratories—housed the experimental graphite reactor. X-10 (present-day ORNL) served as a pilot scale facility for the larger plutonium production facilities built at Hanford, Washington (Olwell 1999, Broad 2007, Reed 2014, Johnson 2018).

The missions of the three ORR installations have continued to evolve, and operations have adapted to meet America's changing defense, energy, and research needs. Section 1.4 describes the current missions of these and several smaller ORR facilities and activities.

1.3. Location and Description

Situated in the Great Valley of East Tennessee between the Cumberland and Great Smoky Mountains, ORR borders the Clinch River (see Figures 1.1 and 1.2). The Cumberland Mountains are 16 km (10 mi) to the northwest and the Great Smoky Mountains are 51 km (31.6 mi) to the southeast. Except for the city of Oak Ridge, the land within 8 km (5 mi) of ORR is semirural and is used primarily for residences, small farms, and cattle pasture. Fishing, hunting, boating, water skiing, and swimming are popular recreational activities. ORR currently encompasses approximately 33,069 acres of mostly contiguous, federally owned land in Anderson and Roane Counties and is under the management of DOE (DOE 2025).

1.3.1. Population

As reported in *US Department of Energy FY 2020 Economic Impact in Tennessee* (East Tennessee Economic Council), ORR supports approximately 43,000 members of the region's labor force. The Vintage US Census Population Estimate for the Knoxville Metropolitan Statistical Area, including Oak Ridge, was 957,608[1] (Census Bureau 2025a). The combined US Census Vintage 2024 Population Estimate for the 10 surrounding counties (Anderson, Blount, Campbell, Cumberland, Knox, Loudon, McMinn, Monroe, Morgan, and Roane) was 1,082,997 (Census Bureau 2025b). Knoxville, the nearest major city, is about 40 km (25 mi) to the east and had a population of 198,722 according to the US Census Vintage 2024 Population Estimate (Census Bureau 2025c). Other municipalities within about 30 km (18.6 mi) of the reservation include Oliver Springs, Clinton, Rocky Top, Lenoir City, Farragut, Kingston, and Harriman.

[1] Vintage 2024 is the base population of the 2020 census plus estimates from the time series starting April 1, 2020, through July 1, 2024.

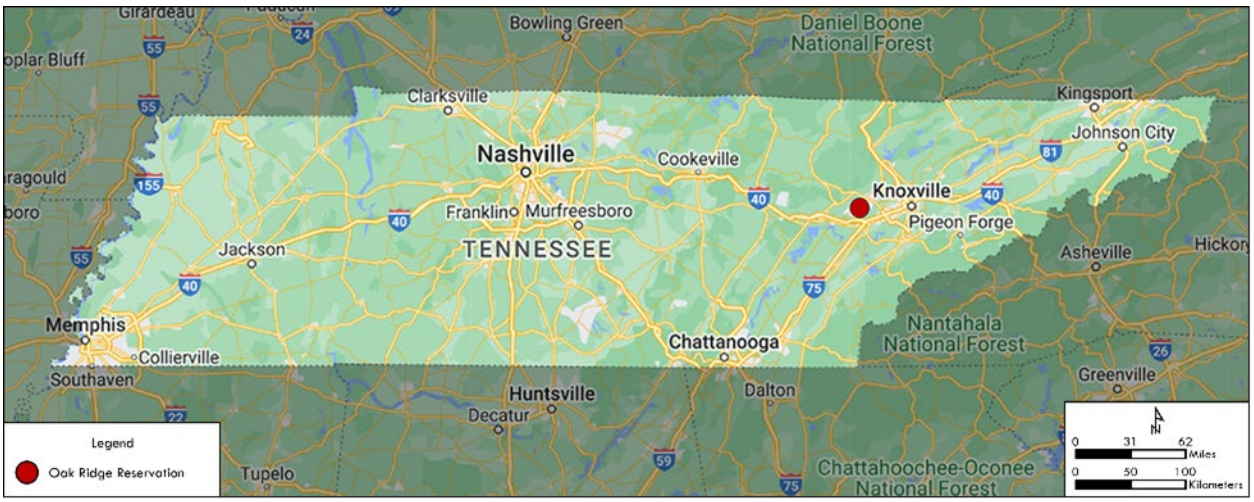


Figure 1.1. Location of the Oak Ridge Reservation in Tennessee

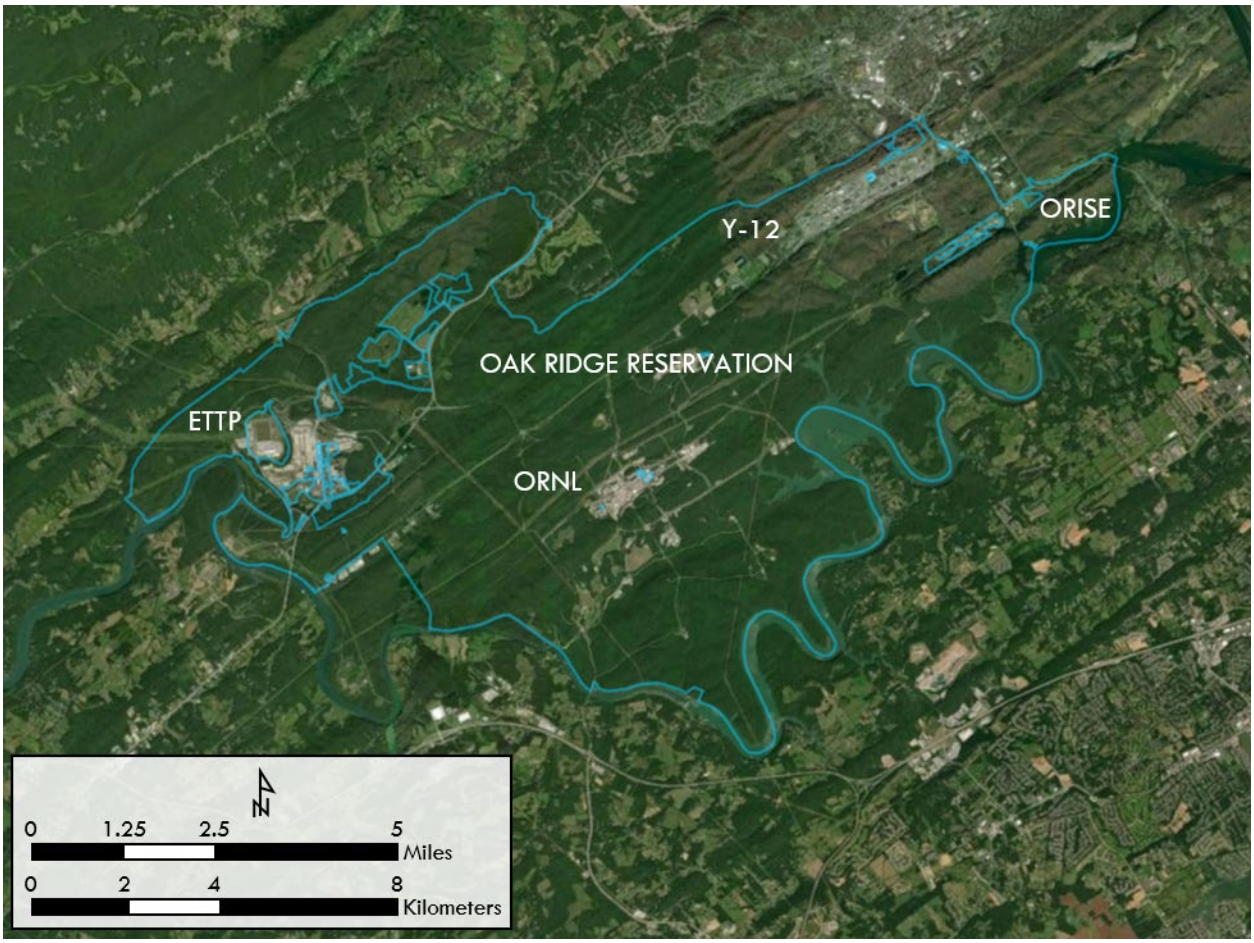


Figure 1.2. Map of the Oak Ridge Reservation

1.3.2. Climate

Although it features significant temperature changes between summer and winter, the climate of the Oak Ridge region qualifies as humid subtropical. The 30-year average temperature for 1991–2020 was 14.9°C (58.8°F). The average temperature for the Oak Ridge area in 2024 was 15.2°C (59.4°F), which is 0.6°C (1.1°F) warmer than normal compared with the 1991–2020 Oak Ridge base period. January temperatures were coldest in 2024, averaging 1.0°C (33.8°F). July was the warmest month, with an average temperature of 25.1°C (77.2°F). Monthly summaries of temperature averages, extremes, and 2024 values are provided in Appendix B, Table B.1.

The average annual precipitation in the Oak Ridge area for the 30-year period from 1991 to 2020 was 1,417.8 mm (55.82 in.), including about 14.5 cm (5.7 in.) of snowfall. Total precipitation during 2024 as measured at meteorological tower (MT)2 was 1227.9 mm (48.3 in.), which is 13 percent below the 30-year average of 1417.8 mm. Monthly summaries of precipitation averages, extremes, and 2024 values can also be found in Appendix B, Table B.1.

The average annual wind data recovery rates (a measure of acceptable data) across locations used for modeling during 2024 were greater than 96 percent for wind sensors at the ORNL towers MT3, MT4, and MT12. Annual wind data recovery during 2024 exceeded 95 percent for ETTP tower MT13. Y-12 tower MT6 recorded an annual recovery rate of 99.6 percent.

In 2024, wind speeds at ORNL Tower D (MT2) measured at 15 m (49 ft) above ground level averaged 1.26 meters per second (2.8 mph). This value was 2.25 meters per second (5.0 mph) for winds at 60 m (198 ft) above ground level. The local ridge-and-valley terrain reduces average wind speeds at valley bottoms, resulting in frequent periods of calm or near-calm conditions, particularly during clear early morning hours in weak synoptic weather environments.

Detailed information on the climate of the Oak Ridge area is available in *Oak Ridge Reservation Physical Characteristics and Natural Resources* (Parr and Hughes 2006) and in Appendix B of this report. An in-depth analysis of wind patterns for ORR conducted from 2009 to 2011 and documented in "Wind Regimes in Complex Terrain in the Great Valley of Eastern Tennessee" (Birdwell 2011) is available online **here**.

1.3.3. Regional Air Quality

The US Environmental Protection Agency (EPA) Office of Air Quality Planning and Standards set national ambient air quality standards (NAAQS) for key pollutants, also known as criteria pollutants. These key pollutants are sulfur dioxide, carbon monoxide, nitrogen dioxide, lead, ozone, particulate matter with an aerodynamic diameter less than or equal to 10 μm (PM_{10}), and fine particulate matter with an aerodynamic diameter less than or equal to 2.5 μm ($PM_{2.5}$). EPA evaluates NAAQS based on ambient, or outdoor, levels of the criteria pollutants. Areas that satisfy NAAQS are classified as attainment areas, while areas that exceed NAAQS for a particular pollutant are considered non-attainment areas for that pollutant.

As of August 30, 2017, EPA designated Anderson, Knox, Blount, and Roane Counties as attainment areas for the $PM_{2.5}$ air quality standard. (ORR is located in Anderson and Roane Counties.) The greater Knoxville and Oak Ridge area is a NAAQS attainment area for all other criteria pollutants for which EPA has made attainment designations (EPA 2025).

1.3.4. Surface Water

The ORR area comprises a series of drainage basins or troughs containing numerous small streams that feed the Clinch River. Surface water drains into a series of tributaries, streams, or creeks in different watersheds. Each of these watersheds drains into the Clinch River, which in turn flows into the Tennessee River. The Tennessee Valley Authority reported 54 inches of precipitation in 2024 for the Tennessee River Valley region, exceeding the average annual rainfall of 51 inches for this region. However, the fall season was very dry, with only 71 percent of

normal rainfall received from October 1 to December 31 (C. Montgomery, Tennessee Valley Authority River System Status Report Archives for 2024, personal communication, June 9, 2025).

ORR's largest drainage basin is Poplar Creek. This creek receives drainage from a 352 km^2 (136 mi^2) area, including the northwestern sector of the reservation. Flow is from northeast to southwest, roughly through the center of ETTP, and the creek discharges directly into the Clinch River.

East Fork Poplar Creek, which discharges into Poplar Creek east of ETTP, originates within the Y-12 Complex and flows northeast along the south side of the complex. Bear Creek also originates within the Y-12 Complex and flows southwest. Bear Creek is affected by stormwater runoff, groundwater infiltration, and tributaries that drain former waste disposal sites in the Bear Creek Valley Burial Grounds Waste Management Area and the current Environmental Management Waste Management Facility (EMWMF).

Both the Bethel Valley and Melton Valley portions of ORNL are in the White Oak Creek (WOC) drainage basin, which covers 16.5 km^2 (6.4 mi^2). The headwaters of WOC originate on Chestnut Ridge, north of ORNL and near the Spallation Neutron Source site. The creek flows west along the southern boundary of the developed area of the ORNL site, then flows southwest through a gap in Haw Ridge to the western portion of Melton Valley, forming a confluence with Melton Branch. The headwaters of Melton Branch originate in Melton Valley east of the High Flux Isotope Reactor complex, and the area of the drainage basin is about 3.8 km^2 (1.47 mi^2). The waters of WOC enter White Oak Lake, an impoundment formed by White Oak Dam. Water flowing over White Oak Dam enters the Clinch River after passing through the WOC embayment area.

1.3.5. Geological Setting

ORR is in the Tennessee portion of the Valley and Ridge Physiographic Province, which is part of the southern Appalachian fold-and-thrust belt. Thrust faulting, associated fracturing of the rock, and differential erosion rates created a series of parallel valleys and ridges that trend southwest to northeast.

Two geologic units on ORR, the Knox Group and the Maynardville Limestone of the Upper Conasauga Group, consist of dolostone and limestone, respectively, and make up the most significant water-bearing geological structures in the Valley and Ridge Province (Zurawski 1978) and on ORR. These bedrock formations are composed of moderately soluble minerals and are prone to dissolution as slightly acidic rainwater and percolating recharge water come in contact with the mineral surfaces. This dissolution increases fracture apertures and can, under some circumstances, form caverns and extensive conduit networks. This geological structure is locally known as the Knox Aquifer. A combination of fractures and solution conduits in the aquifer control flows over substantial areas, and large quantities of water may move long distances. Active groundwater flow can occur at substantial depths (91.5 to 122 m, or 300 to 400 ft) in the Knox Aquifer. The Knox Aquifer is the primary source of groundwater (base flow) for many streams, and most large springs on ORR receive discharge from the Knox Aquifer. Yields of some wells that penetrate larger solution conduits exceed 3,785.4 liters per minute (1,000 gallons per minute). The high productivity of the Knox Aquifer results from the combination of its abundant and sometimes large conduit systems and frequently thick overburden soils that promote recharge and storage of groundwater.

The remaining geologic units on ORR (the Rome Formation, the Conasauga Group below the Maynardville Limestone, and the Chickamauga Group) are composed predominantly of shale, siltstones, and sandstones with a subordinate and locally variable amount of carbonate bedrock. These formations are primarily composed of insoluble minerals such as clays and quartz that were derived from ancient continental erosion. Groundwater occurs in and moves through fractures in these bedrock units. Groundwater availability in such settings depends on the abundance and interconnectedness of fractures and the connection of fractures to sources of

recharge, such as alluvial soils along streams, which can provide some sustained infiltration. The shale and sandstone formations are the poorest aquifers in the Valley and Ridge Province (Zurawski 1978). Well yields are generally low in the Rome, Conasauga, and Chickamauga bedrock formations except in localized areas where carbonate beds may provide greater groundwater storage than adjacent clastic bedrock. Detailed information on ORR groundwater hydrology and flow is available in *Oak Ridge Reservation Physical Characteristics and Natural Resources* (Parr and Hughes 2006).

1.3.6. Natural, Cultural, and Historical Resources

ORR has an exceptional variety of natural, cultural, and historical resources. Ongoing efforts continue to focus on preserving the rich diversity of these resources.

1.3.6.1. Wetlands

Wetlands occur across ORR at low elevations, primarily in riparian zones of headwater streams and receiving streams and in the Clinch River embayments as shown in Figure 1.3. Surveys of wetland resources presented in *Identification and Characterization of Wetlands in the Bear Creek Watershed* (Rosensteel and Trettin 1993), *Wetland Survey of the X-10 Bethel Valley and Melton Valley Groundwater Operable Units at Oak Ridge National Laboratory, Oak Ridge, Tennessee* (Rosensteel 1996), and *Wetland Survey of Selected Areas in the Oak Ridge Y-12 Plant Area of Responsibility, Oak Ridge, Tennessee* (Rosensteel 1997) serve as references to support wetland assessments for upcoming projects and activities.

About 235 hectares (580 acres) of potential wetlands (jurisdictional and non-jurisdictional wetland areas) have been identified on ORR; most are classified as forested palustrine, scrub/shrub, and emergent wetlands (Parr and Hughes 2006). Wetlands identified to date range from several square meters at small seeps and springs to about 10 hectares (25 acres) at White Oak Lake. The Tennessee Department of Environment and Conservation's (TDEC's) wetland mitigation aquatic resource alteration permits, required by Section 401 of the Clean Water Act (CWA 1972), entail monitoring restored or created wetland mitigation sites for 5 years. Activities and conditions in and around the wetlands are verified by site inspections when appropriate.

1.3.6.2. Wildlife and Endangered Species

Animals listed as species of concern by state, federal, or international organizations and known to have appeared on the reservation (excluding the Clinch River bordering the reservation) are listed, along with their status, in Table 1.1. Some of these, such as hellbender, have been seen only once or a few times; others, including wood thrush, are comparatively common and widespread on ORR. As of December 2024, Tennessee had 78 species listed under the federal Endangered Species Act (ESA 1973), including 31 endangered and 47 threatened species. The complete Tennessee Threatened and Endangered List–New Rules is available **here** (TWRA 2024).

Birds, fish, reptiles and amphibians, and aquatic invertebrates are the most thoroughly surveyed animal groups on ORR. Nevertheless, the only federally listed animal species observed on the reservation in recent years are mammals, specifically bat species. For more than 30 years, endangered gray bats have been detected in acoustic surveys and mist net captures. Since 2013, endangered Indiana bats and northern long-eared bats have been detected in acoustic surveys and mist net captures (McCracken et al. 2015). Surveys conducted in 2022 indicate that gray bats and other bat species use several caves on ORR. Suitable roosting and foraging habitat for the three federally listed bat species is abundant across the reservation. Acoustic monitoring continued in 2024 for a select few sites, mostly on development projects. Additionally, ORNL biologists are currently working with US Fish and Wildlife Service (FWS) to develop a Programmatic Biological Assessment that addresses operational activities on the entire ORR. The goal is to streamline the steps to comply with the Endangered Species Act through measures to avoid or minimize harm to the bats during execution of

site cleanups and other DOE mission-critical activities. Bat species of concern found on ORR include the tricolored bat (state-listed as threatened and proposed for federal listing), little brown bat (state-listed as threatened and under consideration for federal listing), Rafinesque's big-eared bat (state-listed as in need of management), and eastern small-footed bat (state-listed as in need of management) (TDEC 2025, TWRA 2024).

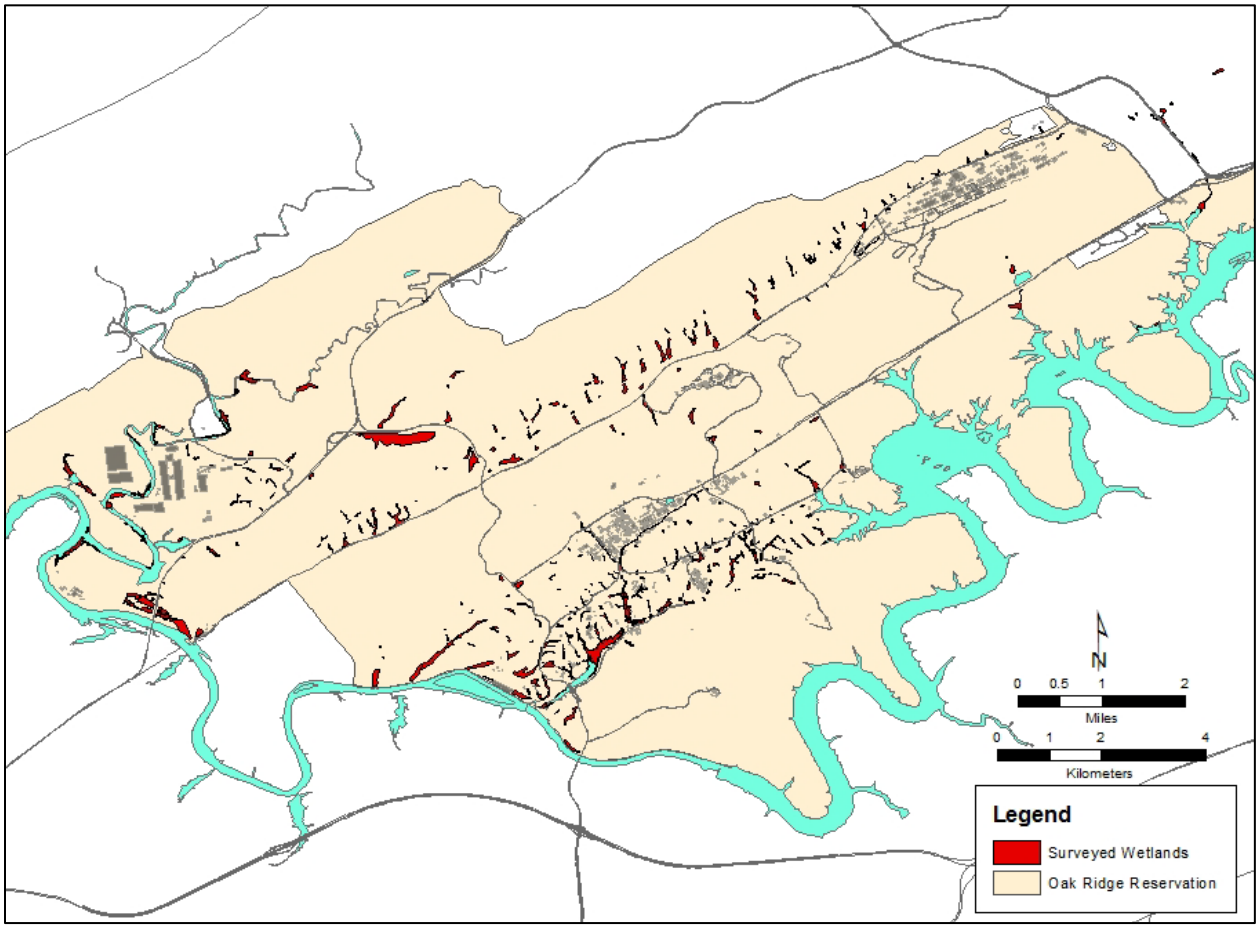


Figure 1.3. Location of ORR wetlands

Table 1.1. Animal species of special concern reported on ORR[a]

Scientific name	Common name	Status[b]			
		Federal	TN	NatureServe[c]	PIF[d]
FISH					
Phoxinus tennesseensis	Tennessee dace		NM	S3	
AMPHIBIANS AND REPTILES					
Cryptobranchus alleganiensis	Hellbender		E	S3	
Hemidactylium scutatum	Four-toed salamander		NM	S3	
Ophisaurus attenuatus longicaudus	Eastern slender glass lizard		NM	S3	
Pituophis melanoleucus	Northern pine snake		T	S3	

Table 1.1. Animal species of special concern reported on ORR[a] (continued)

Scientific name	Common name	Status[b]			
		Federal	TN	NatureServe[c]	PIF[d]
BIRDS					
Swans, Geese, and Ducks					
Branta canadensis	Canada goose	BMC, OA		S5	
Aix sponsa	Wood duck	BMC		S5	
Mareca strepera	Gadwall	BMC		S4	
Mareca americana	American wigeon	BMC		S4	
Anas rubripes	American black duck	BMC		S3	MA
Anas platyrhynchos	Mallard	BMC		S5	
Spatula discors	Blue-winged teal	BMC		S2	
Anas crecca	Green-winged teal	BMC		S4	
Spatula clypeata	Northern shoveler	BMC		S4	
Anas acuta	Northern pintail	BMC		S4	
Aythya valisineria	Canvasback	BMC		S3	
Aythya americana	Redhead	BMC		S4	
Aythya collaris	Ring-necked duck	BMC		S5	
Aythya affinis	Lesser scaup	BMC		S4	
Grebes					
Podilymbus podiceps	Pied-billed grebe	BMC		S4	
Podiceps auritus	Horned grebe	BMC		S4	MA
Frigatebirds, Boobies, Cormorants					
Nannopterum auritum	Double-crested cormorant	BMC, OA		S2	
Bitterns and Herons					
Ixobrychus exilis	Least bittern	BMC	NM	S2	
Egretta caerulea	Little blue heron	BMC	NM	S2	
Nycticorax nycticorax	Black-crowned night heron	BMC		S2	
Butorides virescens	Green heron			S4	MA
Mycteria americana	Wood stork	T		S3	
Kites, Hawks, Eagles, and Allies					
Haliaeetus leucocephalus	Bald eagle	BMC[e]		S3	
Rails, Gallinules, and Coots					
Rallus limicola	Virginia rail	BMC		S1	
Porzana carolina	Sora	BMC		S1	
Fulica americana	American coot	BMC		S2	
Tringa solitaria	Solitary sandpiper	BMC, BCC		S5	
Tringa flavipes	Lesser yellowlegs	BMC, BCC		S5	
Scolopax minor	American woodcock	BMC		S4	MA
Grouse, Turkey, and Quail					
Colinus virginianus	Northern bobwhite	BMC, BCC, E		S2	

Table 1.1. Animal species of special concern reported on ORR[a] (continued)

Scientific name	Common name	Status[b]			
		Federal	TN	NatureServe[c]	PIF[d]
Pigeons and Doves					
Zenaida macroura	Mourning dove	BMC		S5	
Cuckoos and Roadrunners					
Coccyzus americaus	Yellow-billed cuckoo	BMC, BCC, T		S4	PR
Goatsuckers					
Antrostomus carolinensis	Chuck-will's widow	BMC, BCC		S3	IM
Antrostomus vociferus	Eastern whip-poor-will	BMC, BCC		S3	MA
Chordeiles minor	Common nighthawk	BCC		S4	PR
Swifts					
Chaetura pelagica	Chimney swift	BCC		S5	IM
Kingfishers					
Megaceryle alcyon	Belted kingfisher	BCC		S5	MA
Woodpeckers					
Melanerpes erythrocephalus	Red-headed woodpecker	BMC, BCC		S4	PR
Colaptes auratus	Northern flicker	BMC		S5	PR
Tyrant Flycatchers					
Contopus virens	Eastern wood-pewee			S5	MA
Empidonax virescens	Acadian flycatcher			S5	MA
Contopus cooperi	Olive-sided flycatcher	BMC, BCC		S1	
Empidonax traillii	Willow flycatcher	BMC, BCC, E		S2	
Swallows					
Progne subis	Purple martin			S5	
Hirundo rustica	Barn swallow			S5	
Kinglets, Gnatcatchers, and Thrushes					
Hylocichla mustelina	Wood thrush	BMC, BCC		S4	PR
Shrikes					
Lanius ludovicianus	Loggerhead shrike	BMC, BCC, E	NM	S1	
Wood Warblers					
Vermivora chrysoptera	Golden-winged warbler	BMC, BCC	T	S3	IM
Setophaga cerulea	Cerulean warbler	BMC, BCC	NM	S3	MA
Setophaga discolor	Prairie warbler	BMC, BCC		S3	MA
Mniotilta varia	Black-and-white warbler			S4	MA
Protonotaria citrea	Prothonotary warbler	BMC, BCC		S4	
Geothlypis formosa	Kentucky warbler	BMC, BCC		S4	MA
Cardellina canadensis	Canada warbler	BMC, BCC		S3	MA
Icteria virens	Yellow-breasted chat	BCC		S4	MA
Tanagers					
Piranga rubra	Summer tanager	BMC		S4	PR

Table 1.1. Animal species of special concern reported on ORR[a] (continued)

Scientific name	Common name	Status[b]			
		Federal	TN	NatureServe[c]	PIF[d]
Towhees, Sparrows, and Allies					
Pipilo erythrophthalmus	Eastern towhee			S5	MA
Spizella pusilla	Field sparrow	BMC, BCC		S4	MA
Ammodramus savannarum	Grasshopper sparrow	BMC, BCC		S4	IM
Ammodramus henslowii	Henslow's sparrow	BMC, BCC		S1	IM
MAMMALS					
Myotis grisescens	Gray bat	E	E	S2	
Myotis lucifugus	Little brown bat[f]		T	S3	
Myotis sodalis	Indiana bat[g]	E	E	S1	
Myotis septentrionalis	Northern long-eared bat	E	E	S1	
Myotis leibii	Eastern small-footed bat		NM	S2	
Perimyotis subflavus	Tri-colored bat[f]	PE	T	S2	
Corynorhinus rafinesquii	Rafinesque's big-eared bat		NM	S3	
Sorex dispar	Long-tailed shrew		NM	S2	

[a] *Land and surface waters of the Oak Ridge Reservation (ORR) exclusive of the Clinch River, which borders ORR.*

[b] *Status codes:*

E = endangered (TDEC 2025, FWS 2021, TWRA 2024)
PE = proposed endangered (TDEC 2025)
T = threatened (TDEC 2025, FWS 2021)
S1 = critically imperiled (NatureServe 2025, TDEC 2025)
S2 = imperiled (NatureServe 2025, TDEC 2025)
S3 = vulnerable (NatureServe 2025, TDEC 2025)
S4 = apparently secure (NatureServe 2025, TDEC 2025)
S5 = secure (NatureServe 2025, TDEC 2025)
BMC = Birds of management concern (FWS 2011)
BCC = Birds of conservation concern (FWS 2021)
NM = in need of management (TDEC 2025, TWRA 2024)
OA = overly abundant (FWS 2011)
CR = critical recovery for Bird Conservation Region (BCR) 28 (Appalachian Mountains Bird Conservation Region) (PIF 2025)
IM = immediate management for BCR28 (PIF 2025)
MA = management attention for BCR28 (PIF 2025)
PR = planning and responsibility for BCR28 (PIF 2025)

[c] *NatureServe works with over 60 network organizations and over 1,000 conservation scientists to collect, aggregate, and standardize biodiversity statistics.*

[d] *Partners in Flight (PIF) is an international organization devoted to conserving bird populations in the Western Hemisphere.*

[e] *The bald eagle was federally delisted effective August 9, 2007.*

[f] *Under review for federal listing.*

[g] *A single specimen was captured in a mist net bordering the Clinch River in June 2013.*

Birds recorded on the reservation and its boundary waters include the 228 species documented by Roy et al. (2014) plus the cackling goose (*Branta hutchinsii*), purple gallinule (*Porphyrio martinicus*), American bittern (*Botaurus lentiginosus*), and federally threatened wood stork (*Mycteria Americana*) for a total of 236 species. Most of these species are protected under the Migratory Bird Treaty Act (MBTA 1918) and Executive Order 13186, *Responsibilities of Federal Agencies to Protect Migratory Birds* (EO 2001). DOE's updated memorandum of understanding on migratory birds with the FWS (DOE-FWS 2013) strengthens migratory bird conservation on ORR through enhanced collaboration between DOE and FWS.

The reservation contains a rich flora and fauna diversity, with observations of more than 1,100 plant species, 72 fish species, 34 mammal species and more than 200 bird species. Breeding bird surveys conducted along varying numbers of up to 10 routes on ORR provide data for the Partners in Flight Program, a collaborative initiative focused on the conservation of landbirds (see Figure 1.4). Six public nature walks organized by ORNL occurred in 2024, which began in the late winter and carried through mid-summer. The series focused on wildflowers and old-growth forests and also included topics including bird watching, frog calls, and reptile inventories. In past years, the reservation has been nominated for the Presidential Migratory Bird Federal Stewardship Award. A technical manuscript, *Oak Ridge Reservation Bird Records and Population Trends* (Roy et al. 2014), documents known bird records since 1950 and population trends for 32 species of birds.

Several state-listed bird species, such as the golden-winged warbler, cerulean warbler, and little blue heron, are uncommon migrants or visitors to the reservation. The cerulean warbler, listed by the state as in need of management, often appears during the breeding season on ORR. But because this bird's actual breeding status is still uncertain, it is currently listed as a potential breeding bird on the reservation (Roy et al. 2014).



Source: Sarah Darling, ORNL

Figure 1.4. American woodcock fledgling on ORR

The bald eagle (Figure 1.5), which was removed from the federal list of threatened and endangered species on August 9, 2007, is a year-round resident in Tennessee, though it can be difficult to find on the reservation from September through November. Two bald eagle nests were confirmed on the reservation in 2024. These nests were located at the Tower Shielding Facility and the Experimental Gas-Cooled Reactor, both at ORNL.

Other bird species of interest include the migratory wood thrush and barn swallow, which have been observed nesting on the reservation. The Lincoln's sparrow (*Melospiza lincolnii*) (no listed status) was sighted on the reservation in May 2014. Barn owls were documented nesting on the reservation in 2019.



Source: Kelly Roy, ORNL

Figure 1.5. Bald eagle photographed on ORR

Uncommon birds for ORR recorded in recent years include several species associated with wetland habitats. Due to efforts in the early 2000s to mitigate ETTP's K1007 P-1 pond into a high-quality wildlife habitat, purple martin (*Progne subis*) and willow flycatcher (*Epidonax tralillii*) make their home here every spring and summer. The limpkin (*Aramus guarauna*), which is not usually observed in Tennessee, was seen utilizing the ponds in June 2023. While collaborating on detection methodologies for secretive marsh birds, researchers from ORNL and Charles Sturt University in New South Wales, Australia, photographed a purple gallinule (*Porphyrio martinicus*) on a trail camera at the Heritage Center Greenway Powerhouse Trail in 2017 (Figure 1.6). This was the first documented appearance of a purple gallinule on the reservation.

ORNL is continuing to monitor state-listed four-toed salamanders (*Hemidactylium scutatum*) at ORR. Although ORR contains some of the highest densities of this species in eastern Tennessee, they are considered by the state as in need of management. Several of their largest subpopulations on the reservation occur in areas that are slated for development, including the Environmental Management Disposal Facility (EMDF) where individuals were translocated to establish a new subpopulation in other areas of similar habitat type. ORNL has also documented what appear to be state-listed black mountain salamanders (*Desmognathus welteri*, considered by the state as in need of management) on ORR, just south of the Horizon Center. Two state-listed reptiles have inhabited ORR: the northern pine snake (*Pituophis melanoleucus melanoleucus*, state-listed as threatened) and the eastern slender glass lizard (*Ophisaurus attenuatus longicaudus*, state-listed as in need of management). However, there is limited evidence to suggest the number of either species on the reservation.

Several fish species listed and noted for management concern are known to inhabit areas in and around ORR. One fish species, the spotfin chub (*Erimonax monachus*), which is listed as threatened by both the state and the federal



Figure 1.6. Purple gallinule caught on a trail surveillance camera at ETTP in 2017

government, has been sighted and collected in the city of Oak Ridge and may be present on the reservation. The tangerine darter (*Percina aurantiaca*), a species listed by the state as in need of management, has also been recorded near ORR. The lake sturgeon (*Acipenser fulvescens*), state-listed as endangered, is known to inhabit the adjacent Clinch River. The Tennessee dace, listed by the state as in need of management, appears in the Bear Creek watershed, tributaries to the lower East Fork watershed, and Ish Creek. The Tennessee dace also occurs in some sections of Grassy Creek upstream of Scientific Ecology Group, Inc. and International Technology Corporation at Clinch River kilometer 23, south of west Bear Creek Road near Grassy Creek sampling point 1.9.

1.3.6.3. Threatened and Endangered Plants

Four plant species known to be on ORR (spreading false foxglove, Appalachian bugbane, tall larkspur, and butternut) have been under review for federal listing and were previously listed under the Category 2 candidate designation (Nature Conservancy 1995). FWS now informally refers to these as special concern species.

The state of Tennessee lists 16 plant species occurring on ORR as endangered, threatened, or of special concern; these are included in Table 1.2. Although currently unconfirmed, an additional 10

threatened, endangered, or special concern species occur in the area and may be present. These species are also included in Table 1.2. Other plant populations currently under study may be added to the table in future years (TDEC 2021, TDEC 2025).

Table 1.2. Vascular plant species of special concern sighted or reported on or near ORR

Species	Common name	Habitat on ORR	Status/rank code[a,b]
Currently known to be or previously reported on ORR			
Aureolaria patula	Spreading false foxglove	River bluff	S, S3
Berberis canadensis	American barberry	Rocky bluff	S, S2
Bolboschoenus fluviatilis	River bulrush	Wetland	S, S1
Delphinium exaltatum	Tall larkspur	Barrens and woodlands	E, S2
Diervilla lonicera	Northern bush-honeysuckle	Rocky river bluff	T, S2
Draba ramosissima	Branching whitlow-grass	Limestone cliff	S, S2
Elodea nuttallii	Nuttall waterweed	Pond, embayment	S, S2
Eupatorium godfreyanum	Godfrey's thoroughwort	Dry woods edge	S, S1
Fothergilla major	Mountain witch-alder	Woods	T, S2
Helianthus occidentalis	Naked-stem sunflower	Barrens	S, S2
Juglans cinerea	Butternut	Lake shore	T, S3
Juncus brachycephalus	Small-head rush	Open wetland	S, S2
Liparis loeselii	Fen orchid	Forested wetland	T, S1
Panax quinquefolius	American ginseng	Rich woods	S, S3
Platanthera flava var. herbiola	Tubercled rein-orchid	Forested wetland	T, S2
Spiranthes lucida	Shining ladies'-tresses	Boggy wetland	T, S1
Rare plants that occur near and could be present on ORR			
Agalinis auriculata	Earleaf false foxglove	Calcareous barren	E, S2
Allium burdickii[c]	Narrow-leaf ramps	Moist woods	T, CE, S1
Allium tricoccum[c]	Ramps	Moist woods	S, CE, S1
Lathyrus palustris	Marsh pea	Moist meadows	S, S1
Liatris cylindracea	Slender blazing star	Calcareous barren	T, S2
Lonicera dioica	Mountain honeysuckle	Rocky river bluff	S, S2
Meehania cordata	Heartleaf meehania	Moist calcareous woods	T, S2
Pedicularis lanceolata	Swamp lousewort	Calcareous wet meadow	S, S1
Pseudognaphalium helleri	Heller's catfoot	Dry woodland edge	S, S2
Pycnanthemum torreyi	Torrey's mountain-mint	Calcareous barren edge	E, S1

[a] *State status codes (TDEC 2021):*
CE = Status due to commercial exploitation
E = Endangered in Tennessee
S = Special concern in Tennessee
T = Threatened in Tennessee

[b] *State conservation status (NatureServe 2025):*
S1 = Critically imperiled
S2 = Imperiled
S3 = Vulnerable

Acronym: *ORR = Oak Ridge Reservation*

[c] *Ramps have been reported near ORR, but there is not sufficient information to determine which of the two species is present or whether the occurrence may have been the result of planting.*

1.3.6.4. Historical and Cultural Resources

Efforts continue to preserve ORR's rich prehistoric and historical cultural resources. Compliance with the National Historic Preservation Act of 1966 (NHPA 1966) is maintained in conjunction with the National Environmental Policy Act (NEPA 1969) and the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA 1980). The scope of proposed actions is reviewed in accordance with the Cultural Resource Management Plan, DOE Oak Ridge Reservation, Anderson and Roane Counties, Tennessee (DOE 2001). Several facilities on ORR are included on the National Register of Historic Places, part of a National Park Service program to identify, evaluate, and protect historical and archeological resources in the United States. The reservation contains more than 44 known prehistoric sites (primarily archeological evidence of former structures), 254 historic pre-World War II structures, 32 cemeteries, and several historically significant structures from the Manhattan Project era.

The National Defense Authorization Act of 2015 (NDAA 2014), passed by Congress and signed into law on December 19, 2014, included provisions authorizing the Manhattan Project National Historical Park. An agreement by the Secretaries of Energy and Interior established the Manhattan Project National Historical Park on November 10, 2015 (DOE-DOI 2015). The Park includes facilities and lands in Los Alamos, New Mexico; Hanford, Washington; and Oak Ridge, Tennessee. On ORR, the National Park includes the X-10 Graphite Reactor, Buildings 9731 and 9204-3 at the Y-12 Complex, and the K-25 Building Site at ETTP.

The X-10 Graphite Reactor building has been a National Historic Landmark since 1966. Although it was closed to the public in 2024 due to recent ongoing DOE efforts to prioritize cleanup activities and ensure the safety of historic sites, the reactor face and control room have been open for guided tours in the years since obtaining national historic landmark status. Enhancing safe and secure access and improving the visitor experience are important DOE objectives as it moves forward in implementing the National Park.

Buildings 9731 and 9204-3 are also not currently open to the public, but Building 9731 has been open for tours in recent years during the Secret City Festival. As part of their ongoing collaboration, the National Park Service and the DOE will endeavor to develop innovative and virtual approaches to connect park visitors with key resources, as they balance preservation of the historic buildings with the need to ensure safe and secure public access.

A memorandum of agreement (MOA) signed in 2012 among the DOE Oak Ridge Office, the State Historic Preservation Officer, the Advisory Council on Historic Preservation, the City of Oak Ridge, and the East Tennessee Preservation Alliance ensures consistent interpretation of site historic properties at ETTP (DOE 2012). The MOA is being implemented through the National Historic Preservation project that developed the K-25 History Center. The K-25 History Center serves to highlight the historic aspects of ETTP and of the communities that were displaced during the construction of the site.

Construction of the K-25 Interpretive Center, located just north of the K-25 History Center, began on May 11, 2023, and was completed on March 4, 2025. The facility was constructed by the U.S. Army Corps of Engineers using contractor Geiger Brothers Inc. to manage construction and United Cleanup Oak Ridge LLC (UCOR) to provide engineering support. The facility includes a viewing platform with 10-foot-tall wraparound glass windows and exhibits that provide facts and visuals related to the historic importance of the K-25 Building, as well as view scopes and a scale model of the original facility. DOE Oak Ridge Office of Environmental Management (OREM) plans to hold a grand opening for the public in September 2025 that corresponds with the 80th anniversary of the end of World War II.

The K-25 History Center and Interpretive Center complement the Manhattan Project National Historic Park established in 2015, which includes the footprint of the former K-25 Building (DOE-DOI 2015). The National Park Service is assisting in historic interpretation of the site although the K-25 Building site is already undergoing extensive

historic interpretation activities separate and independent from the National Park. As part of the activities to establish the park, DOE launched the K-25 Virtual Museum. The museum details the history of the K-25 Gaseous Diffusion Plant through narrative and photographs that can be viewed **here**.

In addition to the X-10 Graphite Reactor, six additional historic ORR properties are listed individually in the planning for a History Center:

- Freels Bend Cabin
- New Bethel Baptist Church and Cemetery
- Oak Ridge Turnpike Checking Station
- George Jones Memorial Baptist Church and Cemetery
- Bear Creek (Scarboro) Road Checking Station
- Bethel Valley Road Checking Station

Although it is not yet included on the National Register of Historic Places, an area known as the Wheat Community African Burial Grounds was dedicated in June 2000, and a memorial monument was erected at the site.

ORNL and Y-12 programmatic agreements and memorandums of agreement among DOE, the State of Tennessee, the Advisory Council on Historic Preservation, and consulting parties serve to provide a system of review for projects that may potentially affect historical and archaeological resources on ORR. The ORNL and Y-12 programmatic agreements are currently being updated to reflect new architectural building surveys and revisions to each site's Historic Preservation Plans. In 2024, a new MOA was developed to address mitigation activities for the planned demolition of DOE ORNL Office of Science (SC) Buildings 9401-1, 9201-2, 9204-1, 9732-02, 3034, 3036, 3501, 5505, and 2523, and OREM Buildings 3002, 3003, 3018, 3038, 3029, 3030, 3031, 3032, 3033, 3033A, 3118, 3042, 3515, 3542, and 3517. These historic, contaminated buildings were determined to pose excessive environmental risks.

1.4. Oak Ridge Sites

ORR includes a number of sites critical to the mission of DOE. Eight of these sites are described in this section: ORNL, the Y-12 Complex, ETTP, EMWMF, the Oak Ridge National Environmental Research Park, ORISE, the NNSA OST AOEC, and the TWPC.

Led by Amentum, Jacobs, and Honeywell, UCOR is the lead DOE ORR cleanup contractor. In addition to the continuing groundwater remediation at ETTP, UCOR addresses expanded cleanup operations at ORNL and Y-12.

The scope of UCOR activities includes characterization and cleanup of former production facilities, building pads, and impacted environmental media; management and maintenance of active ORR facilities; long-term management of inactive waste disposal sites; and water quality monitoring. The *2024 Cleanup Progress: Annual Report on Oak Ridge Reservation Cleanup* (UCOR 2024) provides detailed information on UCOR activities at ORR and is available **here**.

1.4.1. Oak Ridge National Laboratory

ORNL (shown in Figure 1.7) is managed for DOE by UT-Battelle, LLC (UT-Battelle), a partnership between the University of Tennessee and the Battelle Memorial Institute. The largest science and energy national laboratory in the DOE system, ORNL conducts basic and applied research to deliver transformative solutions to compelling problems in energy and security. The laboratory is home to several of the world's top supercomputers and is a leading neutron science and nuclear energy research facility that includes the Spallation Neutron Source and the High Flux Isotope Reactor. ORNL hosts a DOE leadership computing facility, home of the Frontier supercomputer; one of DOE's nanoscience centers, the Center for Nanophase Materials Sciences; one of DOE's energy research centers; and the Bio-Energy Science Center. UT-Battelle also manages the US ITER project (formerly the International Thermonuclear Experimental Reactor project) for DOE.

Formerly known as X-10, ORNL was established in 1943 to support the Manhattan Project. From an early focus on chemical technology and reactor development, ORNL's research and development portfolio broadened to include programs supporting DOE missions in scientific discovery and innovation, clean energy, and nuclear security. Today ORNL employs about 7,200 workers, and the laboratory's extensive capabilities in scientific discovery and innovation are applied to the delivery of mission outcomes for DOE and other sponsors (Oakridger 2024).

After completing facility upgrades and in-depth safety planning in 2022, OREM and its contractor Isotek Systems, LLC (Isotek) conducted significant processing operations on the remaining inventory of ^{233}U stored at ORNL in 2024. Together, they surpassed EM's 2024 goal by processing 35 canisters of ^{233}U months ahead of schedule. Employees have processed 130 canisters since refurbishing the hot cells inside Building 2026 as part of the U-233 Disposition Project. The effort to process and dispose of the remaining high-dose ^{233}U is OREM's highest priority at ORNL. Additionally, DOE and Isotek have partnered with TerraPower, a private nuclear innovation company, to extract ^{229}Th from the ^{233}U. TerraPower then uses the material to create the ^{225}Ac needed for targeted alpha therapy to treat diseases such as breast, prostate, colon, and neuroendocrine cancers, melanoma, and lymphoma.

UCOR continued to carry out characterization and deactivation of former reactors and isotope production facilities in 2024. A major achievement was shipping the reactor vessel from the Low Intensity Test Reactor (Building 3005) for off-site disposal.

Deactivation work is ongoing in six of the 11 buildings comprising "Isotope Row" that were constructed in the 1950s and early 1960s to process radioisotopes. Highlights of work in 2024 include the following:

- Building 3093 is in its deactivation end state after the removal of four Krypton tanks for disposition.
- Water tanks shielding hot cells were removed from the Alpha Handling Facility of the former Isotope Development Lab (Building 3038).
- In preparation for demolition in 2025, work continued to remove the final hot cell at the Radioisotope Development Laboratory (Building 3026).

Deactivation activities continued at the Oak Ridge Graphite Reactor support facility buildings 3002 (Filter House), 3003 (Fan House) and 3018 (Exhaust Stack) with the process nearing completion and demolition expected to begin in 2025.

At the Fission Production Development Lab (Building 3517), workers are collecting data in preparation for future characterization; they also successfully removed a 500-watt radioisotope thermoelectric generator for recycling into a source of energy for new power systems in partnership with private industry.

ORNL has developed high-level policies that clearly state expectations for continuous improvement and integration of environmental management services through an Environmental Management System for UT-Battelle activities and facilities. These services include waste minimization and pollution prevention, waste management, effluent management, regulatory review, reporting, permitting, and other environmental management programs.

Examples of environmental performance optimization during fiscal year (FY) 2024 include the following:

- The calculated energy use intensity was 250,387 Btu/gross square foot. This is a cumulative reduction of 31.2 percent since FY 2003 and a reduction of 39.1 percent from the FY 2021 baseline, but it is an increase of 5.42 percent from FY 2023. ORNL continues to identify opportunities to reduce energy use intensity by identifying and prioritizing maintenance issues that can improve energy efficiency.



Figure 1.7. Aerial view of the Oak Ridge National Laboratory

- UT-Battelle implemented 28 ongoing and waste minimalization and new pollution prevention projects at ORNL during 2024; these projects eliminated more than 2.6 million kg of waste.
- Eighty percent of all ORNL vehicles are alternative fuel vehicles, with 88 percent of all replacements since FY 2020 being alternative fuel or electric vehicles. Ninety-three percent of light-duty vehicles operate on alternative fuels. ORNL will continue to align its use of alternative fuel vehicles with statutory and regulatory requirements and guidance.

See Section 5.2.1.4 for additional details on ORNL environmental performance data for FY 2024.

1.4.2. Y-12 National Security Complex

The Y-12 Complex (shown in Figure 1.8) was originally constructed as part of the World War II Manhattan Project and began operations in November 1943. The first site mission was the separation of ^{235}U from natural uranium by an electromagnetic separation process. At its peak in 1945, more than 22,000 workers were employed at the Y-12 site.

Today, as part of the NNSA Nuclear Security Enterprise, the Y-12 Complex is a leader in materials science and precision manufacturing. As the main storage facility for the nation's supply of enriched uranium, Y-12 serves as the nation's only source of enriched uranium nuclear weapons components and provides enriched uranium for the US Navy. The Y-12 Complex also supports efforts to reduce the risk of nuclear proliferation and performs complementary work for other government agencies.

In December 2017, UCOR issued the Construction Execution/Management Plan, Outfall 200 Mercury Treatment Facility at the Y-12 National Security Complex, Oak Ridge, Tennessee (UCOR 2017). The Outfall 200 Mercury Treatment Facility is a vital piece of infrastructure that will open the door for demolition of Y-12's large, deteriorated,

mercury-contaminated facilities and subsequent soil remediation by providing a mechanism to limit potential mercury releases into Upper East Fork Poplar Creek. The west end Y-12 storm drain system discharges to Upper East Fork Poplar Creek at Outfall 200, and mercury from historical operations is present at Outfall 200 where storm water enters Poplar Creek.

In FY 2024, progress continued with construction of the Outfall 200 Mercury Treatment Facility, DOE Environmental Management research in new remediation technologies to address mercury releases into the environment from past operations, and contracting for the first mercury remediation technology demonstration. In FY 2024, UCOR assumed construction responsibility for the Outfall 200 Mercury Treatment Facility and began construction of the treatment plant and headworks facility. At the headworks site, workers are building concrete structures for handling normal flows and higher storm flows. In 2024, workers poured approximately 600 yd^3 of concrete. At the treatment site, workers completed construction of a gravity filter and installed additional tanks. A new Technology Demonstration Facility is being developed (formerly the Disposal Area Remedial Action, or DARA, facility) to carry out demonstrations of proposed mercury treatment technologies.

Deactivation activities continued at three large former uranium processing facilities in 2024—Alpha-2, Alpha-4, and Beta-1—with demolition beginning at Alpha-2 later in the year.

The 1940s-era Alpha-2 (Building 9201-02) is one of the largest high-risk excess contaminated facilities at Y-12. Deactivation of the upper floors of Beta-1 (Building 9204-01) was completed in FY 2024 with the pumping and treating of 5.7 million gallons of water from the basement to mitigate weather-based water intrusion. At Alpha-4 (Building 9201-04), crews are addressing mercury vapors and supporting repackaging containers for eventual waste disposition to move the building closer to cold and dark status.

At the end of 2024, the Y-12 Complex had achieved nine of twelve targets that have been established, and the remaining targets were carried into future years. Highlights of achievements include the following (further details and additional successes are presented in Chapter 4 of this report):

- **Energy efficiency.** Y-12 completed chiller plant improvements after obtaining a utility energy service contract and funding approval.
- **Hazardous materials.** A project to disposition and ship legacy mixed waste according to the site treatment plan continued. In 2024, 100 percent of site treatment plan items on the July 28, 2016, baseline inventory were shipped. This was 2 years ahead of schedule.
- **Land, water, and natural resources.** Y-12 upgraded sanitary sewer networks as part of a project to protect the sanitary sewer lines from infill and infiltration.



Figure 1.8. Aerial view of the Y-12 National Security Complex

Y-12 continues to strive to reduce impacts on the environment through increased use of environmentally friendly products and processes and reductions in waste and emissions. In FY 2024, the Y-12 Complex implemented 105 pollution prevention initiatives that resulted in a reduction of more than 8.32 million lbs of waste and projected cost efficiencies of more than $4.4 million. Also in 2024, Y-12 diverted 59.9 percent of municipal waste (over 5.9 million lbs) and 2.8 percent of construction and demolition waste (over 4.0 million lbs) from landfill disposal through source reduction, reuse, and recycle.

Compared to the FY 2003 baseline year, Y-12 has seen an energy intensity reduction of 53.22 percent as of FY 2024. During FY 2024, energy intensity was 195,756 Btu/gross square foot, three-quarters of a percentage lower than the prior year's 197,270 Btu/gross square foot. Continued construction on the new Uranium Processing Facility also contributes to the energy intensity for this year.

Continuing and new construction projects such as the Uranium Processing Facility contribute to energy intensity. Performance goals and status for the Y-12 Complex are listed in Chapter 4, Table 4.1.

1.4.3. East Tennessee Technology Park

ETTP (see Figure 1.9), originally named K-25, is the site of the nation's first gaseous diffusion uranium enrichment plant. It was established as part of the World War II Manhattan Project. Additional uranium enrichment facilities K-29, K-31, and K-33 were built adjacent to K-25 during the Cold War; these facilities formed a complex officially known as the Oak Ridge Gaseous Diffusion Plant. Uranium enrichment operations at the site ceased in 1986, and restoration, decontamination, and decommissioning activities began soon after in preparation for ultimate conversion of the site to a private sector industrial park to be called the Heritage Center. Reindustrialization of the site began in 1996 when

it was renamed the East Tennessee Technology Park.

Crews completed soil remediation at ETTP in calendar year 2024 after the demolition of all unneeded facilities at the site. The site is divided into two cleanup regions: Zone 1, a 1,300-acre area outside the main plant area; and Zone 2, the 800-acre area that comprises the main plant area. The areas in these zones are divided into Exposure Units (EUs) that vary in size from 6 to 38 acres.

The EU-21 trichloroethene (TCE) Project made the final soil shipment from ETTP on May 2, 2024. The project began in July 2021 and was estimated to create 19,000 yd^3 of TCE-contaminated waste. The project shipped more than 102,000 yd^3 of material both on-site and off-site. The project ran into several challenges during the 3-year effort: mercury process piping, multiple high-concentration TCE areas, schedule targets, supply chain issues, and the process for defining the extent of the contamination.

Crews removed two structures from the EU-20 footprint in October as part of the remaining facilities disposition effort. This area included the north end of the previously demolished K-25 Building. The K-2500-J tent, also known as the Segmentation Shop Storage Facility, and the K-2500-AB facility were demolished and hauled to Oak Ridge Reservation Landfills (ORRL). After removing these facilities, radiological surveys on the slabs below the structures were completed in support of national historical preservation and future public access.

Excavation of two remaining soil contamination areas were completed in calendar year 2024: TCE contaminated soil at EU-30 and two "hotspots" in Area B of EU-35. The EU-30 remedial action targeted approximately 500 yd^3 on the southern edge of EU-30, between the former K-1301 and K-1401 facilities. The EU-35 remediation focused on approximately 4,700 yd^3 of contaminated soil around the perimeter of the K-1407-B Pond, which was primarily used as a settling pond for metal hydroxide sludge and other waste streams.

Through the UCOR Efficiency and Stewardship initiative, measures designed to promote environmental resiliency and efficient operations are being incorporated throughout UCOR's processes and activities. The initiative focuses on supporting clean energy technology development through reindustrialization, as well as education and partnerships to leverage resiliency awareness for enhanced operational efficiency. UCOR's partnerships, stakeholder engagement, and efficiency accomplishments towards achieving its environmental stewardship goals in 2024 are detailed further in Section 3.2.1.

OREM continued to see significant momentum in the Reindustrialization Program at ETTP. The former government-owned uranium enrichment complex is being turned into a multiuse industrial park that includes national historical preservation and conservation and green space areas. Reindustrialization efforts at ETTP are expected to generate 1,400 jobs from the $1.35 billion in investments announced by the on-site companies, which are largely focusing on clean energy technology.

OREM has transferred over 1,700 acres for economic development at ETTP, including 470 acres during FY 2024. Marking a significant milestone for the Reindustrialization Program, OREM and UCOR also completed the final transfer of major utilities. ETTP is now served by a public infrastructure system of water, sewer, electric, and natural gas utilities.

Upon regulatory approval, transfer packages are submitted for department and congressional approvals, which finalizes the process. Clean energy and new nuclear businesses are currently under development in these areas and the Oak Ridge Community. For example, Kairos Power has just started construction of the Hermes low-power demonstration reactor at the ETTP Site. This will be the first non-light-water reactor permitted in the United States in over 50 years.



Figure 1.9. Aerial view of the East Tennessee Technology Park

1.4.4. Environmental Management Waste Management Facility

The EMWMF (shown in Figure 1.10) is located in eastern Bear Creek Valley near the Y-12 Complex and is managed by UCOR. The EMWMF was built for the disposal of waste resulting from CERCLA cleanup actions on ORR. The original design was for the construction, operation, and closure of a projected 1.3 million m^3 (1.7 million yd^3) disposal facility. The approved capacity was subsequently increased to 1.8 million m^3 (2.4 million yd^3) to maximize use of the footprint designated in a 1999 Record of Decision (DOE 1999). The facility currently consists of six disposal cells.

The EMWMF is an engineered landfill that accepts low-level, mixed low-level, and hazardous wastes from CERCLA cleanup activities on ORR that meet specific waste acceptance criteria developed in accordance with agreements with state and federal regulators. Waste types that qualify for disposal include soil, dried sludge and sediment, solidified waste, stabilized waste, building debris, scrap equipment, and secondary waste such as personal protective equipment, all of which must meet land disposal restrictions. In addition to the solid waste disposal facility, the EMWMF operates a leachate collection system. In 2024, the facility collected, analyzed, and disposed of approximately 3.42 million gallons of leachate. The leachate is treated at the ORNL Liquids and Gaseous treatment facility, which is also operated by UCOR (UCOR 2024).



Figure 1.10. Aerial view of the Environmental Management Waste Management Facility

In FY 2024, EMWMF received 9,976 waste shipments from cleanup projects at ETTP, ORNL, and Y-12, totaling 131,597 yd^3. The EMWMF landfill has a design capacity of 2.3 million yd^3 and is now over 85 percent filled. Planning continued in FY 2024 for another disposal facility, the Environmental Management Disposal Facility (EMDF), to provide the capacity required to complete Oak Ridge's cleanup mission.

Crews completed fieldwork at the EMDF for the early site preparation activities in May 2024. This work included rerouting portions of Bear Creek Road and the Haul Road and developing other support areas. OREM continues to work with EPA and TDEC on regulatory documents for the EMDF landfill. The Groundwater Field Demonstration Remedial Design Work Plan/Remedial Action Work Plan was approved in October 2023, and the Remedial Design Work Plan for the EMDF design was prepared and reviewed with approval in September 2024.

1.4.5. Oak Ridge Environmental Research Park

DOE established the Oak Ridge National Environmental Research Park (see Figure 1.11) in 1980. Managed for DOE by UT-Battelle, the research park serves as an outdoor laboratory to evaluate the potential environmental consequences of energy use and development and strategies to mitigate those effects. Its large blocks of forest and diverse communities of vegetation offer unparalleled resources for ecosystem-level and large-scale research. Major national and international collaborative research initiatives use it to address issues such as multiple stress interactions, biodiversity, tropospheric air quality, innovative power conductors, solar radiation monitoring, ecological recovery, and monitoring and remediation.

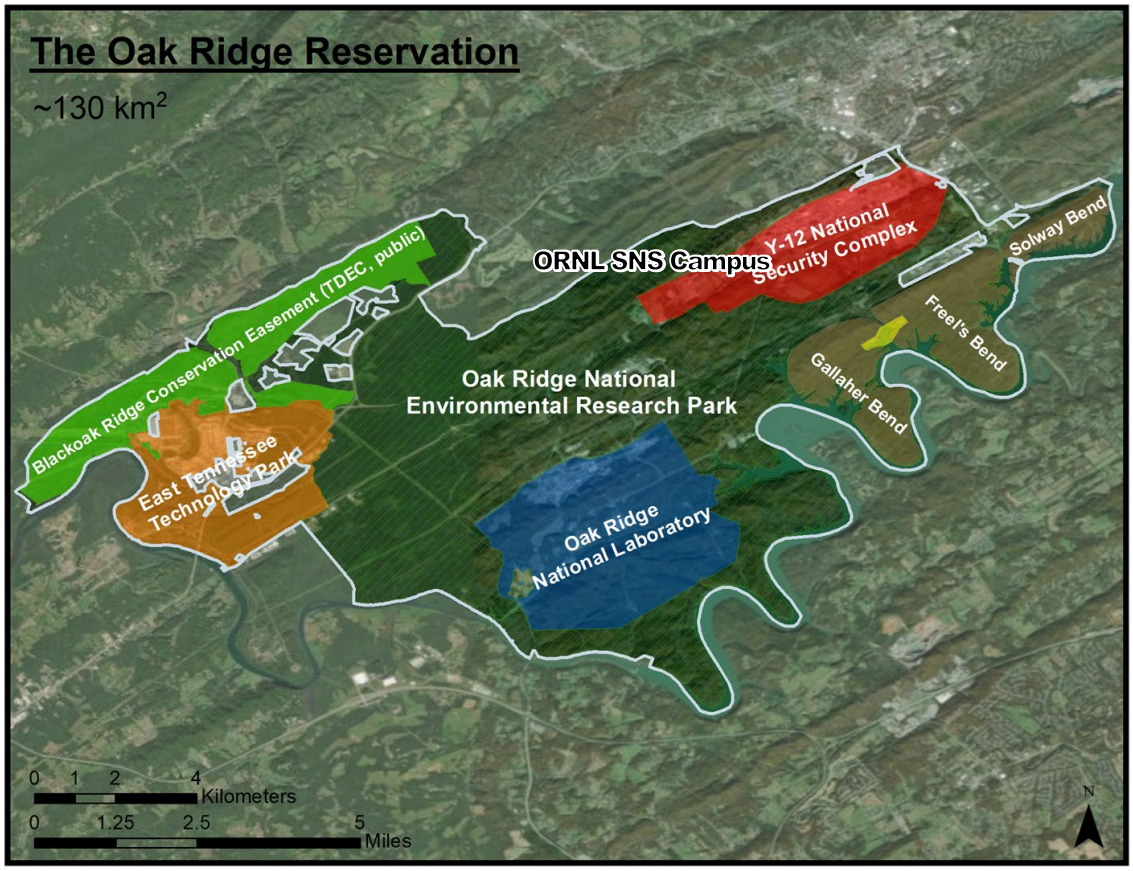


Figure 1.11. Location of the Oak Ridge National Environmental Research Park

Field sites at the research park provide maintenance and support facilities that permit sophisticated and well-instrumented environmental experiments. These facilities include elaborate monitoring systems that enable users to measure environmental factors precisely and accurately for extended periods. Because the park is under the jurisdiction of the federal government, public access is restricted; therefore, experimental sites and associated equipment are not disturbed. National recognition of the research park's value has led to its use in both regional- and continental-scale research projects. Research Park sites offer opportunities for aquatic and terrestrial ecosystem analyses of topics such as biogeochemical cycling of pollutants resulting from energy production, landscape alterations, ecosystem restoration, wetland mitigation, and forest and wildlife management.

1.4.6. Oak Ridge Institute for Science and Education

ORISE is managed for DOE by Oak Ridge Associated Universities. ORISE is located on the southeastern border of ORR in an area that was part of an agricultural experiment station owned by the federal government from the late 1940s to the mid-1980s. The ORISE mission is to develop people and solutions to strengthen our nation's competitive advantage in science. ORISE accomplishes its mission by recruiting and preparing the next generation of our nation's scientific workforce; promoting sound scientific and technical investment decisions through independent peer reviews; facilitating and preparing for the medical management of radiation incidents in the United States and abroad; evaluating health outcomes in workers exposed to chemical and radiological hazards on the job; and ensuring public confidence in environmental cleanup through independent environmental assessments. ORISE creates opportunities for collaboration through partnerships with other DOE facilities, federal agencies, academia, and industry consistent with DOE objectives and the ORISE mission.

In 2024, ORISE's Radiation Emergency Assistance Center/Training Site (REAC/TS) and the Cytogenetic Biodosimetry Laboratory (CBL) hosted a delegation from the Japan Nuclear Regulation Authority, which was originally established to learn the lessons of the Fukushima Daiichi nuclear incident of 2011. The staff of REAC/TS and the CBL continually work to build international relationships such as these in support of radiation safety training and radiation emergency response. Also in the summer of 2024, the ORISE K-12 Science, Technology, Engineering, and Mathematics Education hosted a variety of educator professional development programs, residential research programs, and day camps serving 756 participants in Oak Ridge, Tennessee; Tucson, Arizona; Albuquerque, New Mexico; Towson, Maryland; and elsewhere (ORAU 2025).

1.4.7. National Nuclear Security Administration Office of Secure Transportation, Agent Operations Eastern Command

Beginning in 1947, DOE and its predecessor agencies moved nuclear weapons, weapons components, special nuclear materials, and other important national security assets by commercial and government modes of transportation. In the late 1960s, worldwide terrorism and acts of violence prompted a review of procedures for safeguarding these materials. As a result, a comprehensive new series of regulations and equipment was developed to enhance the safety and security of these materials in transit. Modified and redesigned transport equipment was created to incorporate features that more effectively enhance self-protection and deny unauthorized access to the materials. Also during this time, the use of commercial transportation systems was abandoned, and a totally federal operation was implemented. The organization responsible for this mission within DOE NNSA is the Office of Secure Transportation, or OST.

The NNSA OST AOEC Secure Transportation Center and Training Facility is situated on about 723 hectares (1,786 acres) at ORR. It operates under a user permit agreement with the DOE Oak Ridge Office. The NNSA OST AOEC performs its assigned mission transportation operations, maintains applicable fleet and escort vehicles, and continues extensive training activities for its federal agents.

1.4.8. Transuranic Waste Processing Center

The TWPC is located on an approximately 10.5-hectare (26-acre) tract of land in the Melton Valley area of ORNL about 120 feet west of the existing Melton Valley Storage Tanks; it is managed by UCOR. The TWPC's mission is to receive transuranic waste for processing, treatment, repackaging, and shipment to designated facilities for final disposal.

Transuranic waste consists of materials and debris that are contaminated with elements that have a higher atomic mass and are listed after uranium on the periodic table. The majority of Oak Ridge's inventory of transuranic materials

originated from previous research and isotope production missions at ORNL. Waste determined to be non-transuranic (e.g., low-level radioactive waste or mixed low-level waste) is shipped to the NNSA or other approved facilities. In 2024, the TWPC completed a significant amount of hazardous inventory reduction when it safely and compliantly performed 12 shipments of legacy transuranic waste to the Waste Isolation Pilot Plant in Carlsbad, New Mexico; these shipments resulted in an inventory reduction of 301 drums. The TWPC team also completed 12 shipments of mixed low-level waste, low-level waste, and hazardous industrial waste resulting from the processing and certification of the TRU legacy waste.



Figure 1.12. Aerial view of the Transuranic Waste Processing Center

In FY 2024, TWPC continued its operational focus on management of the challenging waste generated by Nuclear Fuel Services Inc. from its nuclear fuel production activities. This waste, consisting of 4 boxes and 13 drums, was processed and repackaged into 140 drums of compliant soil and debris for disposal.

1.5. References

Birdwell 2011. Birdwell, Kevin Ray, "Wind Regimes in Complex Terrain of the Great Valley of Eastern Tennessee." PhD dissertation, University of Tennessee, May.

Broad 2007. Broad, William J, *Why They Called It the Manhattan Project*. New York Times, October 30, 2007. Retrieved May 25, 2024, from https://www.nytimes.com/2007/10/30/science/30manh.html.

Census Bureau 2025a. *Metropolitan and Micropolitan Statistical Areas Population. Totals: 2020-2024*. US Census Bureau, Washington, DC. Retrieved May 23, 2025, from https://www.census.gov/data/tables/time-series/demo/popest/2020s-total-metro-and-micro-statistical-areas.html.

Census Bureau 2025b. *County Population Totals and Components of Change: 2020-2024*. US Census Bureau, Washington, DC. Retrieved May 23, 2025, from https://www.census.gov/data/tables/time-series/demo/popest/2020s-counties-total.html.

Census Bureau 2025c. *City and Town Population Totals: 2020-2024*. US Census Bureau, Washington, DC. Retrieved May 23, 2025, from https://www.census.gov/data/tables/time-series/demo/popest/2020s-total-cities-and-towns.html.

CERCLA 1980. *Comprehensive Environmental Response, Compensation, and Liability Act*. Title 42 US Code Chapter 103.

CWA 1972. *Clean Water Act.* Title 33 US Code §1251 et seq.

DOE 1999. *Record of Decision for the Disposal of Oak Ridge Reservation Comprehensive Environmental Response, Compensation, and Liability Act of 1980 Waste, Oak Ridge, Tennessee.* DOE/ OR/01-1791&D3, November 1999, US Department of Energy, Oak Ridge Office of Environmental Management, Oak Ridge, Tennessee.

DOE 2001. *Cultural Resource Management Plan*, *DOE Oak Ridge Reservation, Anderson and Roane Counties, Tennessee*. DOE/ORO-2085, US Department of Energy Oak Ridge Operations Office, Oak Ridge, Tennessee, July.

DOE 2011. *Environment, Safety, and Health Reporting.* DOE Order 231.1B, June 27, 2011, US Department of Energy, Washington, DC.

DOE 2012. "Memorandum of Agreement Among the U.S. Department of Energy Oak Ridge Office of Environmental Management, Department of Energy Federal Preservation Officer, the Tennessee State Historic Preservation Office, the Advisory Council on Historic Preservation, the City of Oak Ridge, Tennessee, and the East Tennessee Preservation Alliance, Pursuant to 36 CFR Part 800.6(B)(2) For Decommissioning And Demolition of the K-25 Site and Interpretation of the East Tennessee Technology Park, on the Oak Ridge Reservation, Roane County, Tennessee." US Department of Energy, Oak Ridge Operations, Oak Ridge, Tennessee, August 6, 2012.

DOE 2020. *Radiation Protection of the Public and the Environment.* DOE Order 458.1, Chg 4 (LtdChg), September 15, 2020, US Department of Energy, Washington, DC.

DOE 2025. 2025 Remediation Effectiveness Report for the US Department of Energy Oak Ridge Site, Oak Ridge, Tennessee, Data and Evaluations. DOE/OR/01-2989&D1, April 2025, US Department of Energy, Oak Ridge Office, Oak Ridge, Tennessee.

DOE-DOI 2015. "Memorandum of Agreement Between the United States Department of the Interior and the United States Department of Energy for the Manhattan Project National Historical Park." Washington, DC, November 10, 2015.

DOE-FWS 2013. "Memorandum of Understanding between the United States Department of Energy and the United States Fish and Wildlife Service Regarding Implementation of Executive Order 13186, 'Responsibilities of Federal Agencies to Protect Migratory Birds'." US Department of Energy and US Fish and Wildlife Service, Washington, DC. Retrieved from https://www.fws.gov/sites/default/files/documents/memorandum-of-understanding-doe.pdf.

East Tennessee Economic Council. *US Department of Energy FY 2020 Economic Impact in Tennessee.* Oak Ridge, Tennessee.

EO 2001. *Responsibilities of Federal Agencies to Protect Migratory Birds*. Issued January 10, 2001.

EPA 2025. *Tennessee Nonattainment/ Maintenance Status for Each County by Year for All Criteria Pollutants.* April 30, 2025. Retrieved May 19, 2025, from https://www3.epa.gov/airquality/greenbook/anayo_tn.html.

ESA 1973. *Endangered Species Act*. Title 16 US Code Chapter 35 §1531 et seq.

FWS 2011. *Birds of Management Concern and Focal Species*. US Department of the Interior, US Fish and Wildlife Service, Migratory Bird Program, Falls Church, Virginia. Retrieved May 25, 2024, from https://www.fws.gov/sites/default/files/documents/Birds-of-Management-Concern-and-Focal-Species.2011_2.pdf.

FWS 2021. *Birds of Conservation Concern 2021*. US Department of the Interior, US Fish and Wildlife Service, Migratory Birds, Falls Church, Virginia. Retrieved from https://www.fws.gov/media/birds-conservation-concern-2021.

Hogan 2021. Hogan, Colbi W, "Displaced to Save the World: Strategies for Using Historic Preservation and Education to Interpret Pre-1942 Communities in Oak Ridge, Tennessee." PhD dissertation, Middle Tennessee State University, August.

Johnson 2018. Johnson, Charles W. (March 1, 2018). *Oak Ridge*. The Tennessee Historical Society. Retrieved May 26, 2024, from https://tennesseeencyclopedia.net/entries/oak-ridge.

MBTA 1918. *Migratory Bird Treaty Act.* Title 16 US Code §§703–712.

McCracken et al. 2015. McCracken, M.K., N.R. Giffen, A.M. Haines, and J.W. Evans, *Bat Species Distribution on the Oak Ridge Reservation.* ORNL/TM-2015/248, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Nature Conservancy 1995. *The Oak Ridge Reservation, Biodiversity, and the Common Ground Process Final Report*. Prepared for DOE under contract DE-AC05-840R21400, October. Retrieved May 26, 2024, from https://www.nerp.ornl.gov/wp-content/uploads/2018/07/orr_tnc_1995.pdf.

NatureServe 2025. NatureServe Network Biodiversity Location Data accessed through NatureServe Explorer [web application]. NatureServe, Arlington, Virginia. Retrieved May 25, 2025, from https://explorer.natureserve.org/.

NDAA 2014. National Defense Authorization Act of 2015. HR 3979, SEC. 3039.

NEPA 1969. *National Environmental Policy*. Title 42, US Code Chapter 55.

NHPA 1966. *National Historic Preservation Act*. Public Law 89-665; Title 54, US Code 300101 et seq.

Oakridger 2024. *ORNL director provides update on fast-growing lab.* November 27, 2024. Retrieved July 17, 2025, from https://www.oakridger.com/story/news/local/2024/11/26/ornl-director-provides-update-on-fast-growing-lab/76569064007/.

Olwell 1999. *Help Wanted for Secret City: Recruiting Workers for the Manhattan Project at Oak Ridge, Tennessee, 1942–1946*. Tennessee Historical Quarterly, Spring 1999, 58(1): 52–69.

ORAU 2025. *ORAU Story 2024.* 2024 Annual Report for Oak Ridge Associated Universities, 100 ORAU Way, Oak Ridge, Tennessee 37830. Retrieved July 13, 2025, from https://www.orau.org/news/annual-report.html.

Parr and Hughes 2006. Parr, P.D. and J.F. Hughes, *Oak Ridge Reservation Physical Characteristics and Natural Resources.* ORNL/TM-2006/110, Oak Ridge National Laboratory, Oak Ridge, Tennessee. Retrieved May 26, 2025, from https://www.osti.gov/servlets/purl/921773.

PIF 2025. Avian Conservation Assessment Database Scores. Bird Conservancy of the Rockies. Database updated Spring 2025. Retrieved May 25, 2025, from https://pif.birdconservancy.org/avian-conservation-assessment-database-scores/.

Reed 2014. Reed, Bruce Cameron. *The History and Science of the Manhattan Project, Second Edition*. Springer-Verlag, New York.

Rosensteel 1996. Rosensteel, Barbara A., *Wetland Survey of the X-10 Bethel Valley and Melton Valley Groundwater Operable Units at Oak Ridge National Laboratory, Oak Ridge, Tennessee*. ORNL/ER 350, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Rosensteel 1997. Rosensteel, Barbara A., *Wetland Survey of Selected Areas in the Oak Ridge Y-12 Plant Area of Responsibility, Oak Ridge, Tennessee*. Y/ER-279, Y-12 National Security Complex, Oak Ridge, Tennessee.

Rosensteel and Trettin 1993. Rosensteel, Barbara A. and Carl C. Trettin*, Identification and Characterization of Wetlands in the Bear Creek Watershed.* Y/TS-1016, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Roy et al. 2014. Roy, W.K., N.R. Giffen, M.C. Wade, A.M. Haines, J.W. Evans, and R.T. Jett, *Oak Ridge Reservation Bird Records and Population Trends*. ORNL/TM-2014/109, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Souza 2001. Souza, Peter A., *Cultural Resource Management Plan: Department of Energy Oak Ridge Operations Office, Anderson and Roane Counties, Tennessee*. DOE/ORO 2085, US Department of Energy, Oak Ridge Operations Office, Oak Ridge, Tennessee, July 2001.

TDEC 2021. *Tennessee Natural Heritage Program Rare Plant List*. Tennessee Department of Environment and Conservation, Division of Natural Areas, Nashville, Tennessee.

TDEC 2025. *Rare Species Dataviewer*. Tennessee Department of Environment and Conservation, Nashville, Tennessee. Retrieved May 29, 2025, from https://dataviewers.tdec.tn.gov/dataviewers/f?p=9014:3:118904174220701.

TWRA 2024. *Rules and Regulations for In Need Management, Threatened, and Endangered Species.* Chapter 1660-01-32, Rules of the Tennessee Wildlife Resources Agency, Biodiversity, Tennessee Department of Environment and Conservation, Nashville, Tennessee, December 2024. Retrieved July 17, 2025, from https://publications.tnsosfiles.com/rules/1660/1660-01/1660-01-32.20241225.pdf.

UCOR 2017. *Construction Execution/Management Plan, Outfall 200 Mercury Treatment Facility at the Y-12 National Security Complex, Oak Ridge, Tennessee*. UCOR-4972/R3, UCOR, Oak Ridge, Tennessee, October 15.

UCOR 2024. *2024 Cleanup Progress: Annual Report to the Oak Ridge Regional Community, Oak Ridge, Tennessee*. OREM- 24-7651, UCOR, Oak Ridge, Tennessee. Retrieved July 21, 2025 at https://www.energy.gov/sites/default/files/2024-12/Cleanup%20Progress%202024.pdf.

Zurawski 1978. Zurawski, A., "Summary Appraisals of the Nation's Ground-Water Resources–Tennessee Region." US Geological Survey Professional Paper 813-L.



Migratory birds known to nest on the Oak Ridge Reservation, such as this summer tanager, are covered by the Migratory Bird Treaty Act. DOE and its partners follow a wildlife management plan to protect migratory birds and their habitats.

2

Compliance Summary and Community Involvement

Activities conducted on ORR must conform to environmental standards established by federal and state statutes and regulations, DOE orders, contract-based standards, and compliance and settlement agreements where applicable. EPA and TDEC are the principal regulating agencies that issue permits, review compliance reports, participate in joint monitoring programs, inspect facilities and operations, and enforce compliance with applicable regulations.

The following sections summarize the major environmental statutes and their 2024 status for DOE operations on ORR. Note that the DOE Reindustrialization Program, typically in coordination with the Community Reuse Organization of East Tennessee, has leased several facilities at ETTP and the Oak Ridge Science and Technology Park at ORNL to private entities over the past several years. This report does not discuss the compliance status of these lessee operations.

2.1. Laws and Regulations

Table 2.1 is a summary of the principal environmental standards applicable to DOE activities on the reservation and their 2024 status and the sections in this report that provide more detailed information.

2.2. External Oversight and Assessments

Table 2.2 lists the inspections of ORR's environmental activities conducted by regulatory agencies for each of the major ORR sites (ETTP, Y-12, and ORNL) during 2024. This table does not include internal DOE or DOE contractor assessments, audits, or evaluations.

2.3. Reporting of Oak Ridge Reservation Spills and Releases

Substances defined as hazardous under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) are considered harmful to human health and the environment. Because many are commonly used substances that are harmless in normal uses but can be dangerous when released, CERCLA establishes reportable quantities for hazardous substance releases. Neither ETTP, Y-12, nor ORNL had any spills exceeding CERCLA reportable quantity limits.

Certain releases of oil must be reported if they "cause a film or sheen upon or discoloration of the surface of the water or adjoining shorelines or cause a sludge or emulsion to be deposited beneath the surface of the water or upon adjoining shorelines" (40 *Code of Federal Regulations* 110.3[b]). Neither ETTP, Y-12, nor ORNL had any reportable releases of oil to area waterways.

Neither ETTP, Y-12, nor ORNL had any reportable releases of extremely hazardous substances, as defined by the Emergency Planning and Community Right-to-Know Act, in 2024. See Sections 3.3.12, 4.3.10, and 5.3.10 of this report for more information.

2.4. Notices of Violations and Penalties

ETTP had no notices of environmental violations or penalties in 2024.

In 2024, there were no Clean Air Act violations or exceedances at Y-12. Compliance with the Y-12 National Pollutant Discharge Elimination System (NPDES) water discharge permit limits was 100 percent. Non-compliances with the Clean Water Act were as follows:

- On July 17, 2024, a Notice of Violation was received from TDEC for a fish kill resulting from a potable water line break on June 20, 2024.
- On October 1, 2024, a fish kill occurred when controlled low-strength material (concrete mix) from UCOR pre-demolition activities entered East Fork Poplar Creek through an abandoned drain line from the basement of Building 9201-02. The discharge resulted in high turbidity, elevated pH, and the death of approximately 1,300 fish and other aquatic organisms.
- On July 28, 2024, the instantaneous flow rate in the sanitary sewer peaked at approximately 4,000 gallons per minute (gpm), exceeding the 2,100-gpm limit. This was a result of a 2.2-inch rainfall in 2.5 hours.

Personnel from the TDEC Division of Solid Waste Management performed an unannounced Resource Conservation and Recovery Act hazardous waste compliance inspection of Y-12 from May 21-22, 2024. One issue was identified: a 10-gal container of hazardous waste was not labeled with the accumulation start date. This was corrected immediately. The issue and its causes were reviewed to prevent recurrence.

TDEC conducted a compliance inspection at ORNL on December 12, 2024, and a minor violation was issued for a petroleum underground storage tank. The violation was immediately resolved and was closed by TDEC on January 14, 2025. There were no notices of environmental violations or penalties received by other contractors (Isotek and UCOR) who conducted activities at ORNL in 2024. ORNL wastewater treatment facilities achieved a numeric permit compliance rate of 100 percent in 2024. The Carbon Fiber Technology Facility also achieved 100 percent compliance with the UT-Battelle City of Oak Ridge Industrial and Commercial User Discharge Pre-Treatment Permit in 2024.

2.5. Community Involvement and Resources

DOE and its contractors provided or supported numerous community involvement activities in 2024 that addressed a range of subjects. These included American Museum of Science and Energy

community meetings hosted by the City of Oak Ridge, ETTP airport public meetings, American Museum of Science and Energy public bus tours of ORR, and public comment periods for environmental permitting and groundwater cleanup.

During 2024, DOE and its contractors continued long-term partnerships with organizations such as East Tennessee Children's Hospital, Second Harvest Foodbank of East Tennessee, Boys and Girls Club of the Tennessee Valley, Court, Appointed Special Advocates, YMCA of East Tennessee, Friends of the Smokies, the University of Tennessee Nuclear Engineering Department, and Roane State Community College. DOE contractors and employees donated over $1.6 million to these and many other charities and programs in FY 2024 (ORNL 2024, UCOR 2024a, UCOR 2024b, Y-12 2024a, Y-12 2024b, Y-12 2024c).

2.5.1. Public Comments Solicited

To keep the public informed of comment periods and other matters related to cleanup activities on ORR, DOE publishes online notices at https://www.energy.gov/orem/services/community-engagement, conducts public meetings, and issues notices in local newspapers, as appropriate. Information on environmental policy and DOE's commitment to providing sound environmental stewardship practices and keeping the public informed is available to the public through sponsored forums and public documents such as this report. In 2024, public comments were solicited on the East Tennessee Technology Park Main Plant groundwater remedy selections, among other topics.

2.5.2. Oak Ridge Site Specific Advisory Board

The Oak Ridge Site Specific Advisory Board is a federally appointed citizens' panel that provides independent advice and recommendations to the DOE Oak Ridge Environmental Management Program. The board was formed in 1995 and is composed of up to 22 members chosen to reflect the diversity of genders, races, occupations, views, and interests of persons living near ORR. Members are appointed by DOE and serve on a voluntary basis without compensation. Information on recommendations the board has made since its establishment, minutes of board and committee meetings, and other information are available at https://www.energy.gov/orem/oak-ridge-site-specific-advisory-board. Videos of the first hour of recent board meetings are posted at https://www.energy.gov/orem/listings/oak-ridge-site-specific-advisory-board-meetings. (For more information, call 865-241-4583 or 865-241-4584.)

2.5.3. DOE Information Center

The DOE Information Center, located at 1 Science.Gov Way, Oak Ridge, Tennessee, is a one-stop information facility that maintains a collection of more than 45,000 documents describing environmental activities in Oak Ridge.

The center is open Monday through Friday from 8 a.m. to 5 p.m. and can be reached by phone at 865-241-4780, or toll-free at 1-800-382-6938 (option 6). An online catalog that can be used to search for DOE documents by author, title, date, and other words or phrases is available at https://www.energy.gov/orem/services/community-engagement/doe-information-center.

2.5.4. Other Resources

- Agency for Toxic Substances and Disease Registry: 1-800-232-4636, https://www.atsdr.cdc.gov
- DOE main website: https://www.energy.gov
- DOE Oak Ridge Public Affairs Office: 865-576-4912
- EPA Region 4: 1-800-241-1754 or 404-562-9900, https://www.epa.gov/aboutepa/about-epa-region-4-southeast
- TDEC, DOE Oversight Division: 865-481-0995, https://www.tn.gov/environment/program-areas/rem-remediation/orr.html

- ETTP: https://www.energy.gov/orem/cleanup-sites/east-tennessee-technology-park
- Y-12 National Security Complex: https://www.y12.doe.gov/
- ORNL: https://www.ornl.gov/

Table 2.1. Applicable environmental laws and regulations and 2024 status

Regulatory program description	2024 status	Report sections
The Clean Air Act and State of Tennessee rules regulate the release of air pollutants through permits and quality limits. Emissions of radionuclides are regulated by EPA via National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities. Greenhouse gas (GHG) emissions inventory tracking and reporting are regulated by EPA and by DOE.	In 2024, all activities on ORR were conducted in accordance with Clean Air Act requirements.	3.3.4 4.3.4 5.3.3
The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) provides a regulatory framework for remediation of the release or threat of release of hazardous substances from past practices on ORR.	ORR was placed on the EPA National Priorities List in 1989. The ORR Federal Facility Agreement, initiated in 1992 between EPA, TDEC, and DOE, established the framework and schedule for developing, implementing, and monitoring remedial actions on ORR. The on-site CERCLA EMWMF is operated by UCOR for DOE. Located in Bear Creek Valley, EMWMF is used for disposal of waste resulting from CERCLA cleanup actions on ORR. EMWMF is an engineered landfill that accepts low-level radioactive, hazardous, asbestos, and PCB wastes, and combinations of these wastes, in accordance with specific waste acceptance criteria under an agreement with state and federal regulators. No CERCLA notices of violations were issued for ORR actions during 2024.	3.3.9 4.3.8, 4.3.12 5.3.8
The Clean Water Act seeks to protect and improve surface water quality by establishing surface water standards enabled by a system of permits. Wastewater discharges are regulated by National Pollutant Discharge Elimination System (NPDES) permits issued by TDEC.	Discharges to surface water at each of the three major ORR sites are governed by NPDES permits. In 2024, ETTP, Y-12, and ORNL achieved a compliance rate of 100% with NPDES permit limits (see Appendix D). Two fish kills were reported at Y-12. On July 17, 2024, a Notice of Violation was received from TDEC for a fish kill resulting from a potable water line break on June 20, 2024. On October 1, 2024, controlled low-strength material (concrete mix) from UCOR pre-demolition activities entered East Fork Poplar Creek, resulting in the death of approximately 1,300 fish and other aquatic organisms. An instantaneous flow rate exceedance in the sanitary sewer occurred on July 28, 2024, at Y-12 from excessive rainfall.	3.3.5, 3.3.6 4.3.5 5.3.4
The Energy Independence and Security Act (EISA) Section 438 establishes requirements for federal agencies to reduce storm water runoff from development projects to protect water resources.	A variety of storm water management techniques, referred to as green infrastructure or low impact design practices, have been implemented on ORR to comply with EISA. The associated reporting provides data to support EISA Section 438 compliance.	4.2.6.3, 4.2.6.9 5.2.1.4, 5.2.1.5, 5.2.1.6

Table 2.1. Applicable environmental laws and regulations and 2024 status (continued)

Regulatory program description	2024 status	Report sections
The Emergency Planning and Community Right-to-Know Act (EPCRA), also referred to as the Superfund Amendments and Reauthorization Act Title III, requires reporting of emergency planning information, hazardous chemical inventories, and environmental releases of certain toxic chemicals to federal, state, and local authorities.	In 2024, DOE facilities on ORR operated in accordance with emergency planning and reporting requirements as defined by EPCRA. ETTP had no reportable releases of hazardous or extremely hazardous substances. Y-12 reported seven extremely hazardous substances and 47 hazardous substances that were over Section 312 inventory thresholds. ORNL exceeded the Section 3.13 reporting threshold and reported on the manufacture of nitrate compounds as by-products of on-site sewage treatment.	3.3.12 4.3.10 5.3.10
The National Environmental Policy Act (NEPA) requires consideration of how federal actions may impact the environment and an examination of alternatives to the actions. NEPA also requires that decisions include public input and involvement through scoping and review of certain NEPA documents.	During 2024, DOE planning and decision-making activities at ETTP, Y-12, and ORNL were conducted via site-level procedures that provide requirements for project reviews and NEPA compliance. In 2024, two environmental assessments and 31 NEPA reviews were conducted at Y-12, with one of the reviews being a federal CX document requiring approval by the NNSA NEPA Compliance Officer. UT-Battelle, LLC at ORNL conducted 152 reviews of activities that were approved under general actions or generic CX determinations.	3.3.2 4.3.2 5.3.2
The National Historic Preservation Act (NHPA) provides protection for the nation's historic resources by establishing a comprehensive national historic preservation policy.	ORR has several facilities eligible for inclusion in the National Register of Historic Places. Proposed activities are reviewed to determine potential adverse effects on these properties, and identify methods to avoid, mitigate, or minimize adverse effects or harm. During 2024, activities on ORR were conducted in compliance with NHPA requirements.	3.3.3 4.3.3 5.3.2
ORR Protection of Wetlands Programs are implemented to minimize the destruction, loss, or degradation of ORR wetlands and to preserve and enhance their beneficial value.	Surveys to determine the presence of wetlands are conducted as needed for projects or programs through NEPA and other reviews to facilitate compliance with TDEC and USACE requirements. Wetland protection on ORR is conducted according to 10 *Code of Federal Regulations* 1022 and EO 11990, *Protection of Wetlands*. No new wetlands were delineated at ETTP or Y-12 in 2024. At ORNL, two wetlands were delineated in 2024.	1.3.6.1 5.3.12
The Resource Conservation and Recovery Act (RCRA) governs the generation, storage, handling, and disposal of hazardous wastes. RCRA also regulates underground storage tanks containing petroleum and hazardous substances, universal waste, and recyclable used oil.	Y-12, ORNL, and ETTP are defined as large-quantity generators of hazardous waste, because each generates more than 1,000 kg of hazardous waste per month. Each site is also regulated as a handler of universal waste. In addition, several permits have been issued for hazardous waste management units on ORR. No notices of violation were issued for ETTP in 2024. ORNL had a minor violation that was immediately resolved involving a petroleum underground storage tank. At Y-12, one issue was identified—a 10-gal container of hazardous waste was not labeled with the accumulation start date. This was corrected immediately. The issue and its causes were reviewed to prevent recurrence.	3.3.8 4.3.7, 4.3.13 5.3.6, 5.3.7

Table 2.1. Applicable environmental laws and regulations and 2024 status (continued)

Regulatory program description	2024 status	Report sections
The Safe Drinking Water Act establishes minimum drinking water standards and monitoring requirements.	The City of Oak Ridge supplies potable water to the facilities on ORR and is responsible for meeting all regulatory requirements for drinking water. Sampling results in 2024 for residual chlorine levels, bacterial constituents, and disinfectant by-products in ORR's water system were all within acceptable limits.	3.3.7 4.3.6 5.3.5
The Toxic Substances Control Act regulates the manufacture, use, and distribution of a number of toxic chemicals.	PCB waste generation, transportation, disposal, and storage at ORR are regulated under EPA regulations for each of the three ORR sites with EPA RCRA identification numbers TN3890090001, TN1890090003, and TN0890090004. Each site issues an independent PCB Annual Document Log and PCB Annual Report. In 2024, UT-Battelle operated four PCB storage areas. Three were located at ORNL, and one was located at the Y-12 Complex. The ORR PCB Federal Facilities Compliance Agreement between EPA and DOE continues to provide a mechanism to address legacy PCB-use issues across ORR. The agreement specifically addresses the unauthorized use of PCBs, storage and disposal of PCB waste, PCB spill cleanup and decontamination, PCBs mixed with radioactive materials, PCB research and development, and ORR records and reporting requirements. EPA is updated annually on the status of DOE actions regarding management and the progress on the disposition of legacy PCBs covered by the ORR PCB Federal Facilities Compliance Agreement.	3.3.11 4.3.9 5.3.9
The Bald and Golden Eagle Protection Act protects bald and golden eagles by prohibiting, except under specified conditions, the taking or possession of and commerce in such birds. The act imposes criminal and civil penalties for any such actions.	Bald eagles are known to frequent ORR year-round. Two active bald eagle nests on ORR are protected in accordance with this act.	1.3.6.2
The Endangered Species Act prohibits activities that would jeopardize the continued existence of an endangered or threatened species or cause adverse modification to a critical habitat.	ORR is host to several plant and animal species categorized as endangered, threatened, or of special concern, and these species are protected in accordance with this act.	1.3.6.2, 1.3.6.3
The Migratory Bird Treaty Act protects migratory birds by governing the taking, killing, possession, transportation, and importation of such birds, including their eggs, parts, and nests and any product, manufactured or not, from such items.	ORR hosts numerous migratory birds that are protected under this act.	1.3.6.2

Table 2.1. Applicable environmental laws and regulations and 2024 status (continued)

Regulatory program description	2024 status	Report sections
DOE Order 231.1B, *Environment, Safety, and Health Reporting,* ensures timely collection, reporting, analysis, and dissemination of information on environment, safety, and health issues.	The *2024 Oak Ridge Reservation Annual Site Environmental Report* summarizes ORR environmental activities during 2024 and characterizes environmental performance.	All chapters
DOE Order 435.1, Change 1, *Radioactive Waste Management,* is implemented to ensure that all DOE radioactive waste is managed in a manner that protects workers, public health and safety, and the environment.	Waste certification programs that are protective of workers, the public, and the environment have been implemented for all activities on ORR to ensure compliance with this DOE order.	3.2.6 4.3.14, 4.7 5.3.13
DOE Order 458.1, *Radiation Protection of the Public and the Environment,* issued in June 2011, canceled DOE Order 5400.5 and was established to protect members of the public and the environment from undue risk from radiation. This order established standards and requirements for operations of DOE and DOE contractors.	In 2024, DOE Order 458.1 was the primary contractual obligation for radiation protection programs for UT-Battelle, LLC and Consolidated Nuclear Security LLC, and for all UCOR work scope areas where existing CERCLA decision documents do not specifically identify DOE Order 5400.5 requirements. A dose assessment was performed to ensure that the total dose to members of the public from all DOE ORR pathways did not exceed the 100 mrem annual limit established by this order. The assessment estimated the maximum 2024 dose to a hypothetically exposed member of the public from all ORR potential exposure pathways combined would be about 4 mrem. Therefore, the 2024 maximum effective dose was about 4% of the 100 mrem annual limit given in DOE Order 458.1. Clearance of property from ORNL, ETTP, and the Y-12 Complex was conducted in accordance with approved procedures that comply with DOE Order 458.1. There were no unplanned radiological air emission releases from the three major ORR sites in 2024. No limits were exceeded in 2024.	3.2.6 4.3.4, 4.3.14 5.3.13, 5.5, 5.6.2 Chapter 6 Chapter 7
DOE Order 5400.5, *Radiation Protection,* was established to protect members of the public and the environment against undue risk from radiation. This order established standards and requirements for operations of DOE and DOE contractors.	DOE Order 5400.5 is the primary environmental surveillance radiological applicable, relevant, and appropriate requirement for most CERCLA activities across ORR. It will remain in force until the individual CERCLA decision documents are reissued or revised to incorporate DOE Order 458.1. A dose assessment, performed to ensure the total dose to members of the public from all ORR pathways did not exceed the 100 mrem annual limit established by this order, estimated the maximum 2024 dose to a hypothetical exposed member of the public from all ORR potential exposure pathways combined would be about 4 mrem.	Chapter 7

Table 2.1. Applicable environmental laws and regulations and 2024 status (continued)

Regulatory program description	2024 status	Report sections
Executive Order 13186, *Responsibilities of Federal Agencies to Protect Migratory Birds*, identifies the responsibilities of federal agencies to promote the conservation of migratory bird populations.	A memorandum of understanding entered into by DOE and the US Fish and Wildlife Service meets the requirements under Section 3 of EO 13186. ORR hosts numerous migratory birds that are present either seasonally or year-round. This memorandum, which was updated in September 2013, strengthens migratory bird conservation on ORR through enhanced collaboration between DOE and the US Fish and Wildlife Service.	1.3.6.2

Acronyms:

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
CX = categorical exclusion
DOE = US Department of Energy
EISA = Energy Independence and Security Act
EMWMF = Environmental Management Waste Management Facility
EO = Executive Order
EPA = US Environmental Protection Agency
EPCRA = Emergency Planning and Community Right-to-Know Act
ETTP = East Tennessee Technology Park
GHG = greenhouse gas
mrem = millirem
NEPA = National Environmental Policy Act
NHPA = National Historical Preservation Act
NNSA = National Nuclear Security Administration
NPDES = National Pollutant Discharge Elimination System
ORNL = Oak Ridge National Laboratory
ORR = Oak Ridge Reservation
PCB = polychlorinated biphenyl
RCRA = Resource Conservation and Recovery Act
TDEC = Tennessee Department of Environment and Conservation
UCOR = United Cleanup Oak Ridge LLC
USACE = U.S. Army Corps of Engineers
UT-Battelle = UT-Battelle, LLC
Y-12 or Y-12 Complex = Y-12 National Security Complex

Table 2.2. Summary of external regulatory environmental audits, inspections, and assessments at ORR, 2024

Date	Reviewer	Subject	Issues
		East Tennessee Technology Park	
June 20	TDEC	ETTP NPDES Permit TN0002950 CEI	0
November 9	EPA	ETTP Site Tour	0
		Y-12 National Security Complex	
March 21	TDEC	Quarterly ORR Landfill Inspections of ILF-V, ILF-IV, CDL-VII, and Semiannual Post Closure Inspection of ILF-II	0
March 26	City of Oak Ridge	Sanitary Sewer Inspection	0
April 11	TDEC	Quarterly ORR Landfill Inspections of ILF-II, ILF-V, and CDL-VII	0
May 21–22	TDEC/EPA	Annual RCRA Hazardous Waste Compliance Inspection	1
July 10	TDEC	Air Quality Inspection	0
August 1	TDEC/City of Oak Ridge	ORR Landfill Inspection of ILF-V and CDL-VII Leachate Collection Systems	0
August 1	TDEC/City of Oak Ridge	Sanitary Sewer Inspection	0
August 19	TDEC	Quarterly ORR Landfill Inspection of ILF-V and CDL-VII	0
September 19	TDEC	Quarterly ORR Landfill Inspection of ILF-IV	0
November 22	TDEC	Quarterly ORR Landfill Inspections of ILF-V and CDL-VII. Second Semiannual Post Closure Inspection of ILF-II	0
December 12	TDEC	Quarterly ORR Landfill Inspection of ILF-IV	0
		Oak Ridge National Laboratory (including UT-Battelle, UCOR, and Isotek activities)	
March 4–5	TDEC	Hazardous Waste Compliance Evaluation Inspection (including UT-Battelle, TWPC, and UCOR)	0
March 26	City of Oak Ridge	CFTF Wastewater Pretreatment Permit Inspection	0
April 3	KCDAQM	Hardin Valley Campus Clean Air Act Inspection	0
September 23	City of Oak Ridge	CFTF Wastewater Pretreatment Permit Inspection	0
August 9	TDEC	TWPC Clean Air Act Inspection	0
December 4	TDEC	Clean Air Inspection for ORNL	0

Acronyms:

CDL = Construction/Demolition Landfill
CEI = Compliance Evaluation Inspection
CFTF = Carbon Fiber Technology Facility
EPA = US Environmental Protection Agency
ETTP = East Tennessee Technology Park
ILF = Industrial Landfill
ISOTEK = Isotek Systems, LLC
KCDAQM = Knox County Department of Air Quality Management
NPDES = National Pollutant Discharge Elimination System
ORR = Oak Ridge Reservation
RCRA = Resource Conservation and Recovery Act
TDEC = Tennessee Department of Environment and Conservation
TWPC = Transuranic Waste Processing Center
UCOR = United Cleanup Oak Ridge LLC
UT-Battelle = UT-Battelle, LLC

2.6. References

DOE 2025. 2025 Remediation Effectiveness Report for the US Department of Energy Oak Ridge Site, Oak Ridge, Tennessee, Data and Evaluations. DOE/OR/01-2989&D1, April 2025, US Department of Energy, Oak Ridge Office, Oak Ridge, Tennessee.

ORNL 2024. "Employee-led giving at ORNL nets over $1.1M for area nonprofits, disaster relief in 2024." January 29, 2025. Retrieved May 25, 2025, from https://www.ornl.gov/news/employee-led-giving-ornl-nets-over-11m-area-nonprofits-disaster-relief-2024.

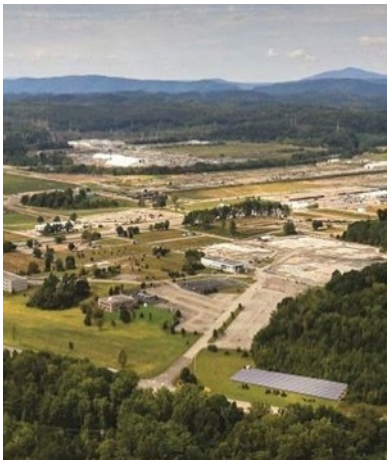
UCOR 2024a. "UCOR awards $45,000 in STEM education mini-grants." UCOR NR 2024-04, May 20, 2024. Retrieved May 25, 2025, from https://ucor.com/ucor-awards_45k_in_mini-grants/.

UCOR 2024b. "United Cleanup Oak Ridge donates $645,000 to East Tennessee Children's Hospital to expand behavioral health program." UCOR JNR 2024-01, June 4, 2024. Retrieved May 25, 2025, from https://ucor.com/ucor-donates-645000-to-etch/.

Y-12 2024a. "CNS awards $5,000 STEM grant." November 12, 2024. Retrieved May 25, 2025, from https://www.y12.doe.gov/news/press-releases/cns-awards-5000-stem-grant.

Y-12 2024b. "CNS awards $180,000 in 2024 grants to community nonprofits." September 19, 2024. Retrieved May 25, 2025, from https://www.y12.doe.gov/news/press-releases/cns-awards-180000-2024-grants-community-nonprofits.

Y-12 2024c. "Bechtel-led CNS supports Helene recovery in Tennessee." October 15, 2024. Retrieved May 25, 2025, from https://www.y12.doe.gov/news/press-releases/bechtel-led-cns-supports-helene-recovery-tennessee.



The East Tennessee Technology Park has changed greatly in recent years as remediation projects have been completed.

3

East Tennessee Technology Park

ETTP was built during World War II as part of the Manhattan Project. Formerly known as the K-25 Site, its primary mission was to enrich uranium for use in atomic weapons. After the war, the mission changed to include the enrichment of uranium for nuclear reactor fuel elements and recycling of uranium recovered from spent fuel, and the name changed to the "Oak Ridge Gaseous Diffusion Plant" (ORGDP). In the 1980s, a reduction in demand for nuclear fuel resulted in the shutdown of the enrichment process and production. The emphasis of the mission then changed to environmental management and remediation operations. In 1996, the name changed to the "East Tennessee Technology Park," or ETTP. The central portion of ETTP is also referred to as "the Heritage Center."

Environmental management and remediation consist of the cleanup of outdoor storage and disposal areas, the demolition and cleanup of facilities, waste management, land restoration, environmental monitoring, and the proper disposal of waste generated from production operations. Beginning in the 1990s, reindustrialization, the conversion of underused government facilities for use by the private sector, became part of ETTP's mission. State and federally mandated effluent monitoring and environmental surveillance involve the collection and analysis of air, water, soil, sediment, and biota samples from ETTP and surrounding areas. Monitoring results are used to assess exposures to the public and the environment, evaluate the performance of treatment systems, and identify concerns within permitted standards for emissions and discharges. On November 10, 2015, the DOE and the US Department of the Interior signed a memorandum of agreement (MOA) establishing the Manhattan Project National Historical Park (MPNHP; DOE 2015). The MOA defines agency roles and responsibilities in park administration and provisions for enhanced public access, management, interpretation, and historic preservation. The ORGDP footprint is included in the MPNHP; details are available on the MPNHP page of the National Park Service website, **here**. In addition, the K-25 Virtual Museum website, found **here**, details its history through narrative, interviews, and photographs.

3.1. Description of Site and Operations

Construction of the K-25 Site (Figure 3.1) began in 1943 as part of the World War II Manhattan Project. The plant's original mission was the production of enriched uranium for nuclear weapons. Enrichment was initially carried out in the S-50 thermal diffusion process facility, which operated for one year, and then in the K-25 and K-27 gaseous diffusion process buildings. Later, the K-29, K-31, and K-33 buildings were built to increase the production capacity of the original facilities by raising the assay of the feed material entering K-27. Following the war years, the site became officially known as ORGDP, the first such uranium processing plant in the world.

After military production of highly enriched uranium was concluded in 1964, the two original process buildings, K-25 and K-27, were shut down. For the next 20 years, the plant's primary mission was the production of low enriched uranium fabricated into fuel elements for nuclear reactors throughout the world. Other missions during the latter part of this 20-year period included developing and testing the gas centrifuge method of uranium enrichment and laser isotope separation research and development.

By 1985, the demand for enriched uranium declined, and the gaseous diffusion cascades at ORGDP were placed in standby mode. That same year, the gas centrifuge program was canceled. The decision to permanently shut down the diffusion cascades was announced in late 1987, and actions necessary to implement that decision were initiated soon thereafter. Because of the termination of the original and primary missions, ORGDP was renamed the "Oak Ridge K-25 Site" in 1989.

Figure 3.2 shows the ETTP site areas before the start of decontamination and decommissioning (D&D) activities. In 1996, the K-25 Site was renamed the "East Tennessee Technology Park" to reflect its new mission.

The ETTP mission is to reindustrialize and reuse site assets through leasing and/or transferring excess or underused land and facilities and by incorporating commercial industrial organizations as partners in the ongoing environmental restoration, D&D, and waste treatment and disposal. The site is undergoing environmental cleanup of its land, including remedial activities for soil and groundwater, as well as the removal of remaining media created during D&D activities. The cleanup approach makes land and various types of buildings (e.g., office, manufacturing) suitable for private industrial use and for title transfer to the Community Reuse Organization of East Tennessee (CROET) or other Not-for-Profit (NFP) entities such as the City of Oak Ridge. The long-term DOE goal for ETTP is to transfer as much of the site property as practicable out of DOE ownership and into the NFP's control for the development of a commercial business and industrial park. The facilities may then be subleased or sold, with the goal of stimulating private industry and recruiting businesses to the area. These transfers also reduce maintenance costs for DOE, which allows additional funds to be reallocated elsewhere on the reservation for environmental cleanup. Figure 3.3 shows the ETTP property transfer status through 2024.

UCOR, the lead environmental management contractor for ETTP, supports DOE in the reindustrialization program as part of the continuing effort to transform ETTP into a private-sector industrial park in addition to a national park and conservation area. Unless otherwise noted, information about non-DOE entities located on the ETTP site is not provided in this document.



Figure 3.1. The K-25 Site in 1946



Figure 3.2. East Tennessee Technology Park since the start of decontamination and decommissioning activities in 1991

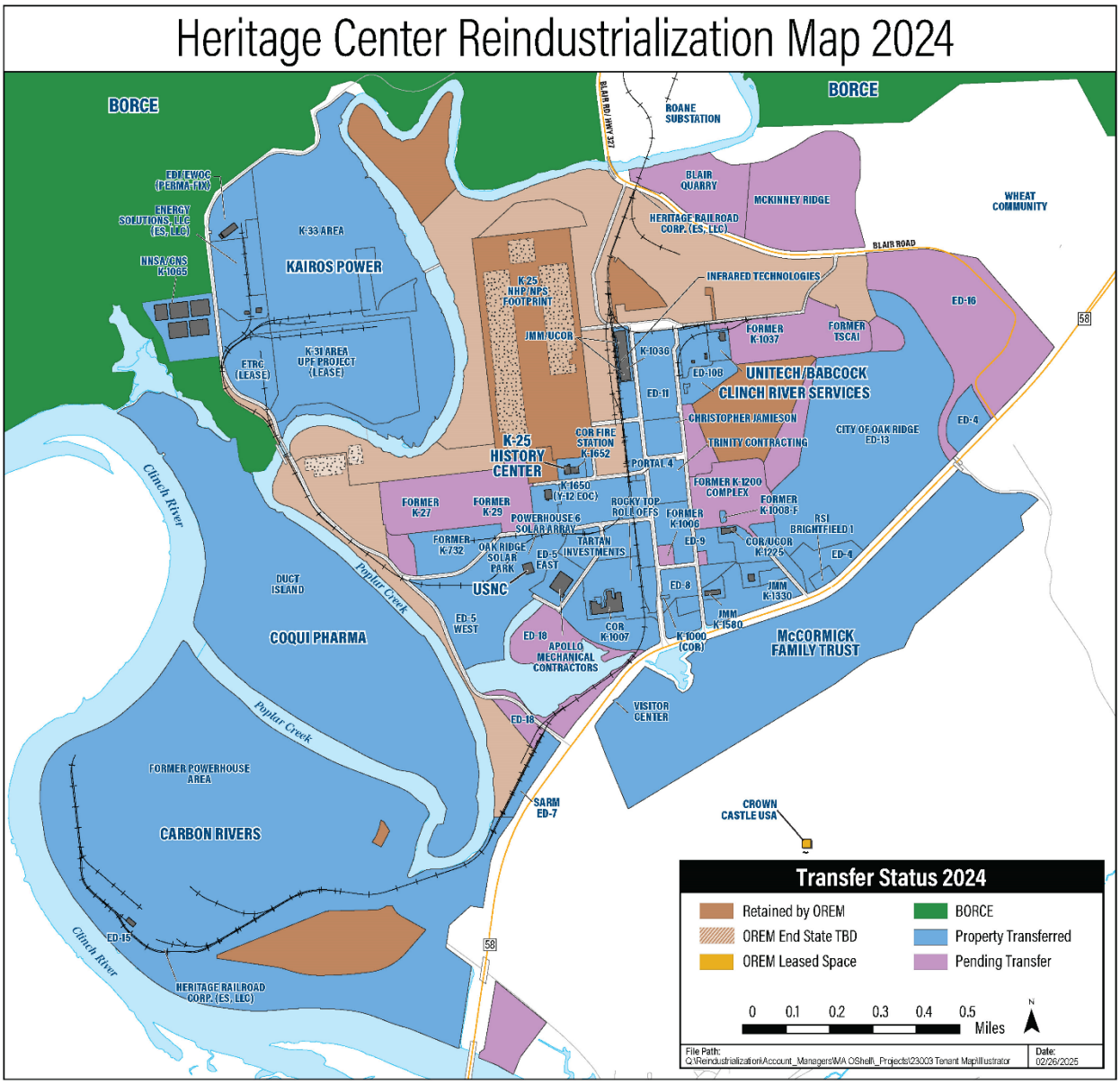


Figure 3.3. East Tennessee Technology Park in 2024, showing progress in reindustrialization

3.2. Environmental Management System

The DOE Environmental Management System (EMS) is integrated with the UCOR Integrated Safety Management System (ISMS). The EMS reflects the elements and framework contained in International Organization for Standardization (ISO) Standard 14001:2004, Environmental management systems—Requirements with guidance for use (ISO 2004). UCOR is committed to incorporating sound environmental management and protection in all business decisions, work processes and activities that are part of the DOE Environmental Management (EM) program in Oak Ridge. UCOR's environmental policy also includes a commitment to continually improve the environmental performance of their operations; to protect and sustain human, natural, and cultural resources; and to complete environmental cleanup safely with reduced risks to the public, workers, and the environment. To

achieve this, UCOR's environmental policy adheres to the following principles, in part:

- **Leadership commitment**. Integrate responsible environmental practices into project operations.
- **Environmental compliance**. Comply with all environmental regulations and standards.
- **Environmental stewardship**. Minimize the effects of our operations on the environment through a combination of source reduction, recycling and reuse, sound waste management practices, and pollution prevention.
- **Partnerships/Stakeholder involvement**. Maintain partnerships through effective two-way communications with our customer and stakeholders.

3.2.1. Environmental Stewardship

UCOR's Efficiency and Stewardship initiative is designed to promote environmental resiliency and efficient operations. Through this program, measures are being incorporated throughout UCOR's processes and activities to focus on resilient operations and infrastructure, as well as education and partnerships to accelerate resiliency awareness and operations. This includes supporting clean energy technology development through reindustrialization, workforce education activities such as the UCOR Parking Lot Rodeo, and participating in community events like BizTown and STEM nights.

3.2.1.1. Workforce and Partnerships

UCOR reinforces environmental stewardship practices throughout the workforce. Three UCOR projects were recognized for efficiency and stewardship in 2024, as summarized below:

- The Environmental Management Disposal Facility (EMDF) Power Line Reuse project was recognized for removing and recycling 2 miles of 3-phase 161kV aluminum conductor line and associated ductile steel poles. The project diverted 26,000 lb of waste with cost savings of $10,620 of offset project costs.
- The Beta-1 Water Treatment System project installed the groundwater treatment system to treat water from the Beta-1 basement, and subsequently discharge the treated water, to the Upper East Fork Poplar Creek (UEFPC). As of September 2024, the treatment system has treated and discharged over 5.6 million gallons of water from the basement and will continue to operate until the deactivation of Beta-1 basement is completed. The project has saved $14,688 in fuel costs.
- The project for K-2500 AB Water Tank Reuse relocated a 7,800-gallon water tank from K-2500 AB to the Y-12 Heavy Equipment Yard for fire suppression operations to eliminate the need of hydrants in this area and allow for site expansion with improved fire safety posture saving a total of $19,925.

Together, the projects represented efficiency accomplishments in cost savings, waste diversion, and waste reduction.

In addition to building awareness and competency throughout the workforce, UCOR is leveraging partnerships and stakeholder engagement to achieve its environmental stewardship goals. These partnerships include public meetings and briefings, the Oak Ridge Site Specific Advisory Board (ORSSAB), Community Reuse Organization of East Tennessee (CROET) and other ORR contractors to develop the most efficient and collaborative approaches.

3.2.2. Environmental Compliance

UCOR maintains various layers of oversight to ensure compliance with legal and other requirements. The methods of evaluation include independent assessments by outside parties, assessments conducted by functional or project organizations, and routine field walkdowns conducted by a variety of functional and project personnel. Issues identified in assessments are handled, as required, by applicable procedures and requirements. Records are maintained for all formal assessments and audits. For additional information, see Section 3.4.

3.2.3. Environmental Aspects/Impacts

Using a graded approach appropriate for EMS includes an environmental policy that provides a unified strategy for the management, conservation, and protection of natural resources; the control and attenuation of risks; and the establishment and attainment of all environmental, safety, and health (ES&H) goals.

Continuous improvements are made to the EMS to reduce impacts from cleanup activities and associated effects on the environment (i.e., environmental aspects) and to communicate and reinforce this policy to its internal and external stakeholders.

3.2.4. Environmental Performance Objectives and Targets

UCOR conserves and protects environmental resources by incorporating environmental protection and the elements of EMS into the daily conduct of business by using appropriate waste management, treatment, storage, and disposal methods. This system fosters a spirit of cooperation with federal, state, and local regulators. UCOR has established a set of core company-level EMS objectives that remain fairly consistent from year to year. These objectives are generally applicable to all operations and activities throughout DOE's provided work scope. The core environmental objectives are based on compliance with applicable legal requirements and efficient environmental practices, and include the following:

- Compliance with all applicable environmental regulations, permits, regulatory agreements, and DOE orders.
- Reduction or elimination of the acquisition, use, storage, generation, and/or release of toxic, hazardous, and radioactive material waste; strategic acquisition of environmentally preferable products, conduct of operations, removal and safe disposition, waste minimization, and efficient practices.
- Reduction of degradation and depletion of environmental resources and maximize cost efficiency through post-consumer material recycling, energy, fuel, and water conservation efforts; and transfer of excess DOE real estate to become a valuable asset for public reuse.
- Reduction of the environmental impact on surface water and groundwater resources.
- Reduction of the environmental impact associated with project and facility activities.

The EMS objectives and targets provide performance measures that demonstrate reduced environmental impact from mission activities and increased efficiency. Each year, EMS performance and activities are reported in a DOE web-based dashboard, which collects data such as energy and water usage, efficient buildings, facility metering, waste diversion, renewable energy, efficient acquisitions, and electronic stewardship.

The Office of Management and Budget's Environmental Stewardship Scorecard is used to track and measure site-level EMS performance. During fiscal year (FY) 2024, OREM and their contractors received a "green" for EMS performance, indicating full implementation of EMS requirements.

3.2.5. Implementation and Operation

DOE and its contractors protect the safety and health of workers and the public by implementing sound work practices which include identifying, analyzing, and mitigating aspects, hazards, and impacts from daily operations. All OREM employees and subcontractors are held responsible for complying with all ES&H requirements during all work activities and are expected to correct noncompliant conditions immediately. UCOR's internal assessments also provide a measure of how well EMS attributes are integrated into work activities through the ISMS. DOE and UCOR's fundamental commitment to incorporating sound environmental management practices in all business decisions, work processes, and activities are embodied in its company-wide environmental management and protection policy.

3.2.6. Pollution Prevention/Waste Minimization/Release of Property

DOE's work control process requires that all waste-generating activities be evaluated for source reduction and that product substitution be used to produce less toxic waste, when practicable. The reuse or recycling of building debris and other generated wastes are evaluated in all cases.

The EMS program fosters waste diversion at every level of its operations, from routine office recycling of paper, cardboard, and plastics, to unique reuse and recycling at the project-field level. UCOR's environmental programs are successful because they are tightly bound to its work control process.

DOE Order 458.1, *Radiation Protection of the Public and Environment* (DOE 2011b), requires that a process be in place to ensure that radiologically contaminated materials are not released to the public or the environment, except in compliance with permit effluent requirements or other agreements with regulatory agencies.

Materials and equipment may be released to the public through an approved pollution prevention/recycling program or through property sales (procedure PROC-PR-2032, *Disposition of Personal Property* [UCOR 2020a], governs the process of releasing personal property), and real property may be transferred to the public through CROET or other NFP entities.

Materials and equipment to be recycled or reused may follow one of two paths. If process knowledge is sufficient to establish that the materials and equipment have never been in contaminated areas (for example, empty beverage cans from a specified break area or an office building), then the materials may be released for recycling or reuse. Materials and equipment that have been in radiologic areas must be examined by trained radiologic control technicians and the results documented before the materials and equipment may be released. Materials and equipment that fail to meet the free release criteria are either decontaminated to the point that they meet the free release criteria or are properly disposed of at an appropriate disposal facility. The release of property from radiologic areas is governed by procedure PROC-RP-4516, *Radioactive Contamination Control and Monitoring* (Table 3.1). In addition to recycled materials and equipment, 224,640 lb of heavy equipment, office furniture, storage containers, generators, and safety wear were released to the public through property sales.

Real property to be transferred must meet the release criteria established by DOE Order 458.1 (DOE 2011b) and the appropriate Record of Decision (ROD). DOE ensures that these requirements are met through independent verification by a third party. Currently, this verification is performed by Oak Ridge Associated Universities (ORAU) as an independent third party. ORAU reviews historical data, facility use history, verification strategies, methodologies, techniques, and equipment. When ORAU deems it appropriate, additional sampling and/or radiological surveys are undertaken. Results of the evaluation and verification are summarized in a report to DOE that is then submitted to DOE Headquarters for approval as part of the transfer package.

Table 3.1. Surface contamination values and DOE Order 458.1 authorized limits for surface activity

Radionuclide	Removable	Total (fixed + removable)
Natural Uranium, ^{235}U, ^{238}U, and associated decay products	1,000	5,000
Transuranic, ^{226}Ra,^{228}Ra,^{230}Th,^{228}Th,^{231}Pa,^{227}Ac,^{125}I,^{129}I	20	100/500
Natural Th, ^{232}Th,^{90}Sr,^{223}Ra,^{224}Ra,^{232}U,^{126}I,^{131}I,^{133}I	200	1,000
Beta-gamma emitters except ^{90}Sr and others noted above	1,000	5,000
Tritium and Special Tritium Compounds	10,000	
Hard to Detect: Pu-241, C-14, Fe-55, Ni-59, and Ni-63	10,000	50,000

Note: *Limits are shown in disintegrations per minute/100 centimeters squared (dpm/100 cm²).*

3.2.7. Competence, Training, and Awareness

The UCOR training program and qualification process ensures that needed skills for the workforce are identified and developed and documents knowledge, experience, abilities, and competencies of the workforce for key positions requiring qualification. Completion and documentation of training, including required reading, are managed by the Local Education Administration Requirements Network (LEARN).

3.2.8. Communication

UCOR communicates externally regarding environmental aspects through the UCOR public website, found **here**, which includes a link to its environmental policy statement in *Environmental Management and Protection*, POL-UCOR-007 (UCOR 2020b), and a list of environmental aspects.

Several other documents and reports that address environmental aspects and cleanup progress are also published and made available to the public including the *Oak Ridge Annual Site Environmental Report* (DOE 2024a) and the *2023 Cleanup Progress—Annual Report to the Oak Ridge Regional Community* (DOE 2024b).

DOE and its contractors participate in a number of public meetings related to environmental activities at the site (e.g., Oak Ridge Site Specific Advisory Board (ORSSAB) meetings, which include community stakeholders, public permit reviews, and public Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) decision document reviews). Written communications from external parties are tracked using the weekly Open Action Report.

3.2.9. Benefits and Successes of Environmental Management System Implementation

An EMS program provides many benefits to an organization's success. Based upon the simplified model of the Plan-Do-Check-Act, it provides a framework by which work incorporates mitigation of environmental hazards into its work control and planning. This translates into many returns to the organization. UCOR uses EMS objectives and targets, strategic acquisition, work control processes in addition to a recycling program to meet efficiency and environmental stewardship goals and requirements. The approach is outlined in UCOR's *Pollution Prevention and Waste Minimization Program Plan for the East Tennessee Technology Park, Oak Ridge, Tennessee* (UCOR 2023a, UCOR-4127/R12). The EMS program is triennially audited by a third party to reverify conformance to ISO 14001:2004, with the most recent having been conducted in 2024. The results of the audit were zero findings, two observations, and three proficiencies. The two observations were analyzed and actions to improve external communications and evaluate waste tracking software for expanded use were implemented, and the issues were closed.

3.2.10. Management Review

A formal EMS program review/presentation with UCOR senior management was conducted in 2024. The review covered the program element identified in ISO 14001:2004 focus areas for the upcoming year, and the environmental policy. Also, the status of EMS calendar year (CY) company-level objectives and targets are periodically communicated to senior management.

3.3. Compliance Programs and Status

During 2024, ETTP operations were conducted in compliance with contractual and regulatory environmental requirements. There were no National Pollutant Discharge Elimination System (NPDES) noncompliances, nor did ETTP receive any notices of violation in 2024. Figure 3.4 shows the trend of NPDES compliance at ETTP since 2013. The following sections provide more detail on each compliance program and the environmental remediation-related activities in 2024.

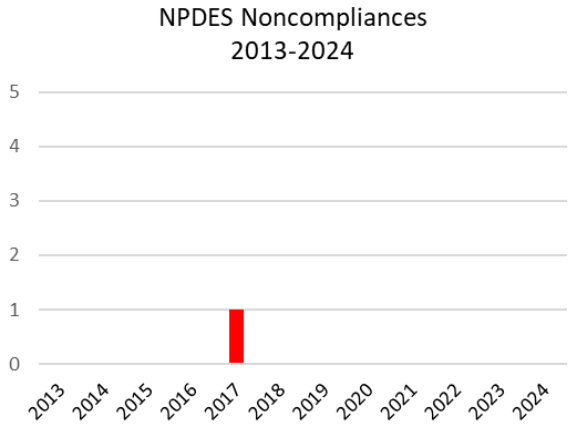


Figure 3.4. East Tennessee Technology Park NPDES permit noncompliances since 2013

In addition, ETTP is tracked on the US EPA Enforcement and Compliance History Online database (FRS ID 110002471094).

3.3.1. Environmental Permits Compliance Status

Table 3.2 contains a list of environmental permits that were in effect at ETTP in 2024. ETTP received no notices of environmental violations or penalties in 2024.

Table 3.3 presents a summary of environmental audits and oversight visits conducted at ETTP in 2024.

3.3.2. National Environmental Policy Act

The National Environmental Policy Act (NEPA) provides a means to evaluate the potential environmental impact of proposed federal activities and to examine alternatives to those actions. ETTP maintains compliance with NEPA through the use of site-level procedures and program descriptions that establish effective and responsive communications with program managers and project engineers to ensure NEPA is a key consideration in the formative stages of project planning.

For many of the current operations at ETTP conducted under CERCLA, NEPA reviews are conducted concurrently with the CERCLA planning process to ensure CERCLA projects and documentation incorporate NEPA values, including analysis of cumulative, off-site, ecological, and socioeconomic impacts. Opportunities for early public involvement are also provided early in the CERCLA process which meets the requirements of NEPA.

For non-CERCLA activities, a checklist incorporating NEPA and EMS requirements has been developed by UCOR's EC personnel as an aid for project planners to document the potential impacts on the environment during UCOR project operations. This checklist is used to collect necessary information to conduct a NEPA review.

To streamline the NEPA review and documentation process of non-CERCLA work, the DOE Oak Ridge Office of Environmental Management (OREM) utilizes the DOE agency-wide list of generic categorical exclusion (CX) determinations that cover certain proposed

activities (i.e., maintenance activities, facility upgrades, personnel safety enhancements) as defined in 10 *Code of Federal Regulations* (CFR) Part 1021 – National Environmental Policy Act Implementing Procedures (DOE 1992b). A CX is a category of actions defined in 40 CFR Section 1508.4 (EPA 1978) 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. For activities that are not covered by a CX and have the potential for environmental impact, NEPA review reports, or environmental assessments (EA) as defined in 40 CFR 1508.9 (EPA 1978), are prepared to determine if the preparation of an environmental impact statement (EIS) or a finding of no significant impact (FONSI) is required for proposed project activities. A FONSI, as described in 40 CFR 1508.13 (EPA 1978), is prepared when there are no significant environmental impacts proposed in the integral components of a project's design. If a FONSI cannot be determined during an EA, then an EIS is prepared as described in 40 CFR 1508.11 (EPA 1978). During 2024, there were no NEPA review reports generated to document UCOR activities at ETTP.

Table 3.2. ETTP environmental permits, 2024

Regulatory driver	Permit title/description	Permit number	Issue date	Expiration date	Owner	Operator	Responsible contractor
CWA	NPDES permit for groundwater and storm water discharges	TN0002950	02-04-2022	03-31-2027	DOE	UCOR	UCOR
CWA	SOP—Waste transportation project; Blair Road and Portal 6 sewage pump and haul permit	SOP-05068	09-22-2022	02-28-2028	TTS	TTS	TTS
RCRA	Hazardous waste corrective action document (encompasses the entire ORR)	TNHW-164	09-15-2015	09-15-2025	DOE	DOE/All[a]	DOE/All[a]

[a] *DOE and ORR contractors that are co-operators of hazardous waste permits.*

Acronyms:

DOE = US Department of Energy
ID = identification (number)
NOA = Notice of Authorization
NPDES = National Pollutant Discharge Elimination System
ORR = Oak Ridge Reservation
PBR = Permit-by-Rule
RCRA = Resource Conservation and Recovery Act of 1976
SOP = state operating permit
TDEC = Tennessee Department of Environment and Conservation
TTS = Turnkey Technical Services, LLC.
UCOR = United Cleanup Oak Ridge LLC

Table 3.3. Regulatory oversight, assessments, inspections, and site visits at ETTP, 2024

Date	Reviewer	Subject	Issues
June 20	TDEC	ETTP NPDES Permit TN0002950 CEI	0
November 9	EPA	ETTP Site Tour	0

Acronyms:

CEI = Compliance Evaluation Inspection
COR = City of Oak Ridge
EPA = US Environmental Protection Agency
ETTP = East Tennessee Technology Park
RCRA = Resource Conservation and Recovery Act
TDEC = Tennessee Department of Environment and Conservation

3.3.3. National Historic Preservation Act Compliance at ETTP

In 1998, the *K-25 Site Cultural Resources Survey/Archaeological Reconnaissance* (DOE 2001, DOE/ORO-2085) was completed at ETTP to identify properties eligible for inclusion in the National Register of Historic Places (NRHP). The NRHP is a US National Park Service program to identify, evaluate, and protect historic and archeological resources in the United States. The survey concluded that there were 120 contributing structures and 37 noncontributing structures within the ETTP Main Plant Historic District, as well as 11 structures not within the historic district eligible for inclusion in the NRHP. There have been more than 800 facilities demolished at ETTP, and 110 of those facilities were eligible for inclusion on the NRHP.

To commemorate the historic contributions of the former ORGDP, a final mitigation plan was developed by DOE in 2012 in exchange for the demolition of the facility. The plan called for the designation of a commemorative area around the building's perimeter from which future surface development would largely be restricted; the demarcation of the building's footprint; the construction of the K-25 Interpretive Center that allows visitors to see across the entire footprint of the former K-25 Building (Figure 3.5); creation of an online virtual museum; and the development of a history center within ETTP Fire Station #4. The final MOA was signed in August 2012 between DOE, the State Office of Historic Preservation, the Federal Advisory Council on Historic Preservation, the City of Oak Ridge, and the East Tennessee Preservation Alliance (DOE 2012). In 2015 the MPNHP was established to incorporate the K-25 footprint; and on February 27, 2020, the K-25 History Center opened to the public (DOI 2015).

Construction of the K-25 Interpretive Center, sited just north of the K-25 History Center, began on May 11, 2023, and was completed on March 4, 2025. The facility was constructed by the U.S. Army Corps of Engineers using contractor Geiger Brothers Inc. to manage construction and UCOR to provide engineering support. The facility includes a viewing platform with 10-foot-tall wraparound glass windows and exhibits that provide quick facts and visuals related to the historic importance of the K-25 Building, as well as view scopes and a scale model of the original facility. OREM plans to hold a grand opening for the public in September 2025 that corresponds with the 80th anniversary of the end of World War II.

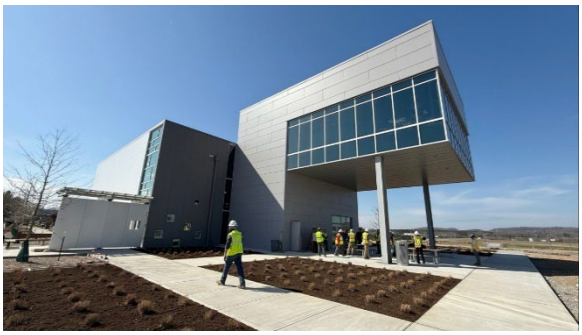


Figure 3.5. Final construction of the K-25 Interpretive Center

NHPA compliance throughout the ORR on D&D projects

In accordance with Section 106 of the National Historic Preservation Act (NHPA), UCOR works with OREM to provide a system of review for UCOR D&D projects throughout the ORR that have the potential to affect historic and archaeological resources on the ORR. The review process is guided by ORNL and Y-12 Programmatic Agreements, which follow the approach outlined in each site's Historic Preservation Plan, as well as MOAs between DOE, the State of Tennessee, the Advisory Council on Historic Preservation, and consulting parties.

In coordination with OREM and the Tennessee State Historic Preservation Officer, the UCOR NHPA coordinator evaluates proposed undertakings to determine if they have the potential to cause adverse effects on facilities identified as historical and cultural resources in the Historic Preservation Plans. DOE activities involving ORR artifacts of historical and/or cultural significance are identified before demolition and are catalogued in a database to aid in historic interpretation. In 2024, no undertakings on historically or culturally sensitive resources were proposed at ETTP.

3.3.4. 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 establishes comprehensive federal and state regulations to limit air emissions and includes five major regulatory programs: the National Ambient Air Quality Standards, State Implementation Plans, New Source Performance Standards, Prevention of Significant Deterioration permitting programs, and National Emission Standards for Hazardous Air Pollutants (NESHAP). Airborne discharges from DOE Oak Ridge facilities, both radioactive and nonradioactive, are subject to regulation by EPA and the TDEC Division of Air Pollution Control.

Full compliance with CAA regulations was demonstrated in 2024. The ETTP ambient air monitoring program as well as source operations tracking and record keeping, provided documentation fully supporting a 100-percent compliance rate.

3.3.5. 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. This act serves as the basis for comprehensive federal and state programs to protect the waters from pollutants (see Appendix C for water reference standards). One of the strategies developed to achieve the goals of the CWA was EPA's establishment of limits on specific pollutants allowed to be discharged in US waters by municipal sewage treatment plants and industrial facilities. EPA established the 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 2024, ETTP discharged storm water and groundwater to the waters of the State of Tennessee under the individual NPDES permit TN0002950, which regulates storm water discharges. Sewage discharges from routine breakrooms, restrooms, and change house showers were discharged to the City of Oak Ridge Rarity Ridge Wastewater Treatment Plant collection network.

In 2024, one CWA violation occurred on February 29, resulting from the unintentional release of approximately 30 mL of hydraulic fluid on the K-1007-P1 Pond. This release resulted in a surface water sheen that was reported to the National Response Center (Incident 1392686) as required.

3.3.6. National Pollutant Discharge Elimination System Permit Noncompliances

In 2024, compliance with ETTP NPDES storm water permit TN0002950 was determined by approximately 110 laboratory analyses, field

measurements, and flow estimates. The NPDES permit compliance rate for all discharge points for 2024 was 100 percent.

3.3.7. Safe Drinking Water Act Compliance Status

Since October 1, 2014, all water at the ETTP site has been supplied by the City of Oak Ridge drinking water plant, located north of Y-12 in Oak Ridge. ETTP operations are in full compliance with this act.

3.3.8. Resource Conservation and Recovery Act Compliance Status

ETTP is regulated as a large-quantity generator of hazardous waste because the facility generates more than 1,000 kg of hazardous waste per month. At the end of 2024, ETTP had two hazardous waste Resource Conservation and Recovery Act of 1976 (RCRA) Central Accumulation Areas, managed and operated by personnel of the Uranium Processing Facility, a Consolidated Nuclear Security, LLC owned project.

TNHW-164 is the hazardous waste corrective action (CA) document that covers areas of concern and solid waste management units on the ORR.

In CY 2024, ETTP prepared and submitted to the TDEC Division of Solid Waste Management the CY 2023 annual report of hazardous waste activities. This report identifies the type and amount of hazardous waste that was generated, shipped off site, or is staged for shipment. In 2024, ETTP was in full compliance with this act.

3.3.9. Comprehensive Environmental Response, Compensation, and Liability Act Compliance Status

CERCLA, also known as "Superfund," was passed in 1980 and amended in 1986 by the Superfund Amendments and Reauthorization Act. Under CERCLA, a site is investigated and remediated if it poses significant risk to health or the environment. The EPA National Priorities List is a comprehensive list of sites and facilities that have been found to pose a sufficient threat to human health and/or the environment to warrant cleanup under CERCLA. The ORR is on the National Priorities List and numerous CERCLA decision documents are approved for ETTP site cleanup actions for both facility demolitions and soil remediation. In 2024, ETTP was in full compliance with this act.

3.3.10. East Tennessee Technology Park RCRA-CERCLA Coordination

The *Federal Facility Agreement for the Oak Ridge Reservation* (DOE 1992a, FFA-PM/18-011, DOE/OR-1014) is intended to coordinate the CA processes of Resource Conservation and Recovery Act (RCRA) required under the Hazardous and Solid Waste Amendments permit with CERCLA response actions.

3.3.11. Toxic Substances Control Act Compliance Status—Polychlorinated Biphenyls

On April 3, 1990, DOE notified EPA Headquarters (as required by 40 CFR Section 761.205, *Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions* [EPA 1979]) that ETTP is a generator with on-site storage, a transporter, and an approved disposer of PCB wastes.

At this time, no PCB-contaminated electrical equipment is in service at ETTP.

Because of the age of many ETTP facilities and the varied uses for PCBs in gaskets, grease, building materials, and equipment, DOE self-disclosed unauthorized use of PCBs to EPA in the late 1980s. As a result, the DOE Oak Ridge Office and EPA Region 4 developed a major compliance agreement known as the *Oak Ridge Reservation Polychlorinated Biphenyl Federal Facilities Compliance Agreement* (DOE 2018, ORR-PCB-FFCA), which became effective December 16, 1996, and was last revised on October 8, 2018, to Revision 6. The facilities that were included on the ORR-PCB-FFCA have been demolished and disposed.

ORR-PCB-FFCA specifically addresses the unauthorized use of PCBs in ventilation ducts and gaskets, lubricants, hydraulic systems, heat

transfer systems, and other unauthorized uses; storage for disposal; disposal; cleanup and/or decontamination of PCBs and PCB items, including PCBs mixed with radioactive materials; and ORR records and reporting requirements. A major focus of the agreement is the disposal of PCB waste. As a result of that agreement, DOE and UCOR continue to notify EPA when additional unauthorized uses of PCBs, such as in paint, adhesives, electrical wiring, or floor tiles, are identified at ETTP. This notification process is routinely incorporated into the CERCLA documentation for demolition and remedial actions (RAs).

The ETTP site prepares a PCB Annual Document Log (PCBADL) per 40 CFR Section 761.180(a) (EPA 1979). The written PCBADL is prepared by July 1 of each year and covers the previous calendar year. The PCBADL documents such things as container inventory, shipments, and PCB spills at the facility. Authorized representatives of EPA may inspect the PCBADL at the facility where they are maintained during normal business hours. The PCBADL must be maintained on-site for a minimum of three years. A PCB Annual Report Form was submitted to EPA using EPA Form 6200-025 online before the due date of July 15, 2024. In 2024, ETTP was in full compliance with this act.

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

The Emergency Planning and Community Right-to-Know Act (EPCRA), which is also identified as Title III of the Superfund Amendments and Reauthorization Act, requires that facilities report inventory that exceed threshold planning quantities and releases of hazardous and toxic chemicals. The reports are submitted electronically and are available online for the local emergency planning committee, the state emergency response commission, and the local fire department. ETTP complied with these requirements in 2024 through the submittal of required reports as applicable under EPCRA Sections 302, 311, 312, and 313. In 2024, ETTP had no reportable releases of hazardous substances or extremely hazardous substances as defined by EPCRA.

3.3.12.1. Chemical Inventories (EPCRA Section 312)

Inventories, locations, and associated hazards of hazardous and extremely hazardous chemicals were submitted in an annual report to state and local emergency responders, as required by EPCRA Section 312. Of the ORR chemicals identified for 2024, six chemicals were located at ETTP. These chemicals were diesel fuel, unleaded gasoline, Chemical Specialties, Inc. Ultrapoles, various lubricating oils, sulfuric acid, and lead (including large, lead-acid batteries). As operations at ETTP are subsiding, there has been a steady decrease in the number of chemicals required to be reported under Section 312.

3.3.12.2. Toxic Chemical Release Reporting (EPCRA Section 313)

EPCRA Section 313 requires facilities to complete and submit a Toxics Release Inventory (TRI) form (Form R) annually. Form R must be submitted for each TRI chemical that is manufactured, processed, or otherwise used in quantities above the applicable threshold quantity. The reports address releases of certain toxic chemicals to air, water, land, and recycling, and waste management activities.

Threshold determinations and reports for each of the ORR facilities are made separately. Operations involving TRI chemicals were compared with regulatory thresholds to determine which chemicals exceeded the reporting thresholds based on amounts manufactured, processed, or otherwise used at each facility. After threshold determinations were made, releases and off-site transfers were calculated for each chemical that exceeded the threshold quantity. In 2024, there were no chemicals that met the reporting requirements.

3.4. Quality Assurance Program

Mission Assurance Program

Quality assurance (QA) program implementation and procedural and subcontract compliance are verified through the UCOR mission assurance program. The program identifies the processes for planning, conducting, and coordinating assessment and oversight of UCOR activities, including both self-performed and subcontracted activities, resulting in an integrated assessment and oversight process.

The program is composed of three key elements, including:

- External assessments conducted by organizations external to UCOR
- Independent assessments conducted by teams composed of UCOR personnel who are not directly involved with the project/function being assessed
- Management assessments, self-assessments, and surveillance conducted by the organization or on behalf of the organization manager

Management and self-assessments are performed by the organization/function with primary responsibility for the work, process, or system being assessed. Management assessments are periodic introspective self-analyses, conducted by or on behalf of management, to evaluate management systems, processes, and programs ensuring the organization's work is properly focused on achieving desired results. Self-assessments are lower-level assessments that can be implemented at any time to document review of emerging issues, facility walkdowns, observation checklists, or similar reviews that do not require extensive planning, approval, or resources. Surveillance (e.g., radiological protection, quality, and safety and health) is performed by functional organizations to evaluate functional program implementation at projects or operational areas.

Issues identified from internal and external assessments are documented, analyses are performed, and CAs are developed and tracked to closure. To perform analysis, data is collected and compiled on a periodic basis which allows for identification of adverse trends and opportunities for improvement for senior management action. UCOR is in the process of enhancing the CA closure process by developing a series of dashboards based upon the identified analysis needs.

3.5. Air Quality Program

The State of Tennessee has been delegated authority by EPA to convey the clean air requirements that are applicable to ETTP operations. New projects are governed by construction and operating permit regulatory requirements. The owner or operator of air pollutant emitting sources is responsible for ensuring full compliance with any issued permit or other generally applicable CAA requirement. During 2024, ETTP DOE EM operations were under UCOR responsibility for regulatory compliance.

3.5.1. Construction and Operating Permits

UCOR ETTP operations are subject to CAA regulations and permitting under TDEC Air Pollution Control rules that are specific to stationary fossil-fueled reciprocating internal combustion engines for emergency use. TDEC originally issued an operating permit (069346P) covering six stationary emergency reciprocating internal combustion engine (e-RICE) units on March 3, 2015. An amended permit was issued on November 22, 2016, that removed one permanently shut-down unit. The last operating permit was amended on November 22, 2016, and covered four stationary e-RICE generators and one stationary e-RICE firewater booster pump. On July 19, 2018, TDEC provided a Notice of Authorization to UCOR for coverage under Permit-by-Rule for all of the ETTP stationary e-RICEs (TDEC 2017b). During 2020 all generators and the firewater booster pump were either removed from the ETTP site or transferred to new owners;

UCOR then surrendered its Permit-by-Rule authorization. No stationary e-RICE units were operated by UCOR at ETTP in 2024.

All other ETTP operations that emit low levels of air pollutants have been classified as insignificant under TDEC rules. Any planned stationary sources that may emit air pollutants are evaluated and compared against applicable pollutant emission limits to document this classification and pursue permitting if required under TDEC regulations.

3.5.1.1. Generally Applicable Permit Requirements

ETTP is subject to a number of generally applicable requirements that involve management and control. Asbestos, ozone-depleting substances (ODSs), and fugitive particulate emissions are specific examples.

Control of asbestos

ETTP's asbestos management program ensures all activities such as demolitions and all other actions involving asbestos-containing materials (ACM) are fully compliant with 40 CFR Part 61, Subpart M, *National Emission Standards for Hazardous Air Pollutants*, "National Emission Standard for Asbestos" (EPA 1984, EPA 1990). This includes using approved engineering controls and work practices, inspections, and monitoring for proper removal and waste disposal of ACM. Most demolition and ACM abatement activities at ETTP are governed under CERCLA. Under this act, notifications of asbestos demolition or renovations, as specified in 40 CFR Section 61.145(b), are incorporated into CERCLA document regulatory notifications.

Non-CERCLA planned demolition or renovation activities were individually reviewed for applicability of the TDEC notification requirements of the rule. During 2024, four Notification of Demolition and/or Asbestos Renovation was submitted to TDEC for non-CERCLA ETTP activities. There were no regulated ACM demolitions during 2024.

The rule also requires an annual notification for all nonscheduled, minor asbestos renovations if the accumulated total amount of regulated or potentially regulated asbestos exceeds stipulated thresholds. For 2024, the total ETTP projected nonscheduled amounts were below thresholds that would require the submittal of an annual notification to TDEC. No releases of reportable quantities of ACM occurred at ETTP during 2024.

Stratospheric ozone protection

The management of ODSs at ETTP is subject to regulations in 40 CFR Part 82, Subpart F, "Recycling and Emissions Reduction" (EPA 1993); these regulations require preparation of documentation to establish that actions necessary to reduce emissions of Class I and Class II refrigerants to the lowest achievable level have been observed during maintenance activities at ETTP. The applicable actions include but may not be limited to the service, maintenance, repair, and disposal of appliances containing Class I and Class II refrigerants, such as motor vehicle air conditioners. In addition, the regulations apply to refrigerant reclamation activities, appliance owners, manufacturers of appliances, and recycling and recovery equipment. During 2024, the ODS inventory was zero.

3.5.1.2. Fugitive Particulate Emissions

ETTP has been the location of building demolition activities, soil remediation activities, and waste debris transportation with the potential for the release of fugitive dust. All planned and ongoing activities include the use of dust control measures to minimize the release of visible fugitive dust beyond the project perimeter. This includes the use of specialized demolition equipment and water misters. Gravel roads in and around ETTP that are under DOE control are wetted with water as needed to minimize airborne dusts caused by vehicle traffic.

3.5.1.3. Radionuclide National Emission Standards for Hazardous Air Pollutants

Radionuclide airborne emissions from ETTP are regulated under 40 CFR Part 61, *National Emission Standards for Hazardous Air Pollutants* (EPA 1989; Rad-NESHAP). Characterization of the impact on

public health of radionuclides released to the atmosphere from ETTP operations was accomplished by conservatively estimating the dose to the maximally exposed member of the public. The dose calculations were performed using the Clean Air Assessment Package—1988 (CAP-88) computer codes, which were developed under EPA sponsorship for use in demonstrating compliance with the 10 mrem/year effective dose Rad-NESHAP emission standard for the entire ORR. Source emissions used to calculate the dose are determined using EPA-approved methods that can range from continuous sampling systems to conservative estimations based on process and waste characteristics. Continuous sampling systems are required for radionuclide-emitting sources that have a potential dose impact of greater than or equal to 0.1 mrem per year to any member of the public. The only ETTP Rad-NESHAP source that operated during 2024—the K-1407 Chromium Water Treatment System (CWTS) Volatile Organic Compound (VOC) Air Stripper—is considered minor based on emissions evaluations using EPA-approved calculation methods. A minor Rad-NESHAP source is defined as having a potential dose impact on the public that is less than 0.1 mrem/year. Compliance is demonstrated using data collected by the ETTP ambient air monitoring program.

Quarterly radiochemical analyses are performed on composited samples collected at all ETTP ambient air sampling stations. The selected isotopes of interest were ^{234}uranium (^{234}U), ^{235}U, and ^{238}U, with the ^{99}technetium (^{99}Tc) inorganic analysis results included as a dose contributor. The concentration for each of the nuclides at each monitoring station are presented in Table 3.4 for the 2024 reporting period. Dose calculations using the concentration results are included in Chapter 7, Table 7.5.

Table 3.4. Radionuclides in ambient air at ETTP, January 2024 through December 2024

Station	Concentration (µCi/mL)[a]			
	^{99}Tc	^{234}U	^{235}U	^{238}U
K11[b]	ND[c]	6.20E-19	5.70E-19	ND
K12[b]	ND	ND	2.53E-19	ND

[a] *µCi/mL = microcuries/milliliter*

[b] *K11 and K12 represent an on-site business exposure equivalent to half of a yearly exposure at this location.*

[c] *ND = not detectable*

3.5.1.4. Quality Assurance

QA activities for the Rad-NESHAP program are documented in the *Quality Assurance Program Plan for Compliance with Radionuclide National Emission Standards for Hazardous Air Pollutants, East Tennessee Technology Park, Oak Ridge Tennessee* (UCOR 2018, UCOR-4257/R2). The plan satisfies the QA requirements in 40 CFR Part 61, Method 114 (EPA 1989), for ensuring that the radionuclide air emission measurements from ETTP are representative of known levels of precision and accuracy and that administrative controls are in place to ensure prompt response when emission measurements indicate an increase over normal radionuclide emissions. The requirements are also referenced in TDEC regulation 1200-3-11-.08, *Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities*, (TDEC 2018). The plan ensures the quality of ETTP radionuclide emission measurement data from continuous samplers and minor radionuclide release points. Only EPA preapproved methods are referenced through the *Compliance Plan National Emission Standards for Hazardous Air Pollutants for Airborne Radionuclides on the Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/ORO/2196, DOE 2020a).

3.5.1.5. Greenhouse Gas Emissions

The EPA rule for mandatory reporting of GHGs (also referred to as the "Greenhouse Gas Reporting Program") was enacted

October 30, 2009, under 40 CFR Part 98 (EPA 2009). According to the rule in general, the stationary source emissions threshold for reporting is 25,000 MT of CO_2 equivalent (CO_2e) or more of GHGs per year. The rule defines GHGs as:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)
- Hydrofluorocarbons
- Perfluorocarbons
- Sulfur hexafluoride (SF_6)

A review was performed of ETTP processes and equipment categorically identified under 40 CFR Section 98.2 (EPA 2009) whose emissions must be included as part of a facility's annual GHG report, starting with the CY 2010 reporting period. Based on total GHG emissions from all ETTP stationary sources during 2024, ETTP did not exceed the annual threshold limit and therefore was not subject to mandatory annual reporting under the GHG rule during this performance period. The total GHG emissions for any continuous 12-month period beginning with CY 2008 have not exceeded 12,390 MT CO_2e of GHGs. The most significant decrease in stationary source emissions was due to the permanent shutdown of the TSCA Incinerator in 2009. The remaining sources are predominantly comfort heating systems, hot water systems, and power generators. For CY 2024, GHG emissions totaled 249 MT CO_2e, which is 0.99 percent of the 25,000 MT CO_2e per year threshold for reporting. The increase starting in 2020 resulted from the leasing of several large bays in Building K-1036 that are heated with natural gas.

The information reported here includes GHG emissions from the industrial landfills at Y-12 that are managed and operated by UCOR. The landfills are not part of the contiguous ETTP site; however, DOE requested that UCOR, as the operator, include landfill GHG emissions with ETTP reporting in the Consolidated Energy Data Report. To be consistent with reporting this information, the landfill emissions are also included with ETTP ASER data.

Total GHG emissions remain well below the levels first reported in the 2008 baseline year as demolition and remediation efforts continue at ETTP. Many of the early reductions were due to lower on-site combustion of fuels (stationary and mobile sources), lower consumption of electricity, and a smaller workforce.

The American Innovation and Manufacturing (AIM) Act of 2020 is a bill that aims to combat climate change by significantly reducing hydrofluorocarbons (HFCs), chemicals commonly used in refrigerants. The AIM Act directs the EPA to implement an 85 percent phasedown of the production and consumption of HFCs by 2035. Operations at ETTP are winding down to the point where insignificant HFC emissions are taking place.

3.5.1.6. Source-Specific Criteria Pollutants

ETTP operations included one functioning minor stationary source, the CWTS, with a potential to emit any form of criteria air pollutant. This unit is equipped with an air stripper to remove VOCs from the influent stream. Potential total VOC emissions from the CWTS air stripper were calculated to be 0.006 ton/year in 2024, as compared to an emission limit of 5 ton/year.

At ETTP, there are no processes or facilities containing inventories of chemicals in quantities exceeding thresholds specified in rules pursuant to CAA.

A variety of minor pollutant-emitting sources released airborne pollutants from ETTP operations, such as vents, and fugitive and diffuse activities. The emissions from all stacks and vents are evaluated following approved methods to establish their low emissions potential. This is done to verify and document their minor source

permit exempt status under all applicable state and federal regulations.

3.5.1.7. Hazardous Air Pollutants (Nonradionuclide)

Unplanned releases of hazardous air pollutants are regulated through the risk management planning regulations under 40 CFR Part 68 (EPA 1994). To ensure compliance, periodic inventory reviews of ETTP operations were performed that used monthly data obtained through the EPCRA Section 311 reporting program. This program applies to any facility at which a hazardous chemical is present in an amount exceeding a specified threshold. A comparison of the EPCRA 311 monthly Hazardous Materials Inventory System chemical inventories at ETTP, with the risk management plan threshold quantities listed in 40 CFR Section 68.130 (EPA 1994), was conducted. This is an ongoing action that documents the potential applicability for maintaining and distributing a risk management plan and ensuring threshold quantities are not exceeded.

ETTP personnel have determined that there are no processes or facilities containing inventories of chemicals in quantities exceeding thresholds specified in rules pursuant to CAA, Title III, Section 112(r), "Prevention of Accidental Releases." Therefore, activities at ETTP are not subject to the rule. Procedures are in place and implemented to continually review new processes, process changes, or activities with the rule thresholds.

3.5.2. Ambient Air

Compliance of fugitive and diffuse sources is demonstrated based on environmental measurements. The ETTP Ambient Air Quality Monitoring Program is designed to provide environmental measurements to accomplish the following:

- Tracking the long-term trends of airborne concentration levels of selected air contaminant species
- Measuring the highest concentrations of the selected air contaminant species that occur in the vicinity of ETTP operations
- Evaluating the potential impact on air contaminant emissions from ETTP operations on ambient air quality

The three sampling programs in the ETTP area are designated as the Environmental Compliance (EC) program, TDEC program, and the ORR perimeter air monitoring program. Figure 3.6 shows an example of a typical EC program air monitoring station. Figure 3.7 shows the locations of all ambient air sampling stations in and around ETTP that were active during the 2024 reporting period.



Figure 3.6. East Tennessee Technology Park ambient air monitoring station (UCOR on the left, TDEC on the right)

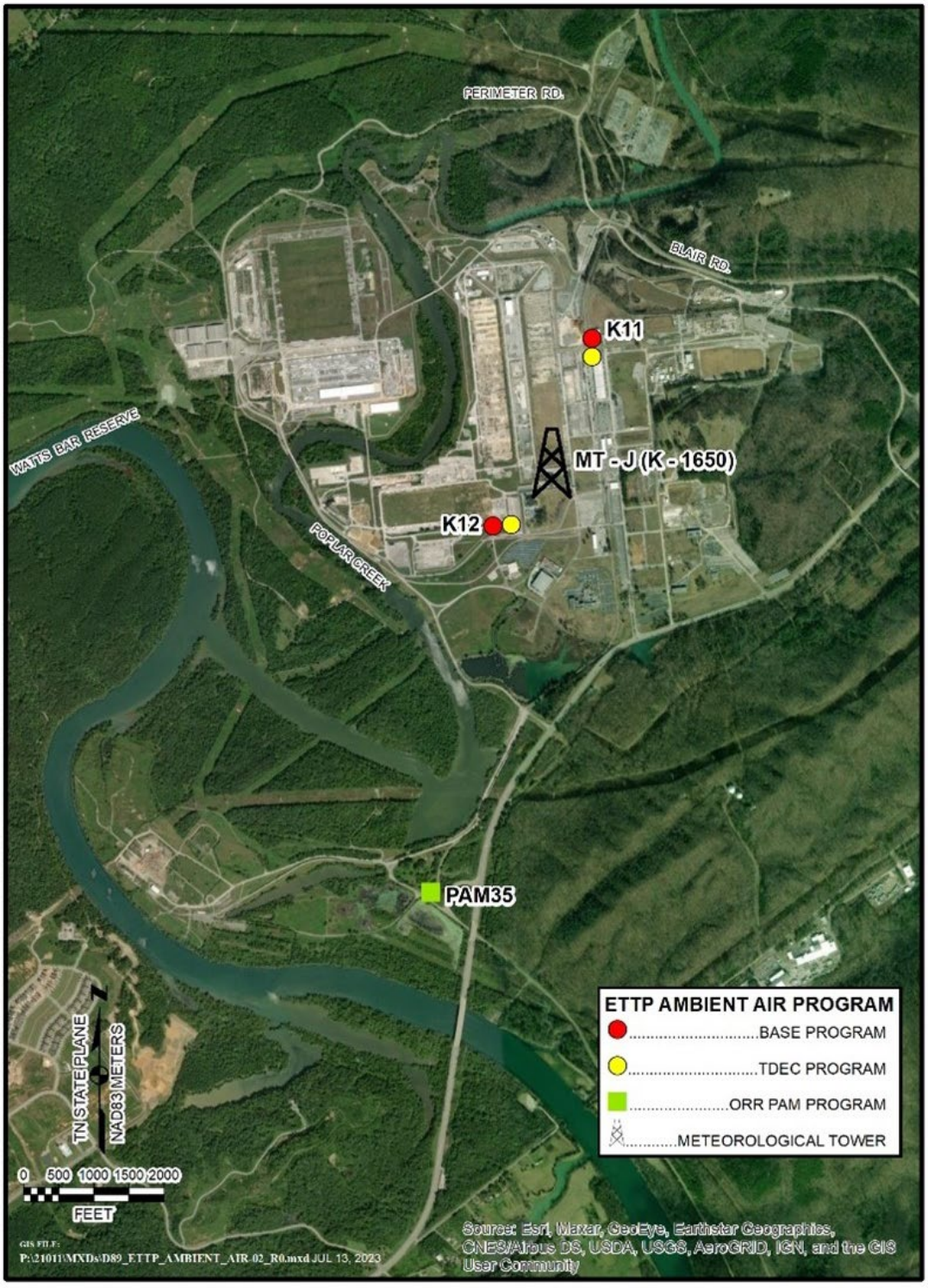
The EC program consisted of two sampling locations throughout 2024. All projects are operating similar high-volume sampling systems. The EC, TDEC, and perimeter air monitoring samplers operate continuously with exposed filters collected weekly. The radiological monitoring results for samples collected at the one ETTP area perimeter air monitoring station are the responsibility of UT-Battelle, LLC. TDEC is responsible for the data collected from their samplers. UT-Battelle, LLC and TDEC results are not included with the EC data presented in this section. However, results from the other programs are requested periodically for comparison.

The analytical parameters were chosen with regard to existing and proposed regulations and with respect to activities at ETTP. The principal reason for EC program stations is to demonstrate that radiological emissions from the demolition of ETTP gaseous diffusion buildings, supporting structures, and associated remediation activities are in compliance with the annual dose limit to the most exposed members of the public that are either on-site (on the ORR) or off-site. K11 and K12 were key sampling locations regarding the potential dose impact on the most exposed member of the public at an on-site business location during slab removals, demolition of small structures, excavation and removal of contaminated soils, and other activities. Changes of emissions from ETTP would warrant periodic reevaluation of the parameters being sampled.

Ongoing ETTP reindustrialization efforts will also introduce new locations for members of the public that may require adding or relocating monitoring site locations. To ensure understanding of the potential impacts on the public and to establish any required emissions monitoring and controls, a survey of all on-site tenants is reviewed every six months through a request for the most recent ETTP reindustrialization map.

All EC program stations collected continuous samples for radiological analyses during 2024. These analyses of samples from the EC stations test for the isotopes ^{234}U, ^{235}U, ^{238}U, and ^{99}Tc.

Stations K11 and K12 are located to provide a conservative measurement of the impact to on-site members of the public.



Acronyms:

ETTP = East Tennessee Technology Park
MT = meteorological tower
ORR = Oak Ridge Reservation
PAM = perimeter air monitoring
TDEC = Tennessee Department of Environment and Conservation

Figure 3.7. East Tennessee Technology Park ambient air monitoring station locations

3.6. Water Quality Program

Water quality is monitored via multiple programs at ETTP. Storm water monitoring is conducted through the NPDES Program (Section 3.6.1) and the Storm Water Pollution Prevention Program (SWPPP; Section 3.6.2). Surface water monitoring is conducted through the Environmental Monitoring Program (EMP) (Section 3.6.3). Groundwater monitoring is conducted through the Water Resources Protection Program (Section 3.6.4).

3.6.1. National Pollutant Discharge Elimination System Permit Monitoring

NPDES monitoring is conducted to demonstrate compliance with the ETTP NPDES Permit. The current NPDES permit was issued on February 4, 2022, became effective on April 1, 2022, and will expire on March 31, 2027. A minor modification to this permit was issued on October 31, 2024, that removed Outfall 690 from the permit. Outfall 690's annual samples were collected prior to the permit modification that removed it from the permit. Under the ETTP NPDES Permit in effect for the majority of 2024, 20 representative outfalls are monitored annually (Figure 3.8). All 20 outfalls are sampled annually for total suspended solids (TSS), pH, and flow. Additionally, select outfalls are sampled annually for zinc (Outfall 142), oil and grease (Outfall 190), PCBs (Outfalls 280, 690), and benzidine (Outfall 430); and semiannually for total chromium and hexavalent chromium (Outfall 170). There were no permit noncompliances in 2024.

3.6.2. Storm Water Pollution Prevention Program

In addition to the NPDES permit required monitoring, storm water is also monitored for a variety of substances, including radionuclides, metals, and organic compounds (UCOR-4028, *East Tennessee Technology Park Storm Water Pollution Prevention Program Sampling and Analysis Plan, Oak Ridge, Tennessee*, UCOR 2024b). Routine SWPPP monitoring is conducted at locations that vary from year to year depending on activities within the drainage basins and historical monitoring results. SWPPP monitoring includes stream impairment monitoring, radiological monitoring, D&D and RA monitoring, CERCLA Phased Construction Completion Report (PCCR) monitoring, legacy contamination monitoring, investigative monitoring, and NPDES permit renewal sampling.



Figure 3.8. Storm water outfall monitoring

3.6.2.1. Radiologic Monitoring of Storm Water

Radiological monitoring is conducted to determine compliance with applicable dose standards. Composite samples from four outfalls were collected following a rain event and analyzed for gross alpha activity, gross beta activity, and specific radionuclides. The estimated discharge of radionuclides from ETTP via the storm water drainage system was calculated based on the radiological monitoring results, daily rainfall data for CY 2024, and flow rates. Table 3.5 presents the total calculated discharge of radionuclides from storm water discharged to off-site waters from ETTP in CY 2024.

Table 3.5. Radionuclides released to off-site waters from the ETTP storm water system in 2024

Isotope	^{234}U	^{235}U	^{238}U	^{99}Tc
Activity level (curies)	0.00443	0.00035	0.00200	0.03320

3.6.2.2. Demolition and Remedial Action Monitoring of Storm Water

Demolition and RA monitoring is conducted to evaluate the effectiveness of demolition and RAs and to ensure that storm water controls are preventing sediment and contaminants from discharging into receiving waters. Grab samples from select outfalls are collected prior to the start of demolition/RAs, following each 1-in. rain event during demolition/RAs, and after completion of demolition/RA activities.

3.6.2.3. K-25 Building ^{99}Tc Contaminated Soil Remedial Action Monitoring

Demolition of the K-25 Building was completed in 2014. The last section of the east wing that was demolished was contaminated with the radioactive isotope ^{99}Tc. Rain and dust control water that contacted the ^{99}Tc-contaminated piping and other building materials is believed to have caused the migration of ^{99}Tc into soils beneath the east wing debris pile during demolition. Remediation of the ^{99}Tc-contaminated soils within the K-25 footprint was completed in 2020. Storm water monitoring in Outfalls 190 and 490, located downgradient of the former K-25 Building, continued in 2024.

Outfall 190 is sampled quarterly. Except for the sample collected in July 2021, ^{99}Tc has not been detected in storm water samples from Outfall 190 since July 2013. Based on this data, it does not appear that ^{99}Tc-contaminated groundwater from the K-25 Building D&D project is discharging to Mitchell Branch via Outfall 190.

Outfall 490 is sampled semiannually. ^{99}Tc was detected in the storm water samples from Outfall 490 in February 2024 and July 2024 but was well below the reference standard of 390,000 picocuries/liter (pCi/L). Outfall 490 discharges into the K-1007-P1 Pond. Discharges from the K-1007-P1 Pond to Poplar Creek are monitored routinely as an exit pathway location per the ETTP EMP. The ^{99}Tc data is evaluated to determine the contribution of ^{99}Tc from the Outfall 490 drainage area to the total ^{99}Tc discharge from the K-1007-P1 pond, as further discussed in Section 3.6.3, "Surface Water Monitoring."

3.6.2.4. EU-21 Remedial Action Monitoring

Exposure Unit (EU)-21 is located between the east and west wings of the former K-25 Building and includes the slab associated with the former K-1024 Maintenance Shop. The K-1024 Maintenance Shop was used for the repair and calibration of instruments and equipment used in the K-25 uranium enrichment process. The maintenance shop used solvents, including trichloroethene (TCE), for cleaning instruments and equipment. As an accepted practice at the time, solvents were frequently discharged into the floor drains, then entered the storm drain network. The main source of TCE in the EU-21 area is presumed to be from Catch Basin 7097, located on the south side of the former K-1024 building. Although TCE is the primary contaminant of concern for the EU-21 soil RA, mercury droplets were discovered during removal of buried pipe. K-1024 was also used for cleaning mercury from line recorder chemical traps between 1946 and 1947, and the equipment shop had a problem with spilled mercury and mercury vapors.

Prior to the soil RA, the storm drain system within the proposed excavation and clean layback footprints was isolated from the active system in order to prevent sediment and contaminants from discharging to Poplar Creek via Outfalls 230 and 240. Outfall 210 receives water from the storm drain system located on the east side of the K-25 east wing (well outside of the excavation and layback footprints). All of the catch basins located on the west side of the K-25 west wing were previously plugged under a separate program.

The EU-21 RA was completed in 2024. Baseline samples were not collected prior to the start of the soil RA due to dry conditions. Monitoring of Outfalls 210, 230, and 240 was conducted during 1-in. rain events and final samples were collected after completion of the RA. All samples were analyzed for VOCs, metals, mercury, and TSS. TCE has not been detected in any of the samples collected from Outfalls 210, 230, or 240 in 2024. Several other parameters have been detected, but only the lead results exceeded their reference standard at these outfall locations.

3.6.2.5. EU-39 Remedial Action Monitoring

Outfall 170 is located downgradient of the EU-39 slab removal RA area. The EU-39 area includes the concrete slabs for the former K-1420 Decontamination and Uranium Recovery Facility, K-1421 Incinerator, and K-1422 Storage Building. The former K-1420 Decontamination and Uranium Recovery Facility provided radiological decontamination, uranium recovery, and metal plating capabilities and served as a storage area for drums of uranium-cascade motor lubricant oil containing PCBs and uranium. The K-1421 Incinerator was used to burn waste oil sludge and low-level contaminated combustibles such as gloves, coveralls, wood, paper, and plastic. The K-1422 Storage Building was used for storage of fissile materials and, reportedly, for uranium hexafluoride cylinder charging or emptying.

Prior to the slab removal RA, lined berms were installed around the K-1420, K-1421, and K-1422 slab to contain sediment, particulates, and debris within the excavation area and to divert sheet flow during rain events. The catch basin leading to Outfall 158, located northeast of the K-1420 pad, was plugged prior to slab demolition. The storm water pipes leading to Outfall 160, north of K-1420 were cut and capped north of the catch basin. There is no discharge pipe in the project area to Outfall 168. Only sheet flow would potentially impact these three outfalls during the slab removal RA. Therefore, storm water samples are obtained from Outfall 170, which is located downstream from the project area.

Monitoring of Outfall 170 was conducted during 1-in. rain events. Final samples were collected after the completion of the RA and analyzed for uranium isotopes, radium-thorium decay series, ^{99}Tc, alpha activity, beta activity, VOCs, PCBs, metals, and TSS. The EU-39 RA was completed in 2024. The alpha activity result of 24.6 pCi/L from the January 2024 storm event was the only result to exceed a reference standard in 2024.

3.6.2.6. EU-35 Remedial Action Monitoring

Outfall 180 is located downgradient of the EU-35 soil RA area. The EU-35 Soil RA 3 area is located in the area of the former K-1407-B Pond. The K-1407-B Pond was primarily used as a settling pond for metal hydroxide sludge and other waste streams that were precipitated/neutralized in the adjacent K-1407-A Neutralization Pit Facility but also received waste from many other nearby facilities. The pond was clean closed under the RCRA in 1994 and covered with 4–10 ft of fill above the contaminated soil. An estimated 2–3 ft of contaminated soil is located between the fill layer and the water table in these areas.

Prior to the soil removal RA, lined berms were installed around open excavations, contaminated soil stockpiles, and any debris to minimize water run-on and to contain contaminated water, debris, sediment, and particulates within the excavation areas. The storm water pipes in the northwestern corner of K-1407 B were temporarily plugged prior to excavation. Storm water samples were obtained from Outfall 180, which is located downstream from the project area.

Monitoring of Outfall 180 was conducted during 1-in. rain events and final samples were collected after completion of the RA and analyzed for uranium and thorium isotopes, ^{99}Tc, alpha activity, beta activity, VOCs, PCBs, metals, mercury, and TSS. The EU-35 RA was completed in 2024. Samples for a 1 in. storm event and final were collected in 2024. The alpha activity result of 15.7 pCi/L, from the July 2024 final sample, was the only result to exceed a reference standard in 2024.

3.6.2.7. Legacy Mercury Contamination Monitoring of Storm Water

Legacy mercury contamination monitoring is conducted to evaluate mercury concentrations over time and to determine if outfalls are contributing to mercury concentrations to site waterways.

Outfalls 180 and 190 discharge storm water from large areas on the north side of ETTP into Mitchell Branch. There were numerous historical mercury operations within Outfalls 180 and 190 drainage areas and the Mitchell Branch sub-watershed. Due to contaminated sediment within storm water networks and potential infiltration into the piping, these are potential contributors to the continuing legacy mercury discharges to Mitchell Branch.

The mercury concentrations detected from grab samples in Outfalls 180 and 190 during 2024 are presented in Table 3.6. Three of the eight mercury grab sample results exceeded the reference standard of 51 nanograms/liter (ng/L). The July 2024 mercury result from Outfall 190 was elevated compared to recent historical data from this location. The surface water locations within Mitchell Branch were sampled approximately one week after the anomalous Outfall 190 mercury result was first reported by the lab. Surface water locations Mitchell Branch kilometer (MIK) 0.45 and the K-1700 Weir are both located downstream from Outfall 190's discharge.

All in stream Mitchell Branch surface water results did not exceed or approach the reference standard for mercury. The mercury concentrations over time in Outfalls 180 and 190 and the K-1700 Weir on Mitchell Branch are presented in Figure 3.9.

Table 3.6. Mercury results for Outfalls 180 and 190 in 2024

Sampling location	Reference standard (ng/L)[a]	2/5/2024 (ng/L)	4/22/2024 (ng/L)	7/16/2024 (ng/L)	10/24/2024 (ng/L)
Outfall 180	51	17.3	**51.8**	**63.7**	47.7
Outfall 190	51	11.5	6.41	**403**	9.36

[a] *ng/L = nanograms/liter*

Note: *Results in bold exceed the reference standard for mercury, which corresponds to TDEC Rule 0400-40-03-.03(4)(j), Organisms Only Criteria.*

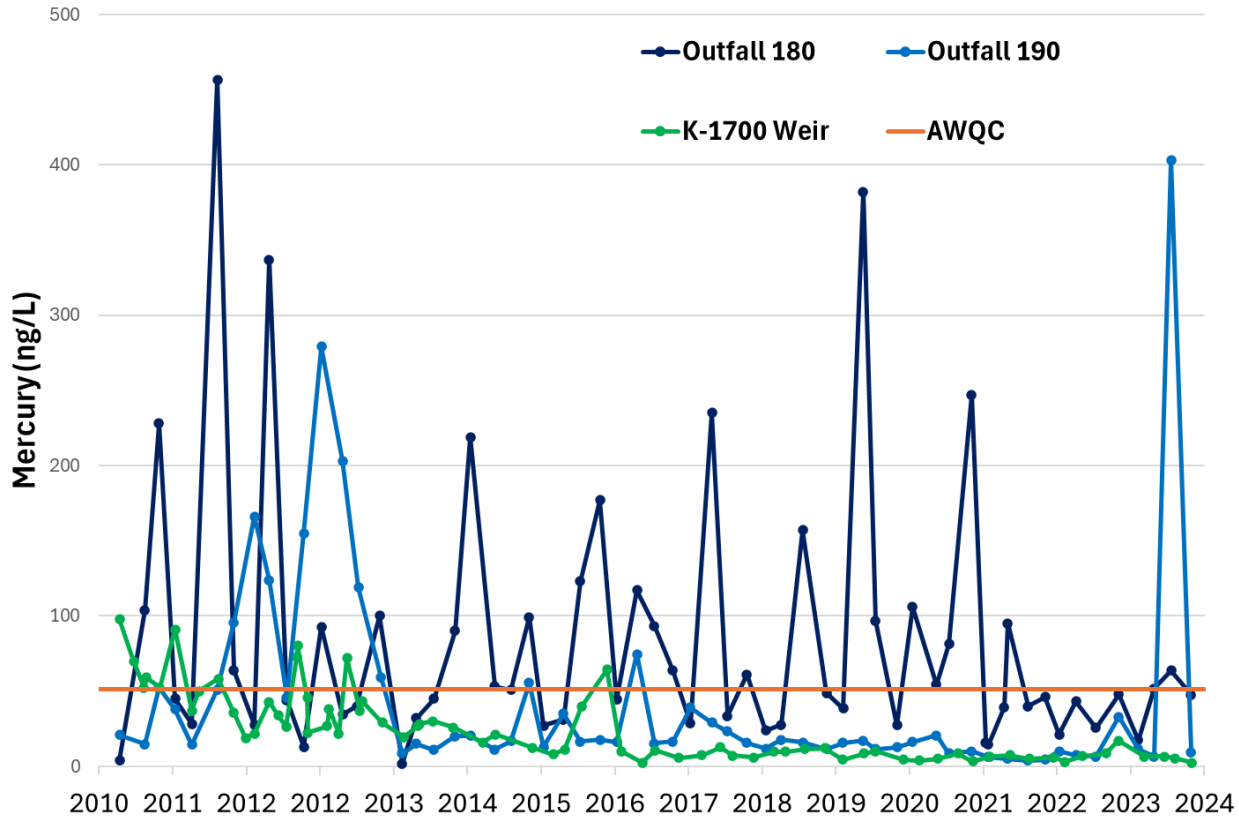


Figure 3.9. Mercury concentrations at Outfalls 180 and 190, and the K-1700 Weir

3.6.2.8. Flow Weighted Mercury Sampling

Monitoring of pollutant loading (flux monitoring) is conducted as part of the SWPPP to support the requirement defined in Section 5.9.1 of the ETTP NPDES permit to properly monitor mercury flux at Outfalls 180 and 190.

As part of the flow-weighted sampling effort at these outfalls, aliquots must be collected during a qualifying storm for the first 3 hours, or for the duration of the storm if it is less than 3 hours in duration. A qualifying storm event is one in which greater than 0.1 in. of rainfall occurs after a period of at least 72 hours following any previous storm event with rainfall of 0.1 in. or greater. Equal volume aliquots should be collected at variable time intervals commensurate with the flow volume that has passed. A minimum of three sample aliquots must be collected to qualify as a valid sampling event. Flow-weighted composite samples can be collected manually or automatically.

Four of the six flow weighted mercury sample results exceeded the reference standard. Flow-weighted sample results from 2024 are shown in Table 3.7.

Table 3.7. Flow-weighted sampling results from Outfalls 180 and 190

Outfall	Date	Mercury result (ng/L)[a]	Total storm event Precipitation (inches)
180	1/8/2024	270	0.26
	2/29/2024	92.7	0.37
	3/7/2024	132	0.85
190	1/8/2024	**53.8**	0.23
	2/13/2024	35.3	0.73
	2/26/2024	16.4	0.38

[a] *Results in bold exceed the reference standard. The reference standard for mercury (51 ng/L) corresponds to TDEC Rule 0400-40-03-.03(4)(j), "Recreation—Organisms Only Criteria."*

3.6.2.9. Investigative Monitoring of Storm Water

Investigative monitoring is conducted based on elevated analytical results, CERCLA requirements, and/or changes in site conditions. Investigative monitoring was conducted at Outfall networks 780, 880, and 890 in 2024.

Outfall 780, 880, and 890 investigative monitoring

Past investigative monitoring in the Old Powerhouse Area since 2018 has occasionally detected elevated concentrations of PCBs, mercury, metals (including arsenic, copper, and lead), and TSS from some of these outfalls. Activities being conducted in the area were not suspected as the cause of the elevated mercury and PCB concentrations, although process knowledge indicated that they could be legacy contaminants.

Outfall 780 once carried storm water runoff from former Buildings K-724 and K-725. These buildings were originally part of the S-50 Thermal Diffusion Plant. Building K-725 was later used for beryllium processing and contained mercury traps that occasionally released mercury. In addition, mercury was reportedly "swept down the floor drains" and into the storm drain system during cleanup activities in the 1970s. Mercury may also have been present in the dust collection system and transported to the storm drain system via storm water runoff during demolition of K-725 in the 1990s. Outfall 780 also received storm water from the K-722 area, where approximately 1,000 gal of oil was landfarmed for dust suppression in the 1980s.

Oak Ridge Forest Products LLC (ORFP) operated a wood yard and chipping facility at the K-722 site. Before ORFP began operation, Outfall 780 was dry and did not discharge water to the Clinch River except during substantial storm events. It is possible that discharge from ORFP mobilized contaminants that have been dormant in the Outfall 780 network for years. As of summer 2023, ORFP is no longer operating at this location.

In spring of 2022, Carbon Rivers, Inc. began operating and storing dismantled windmill parts in the area that is drained by Outfalls 780, 880, and 890. Carbon Rivers' footprint has steadily expanded and currently includes the area formerly used by ORFP, as well as surrounding areas. Carbon Rivers operations are not suspected as the source of these contaminants; however, it is possible that their operations (large equipment and ground disturbance) have contributed to mobilizing contaminants that may have been dormant for years. During the winter pool, when the water level in the Clinch River was sufficiently low to allow access to the end of the outfall piping network, storm water samples were collected from Outfalls 780, 880, and 890 and were analyzed for radionuclides, VOCs, PCBs, metals, mercury, and TSS.

Elevated concentrations of PCBs and lead were detected at Outfall 880. The PCB result of 4.4 µg/L from Outfall 880 was significantly higher than other PCB results from outfalls across the site. Method hold times prevented valid reanalysis of this sample. To investigate further, a follow up PCB sample was collected the following month and yielded a non-detect result for PCBs at Outfall 880. An elevated PCB concentration was also detected in Outfall 890.

Additional investigative sampling is planned for 2025 at Outfalls 780, 880, and 890.

3.6.2.10. Chromium Water Treatment System and Plume Monitoring

The CWTS (Figure 3.10) was constructed to intercept a plume of contaminated groundwater before it enters Mitchell Branch.



Figure 3.10. The Chromium Water Treatment System

The CWTS consists of interceptor wells, pumps, holding tanks, a treatment system, and an air stripper. Effluent is discharged through the pipeline that originally carried effluent from the Central Neutralization Facility (which was demolished). In CY 2024, monitoring was conducted at monitoring well 289 (TP-289), the chromium collection system wells, Outfall 170, and MIK 0.79. Figure 3.11 shows the results of the analyses for hexavalent chromium.

The analytical data indicates that both total and hexavalent chromium concentrations at TP-289 and the collection wells are variable but have trended downward over the long term. In 2024, concentrations of hexavalent chromium at Outfall 170 and MIK 0.79 were only detected in May 2024, with no results exceeding the ambient water quality criterion (AWQC) of 11 µg/L. Results for total chromium at Outfall 170 and MIK 0.79 were within historic ranges, and well below the AWQC for total chromium of 100 µg/L. These results demonstrate the continuing positive impact of the collection well system to minimize the release of chromium into Mitchell Branch.

3.6.2.11. Sampling for NPDES Permit Renewal Application

Preparations are being made for the NPDES permit application to be submitted to TDEC in CY 2026. The application for permit renewal is required to be submitted to TDEC at least 180 days in advance of permit expiration on March 31, 2027, so that TDEC has sufficient time to review. Additionally, DOE will require time to review the application prior to submittal. All permit renewal sampling began after October 2, 2023, and completion is expected before June 30, 2026. Effectively, this allows 33 months for sample collection efforts. This should also allow for sufficient time to process samples, receive laboratory results, and incorporate all relevant information into the permit application.

All 19 representative outfalls in the current ETTP NPDES Permit No. TN0002950 will be sampled for permit renewal purposes. All storm water monitoring results collected for permit renewal sampling will be used in the completion of EPA Form 3510-2F, Application Form 2F, Storm Water Discharges Associated with Industrial Activity, as applicable.

All samples shall be collected from discharges resulting from a qualifying storm event. A qualifying storm event is defined as a storm event in which greater than 0.1 in. of rain fall occurs in a 24-hour period, after a period of at least 72 hours following any previous storm event with rainfall of 0.1 in. or more. Additional sampling directions are specified in UCOR-4028 and are in accordance with EPA Form 3510-2F instructions and ETTP NPDES Permit No. TN0002950 guidance.

Permit renewal sampling results in a suite of more than 175 parameters from each location that are reported by the laboratories. In FY 2024, samples were collected from Outfalls 100, 190, 280, and 724. No results exceeded applicable reference standards. The permit renewal sampling efforts will continue in 2025.

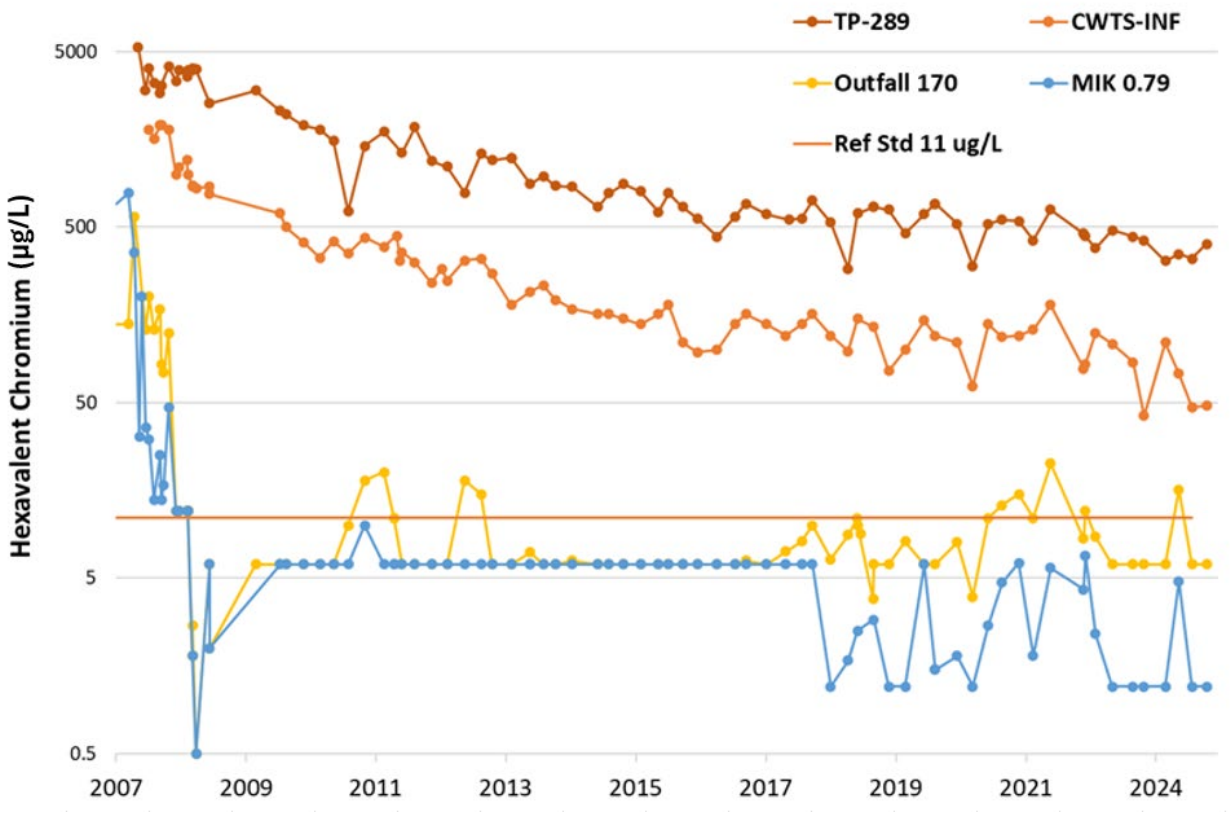
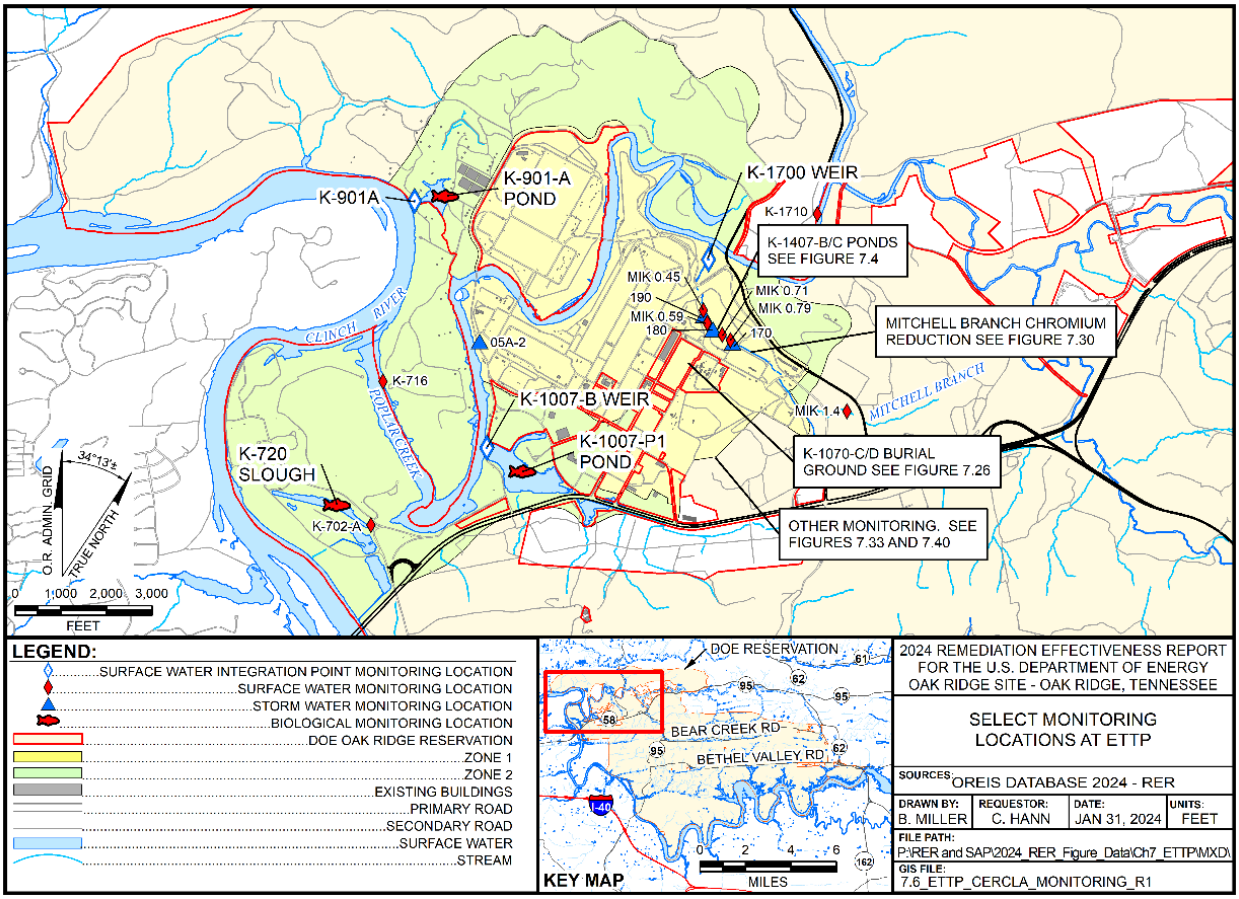


Figure 3.11. Hexavalent chromium sample results for the chromium collection system

3.6.3. Surface Water Monitoring

During 2024, ETTP EMP personnel conducted environmental surveillance activities at 12 surface water locations (Figures 3.12 and 3.13) to monitor surface water conditions at watershed exit pathway locations (K-702-A Slough, K-1700, K-1007-B, and K-901-A) or ambient stream conditions (Clinch River kilometers [CRKs] 16 and 23; K-1710; K-716; and MIKs 0.45, 0.59, 0.71, and 1.4). Monitoring locations K-1700 and MIKs 0.45, 0.59, 0.71, and 1.4 were sampled quarterly; and monitoring locations CRKs 16 and 23, K-716, K-1007-B, K-901-A, and the K-702-A slough were sampled semiannually.



Acronyms:

CRK = Clinch River kilometer *MIK = Mitchell Branch kilometer*

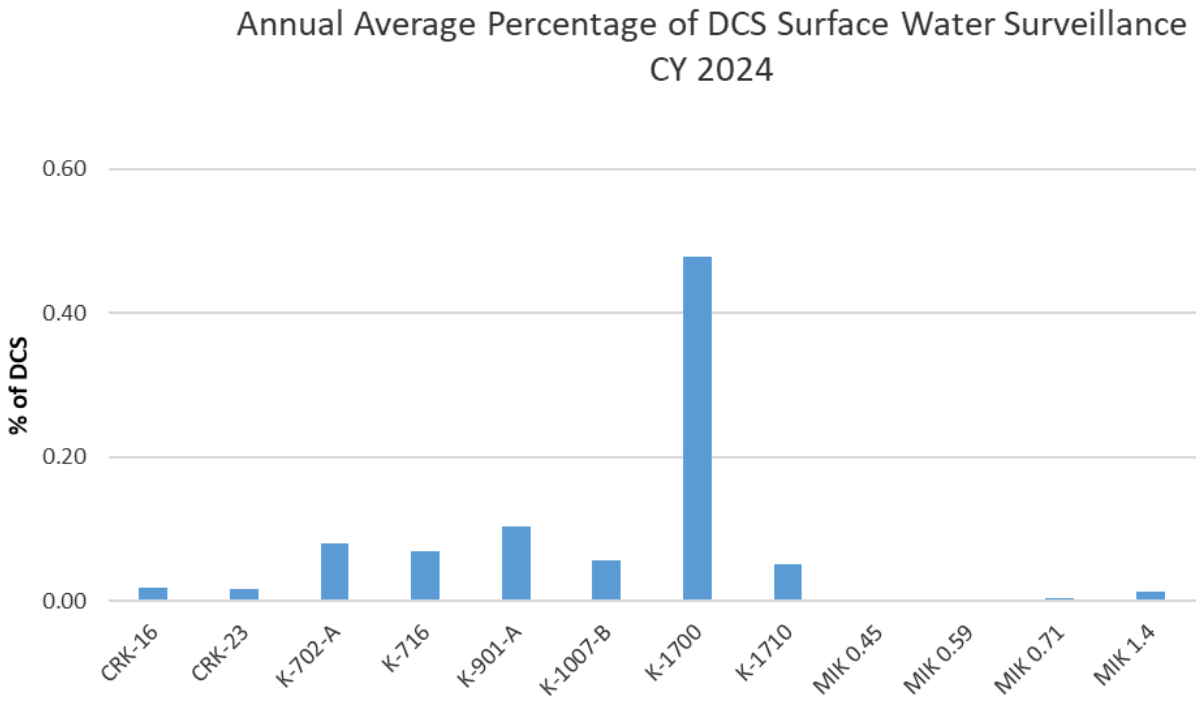
Figure 3.12. Select surface water monitoring locations at East Tennessee Technology Park locations



Figure 3.13. Surface water surveillance monitoring

Results of radiological monitoring were compared with the derived concentration standard (DCS) values in the DOE standard *Derived Concentration Technical Standard* (DOE 2022a).

Radiological data are reported as fractions of DCSs for reported radionuclides, and the fractions for all of the isotopes are added together to produce the sum of fractions (SOF) and averaged to produce a rolling 12-month average. The average SOF is recalculated whenever new data becomes available. If the average SOF for a location exceeds the DCS requirement of remaining below 1.0 (100 percent) for the year, a formal source investigation is required. Sources exceeding DCS requirements would need an analysis of the best available technology to reduce the SOF to less than 1.0 (100 percent). In 2024, the monitoring results yielded SOF values of less than 0.01 (1 percent of the allowable DCS) at all surface water surveillance locations at ETTP (Figure 3.14).



Acronyms: *CRK = Clinch River kilometer DCS = derived concentration standard MIK = Mitchell Branch kilometer*

Figure 3.14. Annual average percentage of derived concentration standards at surface water monitoring locations, 2024

At MIKs 0.45, 0.59, and 0.71, quarterly monitoring is conducted for ^{99}Tc only.

Depending on the monitoring location, water samples may be analyzed for pH, selected metals, radionuclides, PCBs, pesticides, and VOCs. In 2024, 1,647 analytical results and 164 field readings were collected under the EMP. The majority of these results were well within the appropriate AWQC. Sample results that exceeded the appropriate AWQC are summarized in Table 3.8.

The exceedances for pesticides and PCBs may be associated with legacy sediment contamination. All of the pesticides and PCB detections occurred during the dry season when low flow can contribute to higher concentrations of sediment related contaminants in surface waters. The low dissolved oxygen measured at K-901-A on July 16, 2024, is within the historic range for this location and may be attributed to an increase in water temperature in the summer months.

Figure 3.15 illustrates the concentrations of TCE from the Mitchell Branch monitoring locations. In CY 2024, the K-1700 and MIK 0.45 monitoring locations were the only locations where VOCs were detected in surface water.

Concentrations of TCE and total 1,2-dichloroethene (total 1,2-DCE) were below the AWQCs for recreation, organisms only (300 µg/L for TCE and 10,000 µg/L for total 1,2 DCE), which are appropriate standards for Mitchell Branch. In addition, vinyl chloride (VC) has sometimes been detected in Mitchell Branch water.

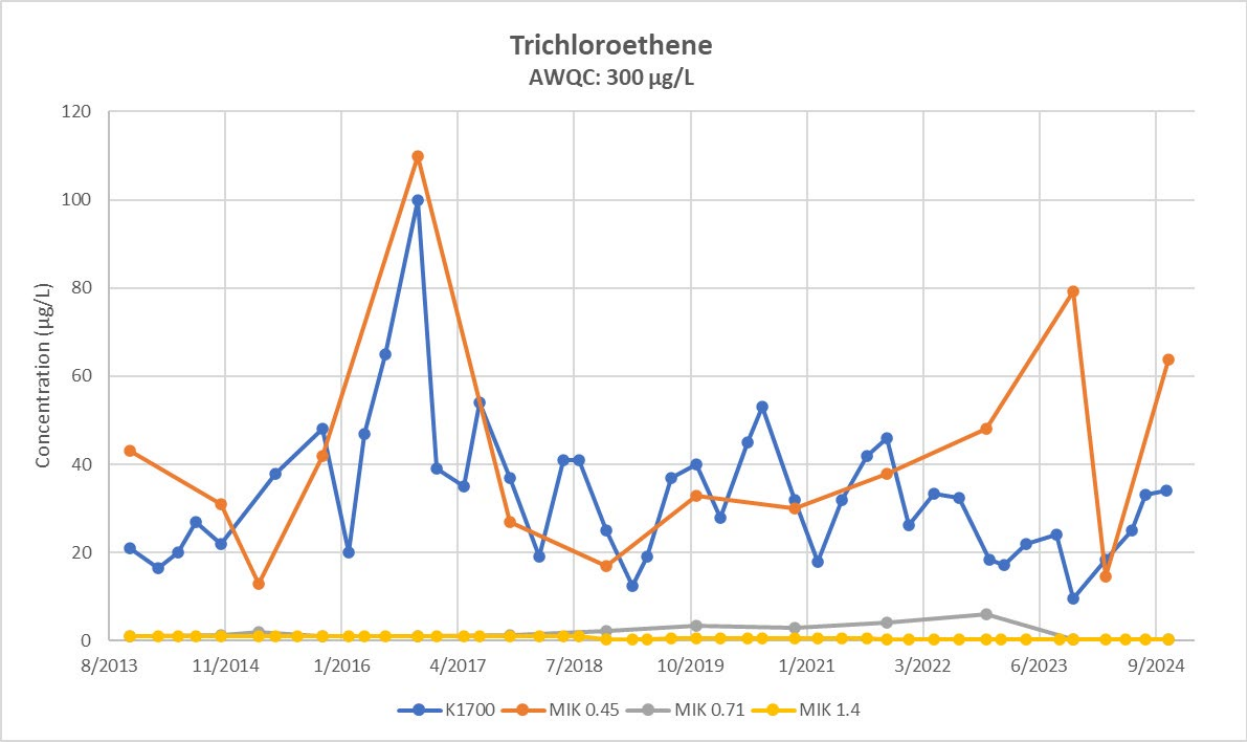
Table 3.8. Water quality criteria exceedances CY 2024

Location ID	Collection date	Chemical name	Reference standard[a]	Result[b]
K1700	6/13/2024	4,4'-DDT	0.0022	0.0185 J
K1700	6/13/2024	Dieldrin	0.00052	0.012 J
K-1007B	7/16/2024	Polychlorinated biphenyl	0.00064	0.446 P
K-901A	7/16/2024	Dissolved oxygen	>5.0	4.8
K1700	10/28/2024	Polychlorinated biphenyl	0.00064	0.0732 J
K1700	10/28/2024	4,4'-DDE	0.0022	0.0121 J
K1700	10/28/2024	4,4'-DDD	0.0031	0.0143 J
K1700	10/28/2024	4,4'-DDT	0.0022	0.0123 J
K1700	10/28/2024	Methoxychlor	0.03	0.0711 J
MIK 1.4	11/4/2024	Polychlorinated biphenyl	0.00064	0.108 J
K-702-A	11/18/2024	Dieldrin	0.00052	0.0102 J
K-702-A	11/18/2024	4,4'-DDE	0.0022	0.0132 J
K-702-A	11/18/2024	4,4'-DDD	0.0031	0.0131 J
K-702-A	11/18/2024	4,4'-DDT	0.0022	0.0096 J
K-702-A	11/18/2024	alpha-Chlordane	0.0043[c]	0.007 J

[a] *The reference standard for alpha-Chlordane and methoxychlor corresponds to TDEC Rule 0400-40-03-.03(3)(g), Fish and Aquatic Life—Criterion Continuous Concentration. All other reference standards correspond to TDEC Rule 0400-40-03-.03(4)(j), Recreation Organisms Only Criteria.*

[b] *All reference standards and results are reported in µg/L. Results with a J qualifier are estimates, not quantified numbers. Results with a P qualifier indicate >25% difference between two columns for Pesticides/Aroclors.*

[c] *A reference standard has not been promulgated for alpha-Chlordane. The reference standard shown is for Chlordane—a mixture that contains, among other compounds, two main isomers, alpha-Chlordane and gamma-Chlordane.*



Acronym: *MIK = Mitchell Branch kilometer*

Figure 3.15. Trichloroethene concentrations in Mitchell Branch

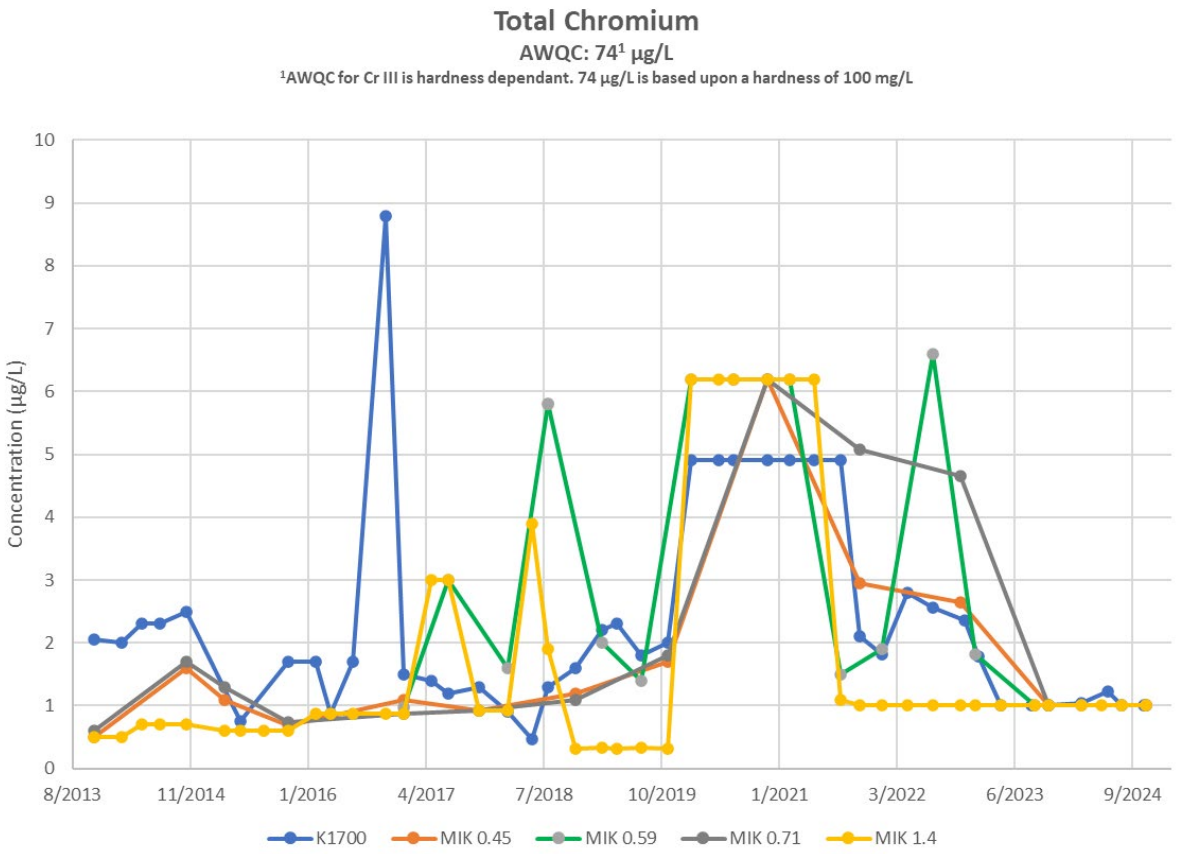
The concentrations for various VOCs in samples collected at Mitchell Branch in CY 2024 were much lower than the baseline samples collected on November 22, 2016. It should be noted that the November 22, 2016, sample date was at the end of an extended dry weather period that began in August 2016.

VOCs have been detected in groundwater in the vicinity of Mitchell Branch and in building sumps discharging into storm water outfalls that discharge into the stream; these compounds have generally not been detected in storm water during the monitoring of network discharges. It appears that the primary source of these compounds is contaminated groundwater.

Since the CWTS was installed, chromium levels in Mitchell Branch have dropped dramatically, with levels of total chromium being routinely measured at less than 6 µg/L (Figure 3.16). In 2024, hexavalent chromium levels in Mitchell Branch were all below the AWQC of 11 µg/L.

In CY 2024, ETTP did not conduct surface water monitoring for per- and polyfluoroalkyl substances (commonly known as "PFAS").

Since the CWTS was installed, chromium levels in Mitchell Branch have dropped dramatically.



***Note**: The AWQC for Cr(III), which is hardness-dependent, is 74 µg/L, based on a hardness of 100 mg/L in the receiving waters. The AWQC for Cr(VI) is 11 µg/L.*

***Acronyms**: AWQC = ambient water quality criterion MIK = Mitchell Branch kilometer*

Figure 3.16. Total chromium concentrations in Mitchell Branch

3.6.4. Groundwater Monitoring at ETTP

ETTP was divided into two zones to complete the primary source RA work. Zone 1 comprises 1,300 acres outside the ETTP Main Plant Area (MPA), and Zone 2 comprises 800 acres of the ETTP MPA. Actions have been ongoing to characterize and address soil, buried waste, and subsurface structures for protection of human health and the environment and to limit further groundwater contamination through source reduction or removal.

In FY 2024, the following two groundwater RODs were approved:

- *Interim Record of Decision for Groundwater in the Main Plant Area at the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2949&D2; MPA Groundwater Interim ROD) on May 16, 2024.
- *Record of Decision for Groundwater in the K-31/K-33 Area at the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2950&D2; K-31/K-33 Groundwater ROD) on May 9, 2024.

Cleanup of the remaining environmental media at ETTP (e.g., remaining groundwater, surface water/sediment, and remaining ecological receptors) will be addressed under the future MPA Groundwater Final ROD, the Zone 1 Groundwater Plumes ROD, and the Remaining Ecology/Surface Water/Sediment Final ROD. In support of the Zone 1 Groundwater Plumes ROD, an *Addendum to the Zone 1 Groundwater Plumes Remedial Investigation Work Plan for the K-1085*

Old Firehouse Burn Area, East Tennessee Technology Park, Oak Ridge, Tennessee (DOE/OR/01-2903&D2/A2) was submitted to EPA and TDEC for review on June 18, 2024.

The data screen and trend assignments show contaminant concentration trends are highly variable across the site. Maximum contaminant levels (MCLs) and maximum contaminant level derived concentrations (MCL-DCs) for radionuclides are used as screening levels for groundwater and are not ROD performance standards. RODs for ETTP groundwater are pending. A *Modification to the East Tennessee Technology Park Administrative Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee* (DOE/OR/01-2477&D4/M1; ETTP RAR CMP) was approved on November 27, 2024. The modification to the ETTP RAR CMP included changes associated with provisional management of slabs, adding land use controls associated with the former Powerhouse Area, and updating CWTS sampling.

A summary of the continuing baseline groundwater monitoring in accordance with the approved ETTP RAR CMP follows:

- Monitoring results from wells in the K-1407-B/C Ponds area are generally consistent with results from previous years and show several-fold concentration fluctuations in seasonal and longer-term periods. Although most VOCs have exhibited significant decreasing trends over the past 10 years, these trends are generally indeterminate over the past 5 years. The continued detection of VOCs at concentrations above 1,000 µg/L and the relatively steady concentrations over recent years suggest the presence of dense nonaqueous phase liquid (DNAPL) in the vicinity of the former K-1407-B Pond.
- VOC concentrations in wells monitored downgradient of K-1070-C/D show a broad area is affected by past disposal releases of liquid VOCs at G-Pit. The persistent, high concentrations of these VOCs in nearby wells suggest an ongoing contaminant source release. However, decreases in parent VOC concentrations, with slight increases in concentrations of some degradation pathway compounds, likely represents the result of natural biodegradation from intrinsic dehalogenating bacteria in groundwater in the vicinity of G-Pit.
- In the K-31/K-33 area, only nickel was measured at levels slightly greater than the MCL and Tennessee groundwater criteria at well UNW-043. Nickel in this well shows a decreasing concentration trend.
- At the K-27/K-29 area, groundwater contamination migrates toward Poplar Creek in both north and south directions from the former area facilities.
  - Alpha activity and total uranium concentrations in BRW-016 in the north exit pathway continued to exceed the MCL in FY 2024. This well was inundated by water from D&D runoff in FY 2019. VC and cis-1,2-DCE also exceeded the MCL in the northern portion of the K-27/K-29 area north exit pathway in FY 2024.
  - Chromium and nickel exceeded the MCL and Tennessee groundwater criteria screening concentration (0.1 mg/L) in the unfiltered samples from well UNW-038 in the south/west exit pathway. TCE also exceeded the MCL screening concentration (0.005 mg/L) in two wells (UNW-038 and UNW-096). The 5-year TCE trends in the K-27/K-29 southern area are stable to increasing at these two wells.
- VOCs are present in groundwater at the now-remediated K-1070-A Burial Ground in the northwestern portion of ETTP. Groundwater contaminated primarily with TCE discharges at downgradient spring 21-002, which flows into the northern end of the K-901-A Holding Pond. Although TCE concentrations fluctuate above and below the MCL screening concentration of 5 µg/L, eight of the last 12 samples collected at spring 21-002 have exceeded the MCL for TCE.

- TCE is the most significant groundwater contaminant detected at spring PC-0, which is submerged beneath the Watts Bar lake level from April to October each year, and is located on the shore of Poplar Creek near the confluence with the Clinch River. During FY 2024, the maximum detected TCE concentration (6 µg/L) slightly exceeded the MCL of 5 µg/L, but remaining samples detected below the MCL. The PC-0 spring exhibits a decreasing trend in TCE concentration over the past 10-year and 5-year periods.

3.6.4.1. K-1407-B/C Ponds

The K-1407-B Pond, constructed in 1943, was primarily used for settling metal hydroxide precipitates generated during neutralization and precipitation of metal-laden solutions treated in the K-1407-A Neutralization Unit. It also received discharge from the K-1420 Metals Decontamination Building, K-1420 plating wastes that generated F006 hazardous wastes pond sludge and wastes from the K-1501 Steam Plant. The K-1407-C Pond, constructed in 1973, was primarily used to store potassium hydroxide scrubber sludge generated at ETTP. It also received sludge from the K-1407-B Pond. When the K-1407-B Pond reached maximum sludge capacity, it was dredged, and the sludge was transferred to the K-1407-C Pond.

The *Remedial Action Report for the K-1407-B Holding Pond and the K-1407-C Retention Basin, Oak Ridge, Tennessee* (DOE 1995) proposed semiannual groundwater monitoring for nitrate, metals, VOCs, and selected radionuclides, including gross alpha and beta activity, ^{99}Tc, ^{90}strontium (^{90}Sr), ^{137}cesium (^{137}Cs), ^{230}thorium (^{230}Th), ^{232}Th, ^{234}U, and ^{238}U. Target concentrations for these parameters were not established (DOE 1993b, DOE 1995). However, as recommended by EPA with concurrence from TDEC, monitoring for the constituents listed for the K-1407-B Pond is conducted in wells UNW-003 and UNW-009, and at the K-1700 Weir on Mitchell Branch.

The primary groundwater contaminants in the K-1407-B/C Ponds area are VOCs. VOCs are widespread and persistent in this portion of ETTP, including contaminant sources upgradient of the ponds. Figure 3.17 presents the combined unconsolidated and bedrock plume boundaries for total VOCs at the top of the map (north of 14th Street).

DOE has compiled analytical data from groundwater monitoring well UNW-003 to evaluate concentration trends for regulated contaminants. Data are compared to EPA's National Primary Drinking Water Regulations MCLs or MCL-DCs for radionuclides, for screening purposes and for identifying constituents and wells for trend analysis. The MCLs and MCL-DCs are not criteria identified in the 1993 K-1407-B/C Ponds ROD.

In recent years, large seasonal variations in VOC concentrations have been measured at well UNW-003, which continues to exhibit high concentrations of VOCs in the unconsolidated zone at the K-1407-B pond. DOE suspects a DNAPL source exists somewhere beneath the former pond site based on persistent high VOC concentrations in both shallow and deeper groundwater wells. Data is consistent in showing significant decreasing contaminant concentration trends for five VOCs (1,1-DCE, cis-1,2-DCE, tetrachloroethene [PCE], TCE, and VC) at this location over the past 10 years. However, no trends could be determined over the past 5 years for these VOCs, but significant decreasing contaminant concentration trends are present for the maximum concentration evaluations for these same five VOCs over the past 10 years. The FY 2024 results from UNW-003 remain consistent with the plume boundary depicted in Figure 3.17.

3.6.4.2. K-1070-C/D G-Pit and Concrete Pad

The K-1070-C/D G-Pit was the primary source of organic contaminant releases to soil and groundwater in the area immediately west of the K-1070-C/D Waste Disposal area. The K-1071 Concrete Pad, located in the southeastern portion of the K-1070-C/D area, was determined to pose an unacceptable health risk to workers from

future exposure to soil radiological contaminants (DOE 1998). The contents of the pit were excavated, and a soil cover was placed over the concrete pad. Residual contaminated groundwater in the K-1070-C/D G-Pit and Burial Ground area will be addressed in a future decision. Monitoring locations, analytical parameters, and cleanup levels were not specified for groundwater monitoring at the K-1070-C/D Burial Ground, although the primary contaminants of concern (COCs) in that area are VOCs. Semiannual samples collected at wells and surface water locations outside the perimeter (downgradient) of the K-1070-C/D Burial Ground are analyzed for VOCs and general water quality parameters. Monitoring at the site focuses on providing data for evaluating changes in contaminant concentrations near the source units or potentially discharging to surface water within the ETTP boundaries.

Following G-Pit remediation, monitoring wells UNW-114, TMW-011, and UNW-064 (see Figure 3.17) were selected to monitor the VOC plume leaving the K-1070-C/D Burial Ground because they were located in the principal known downgradient groundwater pathway. Well monitoring results show elevated VOC concentrations. The VOC concentrations at these three wells began to decrease prior to excavating the G-Pit contents (during FY 2000) and continue to decrease, while daughter VOC concentrations (1,1-DCE, 1,2-dichloroethane [1,2-DCA], and VC) show recent increasing trends. Although 1,1,1-trichloroethane (1,1,1-TCA) was formerly present at concentrations far greater than its 0.2 mg/L MCL, natural biodegradation and advective groundwater processes within the monitoring zone have reduced 1,1,1-TCA concentrations to less than the drinking water standard. Several direct-push technology monitoring points were installed to the west of UNW-114 during investigations conducted in 2005. The purpose of these monitoring points was to investigate groundwater contamination in an area along potential geologically controlled seepage pathways that may have connected the G-Pit contaminant source to the former SW-31 spring. DOE continues to monitor to measure VOC concentrations and their fluctuations downgradient of G-Pit.

DOE has compiled analytical data from K-1070-C/D groundwater monitoring to evaluate concentration trends for regulated contaminants. Data are compared to EPA's National Primary Drinking Water Regulations MCL for screening purposes; however, MCLs are not identified as criteria in the ROD (DOE 1997). Groundwater contaminant trends in the area downgradient of the G-Pit source are mostly stable (*i.e.*, data expresses no upward or downward trend with negligible variance) to indeterminate (*i.e.*, data expresses no upward or downward trend with sufficient statistical variance), with decreasing trends for PCE and TCE at well UNW-114 for the 10-year evaluation period. Although most contaminants exhibit stable, indeterminate, or decreasing trends over the past 5-year and 10-year periods, concentrations of 1,1-dichloroethane (1,1-DCA) and VC at well UNW-114 have risen since 2008 and 2009, respectively. Seasonal variations in VOC concentrations are very commonly observed. The FY 2024 results from UNW-114, UNW-064, and TMW-011 remain generally consistent with the plume boundary depicted in Figure 3.17.

Well UNW-064 is located slightly further downgradient from the contaminant source area than UNW-114 and its monitoring data exhibits a slightly different behavior. Similar to the overall trend observed at UNW-114, the majority of VOC concentrations at UNW-064 decreased from about 2002 to 2006 but have remained relatively stable since that time period. Trend evaluations for VOCs in well UNW-064 for a 10- year period indicate a stable, or no significant, trend for 1,1,2-trichloroethane (1,1,2-TCA), 1,1-DCE, TCE, and VC. The most recent five-year period trends indicate a stable trend for 1,1,2-TCA, 1,1-DCE, and TCE; and no determinate trend for VC at well UNW-064.

Well TMW-011 is located furthest from the contaminant source area near the base of the hill below K-1070-C/D. VOC concentrations at TMW 011 tend to fluctuate in a fashion similar to those at UNW-064, except the seasonal signature is reversed, with higher concentrations in summer

than during winter. This relationship suggests groundwater recharge during winter tends to dilute the VOCs near TMW-011 rather than cause a pulse of higher concentration groundwater, as was observed at the mid-slope location near UNW-064.

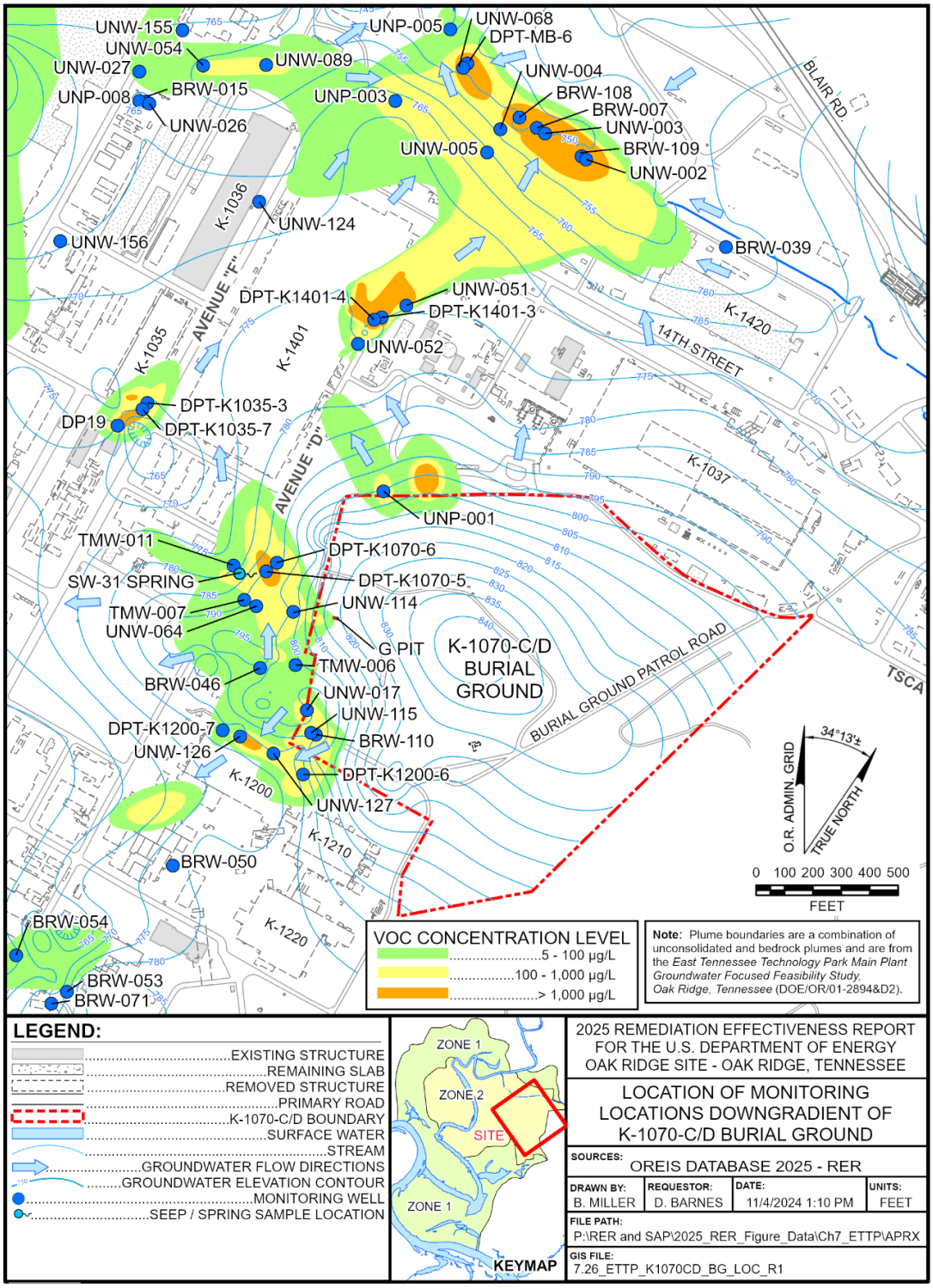


Figure 3.17. Location of monitoring locations downgradient of K-1070-C/D Burial Ground

Overall, throughout the monitoring period of record, there have been decreases in the parent VOC (1,1,1-TCA and TCE) concentrations, with slight increases in concentrations of some of the degradation pathway compounds (e.g., 1,1-DCA and VC) in the vicinity of the source (UNW-064 and UNW-114). The FY 2024 increase in VC concentrations at UNW-114, which generally correlates to TCE and other precursor compounds (i.e., cis-1,2-DCE) decreasing in concentration, likely represents the result of natural biodegradation from intrinsic dehalogenating bacteria in groundwater in the vicinity of these wells.

3.6.4.3. Groundwater Pathway Plumes

Figure 3.18 presents the current sitewide contaminant plume map for the sum of VOC plumes from the MPA Focused Feasibility Study (DOE 2022b), K-31/K-33 Remedial Investigation/Feasibility Study (DOE 2022c), and Zone 1 Remedial Investigation Work Plan (DOE 2022d). Figure 3.18 also shows the locations of exit pathway monitoring wells throughout the ETTP site that are routinely sampled by the Water Resources Restoration Program (WRRP) for known COCs, inferred groundwater flow directions in plume areas, and direction of surface water flow. As shown, the inferred groundwater flow directions are based on the water table piezometric surface contours. Shallow groundwater plumes generally flow in conformance to the local gradients, however in some areas, especially where geologic structures such as bedrock folding, fracturing, and karst development occur, groundwater may flow through secondary porosity features in directions oblique to inferred gradients.

For each of these exit pathway wells, DOE has compiled analytical data for groundwater contaminants for the past 10 years. The compiled data is compared to EPA's National Primary Drinking Water Regulations MCLs or MCL-DCs for radionuclides. The summary of trend evaluations for the exit pathway wells in increments of the past 10 years and the last 5 years of monitoring show that, in general, contaminants that have previously exceeded their respective MCL concentrations have decreased in concentrations. Trends also show mixed results of statistically significant decreases in some cases, increasing trends in other cases, and some instances in which trends are indeterminate or stable. Some metals (e.g., chromium and nickel) tend to be measured at or above MCL concentrations, with a tendency for particle-associated metals to lead to these MCL exceedances, based on often-lower metal concentrations in filtered sample aliquots.

Mitchell Branch

The Mitchell Branch groundwater exit pathway is monitored using surface water data from the K-1700 Weir on Mitchell Branch. Wells BRW-083 and UNW-107, located near the mouth of Mitchell Branch, have also been monitored since 1994. Detection of VOCs in groundwater near the mouth of Mitchell Branch is considered an indication of the migration of the Mitchell Branch VOC plume complex. The intermittent detection of VOCs in this exit pathway is thought to be a reflection of variations in groundwater flowpaths that can fluctuate with seasonal hydraulic head conditions, which are strongly affected by rainfall and long-term and short-term Watts Bar Reservoir fluctuations. During FY 2024, VOCs were not detected in the semiannual samples from these two exit pathway monitoring wells. No other constituents were detected above MCLs or MCL-DCs in FY 2024.

K-1064 Peninsula Burn area

Exit pathway wells BRW-003 and BRW-017 monitor metals and VOCs in groundwater at the K-1064 Peninsula Burn area. Historically, arsenic has been the primary metal detected at concentrations exceeding the MCL in groundwater at the site. However, during FY 2024, concentrations of arsenic were less than the MCL. Historically, VOC contaminants exceeded MCLs in wells BRW-003 and BRW-017. However, regulated VOC concentrations have declined to below screening levels.

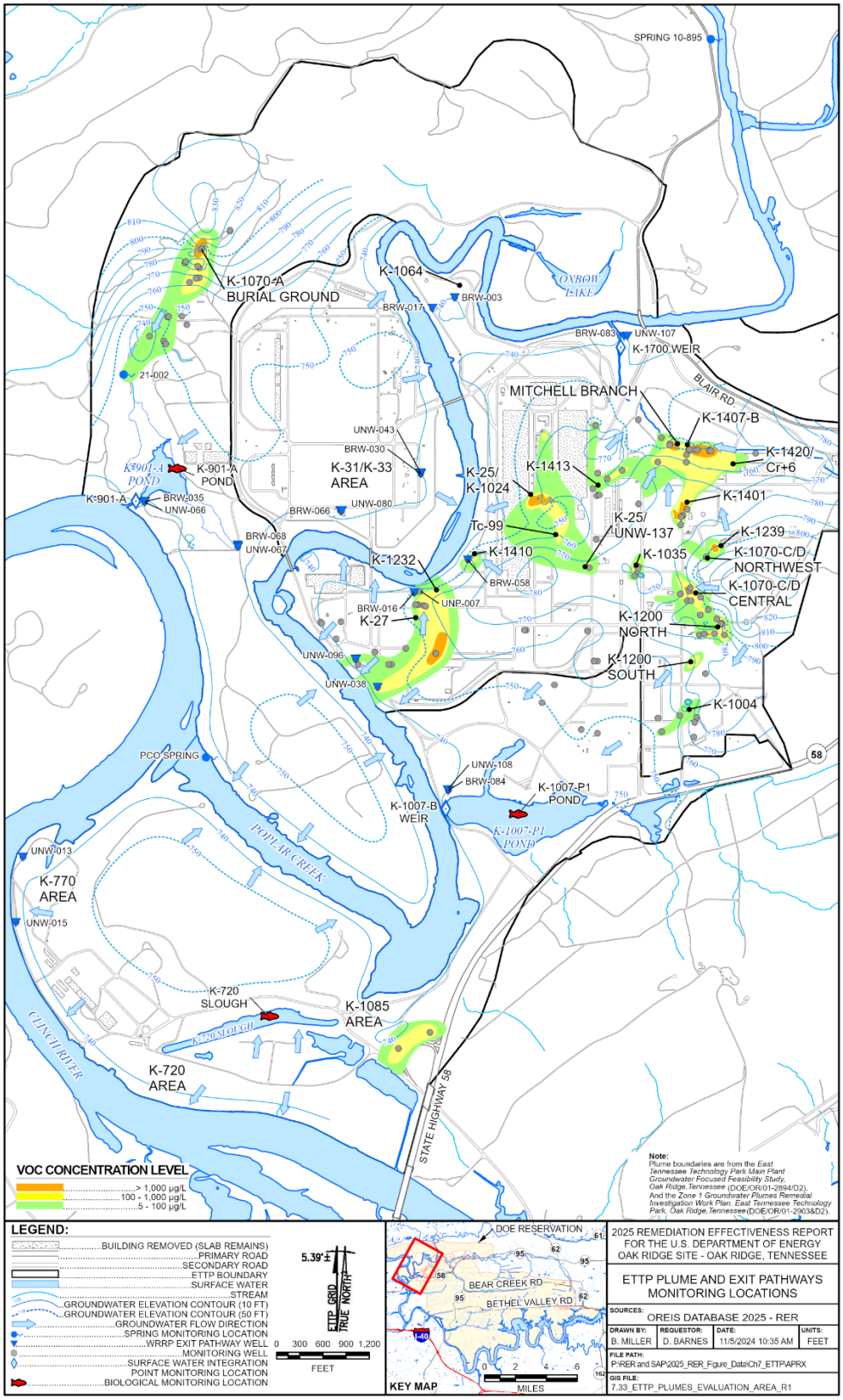


Figure 3.18. East Tennessee Technology Park plume and exit pathways monitoring locations

K-31/K-33 area

Groundwater is monitored in four wells (BRW-066, BRW-030, UNW-080, and UNW-043) that lie between the K-31/K-33 area and Poplar Creek. During FY 2024, only nickel was detected at concentrations greater than its MCL. Nickel was detected in FY 2024 in both filtered and unfiltered samples from UNW-043 at concentrations slightly above (0.11 mg/L) the MCL screening concentration (0.1 mg/L) in the December 2023 sample. However, concentrations of nickel in subsequent samples from UNW-043 in FY 2024 were all below the MCL, and trend evaluations for nickel in UNW-043 indicate declining 5-year and 10-year concentrations trends at this well. Nickel was detected in FY 2024 below the MCL screening concentration in BRW-030 and UNW-080 filtered and unfiltered samples.

K-27/K-29 exit pathway areas

Groundwater discharges toward Poplar Creek in both a northward pathway beneath the K-1232 area and in a south-to-westward pathway, as shown earlier on Figure 3.18. Two wells (BRW-016 and BRW-058) in the northern plume near K-27/29 and two wells (UNW-038 and UNW-096) in the south/western plume have been designated for exit pathway monitoring.

BRW-016 was inundated by water from D&D runoff in FY 2019, resulting in high alpha activity contamination. Alpha activity concentrations in the K-27/K-29 area northern pathway have continued to decrease over the past five years. In comparison to FY 2023, alpha activity remained lower in FY 2024 with a concentration of 37 and 21 pCi/L but remained greater than the MCL screening concentration (15 pCi/L). VOCs have exceeded MCLs in the K-27/K-29 area northern pathway. In FY 2024, VC was detected above its MCL screening concentration (0.002 mg/L), with a maximum detected concentration of 0.035 mg/L in well BRW-058. In addition, cis-1,2-DCE exceeded the MCL (0.070 mg/L) with a maximum concentration of 0.092 mg/L at BRW-058. Trend evaluations for well BRW-058 indicate significant upward trends for VC and no determinate trend cis-1,2-DCE for the prior 10-year period and no determinate trend over the five-year period for VC and cis-1,2-DCE at this well.

In the south/west exit pathway from the K-27/K-29 area, TCE is persistent in the exit pathway wells and exceeds the MCL at both wells with stable concentration trends at well UNW-038 over the 10-year and 5-year periods, and an increasing trend and no determinate trend at well UNW-096 over the 10-year and 5-year periods, respectively. Chromium concentrations equaled or exceeded the MCL in one unfiltered sample from well UNW-038 in FY 2024 with a concentration of 0.68 mg/L. The corresponding filtered sample from UNW-038 was below the chromium MCL at a concentration of 0.0072 mg/L. Nickel concentrations equaled or exceeded the MCL of 0.1 mg/L in well UNW-038 in one unfiltered FY 2024 sample, with maximum concentration 0.14 mg/L. Similar to chromium at UNW-038, the corresponding filtered sample for nickel was below the MCL at a concentration of 0.066 mg/L.

K-1007-P1 Holding Pond area

Wells BRW-084 and UNW-108 are exit pathway monitoring locations at the northern edge of the K-1007-P1 Holding Pond (Figure 3.18). During FY 2024, no regulated contaminants have equaled or exceeded their respective MCLs.

K-901-A Holding Pond and Duct Island areas

Exit pathway groundwater in the K-901-A Holding Pond area (Figure 3.18) is monitored by four wells (BRW-035, BRW-068, UNW-066, and UNW-067) and two springs (21-002 that flows into the K-901-A Holding Pond, and PC-0 that discharges into Poplar Creek on the west side of Duct Island). No regulated contaminants equaled or exceeded MCL concentrations at any of the four wells in FY 2024 samples.

TCE is the most significant groundwater contaminant detected in the springs. TCE that originates from the now-remediated K-1070-A Burial Ground is the principal contaminant detected at spring 21-002.

The conceptual behavior of this TCE contaminant discharging at spring 21-002 plume is described by higher concentration, but lower flow, during

the dry season with apparently subdued effects of rainfall on spring TCE concentrations. During the wet season, the overall TCE concentrations at spring 21-002 are lower; however, wet-season, increased rainfall-driven, groundwater-flow pulses push TCE concentration pulses through conduits that discharge at spring 21-002. TCE exceeded the MCL in FY 2024 samples collected at spring 21-002 with a maximum concentration of 0.02 mg/L detected in the May 2024 sample. The remaining FY 2024 samples for TCE also exceeded the MCL of 0.005 mg/L with concentrations of 0.0054 in March 2024 and 0.016 J mg/L in December 2023. The M-K trends for TCE show a stable and no determinate trend for the 10-year and 5-year periods, respectively at spring 21-002.

PC-0 Spring was added to the sampling program in 2004. During April–October each year, spring PC-0 is submerged beneath the Watts Bar Lake level. In the late winter of 2012, DOE installed a sampling pump in the spring mouth to allow year-round sampling. The contaminant source for spring PC-0 is presumed to be legacy waste disposed of at the former K-1070-F contractor's spoil area located on Duct Island. The TCE concentrations in spring PC-0 have varied between non-detectable levels and 0.026 mg/L and have decreased from their highest measured value in 2006. During FY 2024, the maximum TCE concentration in spring PC-0 quarterly samples was 0.0059 J mg/L measured in a sample collected in December 2023. The remaining FY 2024 samples were all below the MCL screening concentration of 0.005 mg/L, and TCE shows a significant decreasing trend for both the 10-year and 5-year periods.

TCE that originates from the now-remediated K-1070-A Burial Ground is the principal contaminant detected at spring 21-002.

Because water that discharges from the springs monitored in the ETTP area originates mostly from shallow flow systems, the flow rates and dissolved contaminant concentrations are highly variable. For this reason, there is uncertainty associated with the contaminant trend directions assigned to the spring data.

K-770 area

Exit pathway groundwater monitoring is also conducted at the K-770 area, where wells UNW-013 and UNW-015 are used to assess radiological groundwater contamination along the Clinch River (Figure 3.18). Alpha activity measured in samples from well UNW-015 exceeded the 15 pCi/L MCL in both FY 2024 samples. During FY 2024, the maximum alpha activity was 19 pCi/L in the September 2024 sample. The trend analysis determined an increasing trend for both the 10-year and 5-year periods for alpha activity at UNW-015, although FY 2024 is the first year since 2019 that alpha activity has exceeded the MCL at this well. No other regulated contaminants exceeded their MCLs in these two wells.

3.7. Biological Monitoring

The ETTP Biological Monitoring and Abatement Program (BMAP) consists of two tasks designed to evaluate the effects of ETTP legacy operations on the local environment, identify areas where abatement measures would be most effective, and test the efficacy of the measures—1) bioaccumulation studies and 2) instream monitoring of biological communities. Figure 3.19 shows the major water bodies at ETTP and the BMAP monitoring locations along Mitchell Branch. The results from this program will support future CERCLA cleanup actions.

3.7.1. Task 1: Bioaccumulation Monitoring

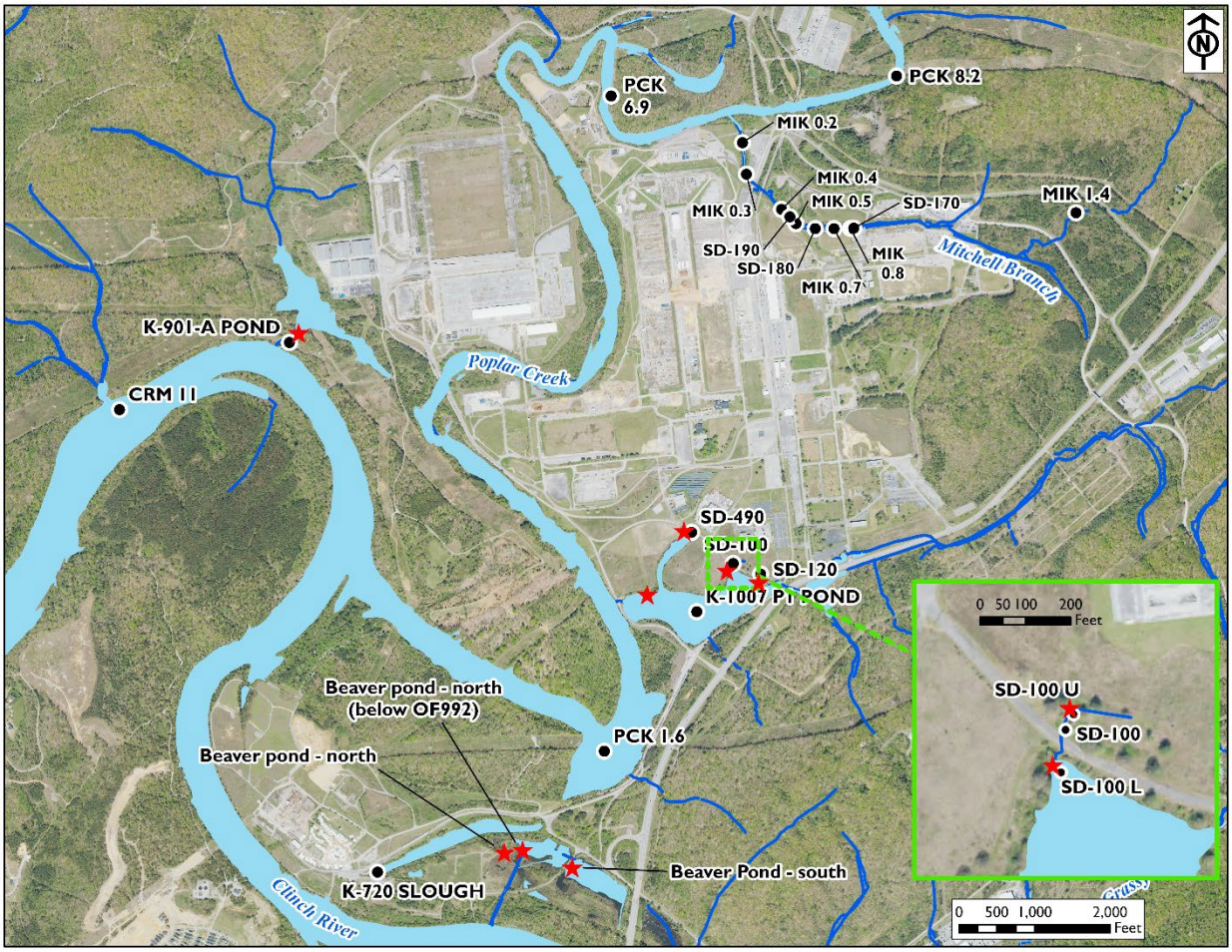
Bioaccumulation monitoring for the ETTP BMAP has focused on evaluating the impact of PCB discharges into the environment because of historical operations at the ETTP complex. It was previously assumed that mercury flux into Poplar Creek and the Clinch River originated largely from Y-12 discharges into East Fork Poplar Creek. However, more recent monitoring has shown that water in ETTP storm drains and biota from lower Mitchell Branch have elevated mercury concentrations as well. Mercury bioaccumulation monitoring is routinely conducted in the watersheds adjacent to ETTP by the Y-12 and

ORNL BMAPs, both on and off the ORR. The available mercury bioaccumulation monitoring data will be presented in the following subsections with long-term trends in PCB contamination in resident fish and caged clams from ETTP waters.

Because the consumption of contaminated fish represents the largest dose of mercury and many other bioaccumulative contaminants to humans, fish fillet concentrations are necessary to assessing human health risks, whereas whole body fish are necessary to assessing ecological risks. Largemouth bass (*Micropterus salmoides*) and various sunfish species are used to monitor mercury and PCB fillet concentrations. Gizzard shad (*Dorosoma cepedianum*) and bluegill (*Lepomis macrochirus*) are used to monitor whole body concentrations at various locations over time. Largemouth bass are larger, upper trophic level predatory fish and are, therefore, susceptible to mercury and PCB bioaccumulation. Fillet concentrations in these fish represent the near maximum potential dose to humans, if eaten. Largemouth bass tend to live in larger, deeper pools of water and are collected in the ponds at ETTP (K-1007-P1 Pond, K-901-A Pond, and K-720 Slough) as well as in off-site river and reservoir locations. Sunfish are short-lived and have small home ranges, so fillet mercury and PCB concentrations in these fish are representative of exposure at the site of collection. These fish are used in long-term studies to monitor changes in bioaccumulation at a given site over time.

Collections of sunfish are restricted to sizes large enough to be taken by sport anglers (generally 50–150 g total weight) to minimize effects of covariance between size and contaminant concentrations, as well as for spatial and temporal comparability. The target sunfish species for bioaccumulation studies in Mitchell Branch and other ORR stream sites is redbreast sunfish (*Lepomis auritus*), but where these fish are not present, other species with similar feeding habits (e.g., bluegill [*L. macrochirus*]) are collected. For bioaccumulative contaminants such as mercury and PCBs, fish bioaccumulation data have become important measures of compliance for both the CWA and CERCLA.

For mercury, the EPA National Recommended Water Quality Criterion for mercury in fish (0.3 micrograms/gram [µg/g]) is used as the trigger point for fish consumption advisories in Tennessee, the target concentration for NPDES permit compliance, and the threshold for impairment designations that require a Total Maximum Daily Load (TMDL) assessment. In addition to fish mercury limits, the state of Tennessee continues to use the statewide AWQC for mercury of 51 ng/L in water, based on organisms only, and 50 ng/L for recreation-water and organisms. Regulatory guidance and human health risk levels have varied more widely for PCBs, depending on the regulatory program and the assumptions used in the risk analysis. The Tennessee water quality criteria for individual Aroclors and total PCBs are both 0.00064 µg/L under the recreation designated use classification and are the target for PCB-focused TMDLs, including for local reservoir (Melton Hill, Watts Bar, and Fort Loudon). However, most conventional PCB water analyses have detection limits much higher than the PCB AWQC.



Note: *Red stars indicate clam sampling locations in and around the ETTP complex in 2024 (all Mitchell Branch sites were sites of clam deployment [except MIK 1.4] but stars have been omitted for clarity).*

Acronyms:

CRM = Clinch River mile PCK = Poplar Creek kilometer MIK = Mitchell Branch kilometer

SD = storm drain

Figure 3.19. Water bodies at the East Tennessee Technology Park

Therefore, in Tennessee and in many other states, assessments of impairment to water body segments, as well as public fishing advisories for PCBs, are based on fish tissue concentrations. Historically, the US Food and Drug Administration threshold limit of 2 µg/g in fish fillet was used for PCB advisories; then for many years in Tennessee, an approximate range of 0.8 to 1 µg/g was used, depending on the data available and factors such as the fish species and size. The remediation goal for fish fillet at the ETTP K-1007-P1 Pond is 1 µg/g. Most recently, the water quality criterion that has been used by TDEC to calculate the fish tissue concentration triggering a determination of impairment and a TMDL of 0.02 µg/g in fish fillet. The fish PCB concentrations at and near ETTP are above this most conservative concentration.

In addition to monitoring for human health and ecological risks as well as long-term trends, bioaccumulation monitoring also includes investigations of sources of contamination to ETTP waterways. Caged Asiatic clams (*Corbicula fluminea*) are used as bioindicators of contaminant sources in Mitchell Branch and other sites around ETTP. These clams are collected from an uncontaminated reference site (Little Sewee Creek in Meigs County, Tennessee) and are

divided into groups of 10 clams of equal mass. In 2024, clams were placed in baskets to be deployed at strategic locations around ETTP (i.e., in and around storm drains) for a four-week exposure period (May 7–June 4, 2024). Two clam baskets were placed at each site with 10 clams in each basket.

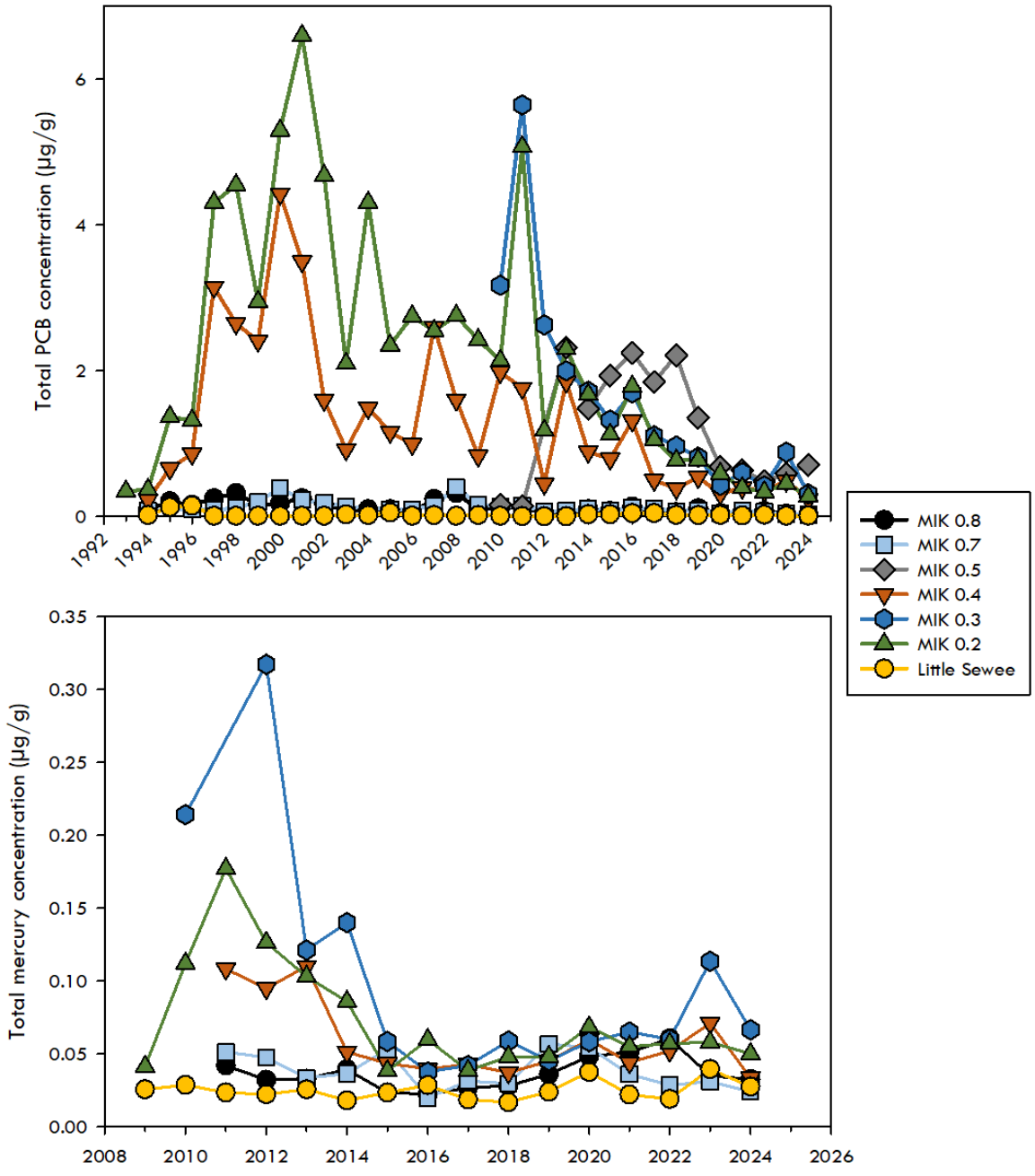
Because these animals are sedentary filter feeders, they accumulate contaminants that are present in the water and in suspended particles at a given site. They are useful indicators of the bioavailable (and therefore potentially toxic) portion of contaminants that enter the environment at a given location, and they provide spatial resolution of contamination on a finer scale than is possible with fish bioaccumulation studies. Caged clams have been used for more than 25 years to evaluate the importance of storm drains and other inputs of PCBs into the waterways around ETTP and for the past 10+ years to monitor total mercury (Hg_T) and methylmercury (MeHg) inputs to Mitchell Branch. Whereas most of the mercury in the environment is inorganic mercury (Hg^{2+}), a small fraction of Hg^{2+} is converted to the more toxic and bioaccumulative MeHg. Because MeHg biomagnifies in aquatic systems, increasing in concentration as it moves up through the food chain, more than 90 percent of the mercury in upper trophic level fish is MeHg. Clams, which feed on periphyton and detritus at the base of the food chain, have a much smaller proportion of MeHg in their tissues but are still good indicators of MeHg hot spots and sources. The soft tissues of the clams from each cage were homogenized, and aliquots were taken for PCB and mercury analysis.

To assess spatial and temporal variability in exposure to PCBs following remediation activities, water samples have been collected for analysis of aqueous PCBs and TSS from the outfalls of K-1007-P1 and K-901-A, upper and lower storm drain (SD)-100, and an uncontaminated reference site (upper First Creek, ORNL). Samples are collected four times each year (March/April, June, July, and August).

3.7.1.1. Mitchell Branch

Figure 3.20 shows long-term monitoring results in caged clams deployed at various sites in Mitchell Branch. The lower portion of this stream (MIK 0.5 [SD-190]–MIK 0.2) has historically been a hot spot for both mercury and PCB contamination. In 2024 PCB concentrations in clams in this stretch of the creek decreased slightly, except at MIK 0.5 when compared to 2023 concentrations, but broadly remained below concentrations seen before 2016. Although there is considerable interannual variability, PCB concentrations in clams placed in lower Mitchell Branch appear to be generally trending downward since peak years in 2000–2001. PCB concentrations in the upper portion of Mitchell Branch (MIK 0.8) were similar to previous years' concentrations and were slightly elevated (0.034 µg/g) with respect to the reference site (0.01 µg/g).

Mercury concentrations in clams deployed in Mitchell Branch in 2024 were similar to concentrations seen in 2023, except at MIK 0.3 and 0.4, where the mercury concentrations decreased by nearly half (from 0.11 to 0.07 µg/g and from 0.07 to 0.03 µg/g, respectively; Figure 3.20). Within the Mitchell Branch system, the highest mercury concentrations were seen in clams deployed at SD180 (0.10 µg/g). Unlike in fish tissue, MeHg in the soft tissues of clams generally made up a small proportion of Hg_T (Figure 3.21). MeHg concentrations in clams remained low in 2024, comparable to concentrations in 2023.

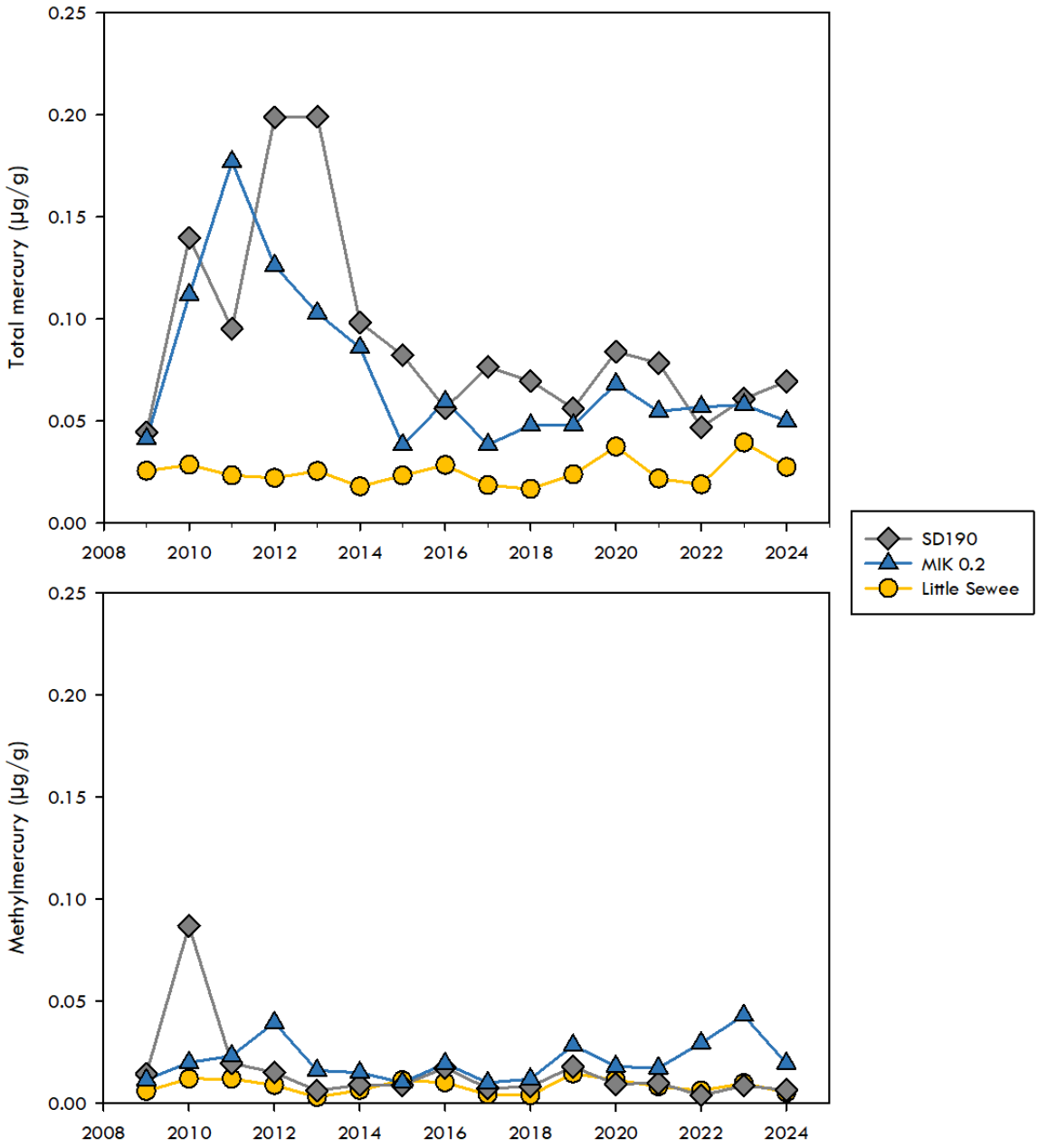


Notes:

1. *N = 2 composites of 10 clams each per year.*
2. *Shown in yellow are data for clams collected from the reference site, Little Sewee Creek (Meigs County, Tenn.).*
3. *Total PCBs is defined as the sum of Aroclors 1248, 1254, and 1260.*

***Acronyms**: MIK = Mitchell Branch kilometer PCB = polychlorinated biphenyl*

Figure 3.20. Mean total PCB (Top: µg/g, wet wt; 1993–2024) and mercury (Bottom: µg/g wet wt; 2009–2024) concentrations in the soft tissues of caged Asiatic clams deployed in Mitchell Branch



Notes:

1. *N = 2 composites of 10 clams each per year.*
2. *Shown in yellow are data for clams collected from the reference site, Little Sewee Creek (Meigs County, Tenn.)*

Acronyms: *MIK = Mitchell Branch kilometer* *SD = storm drain*

Figure 3.21. Total (top panel) and methylmercury (bottom panel) concentrations in the soft tissues of caged Asiatic clams deployed in Mitchell Branch (µg/g wet wt; 2009–2024)

Figure 3.22 shows long-term monitoring results in redbreast sunfish (*L. auritus*) at MIK 0.2. Average PCB concentrations in fish collected at MIK 0.2 in 2024 (0.41 ± 0.1 µg/g) were lower than those seen in 2023 (0.59 ± 0.1 µg/g) but remained comparable to concentrations seen at this site in recent years. Although there is not a regulatory limit for PCBs in fish, the level most often used in practice to issue fish consumption advisories in the State of Tennessee, as previously stated, is 1 µg/g. In 2024, the mean PCB concentration in sunfish fillets collected from MIK 0.2 was below this limit, but was above the most conservative limit of 0.02 µg/g. While the observed fish tissue concentrations in Mitchell Branch are lower than they have historically been, they are still two to three orders of magnitude higher than concentrations seen in the same species at the Hinds Creek reference site in Anderson County.

Hg_T has been monitored more sporadically in redbreast sunfish fillets at MIK 0.2. Figure 3.22 shows long-term trends in Hg_T concentrations (µg/g) in these fish. A rapid increase in fillet Hg_T concentrations was observed in the early 1990s and concentrations have generally remained elevated, with mean concentrations exceeding the AWQC (0.3 µg/g) in most years. Similar to the PCB concentrations in fish from this site, Hg_T concentrations at MIK 0.2 have been oscillating around the EPA's recommended AWQC for the past several years. Mean mercury concentrations in redbreast at this site remained just above the mercury tissue criterion, averaging 0.49 ± 0.05 µg/g in 2024.

3.7.1.2. K-1007-P1 Pond

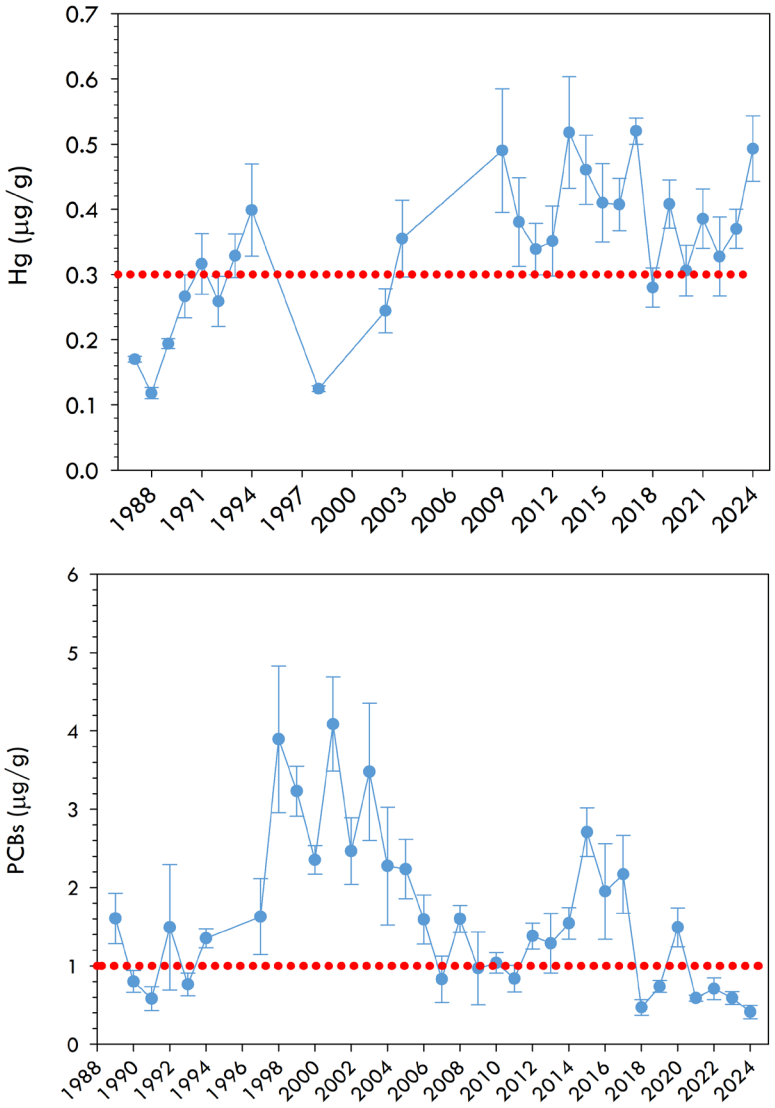
Over the past decade, mean aqueous PCB concentrations in the K-1007-P1 Pond have fluctuated significantly but have generally been lower than concentrations seen before 2009 remediation activities (e.g., 35 ng/L in 2024 compared with 161 ng/L in 2007; Figure 3.23). Concentrations in 2024 were slightly lower than in 2023, but still were also comparable to the lowest recorded average PCB concentration since remediation (26 ng/L in 2015). PCBs tend to be particle associated and are positively correlated with TSS. The fluctuations in PCB and TSS concentrations in water in the K-1007-P1 Pond could be related to fluctuations in aquatic plant coverage, which can affect sediment stability. The aqueous PCB concentrations measured in the K-1007-P1 Pond are above concentrations seen at the First Creek reference site (0.16 ng/L in 2024) and are above the State of Tennessee water quality criterion for the protection of fish and wildlife (14 ng/L).

PCB concentrations in clams placed at lower and upper SD-100 locations have fluctuated significantly since 1995, but displayed a decreasing trend from 2007 to 2010. and 2017 to 2018 (Figure 3.24). PCB concentrations in clams deployed at this site increased significantly in 2021–2023, but in 2024, they decreased significantly at upper SD100 (from 9.9 µg/g to 3.3 µg/g), returning to the range of concentrations recorded from 2008 to 2021. PCB concentrations at upper SD100 have been below values found at lower SD100 for the entire monitoring period, a trend that continued in 2024: concentrations decreased slightly while remaining somewhat elevated from concentrations seen from 2006 to 2021. Although PCB concentrations in clams placed at the K-1007-P1 Pond outfall are an order of magnitude lower than those deployed at upper SD100, concentrations here followed the same temporal trends as those at SD100 locations, with a slight increase 2022 and 2023 followed by a decrease in 2024. PCB concentrations at SD120 and SD490 remained similar to values recorded since 2012. Hg_T and MeHg concentrations in clams deployed at the K-1007-P1 Pond were similar to concentrations in clams deployed at the reference site, Little Sewee Creek (Figure 3.24).

Average PCB concentrations in fish collected from the K-1007-P1 Pond appear to be generally decreasing (Figure 3.25). In FY 2024, mean PCB concentrations in both fillets and whole-body composites of bluegill were below the targets for the K-1007-P1 Pond. Mean PCB concentrations in fillets in the K-1007-P1 Pond were 0.22 µg/g in 2024, which is below the remediation goal for this

pond (1 µg/g total PCBs in fillets). The mean concentration in whole-body bluegill was 1.00 µg/g in 2024, which is below the remediation target for this pond (2.3 µg/g in whole-body composites; Figure 3.26).

The interannual fluctuations in PCB concentrations could be due to water quality changes that have taken place in this pond, e.g., higher TSS, PCB inputs, and fluctuations in vegetation cover (Figures 3.23, 3.25, and 3.26).

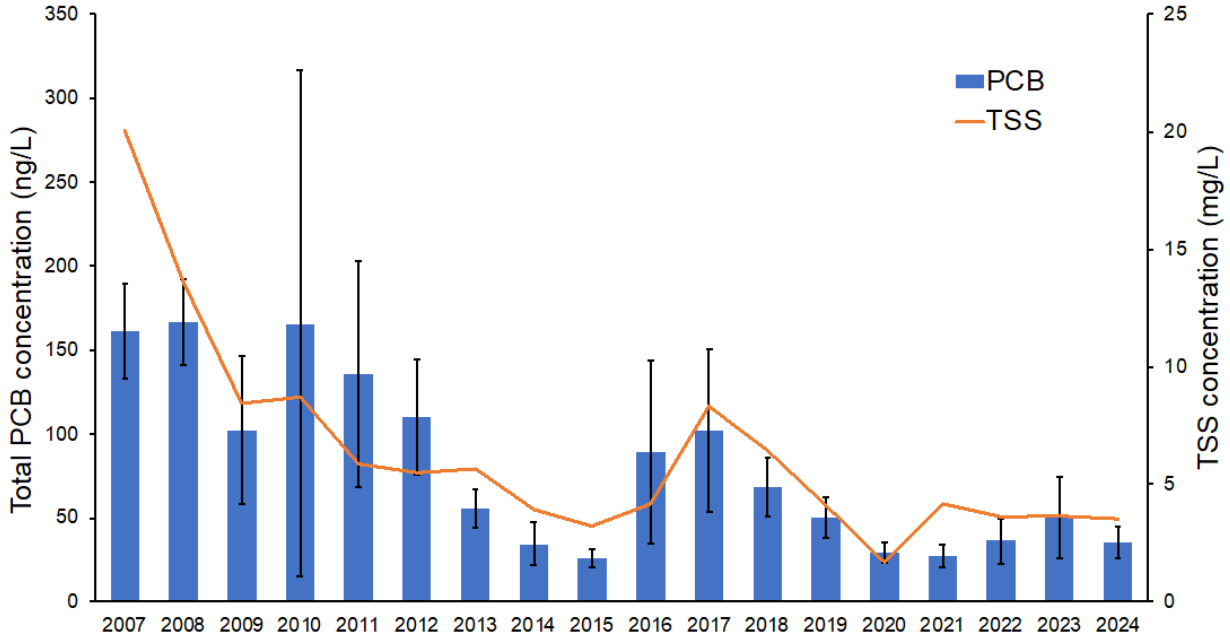


Notes:

1. *N = 6 fish per year.*
2. *Shown in red is the fish advisory level for mercury in fish fillets (0.3 µg/g).*

***Acronyms**: Hg = mercury MIK = Mitchell Branch kilometer PCB = polychlorinated biphenyl*

Figure 3.22. Mean mercury (top panel) and PCBs (bottom panel) concentrations (µg/g, wet wt) in redbreast sunfish fillets in Mitchell Branch (MIK 0.2), 1989–2024

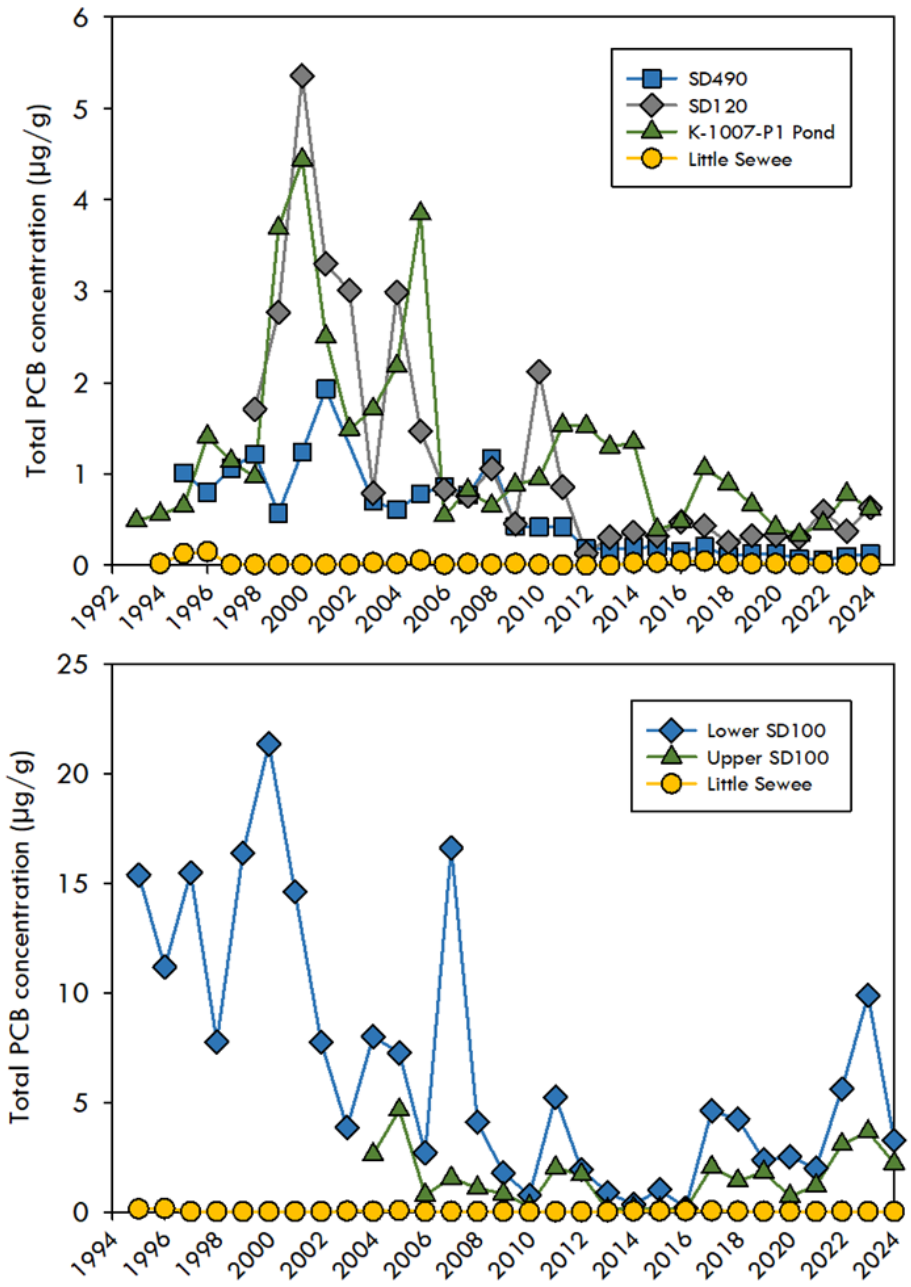


Notes:

1. *Means for PCBs in water and TSS are based on results across all collections made each year.*
2. *Note that mean concentrations of PCBs in water from First Creek were <1.5 ng/L in all years.*

Acronyms: *PCB = polychlorinated biphenyl* *TSS = total suspended solids*

Figure 3.23. Mean aqueous total PCB concentrations, total suspended solids, and vegetation cover in the K-1007-P1 Pond, 2007–2024

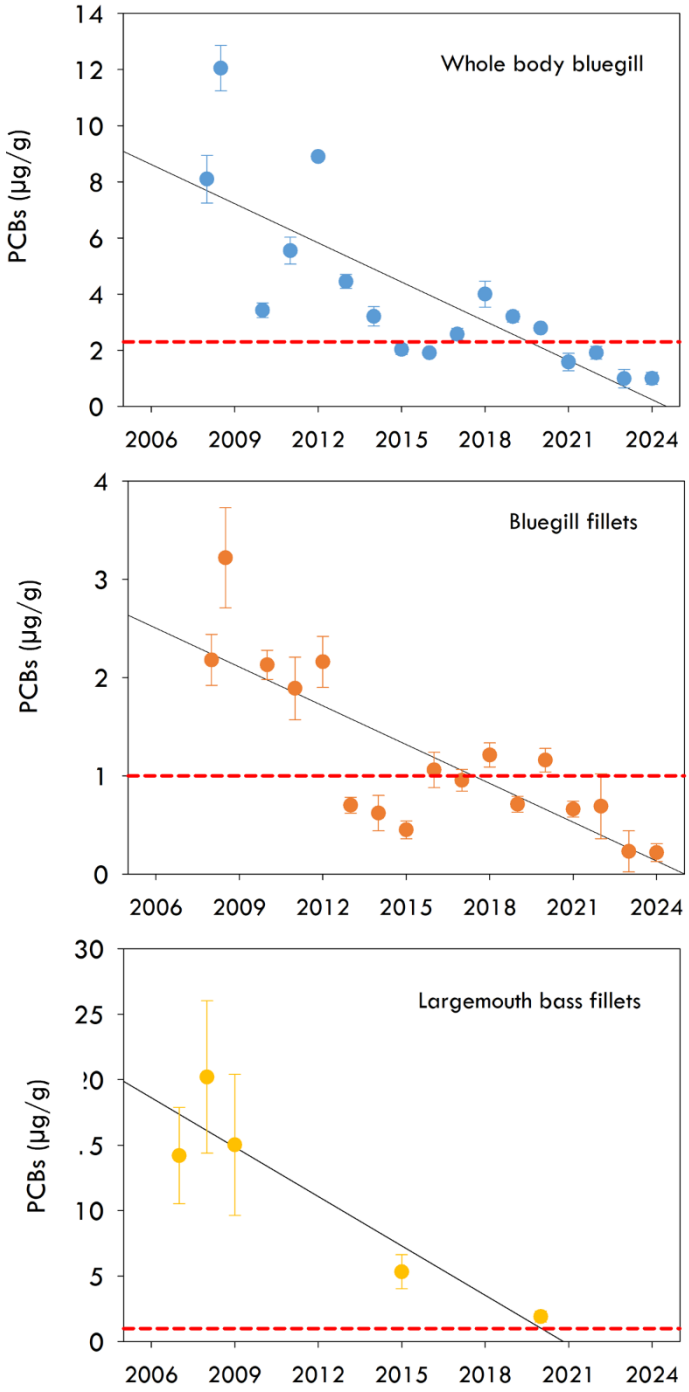


Notes:

1. *N = 2 clam composite samples per site/year.*
2. *Total PCBs defined as the sum of Aroclors 1248, 1254, and 1260.*
3. *Photos: Upper graph shows the SD-490 location; lower graph photo shows placement of clam cages in the Upper SD-100 location.*

Acronyms: *PCB = polychlorinated biphenyl SD = storm drain*

Figure 3.24. Mean total PCB concentrations (µg/g, wet wt) in caged clams placed at K-1007-P1 outfalls compared with reference stream clams (Little Sewee Creek), 1993–2024

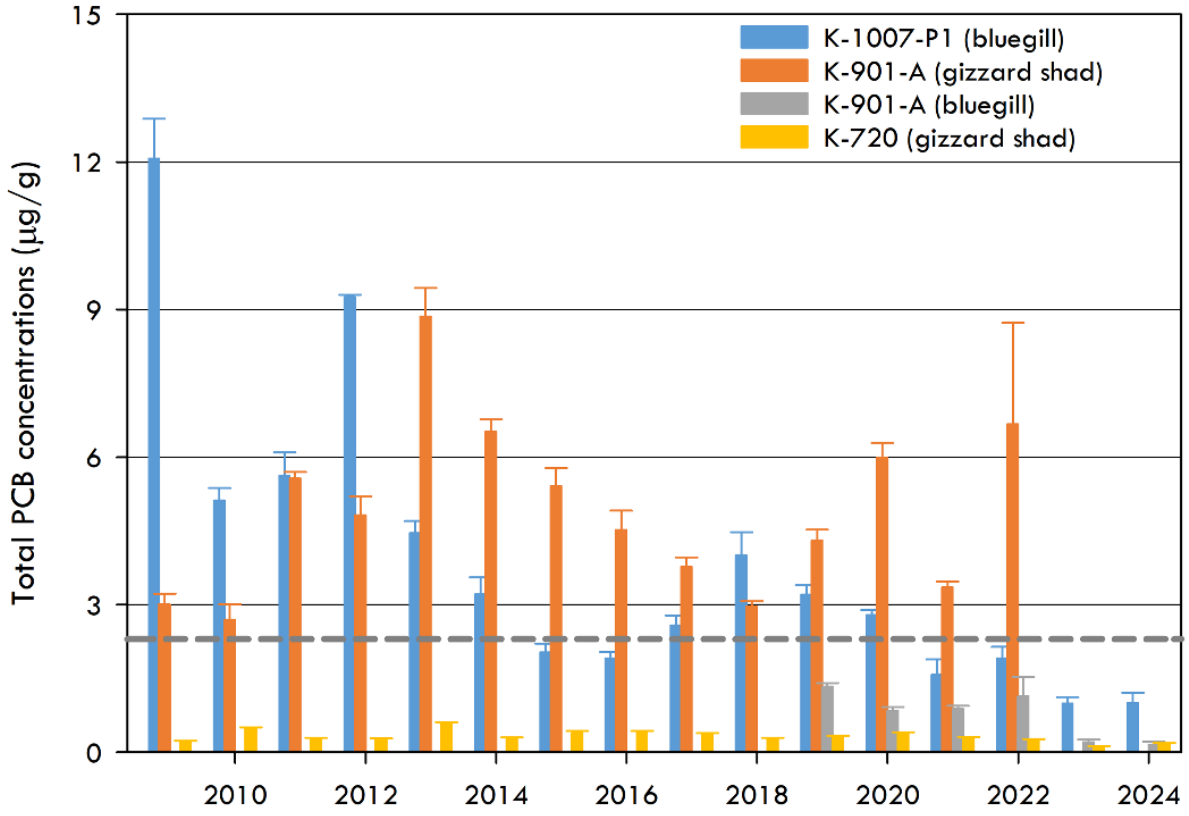


Notes:

1. *For largemouth bass, N = 6 fish per site/year. For bluegill sunfish, N = 20 for fillets and N = 6 composites of 10 whole body fish.*
2. *The target for fillet (1 µg/g) and whole-body concentrations (2.3 µg/g) is shown with the gray dotted lines.*

Acronym: *PCB = polychlorinated biphenyl*

Figure 3.25. Mean PCB concentrations (µg/g, wet wt) in fish from the K-1007-P1 Pond, 2007–2024



Notes:

1. *Total PCBs are defined as the sum of Aroclors 1248, 1254, and 1260.*
2. *The dotted line signifies the target PCB concentration of 2.3 µg/g in whole body fish.*

Acronym: *PCB = polychlorinated biphenyl*

Figure 3.26. Mean (+1 standard error) total PCB concentrations (µg/g, wet wt) in whole body fish from K1007-P1 Pond, K-901-A Holding Pond, and K-720 Slough, 2009–2024

Table 3.9. Average concentrations of total PCBs in fillets and whole-body composites of fish collected in 2024 near the ETTP

Site	Species	Sample type	Sample size (n)	Total PCBs (mean ± SD)	Range of PCB values	No. > target (PCBs)/n	Total Hg (mean + SD)
K-1007-P1 Pond	Bluegill	Fillet	20	0.22 ± 0.09	0.11–0.41	0/20	—
		Whole-body composite	6	1.00 ± 0.21	0.77–1.31	0/6	—
K-901-A Pond	Common carp	Fillet	1	1.69	—	1/1	—
	Largemouth bass	Fillet	14	0.05 ± 0.03	0.02–0.04	0/14	—
K-720 Slough	Largemouth bass	Fillet	16	0.02 ± 0.01	0.01–0.04	0/16	—
	Common carp	Fillet	3	0.55 ± 0.09	0.49–0.65	0/3	—
	Gizzard shad	Whole-body composite	6	0.12 ± 0.01	0.17–0.19	0/6	—
CRM 11.0	Bluegill	Whole-body composite	6	0.02 ± 0.01	0.01–0.03	0/6	—
	Gizzard shad	Whole-body composite	6	0.04 ± 0.005	0.03–0.04	0/6	—
PCM 1.0	Bluegill	Whole-body composite	6	0.08 ± 0.02	0.05–0.10	0/6	—
	Gizzard shad	Whole-body composite	6	0.13 ± 0.02	0.11–0.17	0/6	—
Mitchell Branch	Redbreast sunfish	Fillet	6	0.41 ± 0.09	0.21–0.81	0/6	0.49 ± 0.05
Hinds Creek	Redbreast sunfish	Fillet	6	0.01 ± 0.002	0.01–0.02	0/6	0.08 ± 0.02

Notes:

1. *Average concentrations = µg/g, wet wt.*
2. *Total PCBs = Aroclors 1248, 1254, and 1260.*
3. *Values are mean concentrations (µg/g) ± 1 SE.*
4. *Each whole-body composite sample is composed of 10 individual fish.*
5. *Also shown are the ranges of values observed for PCBs and the number of fish whose fillet PCB concentrations exceeded 1 µg/g out of the total number of fish (or composites) sampled (n). (1 µg/g total PCBs in fish fillets and 2.3 µg/g in whole-body composites.*

Acronyms and abbreviations:

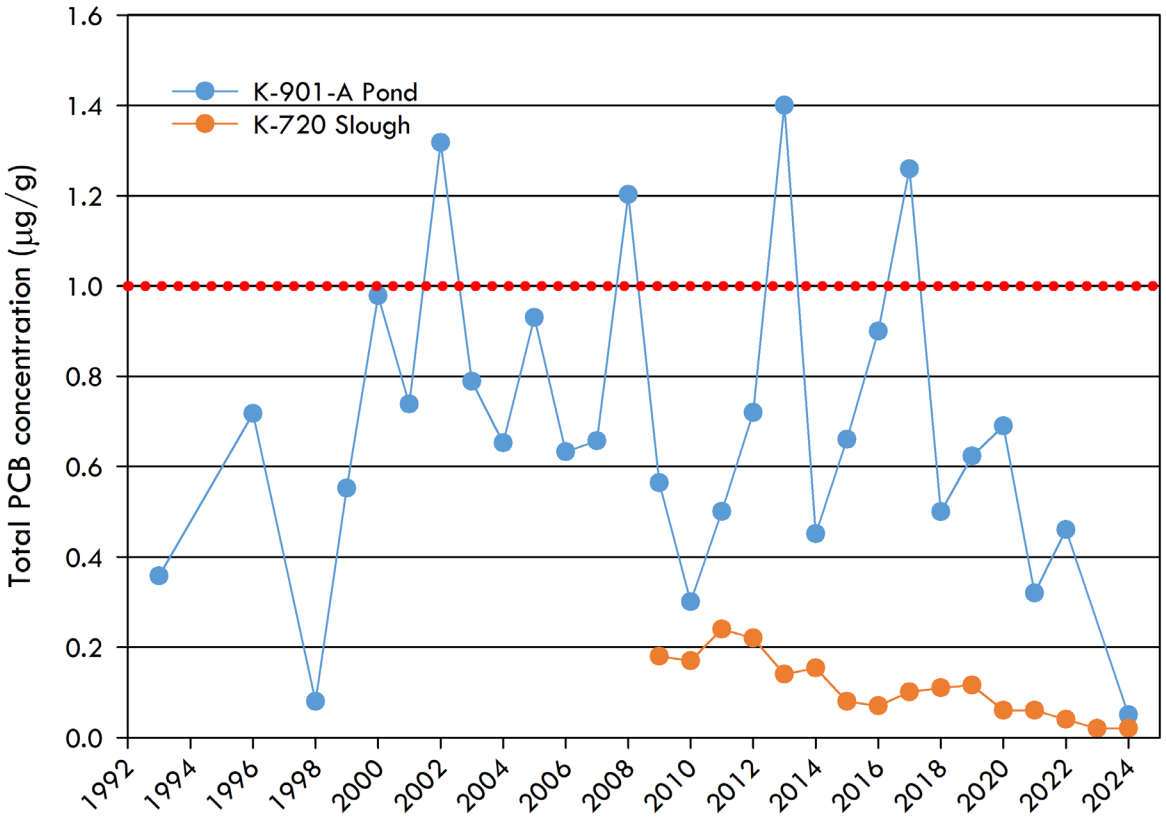
CRM = Clinch River mile
PCB = polychlorinated biphenyl
SE = standard error
n = sample size number
No. = number
PCM = Poplar Creek mile

3.7.1.3. K-901-A Pond

The target fish species for analysis of PCBs in the K-901-A Holding Pond were gizzard shad (*D. cepedianum*) and largemouth bass (*M. salmoides*), but the vegetation planting in this pond was so successful that the habitat for these larger fish has been decreasing and they have become less abundant. In 2024, only one common carp and 14 largemouth bass were collected for analysis.

The PCB concentration in the carp collected in 2024 was 1.69 µg/g, which was higher than in previous years. The mean concentration in largemouth bass seen in 2024 remained the same as 2023 (0.05 µg/g) and was below the target concentration set for the K-1007-P1 Pond of 1 µg/g total PCBs (Figure 3.27). The mean PCB concentration in bluegill fillets in the K-901-A Pond was 0.08 µg/g, which is lower than the concentrations seen in the K-1007-P1 Pond, and well below the target set for both of the ponds.

PCB concentrations in clams deployed in the K-901-A Pond were comparable to those deployed at the reference site, Little Sewee Creek, and were lower in 2024 (0.02 µg/g) than in 2023 (0.03 µg/g; Figure 3.28).



Notes:

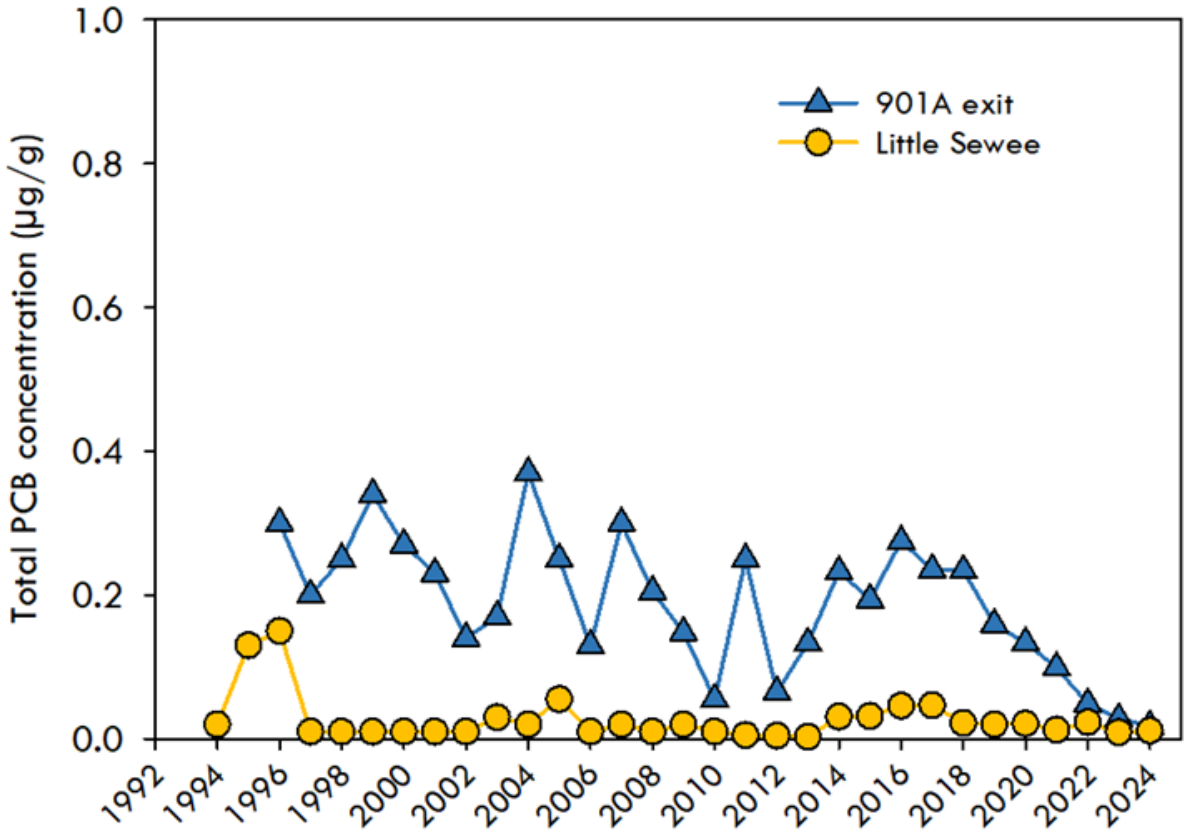
1. *Mean PCBs (± 1 SE) in largemouth bass fillets, 1993-2023 (µg/g).*
2. *N = 6 fish per year, when possible.*
3. *The dotted red line shows the advisory level for PCBs in fish fillets (1 µg/g).*

Acronyms:

PCB = polychlorinated biphenyl

SE = standard error

Figure 3.27. Mean total PCB concentrations in largemouth bass from the K-901-A Pond and the K-720 Slough



Notes:

1. *Total PCBs defined as the sum of Aroclors 1248, 1254, and 1260.*
2. *N = 2 composites of 10 clams each per year.*
3. *Shown in green are data for clams collected from the reference site, Little Sewee Creek (Meigs County, Tenn.).*

Acronym:

PCB = polychlorinated biphenyl

Figure 3.28. Mean total PCB (µg/g, wet wt; 1993–2024) concentrations in the soft tissues of caged Asiatic clams deployed in the K-901-A Pond for a 4-week period

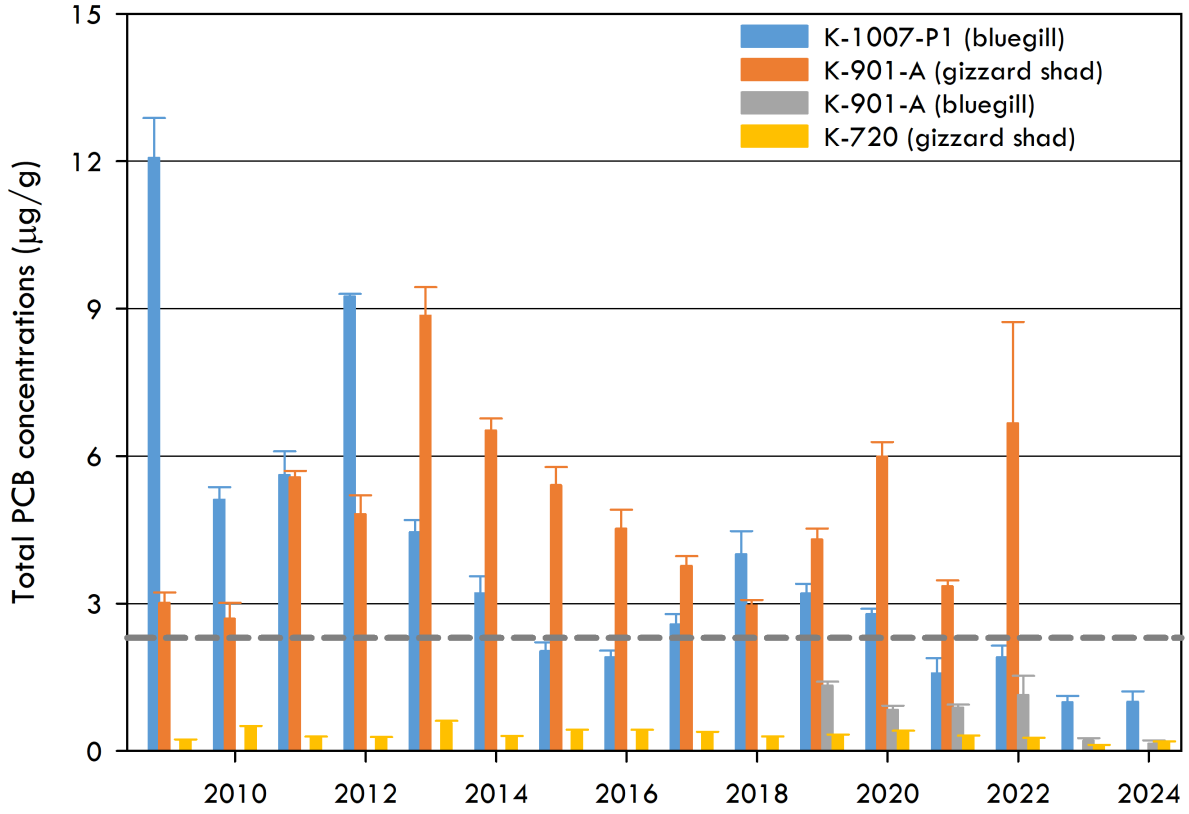
3.7.1.4. K-720 Slough

Routine bioaccumulation monitoring in the K-720 Slough began in 2009 (Figure 3.29). Although the target species for fish fillet monitoring in this slough is largemouth bass, as in the K-901-A Pond it has been difficult to collect a full sample of 20 fish of this species; to complete the collection, common carp also are collected for a total of 20 fish. Figure 3.29 also shows the temporal trends in fish fillet concentrations in the slough. In 2024, PCB concentrations in both fish species monitored were below the state advisory limit of 1 µg/g.

In all cases PCB levels in fish collected from the K-720 Slough were significantly lower than in the K-901-A Holding Pond for the same species (Table 3.9). PCB concentrations in largemouth bass collected from the K-720 Slough have been steadily decreasing since monitoring began (shown earlier in Figure 3.27), averaging 0.02 µg/g in 2024. This concentration is just at the most conservative guideline for PCBs in the State of Tennessee (0.02 µg/g, based on TMDL calculations).

Concentrations in carp collected from the slough were slightly higher than concentrations in bass,

averaging 0.55 µg/g in 2024. Total PCBs in whole body gizzard shad from the K-720 Slough were similar to those seen in recent years and were lower than those seen in whole body fish collected from the other monitored ponds, averaging 0.18 µg/g in 2024.



Notes:

1. *Total PCBs defined as the sum of Aroclors 1248, 1254, and 1260.*
2. *The target sample was 20 largemouth bass, but because these fish are not abundant in the slough, carp and smallmouth buffalo were collected to complete the sample size of 20 fish.*

Acronym:

PCB = polychlorinated biphenyl

Figure 3.29. Mean total PCB (µg/g, wet wt; 2009–2024) concentrations in the fillets of largemouth bass, common carp, and smallmouth buffalo collected from the K-720 Slough

3.7.2. Task 2: Instream Benthic Macroinvertebrate Communities

Benthic macroinvertebrate communities in Mitchell Branch are sampled using ORNL and TDEC protocols (Figures 3.30 and 3.31). Evaluation of long-term trends of macroinvertebrate communities in the stream make it possible to document the effectiveness of pollution abatement activities or remediation, efforts as well as to assess the potential consequences of unanticipated events as sitewide remediation continues (e.g., chromium release into Mitchell Branch).



Figure 3.30. Collecting an invertebrate sample using ORNL BMAP protocols

Long-term monitoring of pollution-intolerant benthic macroinvertebrates such as stoneflies, mayflies, and caddisflies helps us understand changes in ecological health of Mitchell Branch in response to remedial action at ETTP.



Figure 3.31. Sampling for benthic macroinvertebrates with TDEC protocols

3.7.2.1. Benthic Macroinvertebrates

The major objectives of the benthic macroinvertebrate task are to help assess the ecological condition of Mitchell Branch and to evaluate changes in stream ecology associated with changes in facilities operations and RAs within the Mitchell Branch watershed. To meet these objectives, the condition of the benthic macroinvertebrate community of Mitchell Branch has been monitored routinely since late 1986. This summary includes results of samples collected each April from 1987 to 2024 following ORNL BMAP quantitative sampling protocols and samples collected annually (August/September) with TDEC semiquantitative sampling protocols for estimating the North Carolina Biotic Index (NCBI) and the Habitat Index (TDEC 2021). For both sets of protocols, four sites were assessed in Mitchell Branch—MIKs 0.4, 0.7, 0.8, and 1.4. MIK 1.4 serves as the primary reference site, but narrative Biotic Index results for TDEC protocols are based on reference conditions established by TDEC from a suite of reference sites in the same ecoregion as Mitchell Branch. Finally, also included in this summary is a comparison

between the macroinvertebrate community structure at the four Mitchell Branch sites and five other reference sites on the ORR. Most of these reference sites—spanning a range of stream sizes both smaller and larger than Mitchell Branch (based on watershed area)—have been monitored using ORNL protocols since the mid1980s for other biological monitoring projects on ORR (ORNL BMAP and WRRP/Bear Creek Biological Monitoring Program) (as shown earlier in Table 3.9). This summary provides information on how invertebrate community structure at Mitchell Branch sites, including MIK 1.4, compares with the community structure of a range of relatively unaffected reference sites on the ORR.

3.7.2.2. Mitchell Branch—ORNL and TDEC Protocols

Total taxa richness (i.e., the total number of taxa per sample) and *Ephemeroptera*, *Plecoptera*, and *Trichoptera* (EPT) taxa richness (i.e., the total number of pollution-intolerant EPT taxa [mayflies, stoneflies, and caddisflies] per sample) measured using ORNL protocols has varied over the measurement period (1987–2023) in all Mitchell Branch sites (Figure 3.32). Both total taxa richness and EPT taxa richness increased in MIKs 0.4, 0.7, and 0.8 from 1987 to the late 1990s. Despite considerable year to year variations the total taxa richness and EPT taxa richness have expressed a fairly stable trend from the late 1990s and onward in MIKs 0.4, 0.7, and 0.8 (Figure 3.32). Total taxa richness and EPT taxa richness have been fairly consistent throughout the measurement period in the reference site, MIK 1.4, though values have been lower in five of the past seven years (Figure 3.32). In comparing values from April 2024 to those in April 2023, total taxonomic richness and EPT taxonomic richness increased only at MIK 0.8 and no sites showed significant decreases in either total or EPT taxonomic richness values (Figure 3.32). Both richness metric values were lowest at MIK 0.4 and highest at MIK 0.8, though the values at the three upstream sites were more similar to each other than to MIK 0.4 (Figure 3.32). The EPT taxonomic richness at MIK 0.8 displayed a second consecutive year of increased values, reaching levels not seen since 2016 (Figure 3.32).

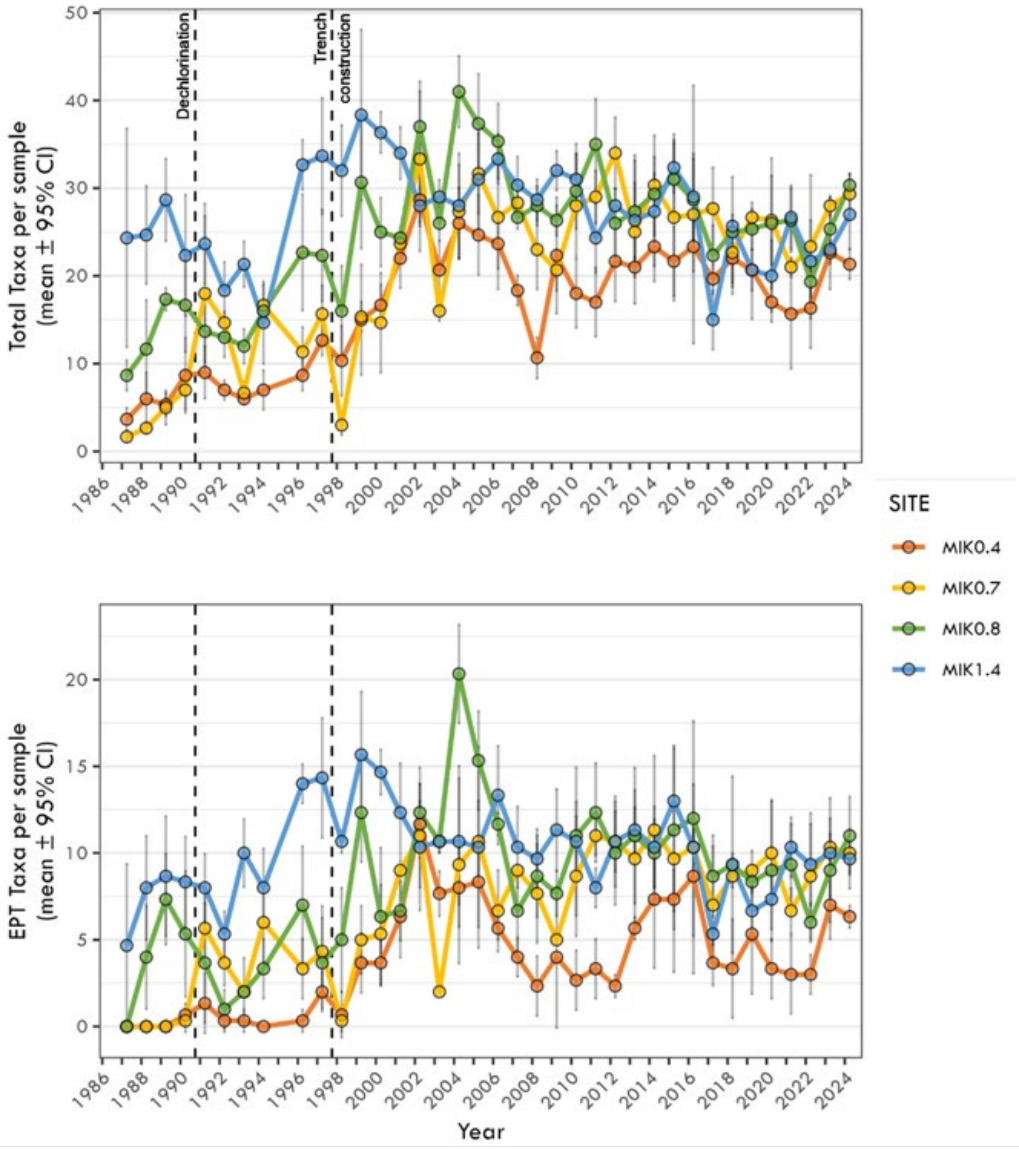
The percent density of the pollution-intolerant taxa (higher values indicate better conditions) was highest at MIK 1.4, the reference site—a trend that has been observed over most of the time series (Figure 3.33).

The percent density of pollution-tolerant taxa (lower values indicate better conditions) in 2024 was lowest at MIK 1.4 and highest at MIK 0.4 (Figure 3.33). In 2024, the percent density of pollution-tolerant taxa at MIK 1.4 was closer to, but slightly above, levels typically observed over the monitoring period (Figure 3.33). These results suggest that the invertebrate community in Mitchell Branch continues to be mildly to moderately degraded downstream of MIK 1.4.

Based on TDEC protocols (TDEC 2021), scores for the TMI (Tennessee Macroinvertebrate Index) in 2024 rated the invertebrate community at MIK 1.4 as passing biocriteria guidelines, whereas scores for communities in the three lower Mitchell Branch sites fell below biocriteria guidelines (Figure 3.34, Table 3.10). From 2023 to 2024, TMI scores decreased at all sites except MIK 0.4, where the score increased. The decreased scores at the three upper MIK sites in 2024 reflected decreases in several different biocriteria, including the taxonomic richness score (MIK 0.8), the EPT richness score (MIK 0.7 and 0.8), the EPT percent abundance score (MIK 0.7), and the clinger percent abundance score (MIK 1.4; Table 3.10). The increased TMI score at MIK 0.4 was due to increases in both the EPT richness and North Carolina Biotic Index scores, indicating that more pollution-intolerant species were present. The improved score at MIK 1.4 reflected increases in EPT taxa richness and the percentage of clinger taxa (Table 3.10). The TDEC protocol states that TMI scores should be calculated only for samples with 160–240 invertebrates identified to genus (TDEC 2021). In 2024, samples at MIK 0.7 and MIK 0.8 fell below this threshold (Figure 3.34), indicating results should be interpreted with caution.

Mitchell Branch is situated within ecoregion 67f, the Southern Limestone/Dolomite Valleys and Low Rolling Hills, which is composed of diverse aquatic habitats and fish fauna (EPA 2013). Based

on TDEC stream habitat protocols, habitat quality was above the ecoregion 67f guideline at all sites within Mitchell Branch (Figure 3.34). Habitat scores remained similar (MIK 0.7 and MIK 0.8) or decreased (MIK 0.4 and MIK 1.4) in 2024, while remaining above the habitat quality threshold over the past four years (Figure 3.34). In general, these decreases were driven by increased sediment deposition, embeddedness of riffles, bank stability, and bank vegetation protection issues. Small riparian width, particularly on the left bank, remains an issue at all sites except MIK 1.4. Habitat conditions related to riffle stability (i.e., frequency of reoxygenation zones) and channel flow improved or remained constant at all sites.



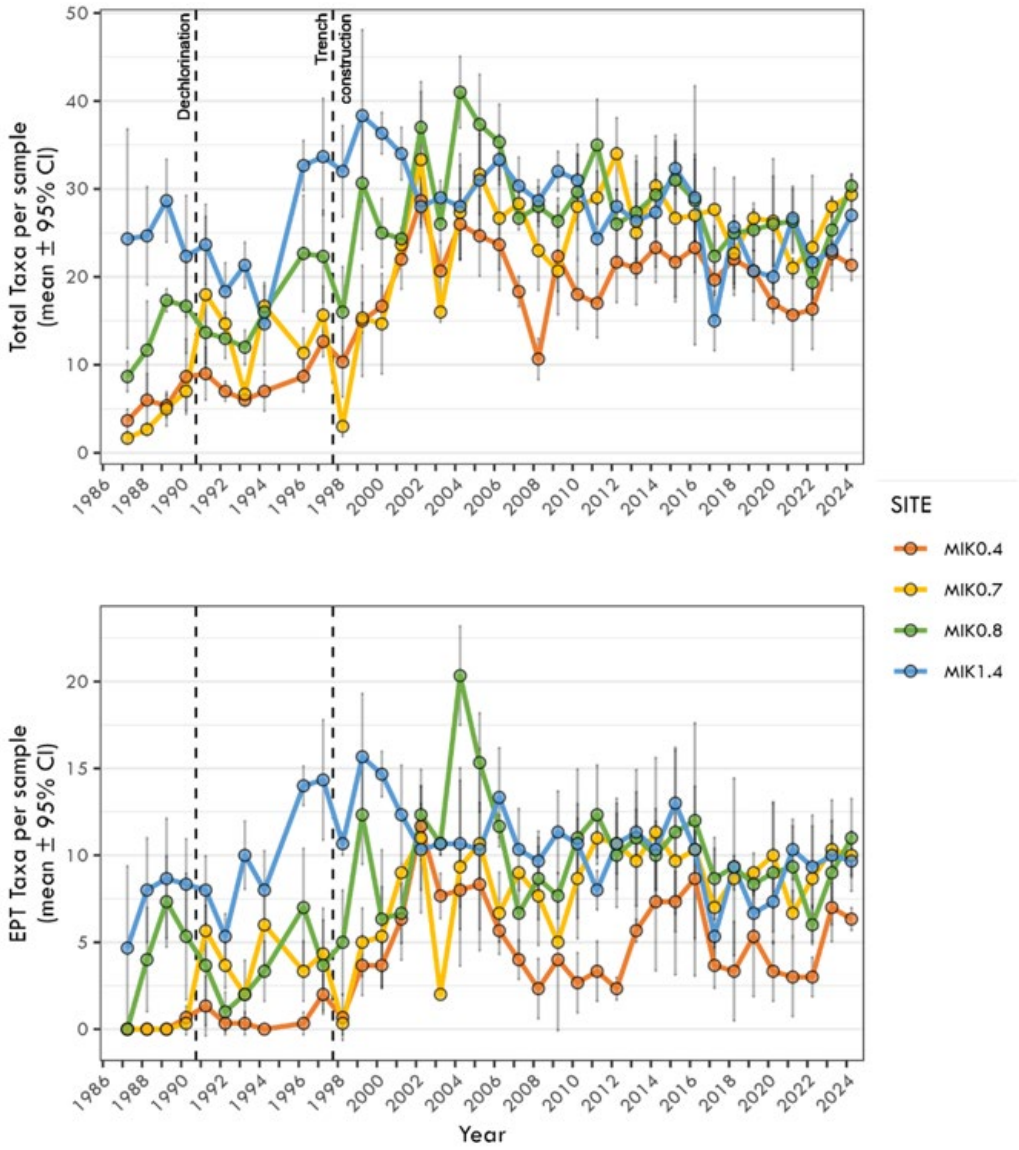
Note: *Samples were not collected in April 1995.*

Acronyms:

EPT = Ephemeroptera, Plecoptera, and Trichoptera *MIK = Mitchell Branch kilometer*

CI = confidence interval

Figure 3.32. Mean (± 95 percent confidence interval) total taxonomic richness (top) and richness of the pollution-intolerant taxa per sample (bottom) for Mitchell Branch sites, April 1987–2024



Notes:

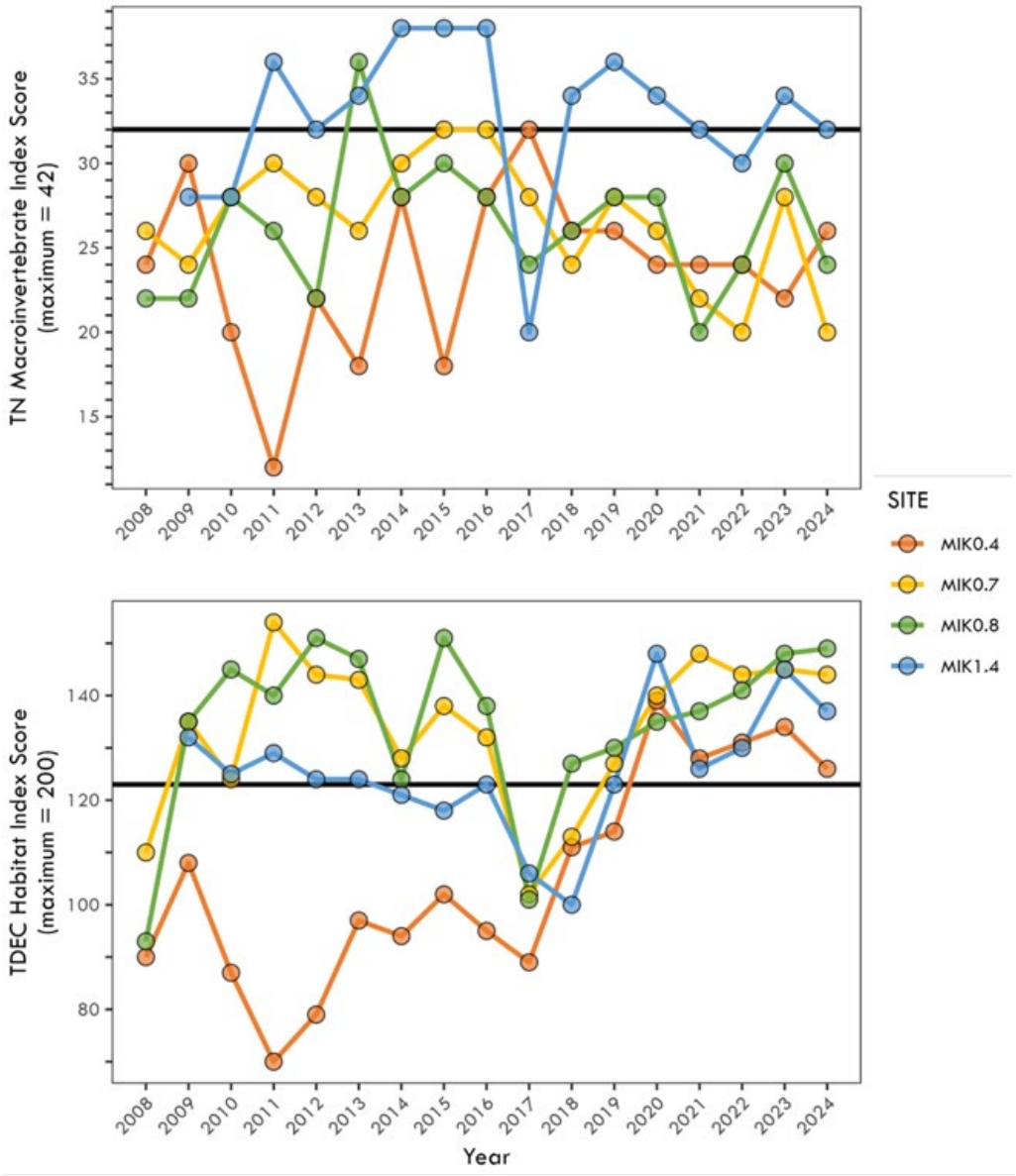
1. *Pollution-intolerant taxa, i.e., stoneflies, mayflies, and caddisflies or Ephemeroptera, Plecoptera, and Trichoptera taxa (top).*
2. *Percentages were based on total densities for each site.*
3. *Samples were not collected in April 1995.*

Acronyms:

MIK = Mitchell Branch kilometer CI = confidence interval

EPT = Ephemeroptera, Plecoptera, and Trichoptera (pollution-intolerant taxa)

Figure 3.33. Mean percent density of pollution-intolerant taxa and of the pollution-tolerant *Orthocladiinae* midge larvae (*Chironomidae*) at Mitchell Branch sites, April 1987–2024



Notes:

1. *Mitchell Branch site MIK 1.4 was not sampled with TDEC protocols in 2008.*
2. *The horizontal line on each graph shows the rating threshold for each index for ecoregion 67f; TDEC macroinvertebrate index threshold is 32; TDEC habitat index threshold is 123. Values above the thresholds are indicative of passing biocriteria or habitat guidelines.*

Figure 3.34. Temporal trends in the TMI (top) and Stream Habitat Index (bottom) scores for four Mitchell Branch sites, August 2008–2024

Table 3.10. Tennessee Macroinvertebrate Index metric values and scores and index scores for Mitchell Branch, August 19, 2024[a,b,c]

Site	Metric values							Metric scores							TMI[d]
	Taxa rich	EPT rich	%EPT	%OC	NCBI	% Cling	%TN Nuttol	Taxa rich	EPT rich	%EPT	%OC	NCBI	% Cling	%TN Nuttol	
MIK 0.4	17	4	10.6	1.9	4.5	76	36.5	2	2	0	6	6	6	4	26
MIK 0.7	12	3	10.3	10.3	5.8	46.2	41	2	0	0	6	4	4	4	20
MIK 0.8	12	2	25	14.3	5.3	73.2	44.6	2	0	2	6	4	6	4	24
MIK 1.4	25	9	40.2	8.9	4.4	51.4	41.6	4	4	4	6	6	4	4	32 **[pass]**

[a] *TMI metric calculations and scoring and index calculations are based on Tennessee Department of Environment and Conservation (TDEC) protocols for ecoregion 67f: TDEC 2021, Quality System Standard Operating Procedures for Macroinvertebrate Stream Surveys, TDEC Division of Water Resources, Nashville, Tennessee. Available* ***here****.*

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

[c] *MIK = Mitchell Branch kilometer*

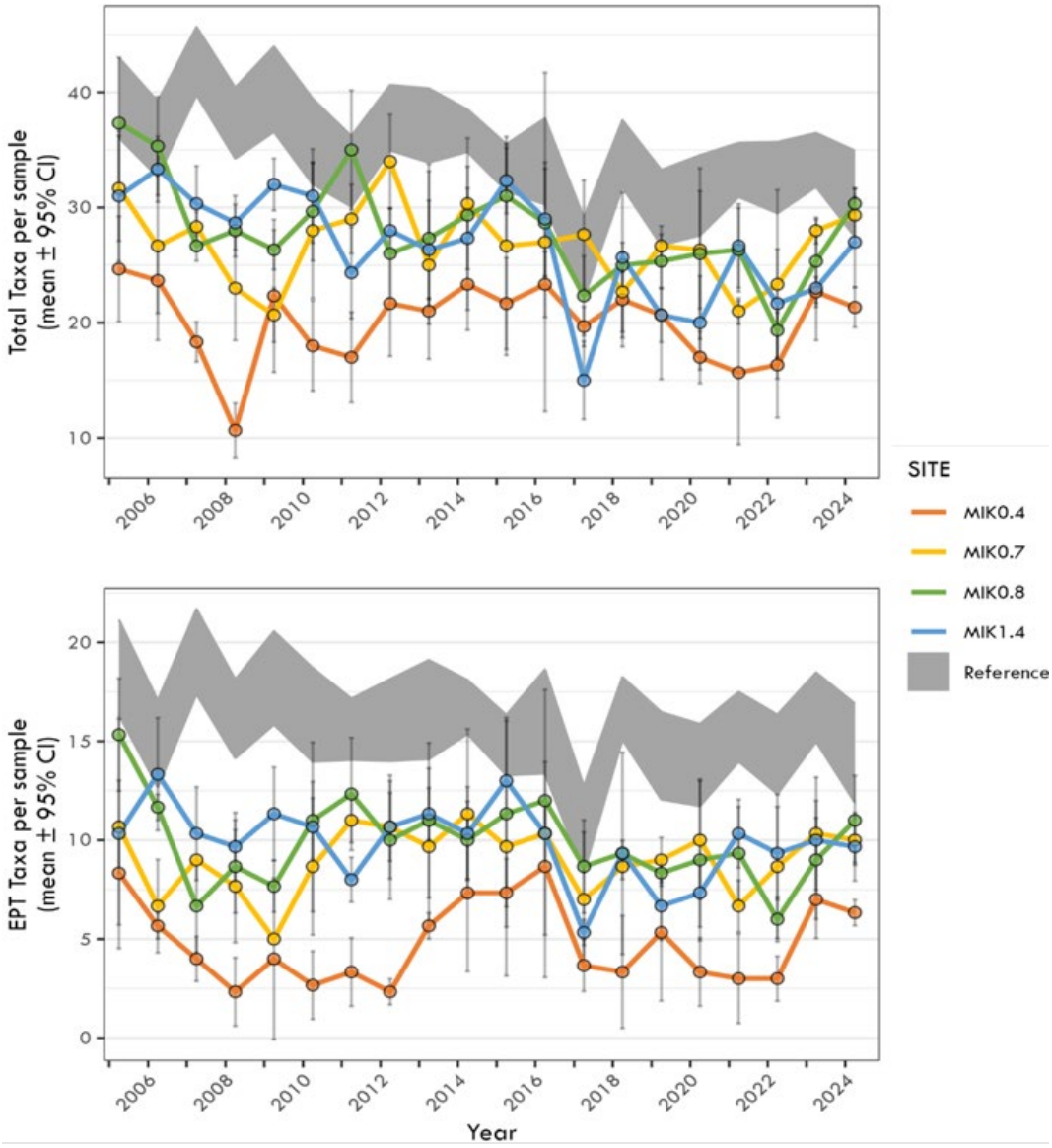
[d] *TMI = Tennessee Macroinvertebrate Index score. TMI is the total index score, and higher index scores indicate higher-quality conditions. A score of ≥ 32 is considered to pass biocriteria guidelines.*

3.7.2.3. Comparison between Mitchell Branch and Other Reference Sites on the ORR

In Figure 3.35, the benthic macroinvertebrate communities in Mitchell Branch are compared to ORR reference streams over an 18-year period. Mean values for total taxa richness and taxa richness of pollution-intolerant (EPT) taxa for Mitchell Branch are shown in Figure 3.35, and percent density of the pollution-intolerant and pollution-tolerant taxa are shown in Figure 3.36. Also shown in gray shading in Figures 3.35 and 3.38 is the 95 percent confidence interval for the five ORR reference sites—First Creek kilometer 0.8, Fifth Creek kilometer 1.0, White Oak Creek kilometer 6.8, Walker Branch kilometer 1.0, and Gum Hollow Branch kilometer 2.9.

In 2024, the total taxonomic richness at MIK 0.4 and MIK 1.4 and the taxonomic richness of pollution-intolerant (EPT) taxa at all Mitchell Branch sites fell below the 95 percent confidence interval of the ORR reference sites (Figure 3.35). Although the overall pattern for EPT taxonomic richness remains similar to that generally seen throughout the time series, the 95 percent confidence interval for total taxonomic richness at the reference sites has shifted down over the course of the time series since the mid-to-late 2000s, though pollution-tolerant taxa may have comprised most of those lost over this time period (Figure 3.36). In contrast to richness metrics, the mean percent densities of pollution-intolerant and pollution-tolerant taxa at MIK 1.4 were not often outside of the range for the reference sites prior to 2019 and 2020 but were similar to those of ORR reference sites in 2021 and 2022; however, the mean percent density of pollution-tolerant taxa was again higher at MIK 1.4 than the reference sites (Figure 3.36). Since 2005, the mean percent densities of pollution-intolerant and pollution-tolerant taxa at all other MIK sites have been outside the 95 percent confidence interval for ORR reference sites, with few exceptions. (Figure 3.36).

These results from the comparison of Mitchell Branch sites with the reference sites, combined with the long-term results for all Mitchell Branch sites discussed above, suggest that from the standpoint of reference sites, MIK 1.4 has generally fallen within or below expected reference conditions on the ORR (depending on the macroinvertebrate metric examined). Furthermore, after a brief excursion in 2019 and 2020, MIK 1.4 has once again fallen outside the 95 percent confidence interval of the mean percent densities of pollution-intolerant and pollution-tolerant taxa at ORR reference sites in 2024. Factors potentially contributing to excursions of invertebrate community metrics outside of the range of other reference sites include the somewhat smaller size of MIK 1.4 compared with the other reference sites (based on watershed area, Table 3.11), which may limit the range of invertebrate species that can colonize and thrive at the site, and habitat characteristics that have typically contributed to the lower-quality habitat at the site, such as low flow and poor substrate quality (seen earlier in Figures 3.33 and 3.34).



Note: *The gray shading on each graph shows the 95 percent confidence interval of values at five additional reference stream sites on the ORR from 2005 to 2023.*

Acronyms:

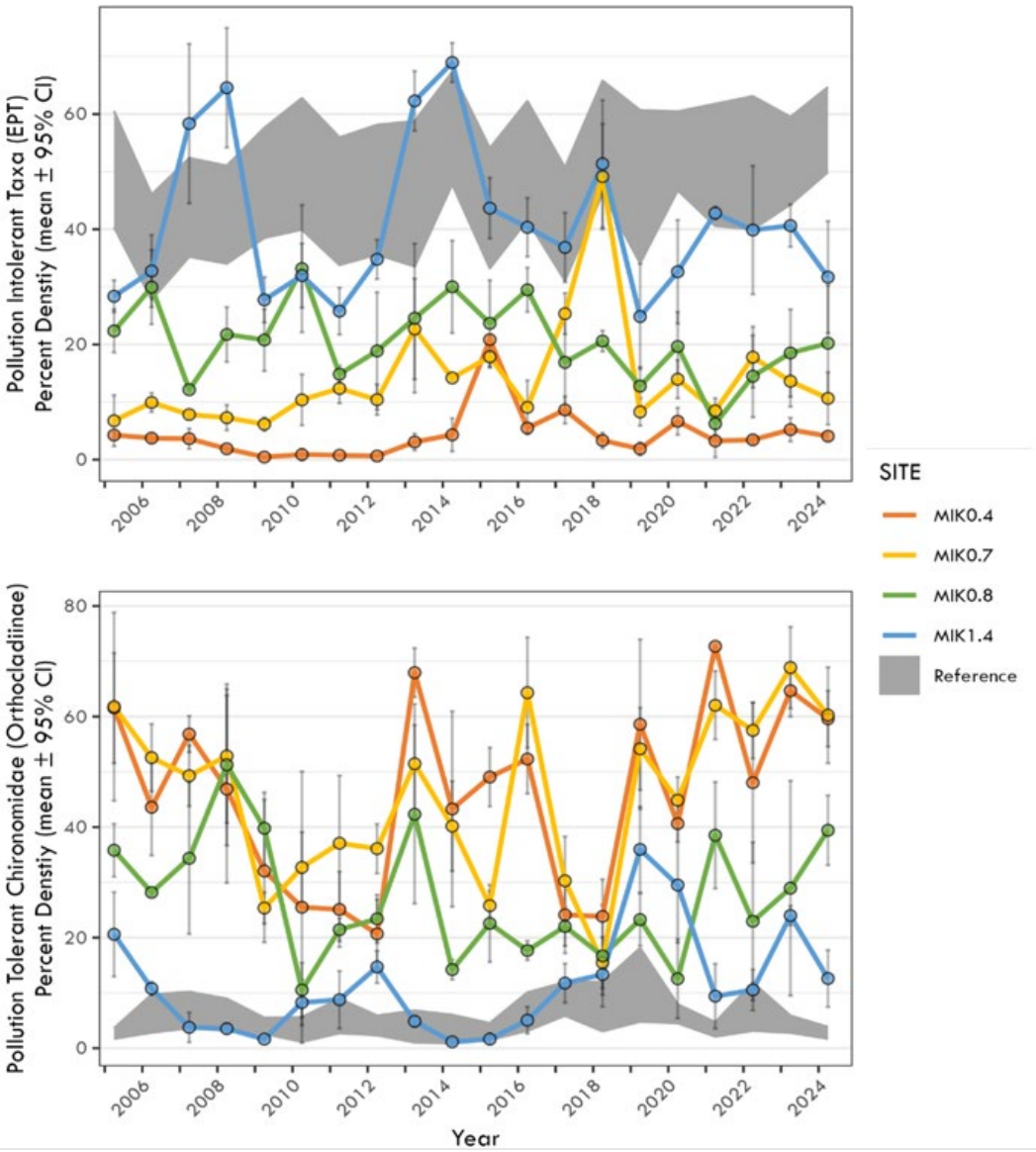
CI = confidence interval

EPT = Ephemeroptera, Plecoptera, and Trichoptera

MIK = Mitchell Branch kilometer

MIK 1.4 = reference site

Figure 3.35. Mean total taxonomic richness (top) and pollution-intolerant taxa per sample (bottom) for the benthic macroinvertebrate community at Mitchell Branch and the 95 percent confidence interval for ORR reference sites, April 2005–2024



Notes:

1. *Pollution-intolerant taxa, i.e., stoneflies, mayflies, and caddisflies or Ephemeroptera, Plecoptera, and Trichoptera taxa (top).*
2. *Pollution-tolerant Orthocladiinae midge larvae (bottom).*
3. *Percentages were based on total densities for each site.*
4. *The gray shading on each graph shows the 95 percent confidence interval for values at five additional reference sites on the ORR from 2005 to 2023.*

Acronyms:

CI = confidence interval MIK 1.4 = reference site EPT = Ephemeroptera, Plecoptera, and Trichoptera
ORR = Oak Ridge Reservation MIK = Mitchell Branch kilometer

Figure 3.36. Mean percent density of pollution-intolerant taxa (top) and pollution-tolerant *Chironomidae* (bottom) in Mitchell Branch the 95 percent confidence interval for ORR reference sites, April 2005–2024

Table 3.11. Stream sites included in the comparison between Mitchell Branch and other reference sites on the ORR

Site	Location		Watershed area (km^2)	Program
	Latitude (N)	Longitude (W)		
Mitchell Branch				
MIK 0.4	35.93859	84.39040	1.554	ETTP BMAP
MIK 0.7	35.93786	84.38792	1.347	ETTP BMAP
MIK 0.8	35.93786	84.38682	1.269	ETTP BMAP
MIK 1.4 (reference)	35.93790	84.37662	0.311	ETTP BMAP
Other ORR reference sites				
First Creek (FCK 0.8)	35.92670	84.32355	0.596	ORNL BMAP
Fifth Creek (FFK 1.0)	35.93228	84.31746	0.596	ORNL BMAP
Gum Hollow Branch (GHK 2.9)	35.96385	84.31594	0.777	Bear Creek BMP/WRRP
Walker Branch (WBK 1.0)	35.95805	84.27953	1.010	ORNL BMAP
White Oak Creek (WCK 6.8)	35.94106	84.30145	2.072	ORNL BMAP

Acronyms:
BMAP = Biological Monitoring and Abatement Program
BMP = Biological Monitoring Program
ETTP = East Tennessee Technology Park
km^2 = square kilometers
MIK = Mitchell Branch kilometer
N = north
ORNL = Oak Ridge National Laboratory
ORR = Oak Ridge Reservation
W = west
WRRP = Water Resources Restoration Program

3.7.3. Task 3: Fish Community

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

Mitchell Branch fish community

Historically, the fish community in Mitchell Branch was most severely affected in the late 1980s and early 1990s. After some recovery in the mid-1990s, Mitchell Branch was affected negatively again in 1998 in association with a remedial activity that replaced a large section of stream bottom with a liner and interlocking rock substrate (Figure 3.37). In recent years, this reach of stream appears to be developing more natural habitat, including a more robust riparian plant community and some instream riffle/pool sequences as substrate is slowly beginning to accumulate throughout the reach (Figure 3.38).



Figure 3.37. Construction of lined section of Mitchell Branch, MIK 0.7, in 1998



Figure 3.38. More recent habitat conditions at Mitchell Branch in 2024

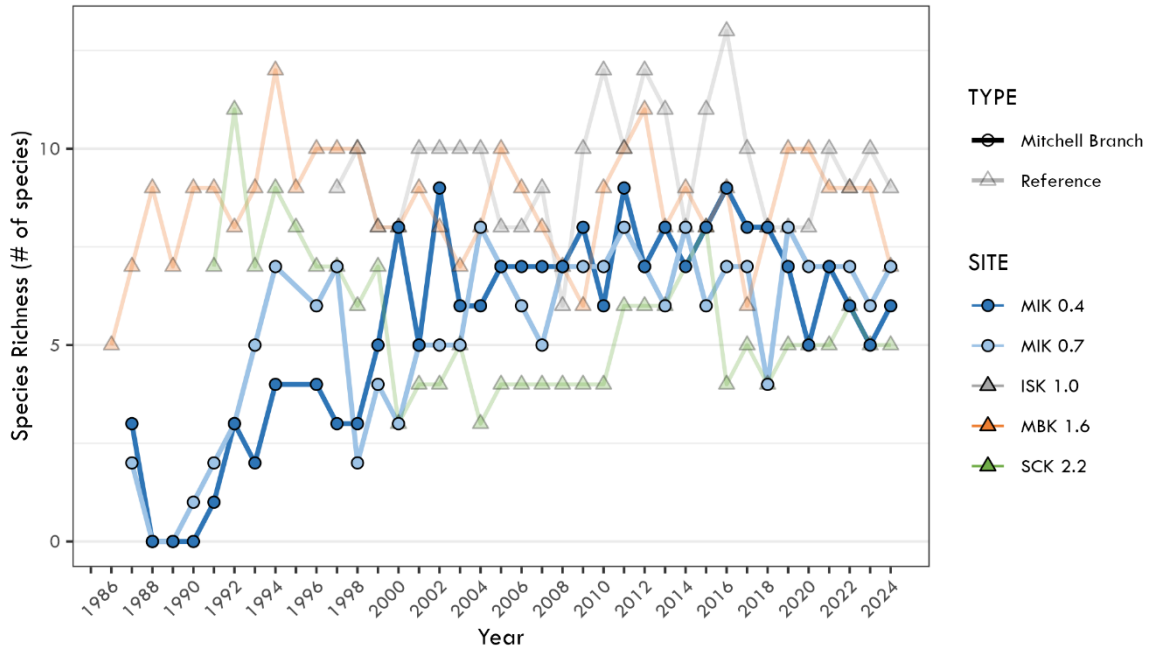
This has added to the complexity of the habitat available for fishes to colonize. Since 2000, the fish community has had relatively stable species diversity but rather large variations in fish density and biomass, which are often reflective of unstable, impaired streams. Streams that experience high density and biomass of tolerant fish species are often indicative of either high nutrient influences on a fish community (i.e., more algal growth means more food at the base of the food chain) or poor instream habitat—and often a combination of both. Of the two sites sampled for fish community, MIK 0.7 has experienced the greatest fluctuations in these community parameters. This is likely due to the modified stream channel and riparian areas and poor instream habitat associated with the remediation work in this reach. Similar conditions are seen in other area streams on the ORR, including sections of East Fork Poplar Creek where tolerant species dominate the concrete- and bedrock-lined channel, which supports little riparian protection. In addition, extremely low precipitation amounts, which often occur in the summer, result in very low flows in many area streams. Small first and second order streams without springs or groundwater influence are most severely affected by these conditions. This may partially explain the decreased density and biomass numbers observed in some years and the apparent return of higher values in following years.

At both MIK 0.4 and MIK 0.7, the 2023 sample of fish community parameters indicated continued variation. Species richness (number of species) at both sites increased slightly compared to 2023 values (Figure 3.39).

Both sites have species richness slightly lower than similar sized reference streams. Density (number of fish) at both sites still remains well above reference conditions (Figure 3.40). Biomass (weight) also remains elevated at both sites (Figure 3.41). Both the lower Mitchell Branch site and the upper site had reduced diversity and density of sensitive fish species in 2024 compared to reference sites.

Over the last decade, there has been a slight uptick in the occurrence of sensitive fish species at both sampled sites in Mitchell Branch, which can be attributed to the regular presence of fish such as banded sculpin (*Cottus carolinae*) that appear to be a resident species in Mitchell Branch, and also occasional occurrences of other more sensitive fish. In 2024, no new species were observed in the two sites and the resident banded sculpin continued to be very limited at both sites. However, new species of darters, suckers, and sunfish continue to be discovered within Mitchell Branch every year, and some represent unique sensitive species in this reach of stream.

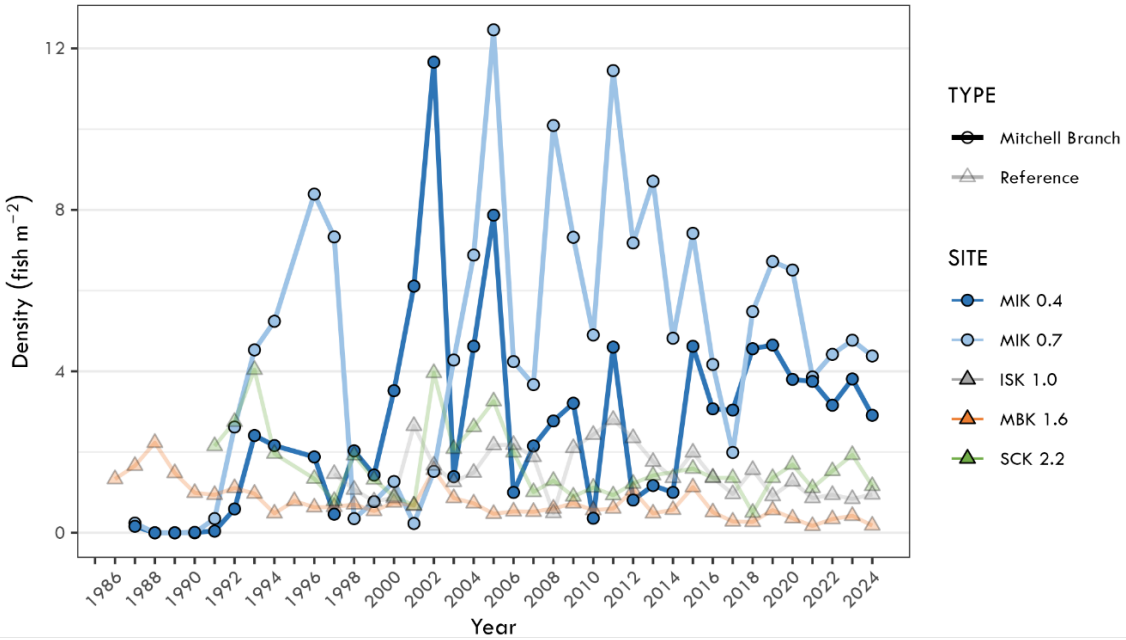
In general, the Mitchell Branch fish communities at MIK 0.4 and MIK 0.7 continue to lack diverse resident species that are sensitive to stress or that have specialized feeding or reproductive requirements, such as darters or suckers that occur consistently at higher frequencies in the reference streams. Like the benthic communities, fish community monitoring provides an integrated response to all of the various water chemistry and habitat influences in a stream. Identifying the major stressor influences on the community (i.e., causal analysis) would require additional investigatory strategies coupled with the monitoring data.



Acronyms:

ISK = Ish Creek
MIK = Mitchell Branch kilometer
MBK = Mill Branch kilometer
SCK = Scarboro Creek

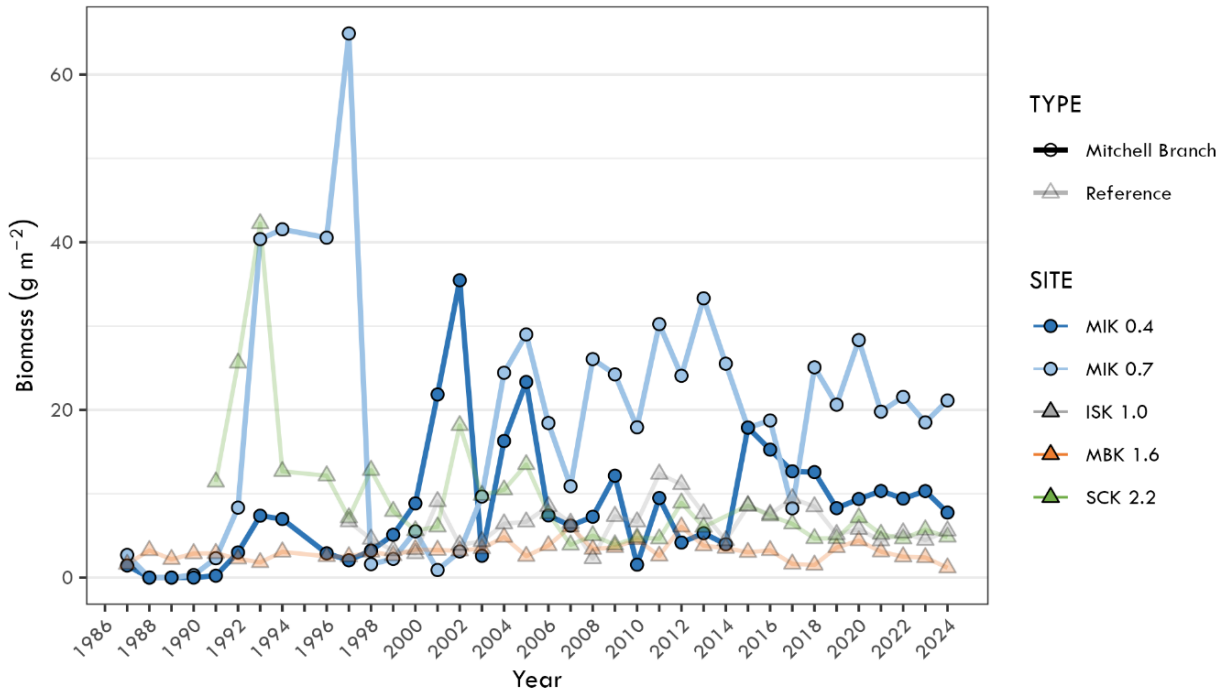
Figure 3.39. Species richness for the fish communities at sites in Mitchell Branch and in reference streams Mill Branch, Scarboro Creek, and Ish Creek, 1987–2024



Acronyms:

ISK = Ish Creek
MIK = Mitchell Branch kilometer
MBK = Mill Branch kilometer
SCK = Scarboro Creek

Figure 3.40. Density for the fish communities at sites in Mitchell Branch and in reference streams Mill Branch, Scarboro Creek, and Ish Creek, 1987–2024



Acronyms:

ISK = Ish Creek
MBK = Mill Branch kilometer
MIK = Mitchell Branch kilometer
SCK = Scarboro Creek

Figure 3.41. Biomass for the fish communities at sites in Mitchell Branch and in reference streams Mill Branch, Scarboro Creek, and Ish Creek, 1987–2024

During routine bioaccumulation sampling, several species of fish are collected regularly at MIK 0.2 that are infrequently observed in the Mitchell Branch fish community monitoring activities at the upstream sites. These included four pollution-sensitive species: black redhorse (*Moxostoma duquesnei*), snubnose darter (*Etheostoma simoterum*, greenside darter (*Etheostoma blennioides*), and northern hogsucker (*Hypentelium nigricans*) (Figure 3.42). Future monitoring will help determine if these species are becoming established farther upstream in Mitchell Branch or are merely seasonal migrants to the stream's lower section, which is easily accessible from the much larger Poplar Creek.

K-1007-P1 Pond fish community

The fish communities in the K-1007-P1 Pond are assessed annually. This sampling is conducted to evaluate the effectiveness of remediation efforts implemented in 2009 and is aimed at reducing the PCBs available for transfer out of the pond via natural routes (i.e., trophic transfer). The RAs included capping contaminated sediment with fill dirt, planting native aquatic vegetation to stabilize sediment, and removing potentially contaminated fish from the pond. Fish initially were removed from the pond using the piscicide rotenone, and uncontaminated native fish were stocked in the pond with the goal of establishing a sunfish-dominated community. Sunfish have a shorter lifespan than many other species of fish, especially higher trophic level fish, and they have a prey source that is generally varied but consistently lower on the aquatic food chain compared with species such as largemouth bass, thus reducing the likelihood that contaminants would biomagnify in the system.



Black redhorse *(Moxostoma duquesnei)*



Snubnose darter *(Etheostoma simoterum)*



Northern hogsucker *(Hypentelium nigricans)*



Greenside darter *(Etheostoma blennioides)*

Photos: Chris Bryant

Figure 3.42. Sensitive fish species observed in lower Mitchell Branch

Overall, the K-1007-P1 Pond fish community surveys conducted in February 2024 revealed the presence of nine species of fish. An observation of particular importance from earlier surveys is the abundance of sunfish species (bluegill, redear sunfish, and warmouth), which constitute approximately 91 percent of the total fish population in the pond (Figure 3.43). Bluegill, the most prevalent of these species, were historically the dominant sunfish species in the pond, and they are the desired bioindicator fish species to have in the remediated pond. Although largemouth bass continue to persist in the pond, their abundance remains relatively low. Despite removal efforts, their presence is likely to continue, given the habitat conditions currently in the pond (i.e., abundant prey sources and open water). Gizzard shad (*D. cepedianum*) continues to be present in the pond and are suspected of reproducing some years. Although they constituted a much larger portion of the fish population in 2020, they have rarely been found in samples since then. Their abundance has had some minor fluctuations each year but in general has remained relatively low compared with earlier years.

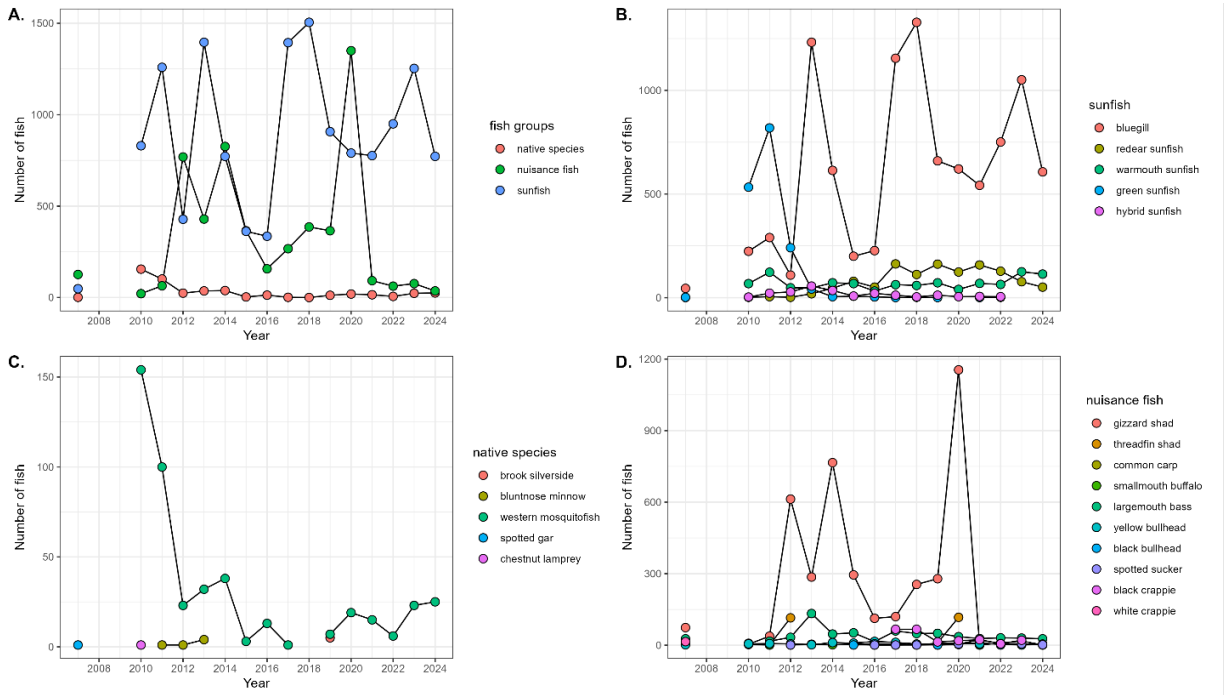


Figure 3.43. Changes in the K-1007-P1 Pond fish community from 2007–2024

3.8. Environmental Management and Waste Management Activities

Remediation activities were underway across ETTP in 2024. Wastes were generated during these operations and were handled in accordance with the applicable regulations.

3.8.1. Waste Management Activities

Most of the waste generated during FY 2024 cleanup activities in Oak Ridge went to disposal facilities on the ORR—namely, the Environmental Management Waste Management Facility (EMWMF) and the Oak Ridge Reservation Landfills (ORRL). These facilities are owned by DOE and operated and maintained by UCOR. They have been vital to cleanup progress and success, enabling OREM to accomplish more cleanup by avoiding costly and unnecessary cross-country shipments.

EMWMF only receives low-level radioactive and hazardous waste meeting specific criteria. The waste is mostly soil and building debris. In FY 2024, EMWMF received 1,526 waste shipments from cleanup projects at ETTP, ORNL, and Y-12, plus 145 clean fill shipments for the enhanced operational cover expansion and constructing access roads and dump ramps. The EMWMF landfill has a design capacity of 2.3 million yd^3 and is now over 85.3 percent filled.

EMWMF generated 12.02 million gal of wastewater in FY 2024. Approximately 3.42 million gal of leachate (water that enters the leachate collection system) was transported by tanker to the ORNL Liquid and Gaseous Waste Operations for treatment and release. Approximately 8.6 million gal of contact water (water that contacts waste but does not enter the leachate collection system) was released to Bear Creek after laboratory analysis verified it met all regulatory limits and discharge standards. ORRL accepts sanitary/industrial waste and construction/demolition debris. In FY 2024, these three active landfills received 9,976 waste shipments, totaling 131,597 yd^3.

ORRL also manages nonregulated leachate. In FY 2024, ORRL compliantly discharged 3.8 million

gal of leachate from the three active landfills to the Y-12 sanitary sewer system.

In FY 2024, ORRL continued improvements for all sediment and erosion controls. These measures included upgrading drainage features, which significantly reduces the amount of sediment released from these landfills. TDEC inspections in FY 2024 noted excellent sediment and erosion controls with no areas of concern or violations.

Construction/Demolition Landfill VII Area 5 expansion was completed in FY 2024, and the Spoils Area expansion was constructed to 95 percent completion. Work continued on seep mitigations for Sanitary Landfill II (a closed landfill) and active Landfill VII with recontouring of Phases 2 and 3 completed. Landfill VII minor modification trenching continues with Trenches 1 and 2 completed during FY 2024.

EMWMF will reach capacity before OREM completes its cleanup at Y-12 and ORNL. Planning continued in FY 2024 for another disposal facility, the EMDF, to provide the capacity required to complete Oak Ridge's cleanup mission.

Crews completed fieldwork for the early site preparation activities in May 2024. This work included rerouting portions of Bear Creek Road and the Haul Road, and development of other support areas.

Fieldwork for the Groundwater Field Demonstration (GWFD) began in April 2024. A cover system is being installed to replicate conditions following construction of the landfill liner system. Groundwater elevations will be monitored for two wet seasons following installation of the cover to ensure the liner system will be above the groundwater elevation in this area. Topsoil and clean fill removed from the EMDF area during construction activities benefited other UCOR projects at ETTP.

OREM continues to work with EPA and TDEC on regulatory documents for the EMDF landfill. The GWFD Remedial Design Work Plan/Remedial Action Work Plan was approved in October 2023 and the Remedial Design Work Plan for the EMDF design was prepared and reviewed with approval in September 2024.

OREM continued to monitor 31 groundwater wells at the selected site for the disposal facility, measuring and recording water levels and groundwater characteristic data for the entire year. Several piezometers within the active construction area were not monitored but were protected for continued use when GWFD construction is complete.

The Transuranic Waste Processing Center (TWPC) team completed a significant amount of hazardous inventory reduction in FY 2024 by safely and compliantly performing 12 shipments of legacy transuranic (TRU) waste to the Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico, totaling 301 drums of inventory reduction. The TWPC team also completed 12 shipments of mixed low-level waste (MLLW), low-level waste, and hazardous industrial waste resulting from the processing and certification of the TRU legacy waste.

TWPC's operational focus continued in FY 2024 on managing challenging Nuclear Fuel Services Inc. waste, where 4 boxes and 13 drums were processed and repackaged into 140 drums of compliant soil and debris for disposal.

3.8.2. Environmental Remediation Activities

Several years of characterization, data analysis, delineation, and modeling have resulted in the identification of numerous contaminated areas at ETTP that are now in the final stages of cleanup. Remediation efforts are being performed to eliminate hazards at the site and pave the way for future industrial use.

The site is divided into two cleanup regions: Zone 1, a 1,300-acre area outside the MPA, and Zone 2, the 800-acre area that comprises the MPA. The areas in these zones are divided into EUs that vary in size from 6 to 38 acres. Remediation efforts are designed to protect groundwater, wildlife, and the future workforce.

Highlights of this effort are given below. For details, please see the *2024 Cleanup Progress—*

Annual Report to the Oak Ridge Regional Community (UCOR 2025, OREM-24-7651).

3.8.2.1. Soil Remediation

Crews completed soil remediation at ETTP in CY 2024. That effort involved excavating and disposing of 554,000 yd^3 of soil, equaling nearly 50,000 dump truck loads. Completion of this remediation, referred to as Vision 2024, comes four years after completed demolition of all unneeded facilities at the site. Some of the approaches that helped keep remediation efforts on track included shipments by rail for some of the waste, implementing efficient methods for loading and transporting excavated soil, and reusing topsoil excavated from other OREM projects for backfill. During this cleanup, OREM worked to transform ETTP into a multiuse industrial park, with 25 businesses currently operating at the site. It also focused on historic preservation and conservation, designating land for these purposes.

Highlights at ETTP for 2024 include the following activities:

- The EU-21 TCE Project made the final soil shipment from ETTP on May 2, 2024. The project began in July 2021 and was estimated to create 19,000 yd^3 of TCE-contaminated waste. The project shipped more than 102,000 yd^3 of material both onsite and offsite. The project ran into several challenges during the three-year effort: mercury process piping, multiple high-concentration-TCE areas, schedule targets, supply chain issues, and the process for defining the extent of the contamination.
- Crews removed two structures from the EU-20 footprint in October as part of the remaining facilities disposition effort. This area included the north end of the previously demolished K-25 Building. The K-2500-J tent, also known as the Segmentation Shop Storage Facility, and the K-2500-AB facility were demolished and hauled to ORRL. After removing these facilities, radiological surveys on the slabs below the structures were completed in support of national historical preservation and future public access.
- Excavation of two remaining soil contamination areas were completed in CY 2024: TCE contaminated soil at EU-30 and two "hotspots" in Area B of EU-35. The EU-30 RA targeted approximately 500 yd^3, and took place on the southern edge of EU-30, between the former K-1301 and K-1401 facilities. The EU-35 remediation focused on approximately 4,700 yd^3 of contaminated soil around the perimeter of the K-1407-B Pond, which was primarily used as a settling pond for metal hydroxide sludge and other waste streams that were precipitated/neutralized in the adjacent K-1407-A Neutralization Pit Facility.

3.8.2.2. Groundwater Protection

Now that crews have finished excavating and removing contaminated soil from the site in 2024, the spotlight is turning to groundwater.

ETTP is divided into three sections for groundwater remediation planning.

One section is the MPA, which encompasses most of the operations area at the former enrichment complex. The MPA Groundwater Interim ROD (DOE/OR/01-2949&D2) was approved on May 16, 2024.

The second section is the area where the large K-31 and K-33 uranium enrichment buildings once stood. The K-31/K-33 Groundwater ROD (DOE/OR/01-2950&D2) was approved for groundwater in this area on May 9, 2024.

The third section encompasses Zone 1, the area immediately surrounding the main plant and K-31/K-33 areas. Cleanup of the Zone 1 groundwater plumes will be addressed in a future ROD. In support of this upcoming ROD, DOE/OR/01-2903&D2/A2 was submitted to EPA and TDEC for review on June 18, 2024.

The preferred approach for groundwater remediation in the MPA is a process called enhanced in situ bioremediation. A widely used technology for treating contaminated waste involves injecting microorganisms and a carbon

source such as vegetable oil into the ground. The microorganisms reduce or detoxify the contaminants.

For the K-31/K-33 area, OREM is proposing a process called monitored natural attenuation along with land use controls. Monitored natural attenuation relies on natural processes that reduce contaminant concentrations in groundwater. Using this process as the RA involves monitoring groundwater conditions with land use controls, limiting potential exposures.

3.8.3. Reindustrialization

The Reindustrialization Program maintained progress in 2024 by continuing partnerships and planning for the transfer of remediated land and remaining infrastructure at ETTP to public or private ownership for the economic benefit of the community. Reindustrialization efforts at ETTP are expected to generate 1,400 jobs from the $1.35 billion in investments announced by the onsite companies (Figure 3.44).

OREM has transferred over 1,700 acres for economic development at ETTP, including 470 acres during FY 2024. OREM and UCOR also completed the final transfer of major utilities, marking a significant milestone for the Reindustrialization Program. ETTP is now served by a public infrastructure system of water, sewer, electric, and natural gas utilities.

Clean energy technology has been a focus of these industrial development efforts. For instance, Kairos Power has just started construction of the Hermes Low-Power Demonstration Reactor at the site. This will be the first non-light-water reactor permitted in the United States in over 50 years. The company's $100 million investment will bring 55 high quality jobs to the site.

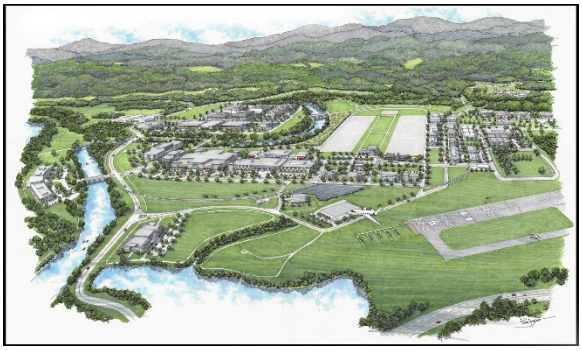


Figure 3.44. Artist's rendering of East Tennessee Technology Park as a multiuse industrial park

The national historical preservation activities continued with the ongoing construction of the K-25 Interpretive Center, which is scheduled to open to the public in September 2025. This new facility is adjacent to the K-25 History Center and is positioned to overlook the former K-25 Building footprint.

Public involvement

Since 2011, DOE and its contractors have provided environmental management, remediation, and cleanup services to OREM to move forward the site's transformation to a multiuse industrial center, national park, and recreational area.

OREM and UCOR continued to share progress and lessons learned with the community and stakeholders through a variety of outlets. In 2024, the ORSSAB issued a recommendation on the site's budget request and discussed ongoing expansion of ORR waste disposal capacity through ongoing development of the planned new on-site waste disposal facility, the EMDF. ORSSAB also hosted the annual EM SSAB Fall Chairs Meeting, allowing board members to meet representatives from similar boards at other DOE sites across the country and receive updates from DOE leadership.

3.9. References

DOE 1992a. *Federal Facility Agreement for the Oak Ridge Reservation*. FFA-PM/18-011, DOE/OR-014, January 1, 1992, or latest revision, US Environmental Protection Agency Region IV, US Department of Energy, and Tennessee Department of Environment and Conservation, Oak Ridge, Tennessee.

DOE 1992b. *National Environmental Policy Act Implementing Procedures*. April 24, 1992, 10 CFR Part 1021. US Department of Energy, Washington, DC.DOE 1993a. *Radiation Protection of the Public and the Environment,* DOE Order 5400.5, Chg. 2, January 7, 1993. US Department of Energy, Washington, DC.

DOE 1993b. *Record of Decision for the K-1407-B/C Ponds at the Oak Ridge K-25 Site, Oak Ridge, Tennessee*. DOE/OR/02-1125&D3, September 1, 1993, US Department of Energy, Office of Environmental Management, Oak Ridge, Tennessee.

DOE 1995. *Remedial Action Report for the K-1407-B Holding Pond and the K-1407-C Retention Basin*. DOE/OR/01-1371&D1, August 3, 1995, US Department of Energy, Office of Environmental Management, Oak Ridge, Tennessee.

DOE 1997. *Record of Decision for the K-1070-C/D Operable Unit, East Tennessee Technology Park, Oak Ridge, Tennessee*. DOE/OR/02-1486&D4, November 1997. US Department of Energy, Washington, DC.

DOE 2001. *Cultural Resource Management Plan, DOE Oak Ridge Reservation, Anderson and Roane Counties, Tennessee*. DOE/ORO-2085, US Department of Energy, Oak Ridge Operations, Washington, DC.

DOE 2011b. *Radiation Protection of the Public and the Environment*. DOE Order 458.1. Approved February 11, 2011. US Department of Energy, Washington, DC.

DOE 2012. *Memorandum of Agreement Among the U.S. Department of Energy Oak Ridge Office of Environmental Management, Department of Energy Federal Preservation Officer, the Tennessee State Historic Preservation Office, the Advisory Council on Historic Preservation, the City of Oak Ridge, Tennessee, and the East Tennessee Preservation Alliance, Pursuant to 36 CFR Part 800.6(B)(2) For Decommissioning And Demolition of the K-25 Site and Interpretation of the East Tennessee Technology Park, on the Oak Ridge Reservation, Roane County, Tennessee*, August 6, 2012, US Department of Energy, Oak Ridge Operations, Oak Ridge, Tennessee.

DOE 2018. *Oak Ridge Reservation Polychlorinated Biphenyl Federal Facilities Compliance Agreement*. ORR-PCB-FFCA, Revision 6. US Department of Environmental Protection Agency, US Department of Energy, Oak Ridge Field Office, Oak Ridge, Tennessee.

DOE 2020. *Compliance Plan National Emission Standards for Hazardous Air Pollutants for Airborne Radionuclides on the Oak Ridge Reservation, Oak Ridge, Tennessee.* DOE/ORO/2196, Rev. 2, May 1, 2020, US Department of Energy, Oak Ridge Office of Environmental Management, Oak Ridge, Tennessee.

DOE 2022a. *Derived Concentration Technical Standard*. DOE-STD-1196-2022, December 2022, US Department of Energy, Washington, DC.

DOE 2022b. *East Tennessee Technology Park Main Plant Groundwater Focused Feasibility Study, Oak Ridge, Tennessee*. DOE/OR/01-2894&D2, February 2022, US Department of Energy, Oak Ridge Office of Environmental Management, Oak Ridge, Tennessee.

DOE 2022c. *Remedial Investigation/Feasibility Study Report for the K-31/K-33 Area at the East Tennessee Technology Park, Oak Ridge, Tennessee.* DOE/OR/01-2893&D2, July 2022, US Department of Energy, Oak Ridge Office of Environmental Management, Oak Ridge, Tennessee.

DOE 2023a. *Interim Record of Decision for Groundwater in the Main Plant Area at the East Tennessee Technology Park, Oak Ridge, Tennessee*. DOE/OR/01-2949&D1, July 24, 2023, US Department of Energy, Oak Ridge Office of Environmental Management, Oak Ridge, Tennessee.

DOE 2023b. *Record of Decision for Groundwater in the K-31/K-33 Area at the East Tennessee Technology Park, Oak Ridge, Tennessee.* DOE/OR/01-2950&D1, July 20, 2023, US Department of Energy, Oak Ridge Office of Environmental Management, Oak Ridge, Tennessee.

DOE 2023c. *Proposed Plan for an Interim Record of Decision for Groundwater in Main Plant Area at East Tennessee Technology Park, Oak Ridge, Tennessee.* DOE/OR/01-2921&D2, January 2023, US Department of Energy, Oak Ridge Office of Environmental Management, Oak Ridge, Tennessee.

DOE 2023d. *Proposed Plan for the Record of Decision for Groundwater in the K-31/K-33 Area at the East Tennessee Technology Park, Oak Ridge, Tennessee.* DOE/OR/01-2922&D2, January 2023, US Department of Energy, Oak Ridge Office of Environmental Management, Oak Ridge, Tennessee.

DOE 2023e. *Zone 1 Groundwater Plumes Remedial Investigation Work Plan, East Tennessee Technology Park, Oak Ridge Tennessee*. DOE/OR/01-2903&D2/A1, April 1, 2023, US Department of Energy, Oak Ridge Office of Environmental Management, Tennessee.

DOE 2024a. *2023 Oak Ridge Reservation Annual Site Environmental Report*. DOE-SC-OSO/RM-2024-02, September 2024, US Department of Energy, Oak Ridge Office of Environmental Manage*ment,* Oak Ridge, Tennessee.

DOE 2024b. *Addendum to the Zone 1 Groundwater Plumes Remedial Investigation Work Plan for the K-1085 Old Firehouse Burn Area, East Tennessee Technology Park, Oak Ridge, Tennessee.* DOE/OR/01-2903&D2/A2, June 2024, US Department of Energy, Oak Ridge Office of Environmental Management, Tennessee.

DOE 2024c. *East Tennessee Technology Park Administrative Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee.* DOE/OR/01-2477&D4/M1, September 2024, US Department of Energy, Oak Ridge Office of Environmental Management, Tennessee.

DOE 2024d. *Interim Record of Decision for Groundwater in the Main Plant Area at the East Tennessee Technology Park, Oak Ridge, Tennessee.* DOE/OR/01-2949&D2, May 2024, US Department of Energy, Oak Ridge Office of Environmental Management, Tennessee.

DOE 2024e. *Record of Decision for Groundwater in the K-31/K-33 Area at the East Tennessee Technology Park, Oak Ridge, Tennessee.* DOE/OR/01-2950&D2, May 2024, US Department of Energy, Oak Ridge Office of Environmental Management, Tennessee.

DOE 2025. Oak Ridge Partners Complete Construction of Facility Overlooking K-25 Footprint. US Department of Energy, Oak Ridge office of Environmental Management, Oak Ridge, Tennessee. Retrieved May 20, 2025, from https://www.energy.gov/em/articles/oak-ridge-partners-complete-construction-facility-overlooking-k-25-footprint.

DOI 2015. *Interior and Energy Departments Formally Establish the Manhattan Project National Historical Park.* Retrieved July 6, 2023, from https://www.doi.gov/pressreleases/interior-and-energy-departments-formally-establish-manhattan-project-national.

EPA 1975. *National Primary Drinking Water Regulations*. December 24, 1975, 40 CFR Part 141, Subparts B and G. US Environmental Protection Agency, Washington, DC.

EPA 1978. *Terminology and Index*, "Categorical exclusion." November 29, 1978, 40 CFR Section 1508.4. US Environmental Protection Agency, Washington, DC.

EPA 1978. *Terminology and Index*, "Environmental assessment." November 29, 1978, 40 CFR Section 1508.9. US Environmental Protection Agency, Washington, DC.

EPA 1978. *Terminology and Index*, "Environmental impact statement." November 29, 1978, 40 CFR Section 1508.11. US Environmental Protection Agency, Washington, DC.

EPA 1978. *Terminology and Index*, "Finding of no significant impact." November 29, 1978, 40 CFR Section 1508.13. US Environmental Protection Agency, Washington, DC.

EPA 1979. *Polychlorinated Biphenyls (PCBS) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions*. May 31, 1979, 40 CFR Part 761. US Environmental Protection Agency, Washington, DC.

EPA 1984. *National Emission Standards for Hazardous Air Pollutants*, "National Emission Standard for Asbestos," April 5, 1984, 40 CFR Part 61, Subpart M. US Environmental Protection Agency, Washington, DC.

EPA 1989. *National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities.* 40 CFR Section 61.93(b)(1)(iii), Emission monitoring and test procedures; appendix B, Method 114, EPA 1989; updated Sept 9, 2002. US Environmental Protection Agency, Washington, DC.

EPA 1990. *National Emission Standards for Hazardous Air Pollutants*, Subpart M—National Emission Standard for Asbestos, Standard for demolition and renovation, Notification requirements. November 20, 1990, 40 CFR Section 61.145(b). US Environmental Protection Agency, Washington, DC.

EPA 1993. *Protection of Stratospheric Ozone*, Subpart F—Recycling and Emissions Reduction. May 14, 1993, 40 CFR Part 82, US Environmental Protection Agency, Washington, DC.

EPA 1994. *Chemical Accident Prevention Provisions*. January 31, 1994, 40 CFR Part 68. US Environmental Protection Agency, Washington, DC.

EPA 2009. *Mandatory Greenhouse Gas Reporting*. October 30, 2009, 40 CFR Part 98. US Environmental Protection Agency, Washington, DC.

EPA 2013. Level III and IV ecoregions of the continental United States: Corvallis, Oregon, US Environmental Protection Agency, National Health and Environmental Effects Research Laboratory, map scale 1:3,000,000, from https://www.epa.gov/eco-research/level-iii-and-iv-ecoregions-continental-united-states.

ISO 2004. *Environmental management systems—Requirements with guidance for use*. ISO 14001:2004. November, International Organization for Standardization, Geneva, Switzerland.

K-25 Virtual Museum 2015. United Cleanup Oak Ridge LLC, US Department of Energy, Oak Ridge, Tennessee. Retrieved April 19, 2023, from https://k25atomichistorycenter.org/.

TDEC 2018. *Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities*. TDEC Rule 1200-03-11-.08, September 2018 revised (1996). Tennessee Department of Environment and Conservation, Nashville, Tennessee.

TDEC 2021. *Quality System Standard Operating Procedures for Macroinvertebrate Stream Surveys*, December 2021, DWR-PAS-P-01-QSSOP-122821, Tennessee Department of Environment and Conservation Division of Water Pollution Control, Nashville, Tennessee.

TDEC 2024a. Construction and Operating Permits, Permits-by-Rule. TDEC Rule 1200-03-09-.07, December 2024 revised. Tennessee Department of Environment and Conservation, Nashville, Tennessee.

TDEC 2024b. *General Water Quality Criteria, Criteria for Water Uses.* TDEC Rule 0400-40-03-.03, March 2024. Tennessee Department of Environment and Conservation, Nashville, Tennessee.

UCOR 2018. *Quality Assurance Program Plan for Compliance with Radionuclide National Emission Standards for Hazardous Air Pollutants, East Tennessee Technology Park, Oak Ridge, Tennessee*. UCOR-4257/R2, September, URS | CH2M Oak Ridge LLC, Oak Ridge, Tennessee. (Not available for public release.)

UCOR 2020a. *Disposition of Personal Property.* PROC-PR-2032, Rev. 10, United Cleanup Oak Ridge LLC, Oak Ridge, Tennessee. (Not available for public release.)

UCOR 2020b. *Environmental Management and Protection*. POL-UCOR-007, Rev. 7, United Cleanup Oak Ridge LLC, Oak Ridge, Tennessee. (Not available for public release.)

UCOR 2024a. *Pollution Prevention and Waste Minimization Program Plan for the East Tennessee Technology Park, Oak Ridge, Tennessee*. UCOR-4127/R12, September, United Cleanup Oak Ridge LLC, Oak Ridge, Tennessee. (Available for public release on request.)

UCOR 2024b. *East Tennessee Technology Park Storm Water Pollution Prevention Program Sampling and Analysis Plan, Oak Ridge, Tennessee*. UCOR-4028/R15, August, United Cleanup Oak Ridge LLC, Oak Ridge, Tennessee. (Available for public release.)

UCOR 2024c. *2024 Cleanup Progress—Annual Report to the Oak Ridge Regional Community*. OREM-24-7637, United Cleanup Oak Ridge LLC, Oak Ridge, Tennessee. (Available for public release.)



Y-12 is a one-of-a-kind manufacturing complex that plays an important role in United States national security. Through Life Extension Program activities, Y-12 produces refurbished, replaced, and upgraded weapons components to modernize the enduring stockpile.

4

The Y-12 National Security Complex

Y-12, a premier manufacturing facility managed and operated by Consolidated Nuclear Security, LLC (CNS) for NNSA, plays a vital role in the DOE Nuclear Security Enterprise. Since 1943, Y-12 has played a key role in strengthening the country's national security and reducing the global threat from weapons of mass destruction. Y-12 has become the complex the nation looks to for support in protecting America's future and developing innovative solutions in manufacturing technologies, prototyping, and safeguards and security.

4.1. Description of Site and Operations

4.1.1. Mission

Y-12 has four mission priorities that enable the national security missions that protect the country and its allies around the world, design and deliver the nation's nuclear stockpile, forge solutions that enable global security and stability, harness the atom to power a global naval fleet, and leverage transformative technologies to address emerging challenges.

Y-12's core mission is to ensure a safe, secure, and reliable US nuclear deterrent, which is essential to national security. Production, surveillance, dismantlement, and storage are the four distinct facets of maintaining the stockpile. Every weapon in the US nuclear stockpile has components manufactured, maintained, or ultimately dismantled by Y-12.

As the nation reduces the size of its arsenal, Y-12 plays a central role in decommissioning weapons systems and providing weapons material for peacetime uses. Y-12 provides the expertise to secure highly enriched uranium that may be vulnerable to terrorists, with the highest security, both domestically and around the world. Y-12 also makes material available for non-weapons uses, such as in research reactors and for producing cancer-fighting medical isotopes and commercial power.

Y-12 provides highly enriched uranium used in the fabrication of fuel for reactors in the Navy's nuclear-powered aircraft carriers and submarines under an agreement with the NNSA Naval Reactors Office. Working with the Naval Reactors Program, Y-12 has supplied the US Navy feedstock from weapons removed from the nation's nuclear weapons stockpile to fuel nuclear-powered submarines and aircraft carriers over the past 10 years.

Located within the city limits of Oak Ridge, Tennessee, the site covers more than 3,000 acres primarily within the Bear Creek Valley, stretching 2.5 mi in length down the valley and nearly 1.5 mi in width across it. Additional NNSA-related facilities located off-site include the Central Training Facility, Alternate Emergency Operations Center, Oak Ridge Enhanced Technology and Training Center, Uranium Processing Facility (UPF) project laydown storage and offices, Y-12 Material Acquisition and Control Facilities, the John M. Googin Technology Development Facility, the Test and Demonstration Facility, the Commerce Park Office Complex, and the Union Valley Sample Preparation Facility.

4.1.2. Modernization

Approximately 34 percent of Y-12's facility footprint is more than 80 years old, and an additional 34 percent falls into the 61 to 80-year-old range. These two categories account for 22 percent of Y-12's buildings, as shown in Figure 4.1. Aging facilities, coupled with increased mission demand, necessitate a robust modernization strategy. Y-12 has been consolidating operations, modernizing facilities and infrastructure, and reducing the legacy footprint, supporting NNSA overall transformation planning.

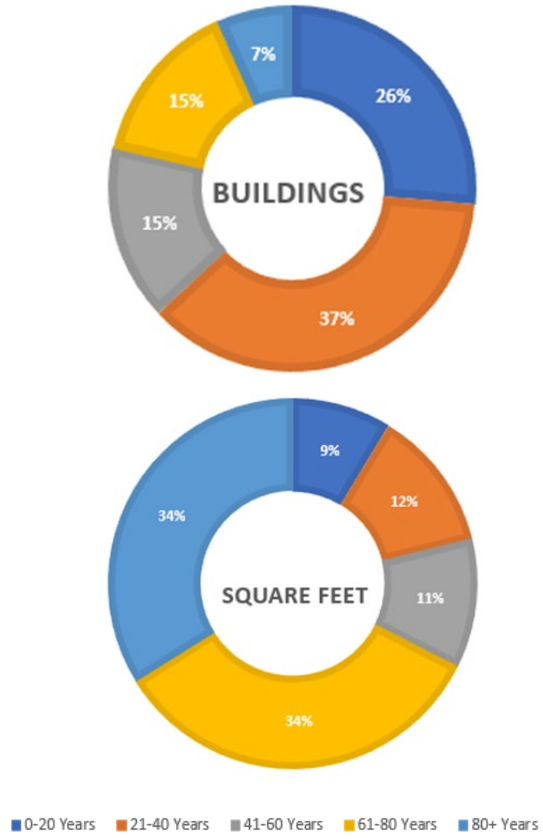


Figure 4.1. Age of facilities at Y-12

Planning for the future site ensures that Y-12 will continue to provide the infrastructure needed to support the primary capabilities and materials missions with new facilities and associated technologies. The envisioned future Y-12 site includes the following elements:

- Major supply chains, including uranium (enriched uranium, depleted uranium, and low enriched uranium) and lithium, are reestablished and/or transformed.
- UPF, Lithium Processing Facility (LPF), Enriched Uranium Manufacturing Center, Assembly and Disassembly Center, and Depleted Uranium Manufacturing Capability are constructed.

- The security posture is sustained and improved through recapitalized and transformed footprint, as well as revitalized security infrastructure and systems.
- The Mercury Treatment Facility and Environmental Management Disposal Facility are constructed, enabling approximately 2.8 million gross square feet (gsf) of excess facility demolition and legacy environmental threats to be remediated.
- A Special Materials capability is established, with operations located in renovated facilities.
- Public tours of Y-12 historic facilities and participation in the Manhattan Project National Historic Park are implemented, to the extent possible.

4.1.3. Production Operations

Y-12's core manufacturing and processing operations are housed in decades-old buildings near or past the end of their expected life spans. The UPF, which is an integral part of Y-12's transformation, is being constructed as one of two main facilities in which enriched uranium will be stored and processed in a more centralized area.

The major production capabilities and associated facilities at Y-12 include the following:

- **Enriched uranium.** Buildings 9212, 9215, and UPF
- **Depleted uranium.** Buildings 9215, 9201-05N, 9201-05W, 9996, and 9998
- **Lithium.** Buildings 9204-02, 9202, and LPF
- **General manufacturing and fabrication.** Building 9201-01
- **Assembly and disassembly.** Building 9204-02E
- **Special materials.** Buildings 9225-03 (2025) and 9990-03
- **Storage.** Buildings 9720-82, 9720-05, 9720-26, 9720-32, 9720-33, 9720-59, and 9811-01

The following planned major construction activities are replacing key production operations currently in aging, oversized facilities. Dates of the construction activities are tentative and subject to change.

- Building 9212 functions are to be replaced by the UPF in 2032, with some Building 9212 processes relocated to Buildings 9215 and 9204-2E.
- Building 9215 enriched uranium functions are to be replaced by the Enriched Uranium Manufacturing Center by 2050.
- Building 9204-02E functions are to be replaced by the Assembly and Disassembly Center by 2055.
- Building 9204-02 lithium functions are to be replaced by the LPF by 2031.
- Depleted uranium fabricating and manufacturing functions from the Building 9215 Complex, Building 9201-05N, and Building 9201-05W are to be replaced by phased line item construction, with the first phase—the Agile Radiation Case Capability—by 2035.
- General manufacturing and fabrication functions from Building 9201-01 are to be replaced by the General Manufacturing Capability by 2045.

4.1.4. Support Facilities

Organization and facilities that support operations ensure Y-12 mission-critical work is completed. The primary missions of the operations support infrastructure are to protect vital national security assets and people and enable site missions. Operations support includes the following:

- Security
- Emergency Services
- Development
- Analytical Chemistry
- General Storage and Warehousing
- Cybersecurity and Information Technology

- Global Security and Strategic Partnerships
- Waste Management
- Stewardship Operations
- Oak Ridge Enhanced Technology and Training Center

The following planned major construction activities are replacing key operations support facilities:

- Complete the West End Protected Area Reduction project, including a new Entry Control Facility, by 2025.
- Construct a phased line item construction development campus, with the first phase—the Applied Technologies Laboratory—by 2037 to replace Buildings 9202 and 9203.
- Implement the Security Infrastructure Revitalization Program to upgrade and replace the legacy Perimeter Intrusion Detection and Assessment System.
- Explore new construction for replacement facilities to support Analytical Chemistry operations, including phased campus construction, beginning in 2029, and a future line item construction project—the Analytical Chemistry Laboratory—in 2033.
- Construct the Oak Ridge Institute for Global Nuclear Security at the new Oak Ridge Enhanced Technology and Training Center campus by 2026.
- Construct new maintenance facilities to support maintenance operations throughout the site, beginning in 2028.
- Construct a new waste management complex to replace the aging West End Treatment Facilities by 2040.
- Implement a digital transformation and cybersecurity strategy.
- Construct a new security complex to accommodate growing requirements by 2046.

4.1.5. Excess Facility Disposition

Currently, there are 44 excess facilities at Y-12, with another 39 buildings and trailers to be excessed within the next 10 years. The major excess process-contaminated facilities, including Building 9201-05, Building 9204-04, and Building 9206, will be transitioned to the DOE Office of Environmental Management (EM) for disposition. The smaller, process-contaminated, ancillary facilities associated with Buildings 9201-05, 9204-04, and 9206; Building 9212-associated facilities; and the Building 9401-03 Complex (Steam Plant) are planned to be dispositioned by NNSA.

Process-contaminated facilities contain radiological and/or chemical contamination resulting from mission operations during the Manhattan Project or Cold War eras. Excess process-contaminated facilities are expected to be sufficiently managed until facility conditions meet criteria for transition to EM. Excess non-process-contaminated facilities are generally expected to be demolished by NNSA; however, some excess non-process-contaminated facilities may be demolished by EM depending on their complexity and/or proximity to process-contaminated facilities.

The Mercury Treatment Facility will be constructed before any mercury-contaminated facilities within the West End Mercury Area can be demolished. Surveillance and maintenance activities, along with utility reroutes, unneeded material cleanout, and fluid and oil disposition, continue while these new facilities are being built.

4.2. Environmental Management System

The Y-12 environmental management system (EMS) applies to site activities and operations managed by CNS as described in Section 4.1. EMS is part of the overall management system that includes organizational structure, planning activities, responsibilities, best practices, procedures, processes, and resources by which CNS accomplishes its environmental policy. EMS

applies to all personnel who perform work related to the CNS mission.

The Y-12 EMS was developed and implemented fully in 2005. CNS models the EMS structure so that it is comparable to the framework within International Organization for Standardization's (ISO) 14001, *Environmental management systems—Requirements with guidance for use* (ISO 2015). The system ensures a structured approach to identifying environmental aspects, setting and achieving environmental objectives, and monitoring environmental performance.

The Y-12 EMS has two areas of focus—environmental compliance and environmental stewardship. Environmental compliance consists of regulatory compliance and monitoring programs that implement federal, state, and local requirements, agreements, and permits. Environmental stewardship promotes and integrates initiatives such as energy and natural resource conservation, air pollutant emission minimization, waste minimization, and the use of environmentally preferable products and services.

4.2.1. Integrating with Integrated Safety Management System

Y-12's Integrated Safety Management System (ISMS) is the basis for planning and implementing environment, safety, and health (ES&H) programs and systems that provide the necessary structure for any work activity that could affect the public, workers, or the environment. EMS elements are incorporated in ISMS to achieve environmental compliance, pollution prevention, waste minimization, resource conservation, and stewardship. Both ISMS and EMS are based on a cycle of continual improvement, commonly known as the "plan-do-check-act cycle," as depicted in Figure 4.2, which shows the relationship between ISMS and the integrated EMS.

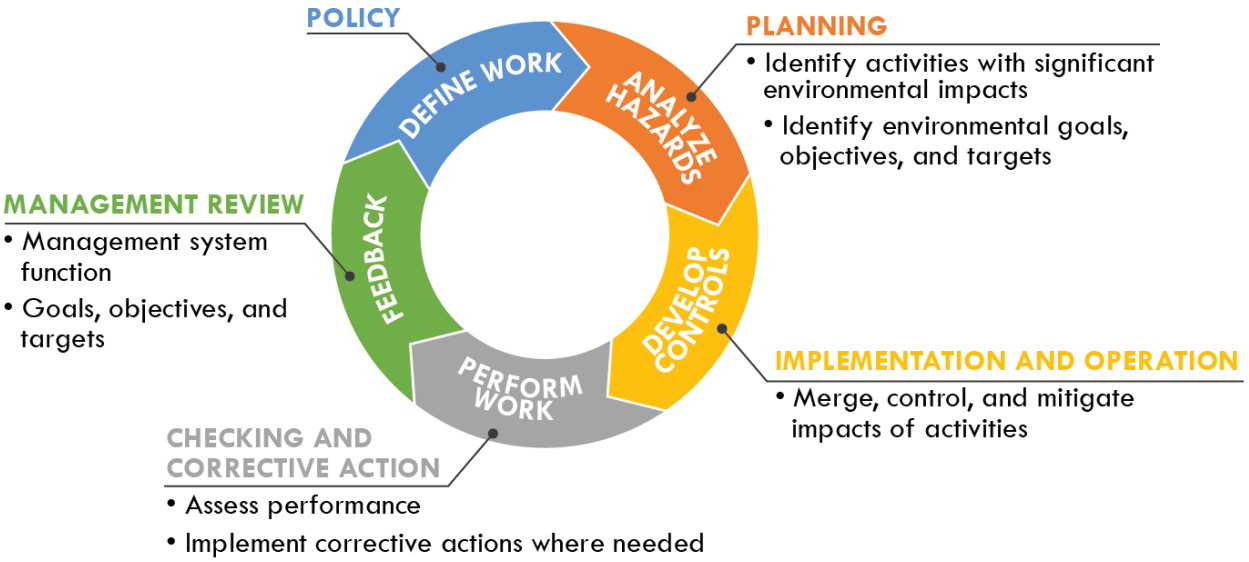


Figure 4.2. The "plan-do-check-act" cycle of continual improvement

4.2.2. Policy

Y-12's environmental policy includes commitments to prevent pollution, protect the environment, comply with applicable requirements, and continually improve the environment. Y-12's ES&H policy is outlined in Figure 4.3.

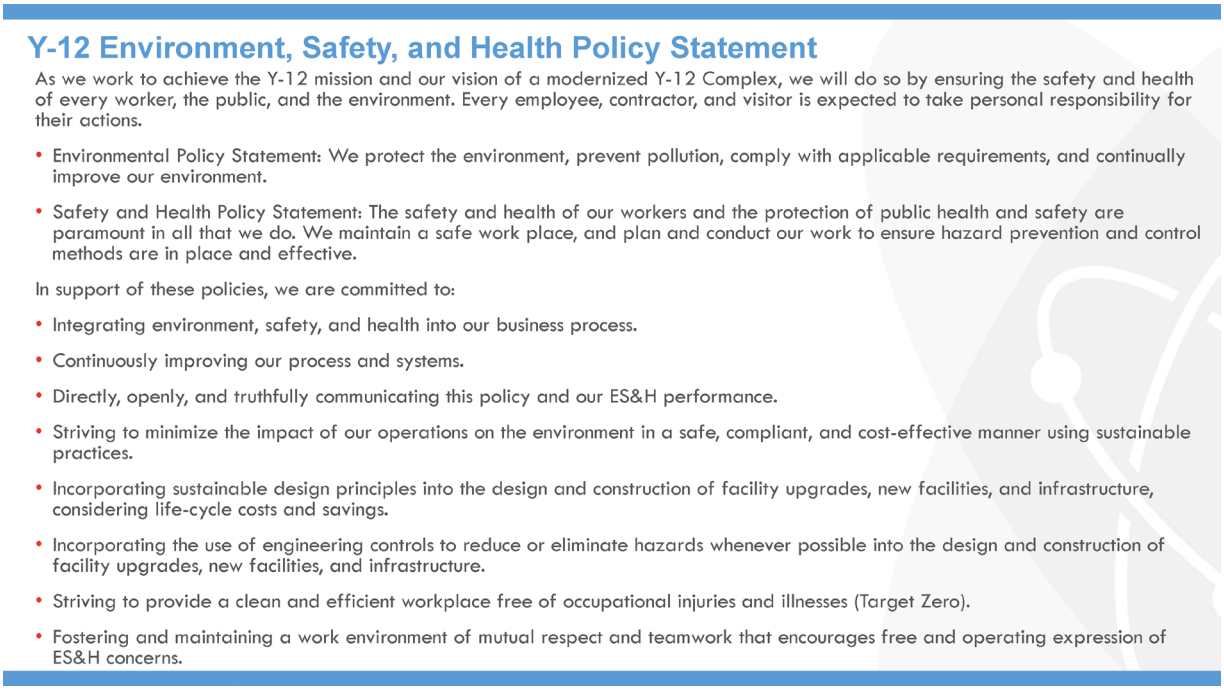


Figure 4.3. Y-12's environment, safety, and health policy

4.2.3. Planning

The following sections describe planning activities conducted as part of the Y-12 EMS.

4.2.3.1. Y-12 Environmental Aspects

Environmental aspects may be thought of as potential environmental hazards associated with a facility operation, maintenance job, or work activity. Environmental aspects and their impacts (i.e., potential risks to and effects on the environment) are evaluated to ensure that the significant aspects of Y-12 activities that are identified continue to reflect stakeholder concerns and changes in regulatory requirements. The EMS ensures that environmental aspects are systematically identified, monitored, and controlled to mitigate or eliminate potential impacts to the environment.

The analysis identified the following as significant environmental aspects in 2024:

- Storm water (runoff from roofs and outdoor storage areas)
- Wastewater (sanitary sewer and process water treated and disposed)
- Aging infrastructure and equipment
- Legacy contamination and disturbance
- Excess facilities and unneeded materials and chemicals
- Surface water (process water and dike emissions to creek)

4.2.3.2. Legal Obligations and Other Requirements

To implement the compliance commitments of the ES&H policy and to meet legal requirements, systems are in place to review changes in federal,

state, or local environmental regulations and to communicate those changes to affected staff. The environmental compliance status is discussed in Section 4.3.

4.2.3.3. Objectives, Targets, and Environmental Action Plans

Y-12 pursues stewardship initiatives by establishing and maintaining environmental commitments, goals, targets, and action plans. Goals and commitments are established annually and consider the site's significant environmental aspects. They are consistent with Y-12's mission, budget guidance, ES&H work scope, and DOE stewardship goals. Targets and action plans are established for broad objectives to pursue improvement in environmental performance in five areas: clean air; energy efficiency; hazardous materials; stewardship of land and water resources; and waste reduction, recycling, and buying green. Highlights of the 2024 environmental achievements are presented in Section 4.2.6.1.

4.2.3.4. Programs

NNSA has developed and funded several programs to integrate environmental stewardship into all facets of Y-12 missions. The programs also address the requirements in DOE orders for protecting various environmental media and helping to promote compliance with all applicable environmental regulatory requirements and permits.

Environmental Compliance

Y-12's Environmental Compliance Department provides environmental technical support services and oversees line organizations to ensure that site operations are conducted in a manner that is protective of workers, the public, and the environment; in compliance with applicable standards, DOE orders, environmental laws, and regulations; and consistent with CNS environmental policy and Y-12 site procedures. The department serves as the interpretive authority for environmental compliance requirements and as the primary point of contact between Y-12 and external environmental compliance regulatory agencies such as the City of Oak Ridge, the Tennessee Department of Environment and Conservation (TDEC), and the EPA. Environmental Compliance staff members administer compliance programs aligned with the major environmental legislation that affects Y-12 activities. Compliance status and results of monitoring and measurements conducted for these compliance programs are presented in this document. The organization maintains and ensures implementation of regulatory requirements and spearheads initiatives to address environmental concerns, to continually improve environmental performance, and to exceed compliance requirements.

Waste Management

The Y-12 Waste Management Program supports the full life cycle of all waste streams within the site. While ensuring compliance with federal and state regulations, DOE orders, Waste Acceptance Criteria, and Y-12 procedures and policies, the program provides services for day-to-day solid and liquid waste operations, including collection and transport, storage, on-site treatment operations, and shipment to off-site treatment and disposal. The program also provides technical support to Y-12 Operations for waste planning, characterizing, packaging, tracking, reporting, and managing waste treatment and disposal subcontracts.

Stewardship Operations Services

The Stewardship Operations Services plays a vital role at Y-12 by promoting pollution prevention; dispositioning materials via recycling, landfill, excess, the Destruction and Recycle facility, and generator services activities; supporting good housekeeping via the PrYde Program; and cleaning up various facility areas via the Clean Sweep Program, various projects, Stewardship/Emergent Risk, and the Unneeded Materials and Chemicals initiative. Additionally, the organization strives to minimize the impact of Y-12 operations by using viable practices for energy efficiency, fleet management, water consumption, resource

conservation, and incorporation of environmentally sound design principles.

Y-12 has implemented continuous improvement activities, such as an Items Available for Reuse section on the site Property Accountability Tracking System and a central telephone number (574-JUNK) to provide employees with easy access to information and assistance related to the proper methods for disposing excess materials.

The Clean Sweep Program provides turnkey services to material generators, including segregation, staging, and materials pickup for excess, recycle, or disposal. "Sustain" areas have been established across the site to improve housekeeping through efficient material disposition. Customers place unneeded items into the transition portion of each Sustain area, and Clean Sweep Program personnel take care of the rest.

Unneeded materials at Y-12 are not automatically assumed to be wastes requiring disposal. Y-12 uses a systematic disposition evaluation process. The first step in the process is to determine if the items can be reused at Y-12. Items that cannot be used at Y-12 are evaluated for use at other DOE facilities or government agencies. Items are then evaluated for potential sale; recycle; or, as a last resort, disposal as waste.

Combining these programs under a single umbrella improves overall compliance with Executive Orders, DOE orders, federal and state regulations, and NNSA expectations, as well as eliminates duplication of efforts, while providing an overall improved appearance at Y-12.

Additionally, implementing these programs supports EMS objectives to disposition unneeded materials and chemicals; continually improves recycle programs by adding new recycle streams as applicable; improves sustainable acquisition (i.e., promotes the purchase of products made with recycled content and bio-based products); meets sustainable design requirements; and adheres to pollution prevention reporting requirements.

Energy Management

The Y-12 Energy Management Program incorporates energy efficient technologies across the site and positions Y-12 to meet NNSA energy requirement needs and reduction requirements as set forth by DOE. The program identifies improvements in energy efficiency in facilities, coordinates energy-related efforts across the site, and is involved with energy performance contracting.

4.2.4. Implementing and Operating

The following sections describe activities conducted as part of the Y-12 EMS to establish, implement, and maintain good environmental practices and procedures.

4.2.4.1. Roles, Responsibility, and Authority

Safe, secure, efficient, and environmentally responsible operation of Y-12 requires the commitment of all personnel. Environmental and Waste Management technical support personnel assist line organizations with identifying and carrying out their environmental responsibilities. Additionally, the Environmental Officer Program helps to communicate environmental regulatory requirements and promotes EMS as a tool to drive continual environmental improvement. Environmental officers coordinate their organizations' efforts to maintain environmental regulatory compliance and promote other improvement activities.

4.2.4.2. Community and Community Involvement

NNSA and CNS are committed to keeping the community informed on operations, environmental concerns, safety, and emergency preparedness. CNS is a member of Oak Ridge and East Tennessee economic development and business development agencies including the East Tennessee Economic Council, the Oak Ridge Chamber of Commerce, and the Anderson County Chamber of Commerce. CNS is also engaged in Anderson County and Oak Ridge's Leadership

programs through its support of the Center for Leadership and Community Development.

Local charities receive donations from funds generated from the sale of aluminum beverage cans through the Employee Aluminum Can Recycling Program. Since the program began, more than $98,400 has been donated to local charities that were nominated by Y-12 employees and voted on by an employee committee.

Y-12 continues to promote sustainable behaviors for environmental improvements at the site and within the community.

4.2.4.3. Emergency Preparedness and Response

Local, state, and federal emergency response organizations are involved in Y-12's emergency drill and exercise program. The annual drill and exercise schedule is coordinated with all organizations to ensure maximum possible participation. At a minimum, the Tennessee Emergency Management Agency (TEMA) Operations Office and the DOE Headquarters Watch Office participate in all Y-12 emergency response exercises.

The exercises, performance drills, and training drills conducted at Y-12 during fiscal year (FY) 2024 focused on topics such as responding to chemical, nuclear criticality, and radiological releases, as well as changing the site's Security Condition. Building evacuation and accountability drills were also conducted.

4.2.5. Checking

The following sections describe Y-12 EMS activities to review, assess, and monitor operations to maintain environmentally safe and compliant practices and continually improve environmental performance.

4.2.5.1. Monitoring and Measuring

Y-12 maintains procedures to monitor overall environmental performance and measure key characteristics of its operations and activities that can have a significant environmental impact. Environmental effluent and surveillance monitoring programs are well established, and results of 2024 program activities are described throughout this chapter. Progress in achieving environmental goals is reported as a monthly metric on PerformanceTrack, the senior management web portal that consolidates and maintains Y-12 site-level performance. Progress is reviewed in periodic meetings with senior management and the NNSA Production Office (NPO). (Note: NPO was replaced by the new Y-12 Field Office [YFO] in April 2024).

4.2.5.2. Environmental Management System Assessments

To periodically verify that the EMS is operating as intended, assessments are conducted as part of the Y-12 internal assessment program. The assessments are designed to ensure that nonconformities with environmental procedures and policies are identified and addressed.

The Environmental Assessment Program conducts several types of assessments, each type serving a distinct but complementary purpose. Assessments range from informal observations of specific activities to rigorous audits of site-level programs.

4.2.6. Performance

This section discusses EMS objectives, targets, other plans, initiatives, and successes that work together to accomplish DOE goals, reduce environmental impacts and risks, and improve effectiveness in overall mission. To report performance, Y-12 uses the Federal Automotive Statistical Tool, which collects fleet inventory and fuel use, and a DOE web-based dashboard, which collects data on metering requirements, water use, renewable energy generation and purchases, greenhouse gas (GHG) generation, and sustainable buildings. Pollution prevention waste reduction and recycling data, sustainable acquisition product purchases, electronic stewardship, and best practices data are also collected in this dashboard system.

Y-12 was given an EMS scorecard rating of "green" for FY 2024, indicating full and effective

implementation of EMS requirements after submitting its annual compliance report via the DOE EMS Site Information Database.

4.2.6.1. Environmental Management System Objectives and Targets

At the end of 2023, Y-12 had achieved nine of 12 targets that had been established; the remaining targets were carried into future years. Highlights include the following, with additional details and successes presented in other sections of this report:

- **Energy efficiency.** Y-12 completed chiller plant improvements after obtaining a utility energy service contract and funding approval.
- **Hazardous materials.** A project to disposition and ship legacy mixed waste according to the site treatment plan continued. In 2024, 100% of site treatment plan items on the July 28, 2016, baseline inventory were shipped. This was two years ahead of schedule.
- **Land, water, and natural resources.** Y-12 upgraded sanitary sewer networks as part of a project to protect the sanitary sewer lines from infill and infiltration.

4.2.6.2. Stewardship Operations Services

Numerous efforts, including increased use of environmentally friendly products and processes and reductions in waste and emissions, have reduced Y-12's impact on the environment. These efforts have been recognized by NNSA, the community, and other stakeholders. Pollution prevention efforts at Y-12 have not only benefited the environment but have also resulted in cost avoidances (Figure 4.4).

In FY 2024, Y-12 implemented 105 pollution prevention initiatives (Figure 4.5), with a reduction of more than 8.32 million lb of waste and projected cost avoidances of more than $4.4 million.

Pollution prevention and source reduction

Across Y-12, sustainable initiatives reduce the impact of pollution on the environment and to increase operational efficiency. Many of these initiatives have pollution prevention benefits or targets eliminating the source of pollution, including the 2024 activities highlighted in this section.

Environmentally preferable purchasing

Environmentally preferable products, including recycled content materials, are purchased for use across the site. In 2024, Y-12 bought more than $7.5 million of materials with recycled content.

Solid waste reduction

Y-12 reduces the amount of solid waste generated, often by diverting waste through source reduction, reuse, and recycling. In 2024, Y-12 diverted 59.9 percent of municipal and 2.8 percent of construction and demolition waste from landfill disposal through reuse and recycle. More than 5.9 million lb of municipal materials from landfill disposal were diverted through source reduction, reuse, and recycling, and more than 4.0 million lb of construction and demolition materials were diverted from landfill disposal.

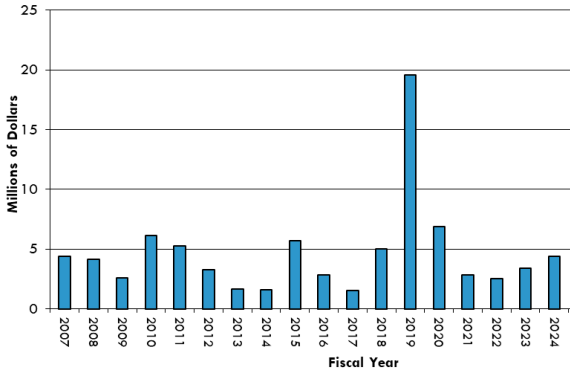


Figure 4.4. Cost avoidances from Y-12 pollution prevention activities, 2007–2024

Hazardous chemical minimization

The Generator Services group provides material disposition management services for waste generators at Y-12, including technical support to assist generators with determining whether the materials can be recycled, excessed, or reused. The Generator Services group can be used by any organization or generator at Y-12. During FY 2024, Generator Services personnel reused, or disseminated to other Y-12 organizations for reuse, various excess materials and chemicals. The Analytical Chemistry Organization implemented new laboratory procedures that reduced the generation of waste.

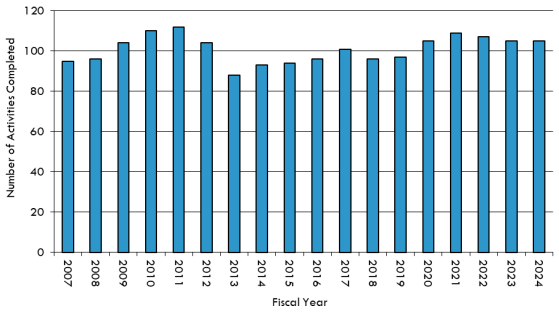


Figure 4.5. Y-12 pollution prevention initiatives, 2007–2024

Recycling

Y-12 has a well-established recycling program. The site continues to identify new material streams and expand the types of materials that can be recycled by finding new markets and outlets for the materials. As shown in Figure 4.6, more than 4.8 million lb of materials were diverted from waste disposal and into viable recycle processes during 2024. Currently, recycled materials range from office-related items to operations-related materials, such as scrap metal, tires, and batteries. Y-12 adds at least one new recycle stream to the Recycle Program each year to continue to increase the waste diversion rate. The Recycle Program was expanded in FY 2024 to include refrigeration equipment to broaden waste diversion efforts.

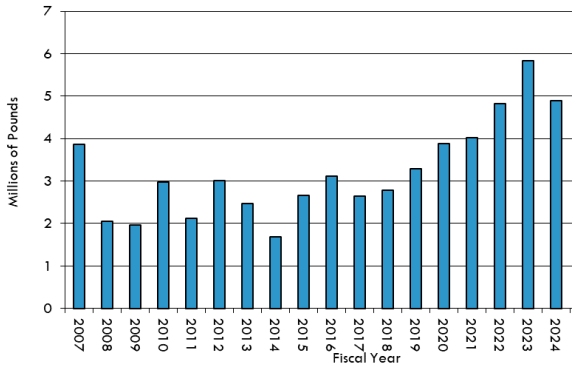


Figure 4.6. Y-12 recycling results, 2007–2024

4.2.6.3. Energy Management

The Energy Management program systematically monitors Y-12's energy and water consumption and recommends opportunities to reduce use and decrease costs. Energy and water usage and intensity, Energy Independence and Security Act of 2007 (EISA, EISA 2007) benchmarking and evaluations, facility metering and monitoring in accordance with the Energy Act of 2020 (EA 2020), and non-fleet vehicles and equipment are components of energy management reporting activities.

Y-12 surpassed DOE's initial goal of a 30 percent energy intensity (Btu/gsf) reduction in goal-subject buildings by 2015 from a FY 2003 baseline, followed by a 1 percent year-to-year reduction thereafter. Compared to the FY 2003 baseline year, Y-12 has seen an overall energy intensity reduction of 53.22 percent.

DOE revised its FY 2024 goal to reduce energy use intensity in goal-subject buildings by 50 percent by 2030 relative to the baseline year 2021. Y-12 is trending toward the goal, accomplishing a 3.61 percent decrease in energy intensity in 2024 from the baseline year, but a 6 percent average annual reduction will be needed to meet DOE's revised baseline goal of a 50 percent reduction by 2030. A significant challenge is that the new goal baseline year was a pandemic year in which a majority of the site population was teleworking. Adding to the challenge, Y-12's workforce numbers continue to grow, with the workforce increased by more than 15 percent between FY 2020 and

FY 2021 in support of increasing site missions. Continued construction on the new UPF also contributes to the energy intensity for this year.

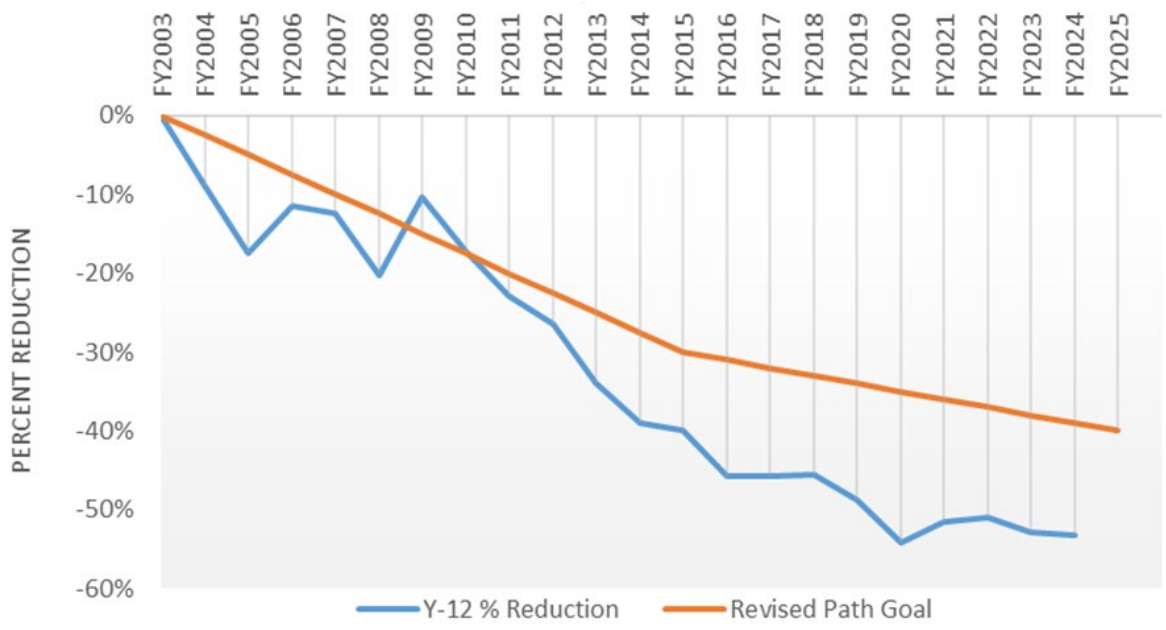
During FY 2024, energy intensity was 195,756 Btu/gsf, three-quarters of a percentage lower than the prior year's 197,270 Btu/gsf. Energy intensity through 2024 is shown in Figure 4.7 and Figure 4.8.

Y-12's modernization efforts before 2030 will lead temporarily to a greater increase in building square footage from new construction than will be compensated by demolition activities. Additionally, buildings with low water use will be dispositioned, while new construction will have significant water demand. Without notable increases in conservation and efficiency measures, modernization phasing is expected to create challenges to maintaining reductions. Yet more aggressive efforts will be needed to meet the 2030 goal.

Work undertaken under the energy savings performance contract, which began in FY 2009, has shown significant and sustained positive effects on the downward trend in energy intensity. Bringing these projects to a close, Y-12 began executing utility energy service contract projects in 2024 to deploy additional energy and water conservation and efficiency measures.

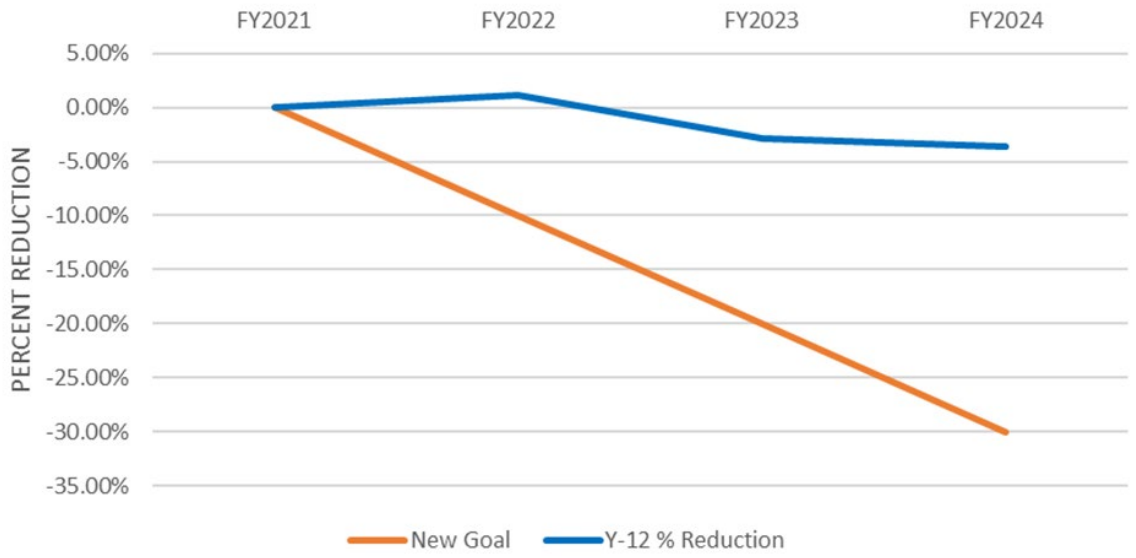
4.2.6.4. Goals and Performance

DOE is required to meet performance goals mandated by statute, including goals for GHG emissions, energy and water use, fleet optimization, green buildings, and renewable energy. In 2024, DOE used its web-based dashboard to collect and consolidate energy and water performance data from all DOE sites. The dashboard focuses on specific DOE goals, and site environmental stewardship plans are completed within the dashboard. These goals, along with the current Y-12 performance ratings, are listed in Table 4.1.



Acronym: *FY = fiscal year*

Figure 4.7. Y-12 energy intensity (Btu per gross square foot) versus 2003 baseline goal



Acronym: *FY = fiscal year*

Figure 4.8. Y-12 energy intensity (Btu per gross square foot) versus revised 2021 baseline goal

Table 4.1. Energy Management goals and performance, 2024

DOE goal	Current status
Energy management	
Reduce energy use intensity (Btu per gross square foot) in goal-subject buildings.	Goal Not Met: Y-12 reduced energy intensity by 3.61% compared to DOE's FY 2024 goal to reduce energy use intensity in goal-subject buildings by 50% by 2030 relative to the baseline year 2021. As Y-12 site population increases every year and the site transforms to meet increased scope in the outyears, energy reductions compared to baseline may not be achievable.
EISA Section 432 continuous (4-year cycle) energy and water evaluations.	Goal Met: Y-12 conducts EISA 432 energy and water evaluations on a continuous 4-year cycle.
Meter individual buildings for electricity, natural gas, steam, and water, where cost-effective and appropriate.	Goal Not Met: Y-12 meters all utilities at a site level, but not all applicable buildings are metered. A significant metering planning project is currently underway to fully implement sitewide building-level metering.
Achieve a net-zero emissions building portfolio by 2045 through building electrification and other efforts.	Goal Not Met: Y-12 does not have a complete net-zero emissions portfolio at this time. Ongoing opportunities for building electrification are considered in capacity studies, new substation construction, and smaller utility energy service contract projects to implement energy measures.
Water management	
Reduce potable water use intensity (gal per gross square foot).	Goal Met: Y-12 exceeded the goal of reducing water intensity by 36% by FY 2025 relative to FY 2007.
Reduce non-potable freshwater consumption (gal) for industrial, landscaping, and agricultural.	Goal Not Applicable. Y-12 does not use industrial, landscaping, or agricultural water.

Table 4.1. Energy Management goals and performance, 2024 (continued)

DOE goal	Current status
Waste management	
Reduce nonhazardous solid waste sent to treatment and disposal facilities.	Goal Met: 59.9% (1,629.1 metric tons/2,718.9 metric tons) of nonhazardous waste diverted from the landfill.
Reduce construction and demolition materials and debris sent to treatment and disposal facilities by 50%.	Goal Not Met: 2.8% (1,821.7 metric tons/61,794.1 metric tons) of construction and demolition materials were diverted from the landfill in FY 2024.
Fleet management	
Reduce petroleum consumption.	Goal Not Met: Y-12 did not meet the interim target of 20% reduction in fleet petroleum consumption in FY 2024 as there was a 13.3% increase from the FY 2005 baseline. Y-12 had 60 additional vehicles in the fleet inventory for FY 2024 compared to FY 2005 baseline inventory and no access to alternate fuel (E85) that would help to meet this metric.
Increase alternative fuel consumption.	Goal Not Applicable: Y-12 does not have access to alternative fuel (E85).
Achieve 100 percent zero-emission vehicle acquisitions by 2035, including 100 percent zero-emission light-duty vehicle acquisitions by 2027.	Goal Met: Y-12 ordered six vehicles with zero-emission capabilities in FY 2024 and one standard pickup for which zero-emission was not available within the U.S. General Services Administration procurement process, thus meeting the goal for the FY 2024 ordering cycle. Y-12 is working toward the goals for 2027 and 2035.
Clean & renewable energy	
Achieve 100 percent carbon pollution-free electricity on a net annual basis by 2030, including 50 percent 24/7 carbon pollution-free electricity.	Goal Not Met: Y-12 has not yet fully achieved these goals.
Increase consumption of clean and renewable non-electric thermal energy.	Goal Not Met: Separating the management and operating contracts between Y-12 and the Pantex Plant in 2024 resulted in losing shared renewable energy credits that had been originating from the Pantex Renewable Energy Project's on-site wind farm. Y-12 continues to generate renewable energy from geothermal wells and nonreflective photovoltaic array associated with a newer building, smaller renewable energy applications for site-specific use, and will purchase energy attribution certificates associated with its local sub-grid region. Y-12 had a 0.5% increase in natural gas use for FY 2024, attributed to increased site population and ongoing modernization efforts.
Sustainable buildings	
Increase the number of owned buildings that are compliant with the Guiding Principles for Sustainable Buildings.	Goal Met: One building was certified as High Performance and Sustainable Buildings in FY 2024.
Acquisition & procurement	
Promote sustainable acquisition and procurement to the maximum extent practicable, ensuring all clauses are included as appropriate.	Goal Met: All eligible contracts after Oct. 1, 2013, contain the sustainable acquisition requirements. The CNS Sustainable Acquisition Program is working with Contracts and Procurement to review the current $150,000 contract threshold for sustainable acquisition requirements to be included in subcontract languages so that future appropriate contracts will have the requirements to purchase sustainably.

Table 4.1. Energy Management goals and performance, 2024 (continued)

DOE goal	Current status
Investments: Improvement measures, workforce, & community	
Implement life-cycle cost-effective efficiency and conservation measures with appropriated funds and/or performance contracts.	Goal Met: Y-12 supported performance contracts issued by NNSA. These contracts have been instrumental in achieving energy, water, building modernization, and infrastructure goals at Y-12.
Electronic stewardship & data centers	
Promote electronics stewardship from acquisition, to operations, to end of life.	Goal Met: Y-12 met the goal of purchasing 95% of eligible electronics as Electronic Product Environmental Assessment Tool registered products. Performance for FY 2024 was 96.4%. Y-12's electronics recycling vendor maintained Responsible Recycling certification; therefore, all FY 2024 shipments were made to a certified recycler. Electronics that were not recycled were those that could not be radiologically cleared for release; therefore, 100% of eligible electronics were recycled to a Responsible Recycling certified recycler or were donated for reuse.
Increase energy and water efficiency in high performance computing and data centers.	Goal Not Met: While data centers have been consolidated at Y-12, which has saved energy and water, they are not fully metered. Current power usage effectiveness is estimated to be 2.4. As the site moves to modernized data centers, the overall energy and water efficiencies will continue to increase.
Adaptation & resilience	
Implement climate adaptation and resilience measures.	Goal Met: Y-12 issued a severe event emergency response plan that addresses severe natural phenomena events, extended loss of power events, and events that result in the loss of mutual aid. Additionally, the site updated its vulnerability assessment and resilience plan, along with identified resilience solutions, which include increasing on-site renewable energy generation; solar powered equipment; new facilities; roof repairs and replacement; chiller upgrades; and heating, ventilation, and air conditioning system repairs and replacements.
Multiple categories	
Reduce Scope 1 and 2 greenhouse gas emissions.	Goal Met: Site Scope 1 and 2 emissions were reduced by 62.6% from the FY 2008 baseline. Most of this can be attributed to infrastructure improvements through energy savings performance contract projects.

Acronyms:
DOE = US Department of Energy
EISA = Energy Independence and Security Act
FY = fiscal year
NNSA = National Nuclear Security Administration

4.2.6.5. Water Management

The current DOE water intensity goal is a 20 percent reduction from a FY 2007 baseline by FY 2015 and year-to-year reductions of 0.5 percent thereafter. In FY 2024, Y-12's water intensity rating was 62.45 gal/ft^2, a 6.62 percent decrease from the previous year and a 70.37 percent reduction from the 2007 baseline.

An overview of water intensity performance is shown in Figure 4.9.

The following actions have contributed to the overall reduction in potable water use:

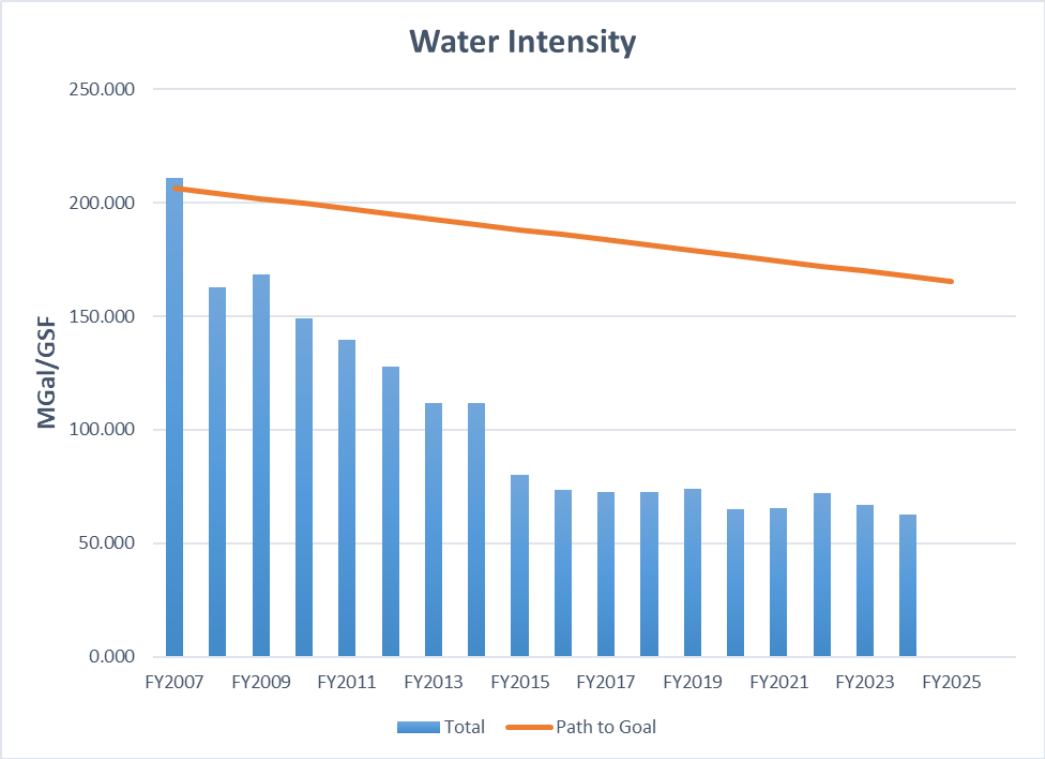
- Steam trap repairs and improvements
- Condensate return installations, repairs, and reroutes

- Replacement of once-through air handling units
- Low-flow fixture installation
- Chiller replacements
- Cooling tower replacements
- Steam replacements to natural gas when possible

Y-12 continues to be plagued by aging infrastructure and associated water line breaks and leaks that have a significant impact on the site's water use efficiency. Replacements and repairs to aging water lines are ongoing.

Internal EISA audits are conducted on covered facilities on a 4-year rotating schedule. Audit results point to continued opportunities for reductions in water usage. Water conservation measures are incorporated into ongoing facility repairs and renovations as funding becomes available. These measures include the following:

- Upgrading toilets and urinals to low-flow, hands-free units
- Installing flow restrictors on faucets and shower heads
- Repairing condenser loop connections so all condenser water is returned to the cooling towers
- Replacing existing once-through water-cooled air conditioning system with air-cooled equivalents
- Planning for the installation of additional advanced potable water meters



Acronyms:

FY = fiscal year GSF = gross square feet Mgal = millions of gallons

Figure 4.9. Water intensity graph from baseline 2007 through FY 2024

4.2.6.6. Fleet Management

There are 648 vehicles in the Y-12 fleet, including 124 agency-owned units, 510 leased from General Services Administration (GSA), and 14 commercially leased special purpose vehicles. The inventory consists of sedans; light-duty trucks, vans, and sport utility vehicles; medium-duty trucks, vans, and sport utility vehicles; and heavy-duty trucks such as road tractors, dump trucks, box trucks, flatbeds, wreckers, and service trucks.

During 2024, Y-12 exchanged nine older GSA-leased vehicles with new units and dispositioned an older E-tagged vehicle through Y-12 Property Sales. The new GSA replacements were ordered with alternative fuel or zero-emission capabilities when available, and these new vehicles have better fuel consumption and GHG emission figures than the older vehicles, which ranged from 7 to 12 years of age.

Vehicle availability was again a struggle during FY 2024. Normally, the majority of replacement orders placed with GSA in the November timeframe would be delivered by September, but manufacturer shortages and cancellations once again had major impacts with the actual vehicle delivery cycle during FY 2024. Additional vehicles will be required in the near future to support Y-12 construction projects such as the LPF and the Mercury Treatment Facility, plus additional CNS involvement and oversight with the UPF project, but the vehicle ordering with GSA is projected to be much improved for FY 2025.

The Y-12 taxi service and UPF bus service continued as transportation sources available for the more than 7,500 employees at the site. This service also helps reduce the number of overall vehicles needed, fuel consumption, and GHG emissions. The taxi service is an important asset to the overall transportation needs of the Y-12 workforce, especially in light of extremely tight vehicle parking availability.

The Y-12 vehicle fleet achieved a 98.5 percent vehicle utilization rate for FY 2024 compared to 98.3 percent in FY 2023. Of the vehicles that failed the utilization rate, all achieved 80 percent or greater utilization scores. Vehicle reassignments were made multiple times throughout the year to help meet utilization goals.

FY 2024 fuel consumption at Y-12 (diesel and gasoline) as reported by GSA decreased by 18.9 percent compared with FY 2023, while miles traveled for those same vehicles was down by 2.88 percent compared to the previous year.

Y-12 continues to use mobile fuel tankers as needed to dispense gasoline and diesel for vehicles because the site lacks a new fuel station, but site preparation has begun to build one just southwest of the existing Y-12 garage at the east end of the plant. Y-12 does not use alternative fuel (E85) because it is not available in the area. Because of this, an Epact 701 waiver (5 miles or 15 minutes away) was granted to Y-12.

4.2.6.7. Electronic Stewardship

Y-12 has various electronic stewardship activities, including virtualizing servers, creating virtual desktop infrastructure, procuring energy efficient computing equipment, reusing and recycling computing equipment, replacing aging computing equipment with more energy efficient equipment, and reconfiguring data centers to achieve more energy efficient operations. More than 96 percent of the desktop computers, laptops, monitors, and thin clients purchased or leased during FY 2024 were registered Electronic Product Environmental Assessment Tool products. Y-12's standard desktop configuration specifies the procurement of Electronic Product Environmental Assessment Tool registered and Energy Star-qualified products.

4.2.6.8. Greenhouse Gases

Compared to the FY 2008 baseline, Y-12 Scope 1 (on-site fuel burning) and Scope 2 (purchased electricity) GHG emissions have been reduced. Emission reductions can be attributed primarily to decreased Scope 1 emissions due to more efficient steam generation and decreased Scope 2 emissions due to energy efficiency projects.

Purchased electricity is by far the biggest contributor to Y-12's GHG footprint. Energy reduction initiatives involving production facilities and utility infrastructure have been completed through energy savings performance contract projects and continue in FY 2024 and FY 2025 through utility energy service contracts.

4.2.6.9. Storm Water Management and the Energy Independence and Security Act

Section 438 of the EISA requires federal agencies reduce storm water runoff from development and redevelopment projects to protect water resources. Y-12 complies with these requirements by using a variety of storm water management practices, often referred to as green infrastructure or low impact development practices. Several green infrastructure initiatives have been implemented to reduce the size and number of impervious surfaces through sustainable vegetative practices and porous pavements.

4.3. Compliance Status

During 2024, Y-12 operations complied with contractual and regulatory environmental requirements. Table 4.2 summarizes the environmental audits conducted at Y-12 in 2024. This section discusses the major environmental programs and activities at the site and provides an overview of the compliance status for the year.

4.3.1. Environmental Permits

Table 4.3 lists environmental permits in force at Y-12.

Table 4.2. Summary of external regulatory audits and reviews, 2024

Date	Reviewer	Subject
March 21	TDEC	Quarterly ORR Landfill Inspections of ILF-V, ILF-IV, CDL-VII, and Semiannual Post Closure Inspection of ILF-II
March 26	City of Oak Ridge	Sanitary Sewer Inspection
April 11	TDEC	Quarterly ORR Landfill Inspections of ILF-II, ILF-V, and CDL-VII
May 21–22	TDEC/EPA	Annual RCRA Hazardous Waste Compliance Inspection
July 10	TDEC	Air Quality Inspection
August 1	TDEC/City of Oak Ridge	ORR Landfill Inspection of ILF-V and CDL-VII Leachate Collection Systems
August 1	TDEC, City of Oak Ridge	Sanitary Sewer Inspection
August 19	TDEC	Quarterly ORR Landfill Inspection of ILF-V and CDL-VII
September 19	TDEC	Quarterly ORR Landfill Inspection of ILF-IV
November 22	TDEC	Quarterly ORR Landfill Inspections of ILF-V and CDL-VII. Second Semiannual Post Closure Inspection of ILF-II
December 12	TDEC	Quarterly ORR Landfill Inspection of ILF-IV

Acronyms:

CDL = Construction Demolitions Landfill
EPA = Environmental Protection Agency
ILF = Industrial Landfill
ORR = Oak Ridge Reservation
RCRA = Resource Conservation and Recovery Act
TDEC = Tennessee Department of Environment and Conservation

Table 4.3. Y-12 environmental permits, 2024

Regulatory driver	Title/description	Permit number	Issue date	Expiration date	Owner	Operator	Responsible contractor
CAA	Title V Major Source Operating Permit	571832	12/01/17	11/30/22[a]	DOE	DOE	CNS
CWA	Industrial and Commercial User Wastewater Discharge (Sanitary Sewer) Permit	1-91	07/20/21	03/31/26	DOE	DOE	CNS
CWA	NPDES Permit	TN0002968	08/05/22	09/30/27[b]	DOE	DOE	CNS
CWA	UPF General Storm Water Permit Y-12 (41.7 ha/103 acres)	TNR134022	10/27/11	09/30/26	DOE	CNS	CNS
CWA	UPF NPDES General Permit for Construction Storm Water	TNR135568	08/06/18	09/30/26	DOE	BNI	BNI
CWA	UCOR ILF-II General Storm Water Permit Y-12 (8.2 acres)	TNR136478	08/03/21	Upon Notice of Termination	DOE	UCOR	UCOR
CWA	Y-12 Outfall 014 Repair Aquatic Resource Alteration Permit	NR1903.116	06/21/19	04/05/25	DOE	DOE	CNS
CWA	Security Infrastructure Revitalization Program NPDES General Construction Permit	TNR136604	11/30/21	Upon Notice of Termination	DOE	DOE	CNS
CWA	No Discharge Portal 20 Pump and Haul Permit	SOP-170-14	06/24/22	06/30/27	DOE	DOE	CNS
CWA	No Discharge Portal 23 Pump and Haul Permit	SOP-170-15	06/20/22	07/30/27	DOE	DOE	CNS
CWA	No Discharge Portal 19 Pump and Haul Permit	SOP-130-31	07/01/23	06/30/28	DOE	DOE	CNS
CWA	No Discharge Environmental Management Waste Management Facility Pump and Haul Permit	SOP-010-43	09/01/22	08/31/27	DOE	UCOR	UCOR
CWA	Oak Ridge Institute for Global Security Aquatic Resource Alteration Permit	NR2003.249	01/14/21	Upon Notice of Termination	DOE	DOE	CNS
CWA	Oak Ridge Institute for Global Security NPDES General Construction Permit	TNR136307	04/26/21	09/30/26	DOE	DOE	CNS
CWA	Y-12 National Security Complex LPF Permit	TNR137245	07/21/23	Upon Notice of Termination	DOE	DOE	CNS
CWA	West End Protected Area Reduction NPDES General Construction Permit	TNR136382	04/26/21	09/30/26	DOE	DOE	CNS
CWA	Monitoring Station 8 and Outfalls 051 and 099 Access Improvements Aquatic Resource Alteration Permit	NR2103.288	11/08/21	04/07/25	DOE	DOE	CNS

Table 4.3. Y-12 environmental permits, 2024 (continued)

Regulatory driver	Title/description	Permit number	Issue date	Expiration date	Owner	Operator	Responsible contractor
RCRA	Hazardous Waste Transporter Permit	TN3890090001	12/20/24	01/31/26	DOE	DOE	CNS
RCRA	Hazardous Waste Corrective Action Permit	TNHW-164	09/15/15	09/15/25	DOE	DOE, NNSA, and all ORR co-operators of hazardous waste permits	UCOR
RCRA	Hazardous Waste Container Storage Units	TNHW-184	03/05/21	03/05/31	DOE	DOE/CNS	CNS/LATS co-operator
RCRA	Hazardous Waste Container Storage and Treatment Units	TNHW-191	09/21/23	09/21/33	DOE	DOE/CNS	CNS co-operator
Solid Waste	Industrial Landfill IV (operating, Class II)	IDL-01-000-0075	Permitted in 1988—most recent modification approved 06/20/19	N/A	DOE	DOE/UCOR	UCOR
Solid Waste	Industrial Landfill V (operating, Class II)	IDL-01-000-0083	Permitted in 1993—most recent modification approved 08/04/22	N/A	DOE	DOE/UCOR	UCOR
Solid Waste	Construction and Demolition Landfill (overfilled, Class IV subject to CERCLA Record of Decision)	DML-01-000-0012	Initial permit 01/15/86	N/A	DOE	DOE/UCOR	UCOR
Solid Waste	Construction and Demolition Landfill VI (post-closure care and maintenance)	DML-01-000-0036	Permit terminated by TDEC 03/15/07				

Table 4.3. Y-12 environmental permits, 2024 (continued)

Regulatory driver	Title/description	Permit number	Issue date	Expiration date	Owner	Operator	Responsible contractor
Solid Waste	Construction and Demolition Landfill VII (operating, Class IV)	DML-01-000-0045	Permitted in 1993—most recent modification approved 08/31/22	N/A	DOE	DOE/UCOR	.81
Solid Waste	Centralized Industrial Landfill II (post-closure care and maintenance)	IDL-01-000-0189	Most recent modification approved 05/08/92	N/A	DOE	DOE/UCOR	UCOR
SDWA	Underground Injection Control Class V Injection Well Permit	Permit by Rule, TDEC Rule 0400-45-06 and -00041	N/A	N/A	DOE	DOE	CNS

[a] *The Title V air permit renewal is still in the review process by TDEC.*

[b] *Some aspects of the current NPDES permit are currently under appeal by NNSA.*

Acronyms:

BNI = Bechtel National Inc.

CAA = Clean Air Act

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act

CNS = Consolidated Nuclear Security, LLC

CWA = Clean Water Act

DOE = US Department of Energy

LATS = LATA-Atkins Technical Services, LLC

LPF = Lithium Processing Facility

N/A = not applicable

NNSA = National Nuclear Security Administration

NPDES = National Pollutant Discharge Elimination System

ORR = Oak Ridge Reservation

RCRA = Resource Conservation and Recovery Act

SDWA = Safe Drinking Water Act

TDEC = Tennessee Department of Environment and Conservation

UCOR = URS|CH2M Oak Ridge LLC (prior to May 2022) or United Cleanup Oak Ridge (after May 2022)

UPF = Uranium Processing Facility

4.3.2. National Environmental Policy Act

As federal agencies, DOE and NNSA comply with National Environmental Policy Act (NEPA) requirements as outlined in 10 CFR 1021, *National Environmental Policy Act Implementing Procedures*. NEPA requires reviews of all federal actions to identify any environmental or public consequences associated with that action. NEPA does not require that certain decisions be made or activities be rejected—it just makes sure that federal agencies evaluate environmental and related social and economic impacts in the decision-making process. This evaluation helps Y-12 and NNSA stay in compliance with many federal and state laws, regulations, and permits.

The broadest and most complex NEPA document for Y-12 is DOE/EIS-0387, *Final Site-Wide Environmental Impact Statement (EIS) for the Y-12 National Security Complex* (DOE 2011a). This document takes into account the myriad activities planned for Y-12 in the foreseeable future. As changes in plans are identified or additional information becomes available, the sitewide document is updated with various supplement analyses. Following the 2011 sitewide EIS, supplement analyses were issued in 2016, 2018, and 2020 (NNSA 2016, NNSA 2018, NNSA 2020). NNSA began a contract for a new supplement analysis in 2024.

NEPA environmental assessments are prepared for larger projects that may not have been covered in the EIS or supplement analysis. Two environmental assessments were completed in 2024:

- DOE/EA-2218, *Environmental Assessment for Activities in Support of the Y-12 National Security Complex Materials Manufacturing Mission*, and its associated Finding of No Significant Impact were completed in January 2024 (NNSA 2024a, NNSA 2024b)
- DOE/EA-2252, *Environmental Assessment for Off-Site Depleted Uranium Manufacturing*, and its associated Finding of No Significant Impact were completed in October and November (NNSA 2024c, NNSA 2024d).

The lowest level of NEPA documentation is a Categorical Exclusion (CX). These documents are used for smaller projects that have fewer environmental impacts and less cost than the types of activities covered by an EIS or environmental assessment.

There were 31 environmental reviews in 2024, with one of these resulting in development of a federal CX document requiring approval by the NNSA NEPA Compliance Officer [NEPA 5092, *East End Substation Construction* (DOE 2024b)]. Some of these environmental reviews against existing NEPA documentation were for new projects, and others may be revisions to older project documents based on new information or small changes in project scope.

The EIS, supplement analyses, environmental assessments, and federal CXs documents are available at the Y-12 publicly accessible website (www.y12.doe.gov) on the Environment, Safety, and Health page under the About tab.

4.3.3. National Historic Preservation Act

In accordance with the National Historic Preservation Act (NHPA, NHPA 1966), NNSA is committed to identifying, preserving, enhancing, and protecting its cultural resources. Compliance activities in 2024 at Y-12 included completing Section 106 reviews of ongoing and new projects to ensure preservation of historic properties, coordinating with the Tennessee State Historic Preservation Office (SHPO) toward the execution of an updated cultural resource survey and a programmatic agreement, as well as collecting and storing historic artifacts.

Y-12 is on approximately 3,500 acres within the northern portion of the 33,316 acres of the ORR. Archaeological surveys in 1992 and 1999 determined that the potential for preserved prehistoric or historic archaeological sites is virtually nonexistent due to the previous amount of disturbance during Manhattan Project-era and later construction. Y-12 continues to conduct archaeological surveys as necessary to comply with NHPA and facilitated surveys in December 2024 of the eastern portion of Pine

Ridge in support of upcoming projects by the Tennessee Valley Authority within the Y-12 footprint.

Y/TS-1983, *Y-12 National Security Complex National Historic Preservation Act Historic Preservation Plan* (BWXT 2003), is reviewed every 5 years to maintain its effectiveness as a guiding document for the NHPA Program at Y-12. In its last review, it was determined that the plan and associated programmatic agreement needed to be updated to accurately reflect the changes at Y-12 since the documents were completed in 2003.

To this end, Y-12 is updating its cultural resource survey, which evaluates all site facilities constructed through 1992 to determine their eligibility for the National Register of Historic Places and inclusion within the redrawn boundaries of the Y-12 Historic District. The proposed survey includes a total of 273 surveyed properties out of 352, including 119 properties assessed in the previous survey and 195 buildings constructed after 1958, which is the end of the period of significance for the previous 1999 survey. The new proposed period of significance extends to 1992 and includes Y-12's role in the Manhattan Project (1943–1945/1946), post-World War II (1945/1946–1950), the Cold War (1950–1992), and peacetime research and development (1950–1992). Work has also begun updating Y-12's programmatic agreement to reflect information provided in the draft cultural resource survey and during consultation with the SHPO.

The NHPA program works through the NEPA process to ensure that the proper level of environmental review is performed before an irreversible commitment of resources is made. In 2024, 27 proposed projects were evaluated to determine whether any historic properties eligible for inclusion in the National Register of Historic Places would be adversely impacted. One building newly recommended as eligible for the National Register of Historic Places was scheduled for demolition in late 2024. Because demolishing a building eligible for the National Register of Historic Places is considered an adverse effect, the SHPO was made aware of the building's demolition status before action was taken. Section 106 documentation for the buildings has been submitted to the SHPO, and Y-12 is consulting with the SHPO to add the building to the NHPA memorandum of agreement between DOE, NNSA, and Y-12 regarding the demolition of excess buildings at Y-12.

4.3.4. Clean Air Compliance Status

The state of Tennessee issues permits as the primary means to impose clean air requirements that are applicable to Y-12. New projects are governed by construction permits and modifications to the Title V operating air permit, and eventually the requirements are incorporated into the sitewide Title V operating permit. Y-12 is currently governed by Title V Major Source Operating Permit 571832.

The permit requires recordkeeping and annual and semiannual reports. More than 2,000 data points are obtained and reported each year. All reporting requirements were met during 2024, and there were no exceedances during the reporting period.

Ambient air monitoring, while not specifically required by any permit condition, is conducted at Y-12 to satisfy requirements in DOE Order 458.1, *Radiation Protection of the Public and the Environment* (DOE 2011b), as a best management practice and to provide evidence of sufficient programmatic control of certain emissions. The monitoring conducted specifically for Y-12 (i.e., mercury monitoring) is supplemented by additional monitoring conducted for ORR and by both on- and off-site monitoring conducted by TDEC.

Section 4.4 provides additional information about Clean Air Act (CAA) activities conducted at Y-12.

4.3.5. Clean Water Act Compliance Status

During 2024, Y-12 continued compliance with the National Pollutant Discharge Elimination System (NPDES) water discharge permit limits. Data obtained as part of the NPDES program are provided in a monthly report to TDEC. The

percentage of compliance with permit discharge limits for 2024 was 100 percent.

Approximately 4,200 data points were obtained from sampling required by the NPDES permit. Y-12's new NPDES permit was issued on August 5, 2022, and became effective on October 1, 2022. The new permit is currently under appeal in part, and settlement negotiations are ongoing.

On July 17, 2024, a Notice of Violation was received from TDEC for a fish kill resulting from a potable water line break on June 20, 2024.

On October 1, 2024, a fish kill occurred when controlled low-strength material (concrete mix) from UCOR pre-demolition activities entered East Fork Poplar Creek (EFPC) through an abandoned drain line from the basement of Building 9201-02. The discharge resulted in high turbidity, elevated pH and the death of approximately 1,300 fish and other aquatic organisms.

On July 28, 2024, the instantaneous flow rate in the sanitary sewer peaked at approximately 4,000 gpm, exceeding the 2,100-gpm limit. This was a result of a 2.2-inch rainfall in 2.5 hours.

4.3.6. Safe Drinking Water Act Compliance Status

The City of Oak Ridge supplies potable water to Y-12 and meets all federal, state, and local standards for drinking water. The water treatment plant, located north of Y-12, is operated by the City of Oak Ridge. Y-12 potable water distribution is operated by a state-certified distribution system operator. The distribution system is regulated by TDEC as a public water system, with public water distribution system identification number 0001068.

TDEC water resource regulation Chapter 0400-45-01, "Public Water Systems," (TDEC 2019) sets limits for biological contaminants, chemical activities, and chemical contaminants. Sampling for total coliform, chlorine residuals, lead, copper, and disinfectant byproducts is conducted by Y-12's Environmental Compliance organization, with oversight by a state-certified operator.

Y-12's potable water distribution system was last reviewed by TDEC in 2021 and received a sanitary survey score of 100 out of a possible 100 points and, thus, retained its approved status as a public water system in good standing with TDEC. All total coliform samples collected during 2024 were analyzed by the state of Tennessee laboratory, and all results were negative.

The analytical results for disinfectant byproducts (total trihalomethanes and haloacetic acids) for Y-12's water distribution system were within allowable TDEC and Safe Drinking Water Act limits for the yearly average. Y-12's potable water system is sampled triennially for lead and copper. The system was last sampled in 2024. The results were below TDEC and Safe Drinking Water Act limits and met established requirements.

4.3.7. Resource Conservation and Recovery Act Compliance Status

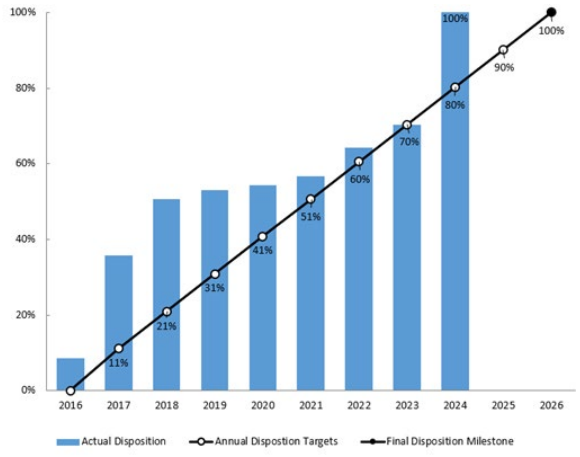
The Resource Conservation and Recovery Act (RCRA) regulates hazardous wastes that, if mismanaged, could present risks to human health or the environment. The regulations are designed to ensure that hazardous wastes are managed from the point of generation to final disposal. In Tennessee, EPA delegates the RCRA program to TDEC, but EPA retains an oversight role. Y-12 is considered a large quantity generator because it may generate more than 1,000 kg of hazardous waste in a month and because it has RCRA permits to store hazardous wastes for up to 1 year before shipping off-site to licensed treatment and disposal facilities. Y-12 also has a number of satellite accumulation areas and 90-day waste storage areas.

Mixed wastes are materials that are both hazardous (under RCRA guidelines) and radioactive. The Federal Facility Compliance Act requires that DOE work with local regulators to develop a site treatment plan to manage mixed waste (FFCA 1992). The plan identifies available treatment technologies and disposal facilities (federal or commercial) that can manage mixed waste produced at federal facilities and outlines a schedule for treating and disposing of the waste

streams that cannot be treated and disposed of in strict compliance with RCRA time limits.

The *Site Treatment Plan for Mixed Wastes on the US Department of Energy Oak Ridge Reservation* (TDEC 2024c) is updated annually and submitted to TDEC for review. Site treatment plan-listed mixed waste is documented, as well as efforts to seek new commercial treatment and disposal outlets for various waste streams. NNSA has developed a disposition schedule for the mixed waste in storage and will continue to maintain the plan, as a reporting mechanism, as progress is made.

In August 2016, NNSA formally requested, and TDEC provided concurrence for, the addition of 81 mixed low-level radioactive waste containers to the ORR site treatment plan. Disposition milestones to address this mixed waste were developed for FYs 2016 through 2026, as shown in Figure 4.10. In FY 2024, Y-12 staff dispositioned 100 percent of this inventory. In FYs 2023 and 2024, 14 containers of mixed transuranic waste and 25 containers of mixed low-level radioactive waste were added to the site treatment plan.



Note: *As part of the Oak Ridge Reservation Site Treatment Plan.*

Figure 4.10. Disposition of Y-12 legacy mixed waste inventory by fiscal year, 2016–2024

The quantity of hazardous and mixed wastes generated by Y-12 in 2024 decreased compared to the previous year, as shown in Figure 4.11. Y-12 is a state-permitted treatment, storage, and disposal facility. Under its permits, Y-12 received 5,400 kg of hazardous and mixed waste from off-site in 2024. The 5,400 kg of hazardous waste received at Y-12 was generated from CNS activities at the Union Valley Facility and ETTP. Waste from these facilities is shipped to Y-12, where it is aggregated to allow economical shipments to disposal facilities. The majority (70 percent) was generated as a result of analytical chemistry laboratory operations at the Union Valley Facility. Hazardous waste was also generated from UPF project operations at ETTP.

In addition, 840,321 kg of hazardous and mixed waste was shipped to DOE-owned and commercial treatment, storage, and disposal facilities. More than 8 million kg of hazardous and mixed wastewater was treated at on-site wastewater treatment facilities.

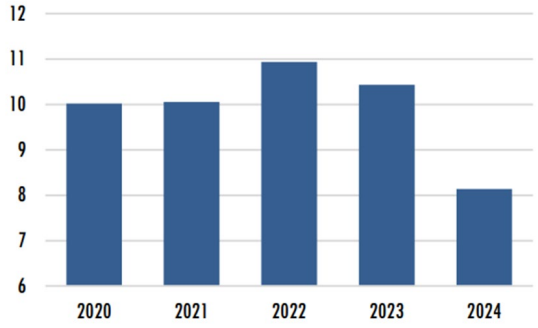


Figure 4.11. Y-12 hazardous waste generation (in million kg), 2020–2024

4.3.7.1. Resource Conservation and Recovery Act Underground Storage Tanks

Y-12 has no active petroleum underground storage tanks.

4.3.7.2. Resource Conservation and Recovery Act Subtitle D Solid Waste

ORR landfills operated by DOE EM are located within the Y-12 boundary. The facilities include two Class II operating industrial solid waste disposal landfills and one operating Class IV construction demolition landfill. The facilities are permitted by TDEC and accept solid waste from DOE operations on ORR. In addition, one Class IV

facility (Spoil Area 1) is overfilled by 8,945 m^3 and has been the subject of a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) remedial investigation and feasibility study. A CERCLA Record of Decision for Spoil Area 1 was signed in 1997 (DOE 1997). One Class II facility (Landfill II) has been closed and is subject to post-closure care and maintenance.

Associated TDEC permit numbers are noted in Table 4.3. Additional information about the operation of these landfills is provided in Section 4.8.2.

4.3.8. Resource Conservation and Recovery Act-Comprehensive Environmental Response, Compensation, and Liability Act Coordination

The ORR Federal Facility Agreement (DOE 1992) is used to coordinate the corrective action processes of RCRA required under the ORR Corrective Action TNHW-164, which was renewed for a 10-year period from September 15, 2015, through September 15, 2025. As required in TNHW-164, the annual update of solid waste management units and areas of concern was submitted to TDEC in January 2024 as an update of the previous year's activities.

4.3.9. Toxic Substances Control Act Compliance Status

Storage, handling, and use of polychlorinated biphenyls (PCBs) are regulated under the Toxic Substances Control Act (TSCA). Capacitors manufactured before 1970 believed to be oil-filled are handled as though they contain PCBs, even when that cannot be verified from manufacturer records. Certain equipment containing PCBs and PCB waste containers must be inventoried and labeled. The inventory is updated by July 1 of each year and was last submitted on June 25, 2024.

Given the widespread historical uses of PCBs at Y-12 and fissionable material requirements that must be met, EPA and DOE negotiated an agreement to assist ORR facilities in becoming compliant with TSCA regulations (DOE 2012). This agreement, known as the ORR PCB Federal Facility Compliance Agreement, addresses PCB compliance issues that are unique to these facilities. Y-12 operations involving TSCA-regulated materials were conducted in accordance with TSCA regulations and the agreement.

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

The Emergency Planning and Community Right-to-Know Act requires facilities to report inventories (i.e., Tier II report sent to state and local emergency responders) and releases (i.e., toxic release inventory report submitted to state and federal environmental agencies) of certain chemicals that exceed specified thresholds (EPCRA 1986). Y-12 submitted reports for reporting year 2024 in accordance with requirements under Sections 303, 311, 312, and 313 of the Act.

Y-12 had no unplanned release of a hazardous substance that required notification of the regulatory agencies. (Section 4.3.11 provides additional information.) Inventories, locations, and associated hazards of over-threshold hazardous and extremely hazardous chemicals were submitted to TEMA and local emergency responders in the annual Tier II report required by Section 312. Data submittal was through the E-Plan web-based reporting system, as requested by TEMA. Some local emergency responders accepted data through the E-Plan system, but others require that electronic copies of the Tier II reports be submitted via email. Y-12 reported seven extremely hazardous substances and 47 hazardous substances over Section 312 inventory thresholds in 2024. Nine hazardous substances were over threshold during 2024 and were not reported in 2023.

In 2024, the Central Training Facility had one extremely hazardous substance over threshold and was reported through the E-Plan system.

Y-12 operations are evaluated annually to determine the applicability for submittal of a toxic release inventory report to TEMA and EPA in accordance with Section 313 requirements. The amounts of certain chemicals manufactured, processed, or otherwise used are calculated to

identify those that exceed reporting thresholds. After threshold determinations are made, releases and off-site transfers are calculated for each chemical that exceeds a threshold. Submittal of the data to TEMA and EPA is made through the Toxics Release Inventory-Made Easy (abbreviated as TRI-ME) web-based reporting system operated by EPA. Seven chemicals were reported for 2024 on the Toxic Release Inventory report. Table 4.4 lists the reported chemicals for Y-12 and Central Training Facility for 2023 and 2024.

4.3.11. Spill Prevention, Control, and Countermeasures

Section 311 of the Clean Water Act regulates the discharge of oils or petroleum products to waters of the United States and requires spill prevention, control, and countermeasure plans be developed and implemented to minimize the potential for oil discharges (CWA 1972). The major requirements for plans are contained in 40 Part 112. These regulations require that these plans be reviewed, evaluated, and amended at least once every 5 years, or earlier if significant changes occur. The rule includes requirements for oil spill prevention, preparedness, and response to prevent oil discharges to navigable waters and adjoining shorelines. Specific facilities are required to prepare, amend, and implement spill prevention, control, and countermeasure plans.

Y/SUB/02-001091/9, *Spill Prevention, Control, and Countermeasure Plan for the U.S. Department of Energy Y-12 National Security Complex* (CNS 2024) presents the requirements to be implemented by Y-12 to prevent spills of oil and the countermeasures to be invoked should a spill occur. In general, the first response of an individual discovering a spill is to call the Y-12 Operations Center. Spill response materials and equipment are stored near tanks, drum storage areas, and other strategic areas to facilitate spill response. All Y-12 personnel and subcontractors are required to have initial spill and emergency response training before they can work on the site.

4.3.12. Unplanned Releases

Y-12 has procedures for notifying off-site authorities of categorized events at Y-12. Off-site notifications are required for specified events according to federal statutes, DOE orders, and the Tennessee Emergency Management Agreement. As an example, certain observable oil sheens on EFPC must be reported to the EPA National Response Center, among others. Spills of CERCLA reportable quantity limits must be reported to the EPA National Response Center, DOE, TEMA, and the Anderson County Local Emergency Planning Committee.

In addition, Y-12's Occurrence Reporting Program provides timely notification to the DOE community of events and site conditions that could adversely affect public or worker health and safety, the environment, national security, DOE safeguards and security interests, DOE facilities functions, or DOE's reputation.

Y-12 occurrences are categorized and reported through the Occurrence Reporting and Processing System, which provides NNSA and the DOE community with a readily accessible database of information about occurrences at DOE facilities, causes of those occurrences, and corrective actions to prevent recurrence of the events. DOE analyzes aggregate occurrence information for generic implications and operational improvements.

During 2024, there were no reportable releases to the environment, including no reportable radiological air emission releases for Y-12.

Table 4.4. Emergency Planning and Community Right-to-Know Act Section 313 toxic chemical release and chemicals manufactured, processed, or otherwise used for Y-12 and the Central Training Facility

Report	Chemical/ Compound	2023			2024			Comments
		Manufactured (lb)	Processed (lb)	Otherwise used (lb)	Manufactured (lb)	Processed (lb)	Otherwise used (lb)	
Y-12	Chromium/ Chromium Compounds	0	169,521	17,475	0	406,877	9,691	2024 increased amount recycled and metal processed; decreased UPF construction materials otherwise used.
Y-12	Cobalt	0	40,072	2,912	0	25,366	1,921	2024 decreased amount recycled; decreased UPF construction materials otherwise used.
Y-12	Copper	0	250,743	13,880	0	249,700	6,356	2024 similar amounts recycled; continued decreased UPF construction materials otherwise used.
Y-12	Lead/Lead Compounds	0	91,984	35,435	0	110,754	11,089	2024 slight increase amount recycled; decreased construction materials otherwise used. Central Training Facility lead counts for ammunition are not included in the Y-12 report but in a standalone report for 2024.
Y-12	Manganese	0	117,437	9,172	0	98,391	2,098	2024 slight decrease amount of recycled and metal processed; decreased UPF construction materials otherwise used.
Y-12	Methanol[a]	0	0	6,372	0	0	2,412	Not reportable under threshold for 2023 or 2024. Building 9767-4 no longer in use for the brine system.
Y-12	Nickel	0	409,514	26,664	0	405,568	6,221	2024 amount recycled and metal processed close to 2023; decreased UPF construction materials otherwise used.
Central Training Facility	Lead/Lead Compounds	0	0	1,109	0	0	832	2024 data is reported separately from Y-12 because the facility is not adjacent/adjoining to the Y-12 site. Slight decrease in amount of ammunition used for 2024.

[a] *Not reported during 2024*

Acronyms:

UPF = Uranium Processing Facility

4.3.13. Audits and Oversight

In 2024, Y-12 was inspected by federal, state, or local regulators on 11 occasions, as listed in Table 4.2.

As part of the City of Oak Ridge's pretreatment program, city personnel collect samples from the Y-12 monitoring station to conduct compliance monitoring, as required by the pretreatment regulations. City personnel also conduct compliance inspections twice yearly. No issues were identified in 2024.

Personnel from the TDEC Division of Solid Waste Management and the EPA RCRA Enforcement Section conducted an unannounced RCRA hazardous waste compliance inspection of Y-12 on May 21–22, 2024. The inspections covered waste storage areas and records reviews. One issue was identified—a 10-gal container of hazardous waste was not labeled with the accumulation start date. This was corrected immediately. The issue and its causes were reviewed to prevent recurrence.

Personnel from the TDEC Division of Air Pollution Control conducted an air quality inspection on July 10, 2024. The inspection covered 10 air emission sources, including some emergency generators, and inspections of the facilities. Title V air permit records were also reviewed. No issues were identified.

4.3.14. Radiological Release of Property

Releasing property from Y-12 is conducted in accordance with approved procedures that comply with DOE Order 458.1. Property consists of real property (i.e., land and structures) and personal property (i.e., property of any type except real property) (DOE 2011b).

At Y-12, there are three paths for releasing property to the public based on the potential for radiological contamination:

- Survey and release property potentially contaminated on the surface (Section 4.3.14.1).
- Evaluate materials with a potential to be contaminated in volume (Section 4.3.14.2).
- Evaluate using process knowledge (surface and volumetric) (Section 4.3.14.3).

Table 4.5 summarizes some examples of the property released in 2024 and their amounts. Y-12 recycled more than 4.88 million lb of materials off-site for reuse, including computers, electronic office equipment, used oil, scrap metal, tires, batteries, lamps, and pallets.

Table 4.5. Summary of materials released in 2024

Category	Amount released
Real property (land and structures)	None
Computer equipment recycle:	39,768 lb
– Computers	
– Monitors	
– Printers	
– Mainframes	
Recycling examples:	
– Used oils	61,191 gal
– Used tires	39,680 lb
– Scrap metal	3,887,733 lb
– Lead acid batteries	99,480 lb
Public and negotiated sales:	
– Brass	5,841 lb
– Miscellaneous furniture	10,332 lb
– Vehicles and miscellaneous equipment/materials	635,430 lb
External transfers	N/A

Note: *External transfers include vehicles, miscellaneous equipment, and materials transferred to various federal, state, and local agencies for reuse during FY 2024. Y-12 transferred property with an acquisition value of approximately $2,628,244; however, the weight of the transferred items in pounds was unable to be quantified.*

The paths discussed in Sections 4.3.14.1 and 4.3.14.2 use pre-approved authorized limits as outlined in DOE Order 458.1. The basis of these standards is to limit the dose to any member of the public to a maximum of 1.0 mrem (0.01 mSv) per year total effective dose from clearing materials from regulatory control. These authorized limits are applicable to the release of personal property only (including recycled material). No real property was released from Y-12 in 2024.

4.3.14.1. Property Potentially Contaminated on the Surface

Property that is potentially contaminated on the surface is completely surveyed, unless it can be released based on process knowledge or through a survey plan that provides survey instructions, along with technical justification (process knowledge) for the plan, based on NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual* (NRC 2000) and NUREG-1575, Supplement 1, *Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual* (NRC 2009). Table 4.6 lists the surface contamination limits used at Y-12 to determine whether materials and equipment (M&E) are suitable for release to the public.

As noted in Table 4.6, Y-12 uses an administrative limit for average and maximum activity of 240 dpm/100 cm^2 for radionuclides in Group 3 and 2,400 dpm/100 cm^2 for radionuclides in Group 4. Y-12 also uses an administrative limit for removable activity of 240 dpm/100 cm^2 for radionuclides in Group 3. Using the more-restrictive administrative limits ensures that M&E do not enter into commerce exceeding the definition of contamination for high-toxicity alpha emitters and for beta and gamma emitters, respectively, found in 49 CFR 173, *Shippers—General Requirements for Shipments and Packaging*.

4.3.14.2. Property Potentially Contaminated in Volume

Materials, such as activated materials, smelted-contaminated metals, liquids, and powders, are subject to volumetric contamination (i.e., radioactivity per unit volume or per unit mass) and are treated separately from surface-contaminated objects. Materials that may be subject to volumetric contamination are evaluated for release by one of the following three methods:

- **Unopened, sealed containers.** Material is in an original manufacturer's sealed, unopened container. A seal can be visible (e.g., lock tabs, heat shrink) or unseen (e.g., unbroken fluorescent bulbs, sealed capacitors), as long as the container remains unopened.
- **Process knowledge.** If contamination being able to enter a system is unlikely, then process knowledge is documented and used as the basis for release. Often, this is accompanied by confirmatory surveys.
- **Analytical.** The material is sampled, and the results are evaluated against the preapproved authorized limits in DOE Order 458.1. If preapproved authorized limits have not been obtained, then analytical results are evaluated against measurement method critical levels or background levels from materials that have not been impacted by Y-12 activities. If results meet defined criteria, then they are documented, and the material is released.

Y-12 was granted approval to use the DOE Order 458.1 preapproved authorized limits for volumetric contamination on July 20, 2021, which is documented in NPO letter COR-NP0-60 ESH-7.20.2021-919599, "Approval to Use Pre-Approved Authorized Limits for the Release and Clearance of Volumetric Radioactivity of Personal Property" (NNSA 2021). Table 4.7 lists these volumetric contamination limits for various groups of radionuclides. When multiple radionuclides exist in a single sample, a sum of fractions is used to verify that material meets the specified limits.

Table 4.6. DOE Order 458.1 preapproved authorized limits for surface contamination[a,b]

Radionuclide[c]	Average[d,e]	Maximum[d,e]	Removable[f]
Group 1: Transuranics, ^{125}I, ^{129}I, ^{227}Ac, ^{226}Ra, ^{228}Ra, ^{228}Th, ^{230}Th, ^{231}Pa	100	300	20
Group 2: Th-natural, ^{90}Sr, ^{126}I, ^{131}I, ^{133}I, ^{223}Ra, ^{224}Ra, ^{232}U, ^{232}Th	1,000	3,000	200
Group 3: U-Natural, ^{235}U, ^{238}U, associated decay products, alpha emitters	5,000	15,000	1,000
Group 4: Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission), except ^{90}Sr and others noted above[g]	5,000	15,000	1,000
Tritium (applicable to surface and subsurface)[h]	N/A	N/A	10,000

[a] *The values in this table (except for tritium) apply to radioactive material deposited on but not incorporated into the interior or matrix of the property. Authorized limits for residual radioactive material in volume must be approved separately.*

[b] *As used in this table, disintegrations per minute means the rate of emission by radioactive material, as determined by counts per minute measured by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.*

[c] *Where surface contamination by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides should apply independently.*

[d] *Measurements of average contamination should not be averaged over an area of more than 1 m^2. Where scanning surveys are not sufficient to detect levels in the table, static counting must be used to measure surface activity. Representative sampling (static counts on the areas) may be used to demonstrate by analyses the static counting data. The maximum contamination level applies to an area of not more than 100 cm^2.*

[e] *The average and maximum dose rates associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at 1 cm.*

[f] *The amount of removable material per 100 cm^2 of surface area should be determined by wiping an area of that size with dry filter or soft absorbent paper, applying moderate pressure, and measuring the amount of radioactive material on the wiping with an appropriate instrument of known efficiency. When removable contamination of objects on surfaces of less than 100 cm^2 is determined, the activity per unit area should be based on the actual area, and the entire surface should be wiped. Wiping techniques to measure removable contamination levels are unnecessary if direct scan surveys indicate the total residual surface contamination levels are within the limits for removable contamination.*

[g] *This category of radionuclides includes mixed fission products, including ^{90}Sr that is present in them. It does not apply to ^{90}Sr that has been separated from other fission products or mixtures where ^{90}Sr has been enriched.*

[h] *Measurement should be conducted by a standard smear measurement but using a damp swipe or material that will readily absorb tritium, such as polystyrene foam. Property recently exposed or decontaminated should have measurements (smears) at regular time intervals to prevent a buildup of contamination over time. Because tritium typically penetrates material it contacts, the surface guidelines in Group 4 do not apply to tritium. Measurements demonstrating compliance of the removable fraction of tritium on surfaces with this guideline are acceptable to ensure nonremovable fractions and residual tritium in mass will not cause exposures that exceed DOE dose limits and constraints.*

Acronyms:

N/A = not applicable

Table 4.7. DOE Order 458.1 preapproved authorized limits for volumetric contamination[a]

Radionuclide groups[b]	SI units, volume (Bq/g)[f]	Conventional units, volume (pCi/g)[f]
Group 0 Special Case: ^{129}I[c]	0.01	0.3
Group 1 High-energy gamma, radium, thorium, transuranics, and mobile beta-gamma emitters: ^{22}Na, ^{46}Sc, ^{54}Mn, ^{56}Co, ^{60}Co, ^{65}Zn, ^{94}Nb, ^{106}Ru,^{110m}Ag, ^{125}Sb, ^{134}Cs, ^{137}Cs, ^{152}Eu, ^{154}Eu,^{182}Ta, ^{207}Bi, ^{210}Po, ^{210}Pb, ^{226}Ra, ^{228}Ra, ^{228}Th,^{229}Th, ^{230}Th, ^{232}Th, ^{232}U, ^{238}Pu, ^{239}Pu, ^{240}Pu,^{242}Pu, ^{244}Pu, ^{241}Am, ^{243}Am, ^{245}Cm, ^{246}Cm, ^{247}Cm, ^{248}Cm, ^{249}Cf, ^{251}Cf, ^{254}Es, and associated decay chains[d], and others[b]	0.1	3
Group 2 Uranium and selected beta-gamma emitters: ^{14}C, ^{36}Cl, ^{59}Fe, ^{57}Co, ^{58}Co, ^{75}Se, ^{85}Sr, ^{90}Sr, ^{95}Zr, ^{99}Tc, ^{105}Ag, ^{109}Cd, ^{113}Sn, ^{124}Sb, ^{123m}Te, ^{139}Ce, ^{140}Ba, ^{155}Eu, ^{160}Tb, ^{181}Hf, ^{185}Os, ^{190}Ir, ^{192}Ir, ^{204}Tl, ^{206}Bi, ^{233}U, ^{234}U, ^{235}U, ^{238}U, natural uranium[e], ^{237}Np, ^{236}Pu, ^{243}Cm, ^{244}Cm, ^{248}Cf, ^{250}Cf, ^{252}Cf, ^{254}Cf, and associated decay chains[d], and others[b]	1	30
Group 3 General beta-gamma emitters: ^{7}Be,^{74}As, ^{93m}Nb, ^{93}Mo, ^{93}Zr, ^{97}Tc, ^{103}Ru, ^{114m}In, ^{125}Sn,^{127m}Te, ^{129m}Te, ^{131}I, ^{131}Ba, ^{144}Ce, ^{153}Gd, ^{181}W, ^{203}Hg, ^{202}Tl, ^{225}Ra, ^{230}Pa, ^{233}Pa, ^{236}U, ^{241}Pu, ^{242}Cm, and others[b]	10	300
Group 4 Low-energy beta-gamma emitters: ^{3}H, ^{35}S, ^{45}Ca, ^{51}Cr, ^{53}Mn, ^{59}Ni, ^{63}Ni, ^{86}Rb, ^{91}Y, ^{97m}Tc, ^{115m}Cd, ^{115m}In, ^{125}I, ^{135}Cs, ^{141}Ce, ^{147}Nd, ^{170}Tm, ^{191}Os, ^{237}Pu, ^{249}Bk, ^{253}Cf, and others[b]	100	3,000
Group 5 Low-energy beta emitters: ^{55}Fe, ^{73}As, ^{89}Sr, ^{125m}Te, ^{147}Pm, ^{151}Sm, ^{171}Tm, ^{185}W, and others[b]	1,000	30,000

[a] *The screening levels for clearance have been rounded to one significant figure and are assigned for volume radioactivity.*

[b] *To determine the specific group for radionuclides not shown, a comparison of the screening factors, by exposure scenario, listed in Tables B. 1, C.1, and D.1 of NCRP Report No. 123I (NCRP 1996) for the radionuclides in question and the radionuclides in the general groups above will be performed and a determination of the proper group made, as described in ANSI/HPS N13.12-2013, Surface and Volume Radioactivity Standards for Clearance, Annex A (HPS 2013).*

[c] *Because of potential ground-water concerns, the volume radioactivity values for ^{129}I when disposal to landfills or direct disposal to soil is anticipated is assigned to Group 0.*

[d] *For decay chains, the screening levels represent the total activity (i.e., the activity of the parent plus the activity of all progeny) present.*

[e] *The natural uranium screening levels for clearance shall be lowered from Group 2 to Group 1 if decay-chain progeny are present (i.e., uranium ore versus process or separated uranium, for example, in the form of yellowcake). The natural uranium activity equals the activity from uranium isotopes (48.9 percent from ^{238}U, plus 48.9 percent from ^{234}U, plus 2.2 percent from ^{235}U). This approach is consistent with summing radionuclide fractions discussed in ANSI/HPS N13.12-2013, Section 4.4 (HPS 2013).*

[f] *Each individual limit applies to the particular radionuclides, but must be summarized and the Sum of Fractions must be ≤ 1.*

4.3.14.3. Process Knowledge

Process knowledge is used to release property from Y-12 without monitoring or analytical data and to implement a graded approach (less than 100 percent monitoring) for monitoring of some M&E (Classes II and III, NRC 2009). A conservative approach (nearly 100 percent monitoring) is used to release older M&E for which a complete and accurate history is difficult to compile and verify (Class I, NRC 2009). The process knowledge evaluation processes are outlined in Y-12 procedures.

The following are examples of M&E released without monitoring based on process knowledge; however, this does not preclude conducting verification monitoring before sale:

- All M&E from rad-free zones
- Pallets generated from noncontaminated areas
- Pallets that are returned to shipping during the same delivery trip
- Lamps from noncontaminated areas
- Drinking water filters
- M&E approved for release by radiological engineering technical review
- Portable restrooms used in noncontaminated areas
- Documents, mail, diskettes, compact disks, and other office media
- Personal M&E
- Paper, plastic products, water bottles, aluminum beverage cans, and toner cartridges
- Office trash, housekeeping materials, and associated waste
- Breakroom, cafeteria, and medical wastes
- Medical and bioassay samples generated in noncontaminated areas
- Subcontractor, vendor, and privately owned vehicles, tools, and equipment used in noncontaminated areas
- M&E that are administratively released
- M&E that were delivered to stores in error and that have not been distributed to other Y-12 locations
- New computer equipment distributed from the Central Computing Facility
- Subcontractor, vendor, and privately owned vehicles, tools, and equipment that have not been used for excavation activities
- New cardboard
- Consumer glass containers

4.4. Air Quality Program

Sections of Y-12's Title V Permit 571832 contain requirements that are generally applicable to most industrial sites. Examples include requirements associated with control of asbestos, stratospheric ozone-depleting chemicals, and fugitive emissions.

The Title V permit contains specific requirements directly applicable to individual sources of air emissions at Y-12. Major requirements in that section include 40 CFR 61, *National Emission Standards for Hazardous Air Pollutants* (NESHAP), and numerous requirements associated with emissions of criteria pollutants and other nonradiological hazardous air pollutants. In addition, a number of sources that are exempt from permitting requirements under state rules but subject to listing on the Title V permit application are documented, and information about them is available upon request from the Y-12 Clean Air Program.

4.4.1. Construction and Operating Permits

The following Title V permitting actions were submitted and approved in 2024:

- An insignificant activity exemption was completed for the Dismantlement Glovebox GB01 operation in Building 9204-2E.

- A minor permit modification request was made to remove non-operational stationary emergency engines/generators from the Title V air permit.
- An insignificant activity exemption was completed for the walk-in hood process in Building 9204-2E.
- A minor permit modification request was made to add a direct chip melt bottom load furnace operation to Stack 1 processes in Building 9215.
- An operational flexibility request was made to add a new computer numerical control turning and milling machine to the Graphite Carbon Machine Shop in Building 9201-1.
- An insignificant activity request determination was made to add a stationary emergency use internal combustion engine/generator at Building 9103 to the insignificant section of the Title V air permit.
- An insignificant activity exemption was complete for the existing and new electron beam welding operations in Building 9204-2E.
- A minor permit modification request was made to add site remediation activities to the Title V operating air permit.
- A minor permit modification request was made to add a new stationary emergency/standby engine/generator at Building 9225-03 to the Title V air permit.
- An initial notification report for the new stationary emergency/standby engine/generator at Building 9225-03 was made.
- An insignificant activity exemption was completed for the electropolishing operation in Building 9202.
- An insignificant activity exemption was completed for the Room 239 process in Building 9202.
- An insignificant activity exemption was completed for the Development prototype process in Building 9202.
- An insignificant activity request determination was made to add a stationary emergency use internal combustion engine/generator at Building 9949-C1 to the insignificant section of the Title V air permit.

Demonstrating compliance with air permits conditions is a significant effort at Y-12. Key compliance elements are maintaining and operating control devices, monitoring, recordkeeping, and reporting.

High-efficiency particulate air filters and scrubbers are control devices used throughout Y-12. In-place testing to verify the integrity of the filters is routinely performed. Scrubbers are operated and maintained in accordance with source-specific procedures. Monitoring tasks consist of continuous stack sampling, onetime stack sampling, and operation of control devices. The radiological stack monitoring systems on numerous sources throughout Y-12 are part of continuous stack sampling efforts.

The Y-12 sitewide permit requires annual and semiannual reports, including the following:

- Annual ORR radiological NESHAP report, which includes specific information regarding Y-12 radiological emissions.
- Annual Title V compliance certification report, which indicates compliance status with all conditions of the permit.
- Title V semiannual report, which covers a 6-month period for some specific emission sources and consists of monitoring and recordkeeping requirements for the sources.
- Boiler maximum available control technology report for the Y-12 Steam Plant, which requires the boilers to be tuned annually.

Table 4.8 lists the actual emissions versus allowable emissions for the Y-12 Steam Plant.

Table 4.8. Actual versus allowable air emissions from the Y-12 Steam Plant, 2024

Emissions (tons/yr)[a]			
Pollutant	**Actual**	**Allowable**	**Percentage of allowable**
Particulate	2.64	41.0	6.40
Sulfur dioxide	0.21	39.0	0.54
Nitrogen oxides[b]	11.12	81.0	13.70
VOCs[b]	1.91	9.4	20.30
Carbon monoxide[b]	29.19	139.0	21.00

[a] *1 ton = 907.2 kg.*

[b] *When no applicable standard or enforceable permit condition exists for a pollutant, the allowable emissions are based on the maximum actual emissions calculation, as defined in TDEC Rule 1200-3-26-.02(2)(d)3 (maximum design capacity for 8,760 h/yr) (TDEC 2024a). Both actual and allowable emissions were calculated based on the latest EPA compilation of air pollutant emission factors (EPA 1995, 1998).*

Note: *The emissions are based on fuel usage data for January through December 2024. The VOC emissions include VOC hazard air pollutant emissions.*

Acronym:

TDEC = Tennessee Department of Environment and Conservation *VOC = volatile organic compound*

4.4.1.1. Generally Applicable Permit Requirements

Y-12, like many industrial sites, has a number of generally applicable requirements, such as those pertaining to managing and controlling asbestos, ozone-depleting substances, and fugitive particulate emissions.

Asbestos control

Y-12 also has a number of general requirements applicable to removing and disposing of asbestos-containing materials, including monitoring, notifying TDEC of demolitions and renovations, and prescribed work practices for abating and disposing of asbestos materials. There was no reportable release of asbestos in 2024. There were six notifications and six revisions of asbestos demolitions and renovations. Asbestos, ozone-depleting substances, and fugitive particulate emissions are notable examples.

Stratospheric Ozone Protection and Hydrofluorocarbon Phasedown

As required by the 1990 CAA Amendment Title VI, *Stratospheric Ozone Protection,* and in accordance with 40 CFR 82, *Protection of Stratospheric Ozone,* actions have been implemented to comply with the prohibition against intentionally releasing ozone-depleting substances during maintenance activities performed on refrigeration equipment. EPA enacted major revisions to the stratospheric ozone rules in 2017, including regulating non-ozone-depleting substance substitutes as part of 40 CFR 82, Subpart F. These revisions were effective January 1, 2018, for disposal of small appliances and January 1, 2019, for the leak rate provisions for large appliances. There were no appliances at Y-12 that leaked refrigerant in 2024 to trigger this reporting.

On October 1, 2021, EPA began implementing the hydrofluorocarbon phasedown requirements of the American Innovation and Manufacturing Act of 2020, which seeks to reduce hydrofluorocarbon consumption and production to 15 percent of a 2011–2013 baseline by 2036 (AIM 2020). In accordance with 40 CFR 84, *Phasedown of Hydrofluorocarbons,* sitewide use of hydrofluorocarbons is being evaluated to understand future effects of Act phasedowns.

Fugitive particulate emissions

As modernization reduction efforts increase at Y-12, there is a mature project planning process to review, recommend, and implement appropriate work practices and controls to minimize fugitive

dust emissions. The following precautions are used to prevent particulate matter from becoming airborne:

- Where possible, water or chemicals are used to control dust when demolishing existing buildings or structures, performing construction operations, grading roads, or clearing land.
- Asphalt, water, or suitable chemicals are applied on dirt roads, material stockpiles, and other surfaces that can create airborne dusts.
- Hoods, fans, and fabric filters are installed and used to enclose and vent dusty materials.

4.4.1.2. National Emission Standards for Hazardous Air Pollutants for Radionuclides

The release of radiological contaminants, primarily uranium, into the atmosphere at Y-12 occurs almost exclusively as a result of plant production, maintenance, and waste management activities. The major radionuclide emissions contributing to the dose from Y-12 are ^{234}U, ^{235}U, ^{236}U, and ^{238}U, which are emitted as particulates (Figure 4.12). The particle size and solubility class of the emissions are based on review of the operations and processes served by the exhaust systems to determine the quantity of uranium handled in the operation or process, the physical form of the uranium, and the nature of the operation or process. The following four categories of processes or operations are considered when calculating the total uranium emissions:

- Those that exhaust through monitored stacks
- Unmonitored processes for which calculations are performed according to Appendix D of 40 CFR 61
- Processes or operations exhausting through laboratory hoods, also involving 40 CFR 61, Appendix D, calculations
- Emissions from room ventilation exhausts (calculated using radiological control monitoring data from the work area)

Continuous sampling systems are used to monitor emissions from a number of process exhaust stacks at Y-12. In addition, a probe cleaning program is in place, and the results from the cleaning at each source are incorporated into the respective emission point source terms. In 2024, 24 process exhaust stacks were continuously monitored, 23 of which were major sources, and the remaining stack was a minor source. The sampling systems on the stacks have been approved by EPA Region 4.

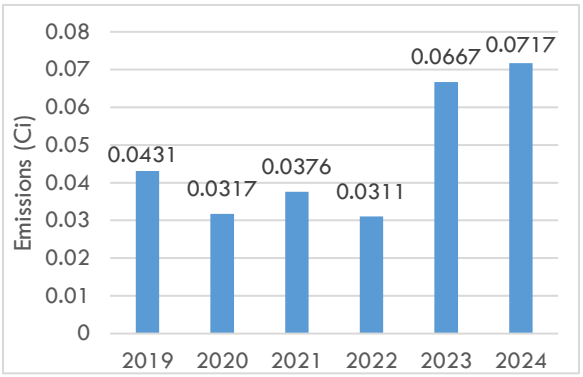


Figure 4.12. Total curies of uranium discharged from Y-12 to the atmosphere, 2019–2024

During 2024, unmonitored uranium emissions occurred from 45 points associated with on-site unmonitored processes and laboratories. Emission estimates for the processes and laboratory stacks were made using inventory data with emission factors provided in 40 CFR 61, Appendix D. The Y-12 source term includes an estimate of these emissions.

The Analytical Chemistry organization operates two main laboratories. One is located in Building 9995, and the other is located in a leased facility on Union Valley Road, about 0.3 mi east of Y-12 and outside the ORR boundary. In 2024, there were no radionuclide emission points (or sources) in the off-site laboratory facility.

Additionally, estimates from room ventilation systems are considered, using radiological control data on airborne radioactivity concentrations in the work areas. Where applicable, exhausts from any area where the monthly concentration average exceeds 10 percent of the derived air

concentration, as defined in *Compliance Plan, National Emission Standards for Hazardous Air Pollutants for Airborne Radionuclides on the Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE 2020), are included in the annual source term. Annual average concentrations and design ventilation rates are used to calculate the annual emission estimate for those areas. Four emission points from room ventilation exhausts were identified in 2024 where emissions exceeded 10 percent of the derived air concentration. All emission points fed to monitored stacks, and any radionuclide emissions were accounted for as noted for monitored emission points; therefore, they are not included in the total overall source term for Y-12.

The Y-12 Title V (Major Source) operating permit contains a sitewide, streamlined alternate emission limit for enriched uranium and depleted uranium process emission units. A particulate limit of 907 kg/yr was set for the sources for the purposes of paying fees. The compliance method requires the annual actual mass emission particulate emissions to be generated using the same monitoring methods required for radiological NESHAP compliance. An estimated 0.0717 Ci (34.8 kg) of uranium was released into the atmosphere in 2024 as a result of Y-12 process and operational activities.

The calculated radiation dose to the maximally exposed off-site individual from airborne radiological release points at Y-12 during 2024 was 0.5 mrem. This dose is well below the NESHAP standard of 10 mrem and is less than 0.2 percent of the roughly 300 mrem that the average individual receives from natural sources of radiation. Chapter 7 discusses how the airborne radionuclide dose was determined.

Lastly, UPF currently is being constructed to house some of the processes that are in existing production buildings. The UPF project was included in the 2018 update of the Y-12 Site Title V Operating Permit, and the facility will be maintained on the Title V Permit as inactive until operations commence.

4.4.1.3. Quality Assurance

Quality assurance (QA) activities for the radiological NESHAP program are documented in Y/TS 874, *Y-12 Plant Quality Assurance Project Plan for National Emission Standards for Hazardous Air Pollutants (NESHAP) Radionuclide Emission Measurements*, which satisfies the QA requirements in 40 CFR 61, Method 114, for ensuring that radionuclide air emission measurements from Y-12 are representative to known levels of precision and accuracy and that administrative controls are in place to ensure prompt response when emission measurements indicate an increase over normal radionuclide emissions (CNS 2020a).

The requirements are also referenced in TDEC Regulation 0400-30-38, "Emission Standards for Hazardous Air Pollutants" (TDEC 2022). The plan ensures the quality of Y-12 radionuclide emission measurements data from the continuous samplers and minor radionuclide release points. It specifies the procedures for managing activities affecting data quality. QA objectives for completeness, sensitivity, accuracy, and precision are discussed. Major programmatic elements addressed in the QA plan are the sampling and monitoring program, emissions characterization, analytical program, and minor source emission estimates.

4.4.1.4. Source-Specific Criteria Pollutants

Proper maintenance and operation of control devices, such as high-efficiency particulate air filters and scrubbers, helps control emissions of criteria pollutants. The primary source of criteria pollutants at Y-12 is the steam plant, where only natural gas and Number 2 fuel oil are permitted to be burned. Actual versus allowable emissions from the steam plant are listed in Table 4.8.

Particulate emissions from point sources result from many operations throughout Y-12. Compliance is demonstrated through several activities, including monitoring the operations of control devices, limiting process input materials, and using certified readers to conduct emission evaluations of visible stacks.

Use of solvent 140/142, methanol, and vertrel throughout Y-12 and volatile organic compounds (VOCs) from the steam plant are primary sources of VOC emissions. Material mass balances and engineering calculations are used to determine annual emissions. The calculated amounts of solvent 140/142 and methanol emitted for 2024 are 8,336.54 lb (4.17 tons) and 220 lb (0.73 tons), respectively.

4.4.1.5. Mandatory Reporting of Greenhouse Gas Emissions Under 40 CFR 98

40 CFR 98, *Mandatory Reporting of Greenhouse Gases*, establishes reporting requirements for owners and operators of certain facilities that directly emit GHGs and for certain fossil fuel suppliers and industrial GHG suppliers. The purpose of the rule is to collect accurate and timely data on GHG emissions that can be used to inform future policy decisions.

The rule requires reporting annual emissions of carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons, perfluorochemicals, and other fluorinated gases (e.g., nitrogen trifluoride and hydrofluorinated ethers). These gases are often expressed in metric tons of carbon dioxide equivalent (CO_2e).

Y-12 is subject only to Subpart A general provisions and reporting from stationary fuel combustion sources covered in 40 CFR 98, Subpart C, "General Stationary Fuel Combustion." Currently, the rule does not require control of GHGs; rather, it requires only monitoring and reporting by sources emitting above the 25,000 CO_2e threshold level.

The Y-12 Steam Plant is subject to this rule. The steam plant has four boilers. The maximum heat input capacity of each boiler does not exceed 99 million Btu/h. Natural gas is the primary fuel source for the boilers; Number 2 fuel oil is a backup fuel source. Other limited, stationary combustion sources are metal-forming operations and production furnaces that use natural gas.

In Building 9212, a gas-fired furnace used for drying wet residues and burning solids in a recovery process has a maximum heat input of 700,000 Btu/h. In Building 9215, 10 natural gas torches, each at 300 standard ft^3/h, are used to preheat tooling associated with a forging and forming press. In Building 9204-02, natural gas is used to heat two electrolytic cells. The maximum rated heat input to the burners on each cell is 550,000 Btu/h.

All of the combustion units burning natural gas are served through the fuel supply and distribution system and are reported as combined emissions consistent with the provisions of 40 CFR 98.36(c)(3). The Tier 1 method was used to calculate GHGs from Y-12. The amount of natural gas supplied to the site, along with the fuel use logs, provides basic information required for calculating GHG emissions.

The emissions report is submitted electronically in the EPA-specified format. Each report is signed by a designated representative of the owner or operator, certifying under penalty of law that the report has been prepared in accordance with the requirements of the rule. The total amount of GHGs, subject to the mandatory reporting rule, emitted from Y-12, is shown in Table 4.9. The decrease in emissions from 2010 to 2017 is because coal is no longer burned since the natural gas-fired steam plant became operational. The slight increase in CO_2e emissions was because fuel oil was burned for a few days in December 2018. A slightly decrease in CO_2e emissions in 2024 was primarily due to no oil and less natural gas being burned in the steam plant boilers.

Table 4.9. Greenhouse gas emissions from stationary fuel combustion sources

Year	Greenhouse gas emissions (metric tons CO_2e)
2010	97,610
2011	70,187
2012	63,177
2013	61,650
2014	58,509
2015	51,706
2016	50,671
2017	50,292
2018	51,010
2019	45,971
2020	46,126.8
2021	43,812.7
2022	43,224.2
2023	42,083.1
2024	40,769.0

4.4.1.6. Hazardous Air Pollutants (Nonradiological)

Beryllium emissions from machine shops are regulated under a state-issued permit and are subject to a limit of 10 g/24 h. Compliance is demonstrated through a onetime stack test and monitoring control device operations. Hydrogen fluoride is used at one emission source, and emissions are controlled through scrubber systems. The beryllium control devices and the scrubber systems were monitored during 2024 and found to be operating properly.

Methanol is released as fugitive emissions (e.g., pump and valve leaks) as part of the brine and methanol system. It is subject to state air permit requirements; however, due to the nature of its release (fugitive emissions only), no specific emission limits or mandated controls exist.

Mercury is a significant legacy contaminant at Y-12, and cleanup is being addressed by DOE EM. Like methanol emissions, mercury air emissions from legacy sources are fugitive in nature and, therefore, are not subject to specific air emission limits or controls. On-site monitoring of mercury is conducted as discussed in Section 4.4.2.1.

In 2007, EPA vacated a proposed Maximum Achievable Control Technology standard that was intended to minimize hazardous air pollutant emissions. At that time, a case-by-case Maximum Achievable Control Technology review was conducted as part of the construction-permitting process for the Y-12 replacement steam plant. The new natural gas-fired steam plant became operational on April 20, 2010, and coal is no longer combusted. Specific conditions aimed at minimizing hazardous air pollutant emissions from the new steam plant were incorporated into the operating permit issued on January 9, 2012, as discussed in Section 4.4.1. In addition, the boiler Maximum Achievable Control Technology standard was revised and reissued on January 31, 2013. TDEC issued a minor modification to the Title V air permit on October 29, 2014, which included the new boiler Maximum Achievable Control Technology requirements. The new requirements (work practice standards) include conducting annual tune-ups and a onetime energy assessment of the boilers to meet these requirements.

The steam plant has no numeric emission limit requirements. The new rule requires that a onetime energy assessment for the steam plant be completed on or after January 1, 2008. The new rule requires that tune-ups for the boilers must be completed 13 months from previous tune-ups. To comply with that requirement, an energy assessment for the Y-12 Steam Plant, performed by a qualified energy assessor, was completed in July 2013. Tune-ups for Boilers 1, 3, and 4 were completed on March 5, 2024. Boiler 2 was placed back into service on August 20, 2024. The tune-up was completed for Boiler 2 on September 18, 2024, within the required 30 calendar days of startup, as outlined by the Title V air permit.

Unplanned releases of hazardous air pollutants are regulated through risk management planning regulations. Y-12 personnel have determined no processes or facilities contain inventories of chemicals in quantities exceeding thresholds specified in rules pursuant to CAA, Title III,

Section 112(r), "Accidental Release Prevention/Risk Management Plan Rule." Therefore, Y-12 is not subject to that rule.

Procedures are in place to review new processes and/or process changes against the rule thresholds.

EPA has created multiple national regulations to reduce air emissions from reciprocating internal combustion engines. Two federal air standards are applicable to these engines: 40 CFR 60, *Standards of Performance for New Stationary Sources*, Subpart IIII, and 40 CFR 63, *National Emission Standards for Hazardous Air Pollutants for Major Sources: Industrial, Commercial, and Institutional Boilers and Process Heaters*, Subpart DDDDD. The compression ignition engines and generators located at Y-12 are subject to these rules. EPA is concerned how reciprocating internal combustion engines are used and the emissions generated from these engines in the form of both hazardous air pollutants and criteria pollutants.

All previous stationary emergency engines and generators were listed in Y-12's Title V air permit application as insignificant activities. However, on January 16, 2013, EPA finalized revisions to standards to reduce air pollution from stationary engines that generate electricity and power equipment at sites of major sources of hazardous air pollutants. Regardless of engine size, the rules apply to any existing, new, or reconstructed stationary reciprocating internal combustion engine located at a major source of hazardous air pollutant emissions.

To comply with the rules, Y-12 prepared a significant permit modification to its Title V (Major Source) Operating Air Permit to add numerous stationary emergency-use engines and generators located throughout the site. The permit application was submitted to TDEC on May 6, 2013. TDEC downgraded the significant modification to a minor modification according to EPA's review and request. In a prior, updated permit application for renewal of Y-12's Title V (Major Source) Operating Air Permit dated March 9, 2011, Y-12 staff identified 40 CFR 60, Subpart IIII, "Standards of Performance for Stationary Compression Ignition Internal Combustion Engines," as applicable to the stationary emergency-use engines located at Y-12.

TDEC issued Y-12 a minor permit modification to the Title V air permit on March 3, 2014, for the emergency engines and generators. Compliance for the engines and generators is determined through monthly operational records that are recorded through a nonresettable hour meter on each engine and generator. The number of hours spent for emergency operation, maintenance checks and readiness testing, and nonemergency operation must be documented. Each engine and generator must use only diesel fuel with low sulfur content (15 ppm) and an acetane index of 40. The vendor, Rogers Petroleum, supplied a onetime statement certifying that all diesel fuel will contain no more than 15 ppm of sulfur by weight and will either have a minimum acetane index of 40 or a maximum aromatic content of 35 volume percent.

Since the above rules were adopted into Tennessee Air Pollution Control regulations, the emergency engines and generators can be considered an insignificant activity if the potential to emit is below the significance thresholds (less than 5 tons/yr of each criteria pollutant and less than 1,000 lb/yr of any hazardous air pollutant evaluated at a 500 h/yr limit). There was also a change to the Tennessee Air Pollution Control regulations that allows for stationary engines to be eligible to be considered insignificant activities. Condition D14 of the Title V permit was amended to incorporate new language specifying stationary reciprocating internal combustion engines are eligible to be considered insignificant activities that must comply with any underlying applicable rules associated with a stationary internal combustion engine.

The emergency engines and generators are used to provide power for critical systems in the event of electrical power failures and outages at Y-12. The engines and generators operate exclusively as emergency engines and generators. Based upon historical usage of the emergency engines, generators, and fire water pumps, and EPA's 500-h default assumption (maximum hour usage),

calculations verify and confirm that potential emissions from each stationary, emergency, internal combustion engine less than 645 hp qualifies, or should be reclassified, as an insignificant activity because the potential to emit is well below the significance thresholds of less than 5 tons/yr of each regulated air pollutant that is not a hazardous air pollutant, and less than 1,000 lb/yr of any hazardous air pollutant, in accordance with Tennessee Air Pollution Control Regulation 1200-03-09-.04(5)(a)4(i) (TDEC 2024d). Approximately 95 percent of Y-12's stationary, emergency engines, generators, and fire water pumps are considered and/or are reclassified as an insignificant activity in accordance with the regulation. These engines are listed in Y-12's Title V air permit.

4.4.1.7. Site Remediation Activities Under the National Emission Standards for Hazardous Air Pollutants (40 CFR 63, Subpart GGGGG)

The Site Remediation Rule (40 CFR 63, Subpart GGGGG) was originally promulgated and effective on October 8, 2003, under the CAA. The rule was aimed at controlling hazardous air pollutants (HAPs) from site remediation. The final rule included an exemption for CERCLA and RCRA corrective action.

After the 2003 rule was issued, the Sierra Club and other environmental groups petitioned the EPA to reconsider the rule and challenged that the agency did not have the authority to exempt CERCLA/RCRA sites under the CAA. On May 13, 2016, EPA proposed amendments to the NESHAP for emissions resulting from site remediations, which are codified at 40 CFR 63, Subpart GGGGG. The proposed amendments were to remove exemptions from the rule for site remediation activities performed under the authority of CERCLA and RCRA corrective action or other required RCRA order.

In 2019, the EPA recommended further amendments to the NESHAP to reflect over a decade of technological advancements that would enable stricter standards. On March 12, 2020, the EPA finalized amendments to the 2003 NESHAP rule for site remediation, and on December 22, 2022, the EPA finalized amendments to the NESHAP for the site remediation source category (40 CFR 63, Subpart GGGGG), which removed exemptions for remediation activities performed under the authority of the CERCLA and RCRA corrective action. Subpart GGGGG applies to active remediation operations at sites that are major sources of HAPs and are co-located at a facility regulated by another NESHAP.

This rule establishes national emissions limitations and work practices standards for HAPs emitted from site remediation activities. It also establishes requirements to demonstrate initial and continuous compliance with the emissions limitations and work practice standards [i.e., sets requirements for volatile organic HAPs (VOHAPs)]. The rule lists more than 90 VOHAPs.

The rule applies to facilities that meet all three of the following conditions as specified in paragraphs (a)(1) through (3) of §63.7881 of the subpart:

(1) Facility conducts site remediation;

(2) Site remediation is co-located with HAP sources; and

(3) Facility is a major HAP source.

Y-12 meets all three requirements listed above. Since the EPA has removed the CERCLA and RCRA exemptions, Y-12 is no longer exempt from the requirements of this rule.

Although the requirements now apply to site remediation activities, Y-12 site remediation activities are only subject to the recordkeeping requirements in §63.7881(c), provided the following criteria are met:

- Determine that the total quantity of the HAP (as listed in the rule) contained in the remediation material excavated, extracted, pumped, or otherwise removed during all of the site remediation conducted is less than 1 megagram (about 2,205 lb) on an annual basis.
- Prepare and maintain written documentation to support the determination that the total HAP quantity is less than 1 megagram (about 2,205 lb) on an annual basis.

- The requirement must be included in the Title V air permit when it is reopened or revised for any reason.

The proposed rule was finalized and issued on December 22, 2022. A site has 18 months from the effective date of the final rule to comply with the requirements.

If the remediation source commenced construction on or before May 13, 2016, the site must comply with the requirements of Subpart GGGGG no later than December 22, 2022, or upon initial startup, whichever is later. If the remediation source commenced construction on or before May 13, 2016, the site must comply with the requirements of Subpart GGGGG no later than June 24, 2024.

The average total VOHAP concentration of a remediation material must be determined by using direct measurement or by knowledge as specified in the rule. The following methods may be used to determine the average VOHAP concentration of any material listed.

- **Direct measurement.** The average total VOHAP concentration of a remediation material must follow the procedures in §63.7943(b)(1) through (3). Direct measurement can be done by sampling, analysis, and calculations of each material.
- **Knowledge of the material.** The average total VOHAP concentration of a remediation material must follow the procedures in §63.7943(c)(1) through (3). Documentation must be prepared that presents the information used as the basis for a person's knowledge of the material stream's average VOHAP concentration.

All samples must be collected and handled according to written procedures prepared and document in a site sampling plan. The plan must describe the procedure by which representative samples of the material streams are collected such that a minimum loss of organics occurs throughout the sample collection and handling process and by which sample integrity is maintained. A copy of the written sampling plan must be maintained on-site in the facility operating records.

The following Y-12 facilities are impacted:

- Liquid Storage Facility/Groundwater Treatment Facility
- East End Volatile Organic Compound Treatment Facility
- Central Mercury Treatment Facility
- Big Spring Water Treatment System
- Outfall 200/Mercury Treatment Facility (future)

In 2024, four separate sampling periods/events were conducted at each of these treatment facilities in accordance with Subpart GGGGG. The average total VOHAP concentration was calculated, resulting in total VOHAP of 0.16 megagram per year, which is well below the 1 megagram limit. Therefore, Y-12 is not subject to the requirements of the rule, except for recordkeeping, provided that Y-12 meets the rule's criteria. Samples at the treatment facilities will continue to be taken every quarter for continuous compliance of the rule.

4.4.2. Ambient Air

To understand the ambient air monitoring in and around Y-12, monitoring is conducted specifically for Y-12, the ORR perimeter, and by TDEC Division of Remediation, Oak Ridge, personnel.

No federal regulations, state regulations, or DOE orders require ambient air monitoring within the Y-12 boundary; however, on-site ambient air monitoring for mercury and radionuclides is conducted as a best management practice. With the reduction of plant operations and improved emission and administrative controls, levels of measured pollutants have decreased significantly. In addition, major processes that emit enriched uranium and depleted uranium are equipped with stack samplers that have been approved by EPA to meet NESHAP requirements.

4.4.2.1. Mercury

The Y-12 Ambient Air Monitoring Program for mercury was established in 1986 as a best management practice. The objectives of the program have been to maintain a database of mercury concentrations in ambient air, to track long-term spatial and temporal trends in ambient mercury vapor, and to demonstrate protection of the environment and human health from releases of mercury to the atmosphere. There are two atmospheric mercury monitoring stations currently operating at Y-12—Ambient Air Station 2 (AAS2) and Ambient Air Station 8 (AAS8)—which are located near the east and west boundaries, respectively, as shown in Figure 4.13. AAS2 and AAS8 have monitored mercury in ambient air continuously since 1986, with the exception of short intervals of downtime because of electrical or equipment outages.

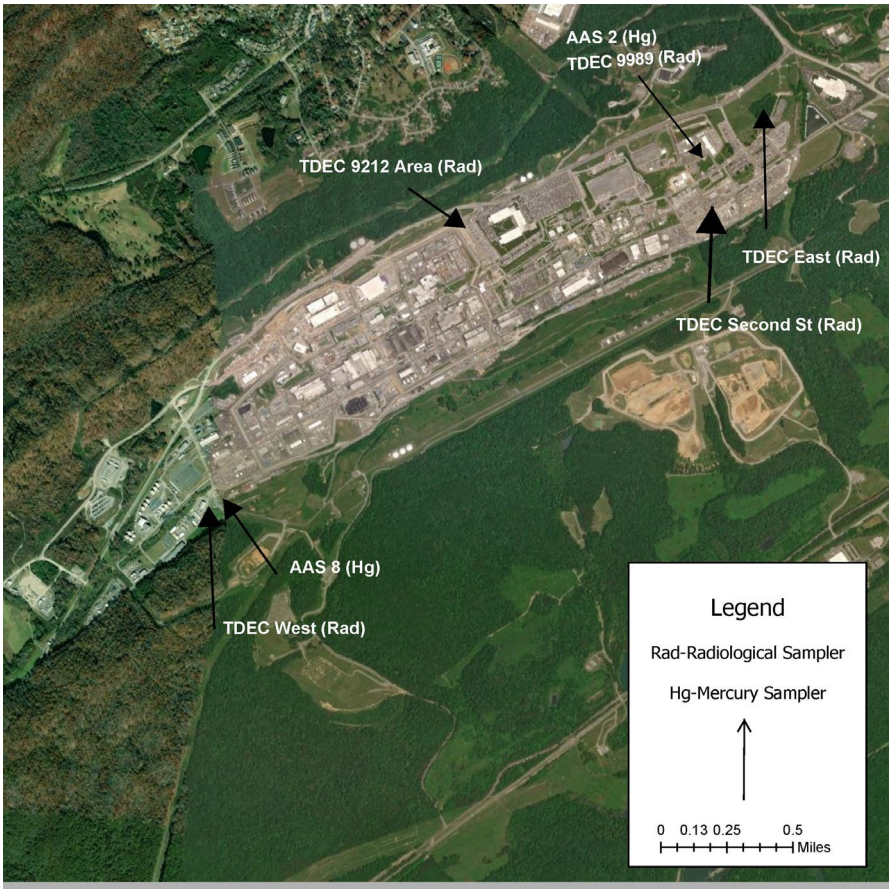
In addition to the Y-12 monitoring stations, two additional monitoring sites have been operated. A reference site (Rain Gauge 2) was developed on Chestnut Ridge in the Walker Branch Watershed for a 20-month period in 1988 and 1989 to establish a reference concentration, and a site was operated at New Hope Pond for a 25-month period from August 1987 to September 1989.

To determine mercury concentrations in ambient air, airborne mercury vapor is collected by pulling ambient air through a sampling train consisting of a Teflon filter and an iodinated-charcoal sampling trap. A flow-limiting orifice upstream of the sampling trap restricts airflow through the sampling train to about 1 L/min. Actual flows are measured bi-weekly with a calibrated Gilmont flowmeter in conjunction with changing the sampling trap. The charcoal in each trap is analyzed for total mercury using cold vapor atomic fluorescence spectrometry after acid digestion. The average concentration of mercury vapor in ambient air for each 14-day sampling period is then calculated by dividing the total mercury per trap by the volume of air pulled through the trap during the corresponding 14-day sampling period.

Average mercury concentration at the ambient air monitoring sites has declined significantly since the late 1980s. Recent average annual concentrations at the two boundary stations are comparable to concentrations measured in 1988 and 1989 at the Chestnut Ridge reference site (Table 4.10). Average mercury concentration at AAS2 for 2024 is 0.0030 μg/m^3 (N = 25), comparable to averages measured since 2003.

After an increase in average concentration at AAS8 for the period 2005 through 2007, possibly due to increased demolition and decommissioning work on the west end, the average concentration at AAS8 for 2024 was 0.0033 μg/m^3 (N = 25), similar to levels reported since 2008 and the early 2000s.

Table 4.10 summarizes the 2024 mercury results with data from 1986 through 1988 included for comparison. Figure 4.14 illustrates temporal trends in mercury concentration for the two active mercury monitoring sites for the period since the inception of the program in 1986 through 2024 (parts [a] and [b]) and seasonal trends at AAS8 from 1994 through 2024 (part [c]). The dashed line superimposed on the plots in Figure 4.14(a) and (b) is the EPA reference concentration of 0.3 μg/m^3 for chronic inhalation exposure. The large increase in mercury concentration at AAS8 observed in the late 1980s (part [b]) was thought to be related to disturbances of mercury-contaminated soils and sediments during Perimeter Intrusion Detection and Assessment System installation and storm drain restoration projects underway at that time within the West End Mercury Area. In Figure 4.14(c), a monthly moving average has been superimposed over the AAS8 data to highlight seasonal trends in mercury at AAS8 from January 1994 through 2024.



Acronyms:

AAS = Ambient Air Station

TDEC = Tennessee Department of Environment and Conservation

Figure 4.13. Locations of ambient air monitoring stations at Y-12

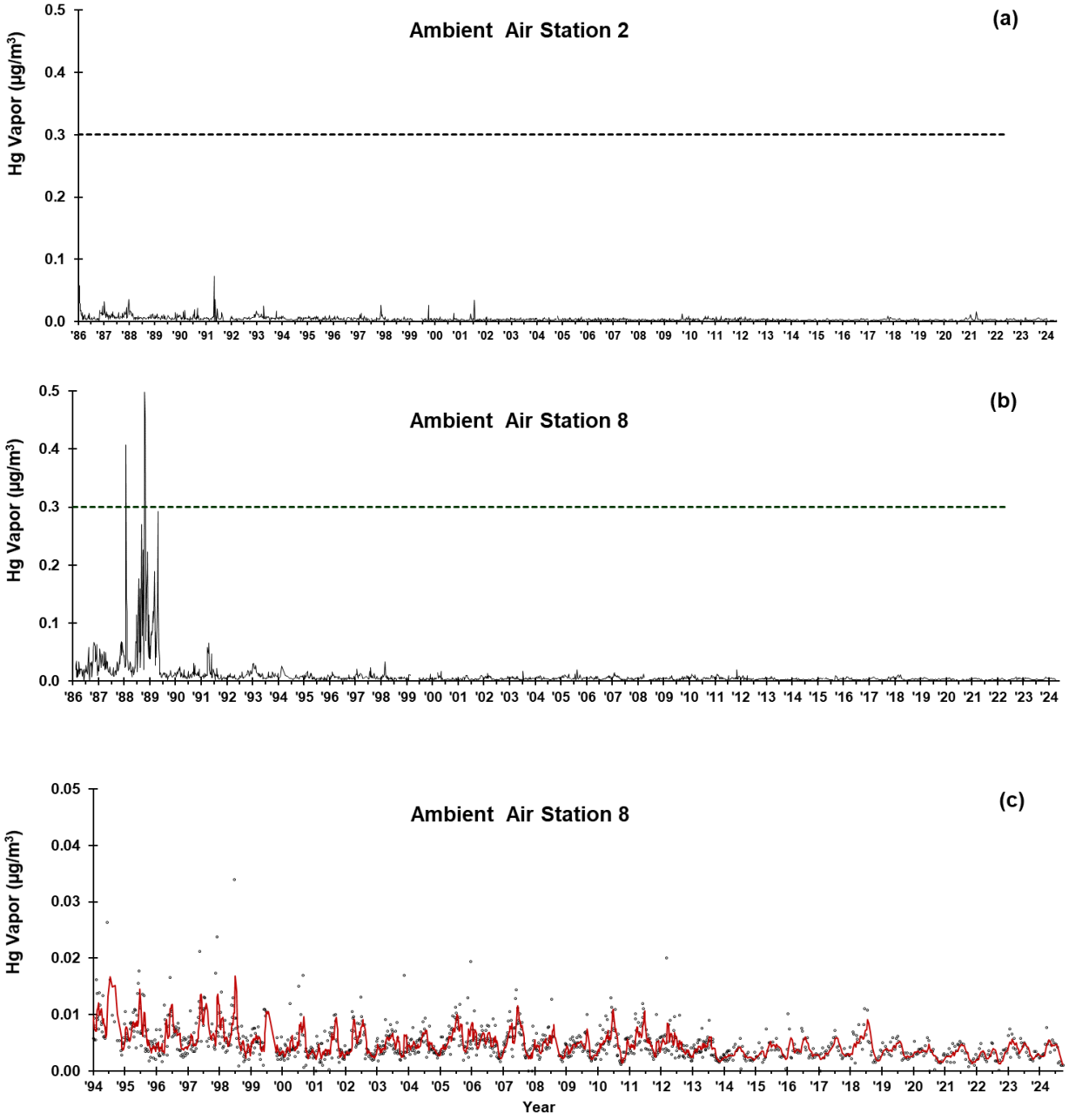
Table 4.10. Summary of data for the Y-12 Ambient Air Monitoring Program for mercury, 2024

Ambient air monitoring stations	Mercury vapor concentration (µg/m³)			
	2024 Minimum	2024 Maximum	2024 Average	1986–1988[a] Average
AAS2 (east end of the Y-12 Complex)	0.0012	0.0064	0.0030	0.010
AAS8 (west end of the Y-12 Complex)	0.0009	0.0077	0.0033	0.033
Reference site, Rain Gauge 2 (1988[b])	N/A	N/A	N/A	0.006
Reference site, Rain Gauge 2 (1989[c])	N/A	N/A	N/A	0.005

[a] *Period in late 1980s with elevated ambient air mercury levels; shown for comparison.*

[b] *Data for period from February 9 through December 31, 1988.*

[c] *Data for period from January 1 through October 31, 1989.*



Note: *The dashed line superimposed on the plots in (a) and (b) is the EPA reference concentration of 0.3 µg/m³ for chronic inhalation exposure. A monthly moving average has been superimposed in (c) over the AAS8 data to highlight seasonal trends in mercury at AAS8 from January 1994 through 2024. Note the different concentration scale on (c).*

Figure 4.14. Temporal trends in mercury vapor concentration for the boundary monitoring stations at Y-12 Complex, July 1986 to December 2024 [(a) and (b)] and January 1994 to December 2024, for Ambient Air Station 8 (c).

The average mercury concentrations at the two mercury monitoring sites in 2024 were comparable to reference levels measured for the Chestnut Ridge reference site in 1988 and 1989. More importantly, measured concentrations continue to be well below current environmental and occupational health standards for inhalation exposure to mercury vapor as determined by the National Institute for Occupational Safety and Health, the American Conference of Governmental Industrial Hygienists, and the EPA.

4.4.2.2. Quality Control

A number of QA and quality control (QC) steps are taken to ensure the quality of the data for mercury in the Ambient Air Monitoring Program.

An hour meter records the actual operating hours between sample changes. This allows for correction of total flow in the event of power outages during the weekly sampling interval.

A Gilmont correlated flowmeter is used for measuring flows through the sampling train. Because these flowmeters have been discontinued, they are shipped back to the manufacturer annually for recalibration in accordance with standards set by the National Institute of Standards and Technology.

A minimum of 5 percent of the samples in each batch submitted to the analytical laboratory are blank samples. The blank sample traps are submitted "blind" to verify trap blank values and to serve as a field blank for diffusion of mercury vapor into used sample traps during storage before analysis.

To verify the absence of mercury breakthrough, 5 percent to 10 percent of the field samples have the front (upstream) and back segments of the charcoal sample trap analyzed separately. The absence of mercury above blank values on the back segment confirms the absence of breakthrough.

Chain-of-custody forms track the transfer of sample traps from the field technicians to the analytical laboratory.

A field performance evaluation was conducted on June 25, 2024, to ensure that proper procedures are followed by the sampling technicians. No abnormalities or problems were noted at the time. Samplers completed all tasks set forth in the sampling procedures.

Sampling station AAS2 experienced a vacuum pump malfunction between July 23, 2024, and August 6, 2024. The pump was removed from service and replaced with a new unit on August 6, 2024.

Sampling station AAS8 experienced a vacuum pump malfunction between April 30, 2024, and May 14, 2024. The pump was removed from service and replaced with a new unit on May 14, 2024.

Analytical QA/QC requirements include the following:

- Use of prescreened and/or laboratory purified reagents
- Analysis of at least two method blanks per batch
- Analysis of standard reference materials
- Analysis of laboratory duplicates (one per 10 samples) (Any laboratory duplicates differing by more than 10 percent at five or more times the detection limit must be rerun [third duplicate] to resolve the discrepancy.)
- Archival of all primary laboratory records for at least 1 year

4.4.2.3. Complementary Ambient Air Monitoring

ORR ambient air monitoring is conducted at multiple locations near the ORR perimeter to measure radiological parameters. Atmospheric dispersion modeling was used to select appropriate sampling locations likely to be affected most by releases from the Oak Ridge facilities. This monitoring provides direct measurement of airborne concentrations of radionuclides, allows facility personnel to determine the relative level of contaminants at the monitoring locations during an emergency,

verifies that the contributions of fugitive and diffuse sources are insignificant, and serves as a check on dose-modeling calculations.

As part of the ORR network, an ambient air station located on the east end of Y-12 (Station 40) measures off-site impacts of Y-12 operations. This station is located near the location of the maximally exposed individual member of the public as determined through dose modeling. ORR network stations are also located in the Scarboro community (Station 46) and just south of the city in the Country Club Estates neighborhood (Station 37).

In addition to this monitoring, multiple high-volume samplers (Figure 4.13) are being used by TDEC's Fugitive Radiological Air Sampling project to monitor air at Y-12. One is located at the west end of the plant, one is east of Building 9212, one is north of Second Street, one is located near AAS2, and one is located on the east end of the plant near the intersection of Scarboro Road and Bear Creek Road.

TDEC also performs ambient air monitoring via precipitation. The EPA RadNet Precipitation Program at the east end of the plant next to the east-end TDEC fugitive air monitor and near ORR perimeter station 40.

Results from TDEC's air monitoring projects at Y-12 and other locations on the ORR are summarized in annual environmental monitoring reports issued by the TDEC Division of Remediation, Oak Ridge Office, and posted on its website **here**.

The State of Tennessee also operates a number of regional monitors to assess ambient concentrations of criteria pollutants such as sulfur dioxide, particulate (various forms), and ozone for comparison against ambient standards. The results are summarized and available through EPA and state reporting mechanisms.

4.5. Water Quality Program

Water quality is monitored at Y-12 to satisfy the NPDES permit and the Industrial Wastewater Discharge Permit. It is also monitored in real time to indicate potential adverse conditions that could be causing an impact on water quality in Upper EFPC.

4.5.1. National Pollutant Discharge Elimination System Permit and Compliance Monitoring

For 2024, the Y-12 NPDES permit (TN0002968) required sampling, analysis, and reporting for about 62 outfalls. Major outfalls are shown in Figure 4.15. The NPDES permit became effective October 1, 2022. (The permit is currently under appeal in part. Y-12 is working with the regulators to resolve.) The number of outfalls changes as they are eliminated or consolidated or if permitted discharges are added. Currently, Y-12 has outfalls and monitoring points in EFPC, Bear Creek, and several tributaries on the south side of Chestnut Ridge, all of which eventually drain to the Clinch River.

Discharges to surface water allowed under the permit include storm drainage; cooling water; cooling tower blowdown; steam condensate; and treated process wastewaters, including effluents from wastewater treatment facilities. Groundwater inflow into sumps in building basements and infiltration to the storm drain system are also permitted for discharge to the creek. The monitoring data collected by sampling and analyzing permitted discharges are compared with NPDES limits where applicable for each parameter. Some parameters, defined as monitor only, have no specified limits.

The water quality of surface streams near Y-12 is affected by current and legacy operations. Discharges from Y-12 processes flow into EFPC before the water exits the site. EFPC eventually flows through the City of Oak Ridge to Poplar Creek and into Clinch River. Bear Creek water quality is affected by area source runoff and groundwater discharges. The NPDES permit requires regular monitoring and storm water characterization in Bear Creek and several of its tributaries.

Requirements of the permit for 2024 were satisfied, and monitoring of outfalls and instream locations indicated excellent compliance. Data obtained as part of the NPDES program, along with other events and observations, are provided in a monthly discharge monitoring report to TDEC. The percentage of compliance with permit discharge limits for 2024 was 100 percent, as shown in Table 4.11.

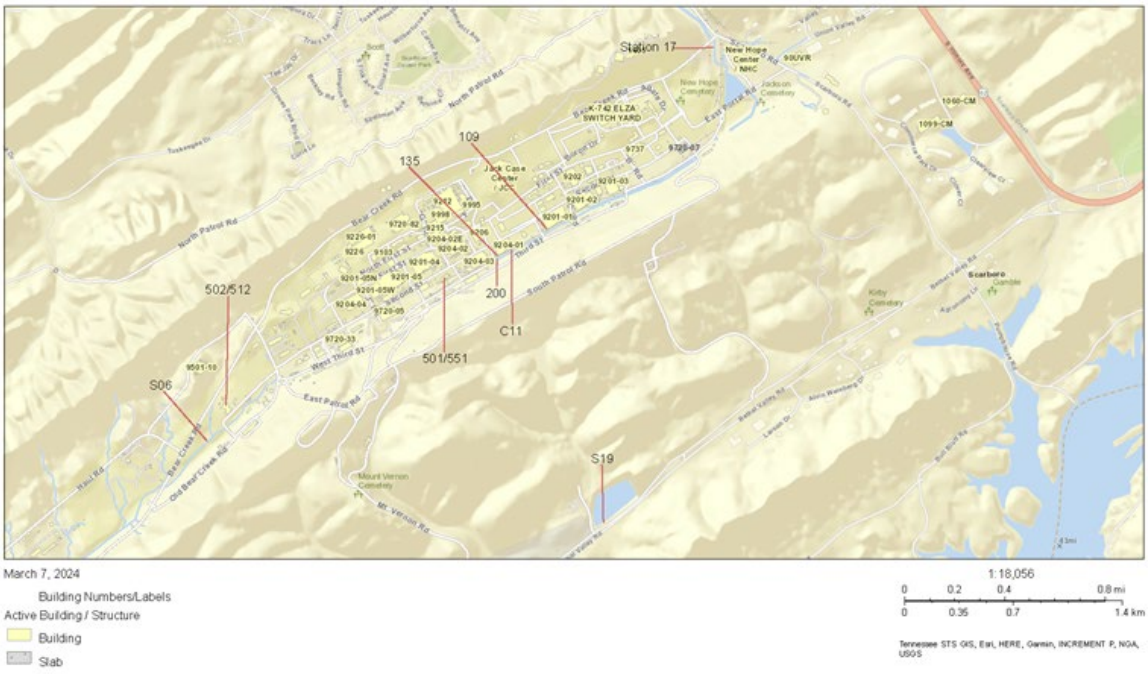


Figure 4.15. Major Y-12 National Pollutant Discharge Elimination System outfalls and monitoring locations

Table 4.11. National Pollutant Discharge Elimination System compliance monitoring requirements and record for Y-12, 2024

Effluent parameter	Daily average (lb)	Daily maximum (lb)	Monthly average (mg/L)	Daily maximum (mg/L)	Percentage of compliance	Number of samples
Outfall 200 (North/South pipes)						
pH, standard units			*a*	9.0	100	14
Temperature, deg C				30.5	100	14
Hexane extractables			10	15	100	13
Cyanide			0.0052	0.022	100	13
Cadmium			0.0043	0.0118	100	13
Silver				0.0081	100	13
Selenium			0.0031	0.02	100	13
PCB, Total				0.00000064	100	12
Total residual chlorine			0.011	0.019	100	13
Ammonia (as N) Summer			1.01	2.02	100	6
Ammonia (as N) Winter			1.92	3.84	100	7
IC_{25} Ceriodaphnia			50% Minimum		100	4
IC_{25} Pimephales			50% Minimum		100	4
Outfall 501 (Central Pollution Control)						
pH, standard units			*a*	9.0	*b*	0
Total suspended solids			31.0	40.0	*b*	0
Total toxic organic				2.13	*b*	0
Hexane extractables			10	15	*b*	0
Cadmium	0.16	0.4	0.07	0.15	*b*	0
Chromium	1.0	1.7	0.5	1.0	*b*	0
Copper	1.2	2.0	0.5	1.0	*b*	0
Lead	0.26	0.4	0.1	0.2	*b*	0
Nickel	1.4	2.4	2.38	3.98	*b*	0
Nitrate/Nitrite				100	*b*	0
Silver	0.14	0.26	0.05	0.05	*b*	0
Zinc	0.9	1.6	1.48	2.0	*b*	0
Cyanide	0.4	0.72	0.65	1.2	*b*	0
PCB				0.001	*b*	0
Outfall 502 (West End Treatment Facility)						
pH, standard units			*a*	9.0	100	1
Total suspended solids		31		40	100	1
Total toxic organic				2.13	100	1
Hexane extractables			10	15	100	1
Cadmium		0.4		0.15	100	1
Chromium		1.7		1.0	100	1

Table 4.11. National Pollutant Discharge Elimination System compliance monitoring requirements and record for Y-12, 2024 (continued)

Effluent parameter	Daily average (lb)	Daily maximum (lb)	Monthly average (mg/L)	Daily maximum (mg/L)	Percentage of compliance	Number of samples
Copper		2.0		1.0	100	1
Lead		0.4		0.2	100	1
Nickel		2.4		3.98	100	1
Nitrate/Nitrite				100	100	1
Silver		0.26		0.05	100	1
Zinc		0.9		1.48	100	1
Cyanide		0.72		1.20	100	1
PCB				0.001	100	1
Outfall 512 (Groundwater Treatment Facility)						
pH, standard units			a	9.0	100	12
PCB				0.001	100	1
Outfall 551						
pH, standard units			a	9.0	100	49
Mercury			0.002	0.004	100	49
Non-Process Outfalls (Dry Weather Sampling) (014, 021, 034, 042,047, 048, 067, 071, 088, 099, 109, 135)						
Temperature				30.5	100	25
pH, standard units			a	9.0	100	28
Ammonia (as N) Summer			1.01	2.02	100	2
Ammonia (as N) Winter			1.92	3.84	100	2
Total Residual Chlorine				0.019	100	28
Outfall 200 (North/South pipes) Wet Weather Flow						
pH, standard units			a	9.0	100	1
Temperature, deg C				30.5	100	1
Ammonia (as N) Summer				2.02	100	0
Ammonia (as N) Winter				3.84	100	1
Cyanide				0.022	100	1
Cadmium				0.0118	100	1
Copper				0.064	100	1
Lead				0.6265	100	1
Nickel				1.705	100	1
Silver				0.0081	100	1
Zinc				0.641	100	1
Selenium				0.02	100	1
Outfall C11 (Instream EFPC) Wet Weather						
Temperature				30.5	100	1
pH			a	9.0	100	1

Table 4.11. National Pollutant Discharge Elimination System compliance monitoring requirements and record for Y-12, 2024 (continued)

Effluent parameter	Daily average (lb)	Daily maximum (lb)	Monthly average (mg/L)	Daily maximum (mg/L)	Percentage of compliance	Number of samples
Ammonia (as N) Summer				2.02	100	0
Ammonia (as N) Winter				3.84	100	1
Cyanide				0.022	100	1
Cadmium				0.0118	100	1
Copper				0.064	100	1
Lead				0.6265	100	1
Nickel				1.705	100	1
Silver				0.0081	100	1
Zinc				0.641	100	1
Selenium				0.020	100	1
Outfall C03 (Instream EFPC) Wet Weather						
Temperature				30.5	100	1
pH			a	9.0	100	1
Ammonia (as N) Summer				2.02	100	0
Ammonia (as N) Winter				3.84	100	1
Cyanide				0.022	100	1
Cadmium				0.0118	100	1
Copper				0.064	100	1
Lead				0.6265	100	1
Nickel				1.705	100	1
Silver				0.0081	100	1
Zinc				0.641	100	1
Selenium				0.020	100	1
Outfall EFP (Station 17) Wet Weather						
Temperature				30.5	100	1
pH			a	9.0	100	1
Ammonia (as N) Summer				2.02	100	0
Ammonia (as N) Winter				3.84	100	1
Cyanide				0.022	100	1
Cadmium				0.0118	100	1
Copper				0.064	100	1
Lead				0.6265	100	1
Nickel				1.705	100	1
Silver				0.0081	100	1
Zinc				0.641	100	1
Selenium				0.020	100	1

Table 4.11. National Pollutant Discharge Elimination System compliance monitoring requirements and record for Y-12, 2024 (continued)

Effluent parameter	Daily average (lb)	Daily maximum (lb)	Monthly average (mg/L)	Daily maximum (mg/L)	Percentage of compliance	Number of samples
Outfall S06 Wet Weather						
Temperature				30.5	100	1
pH			a	9.0	100	1
Ammonia (as N) Summer				2.02	100	0
Ammonia (as N) Winter				3.84	100	1
Cyanide				0.022	100	1
Cadmium				0.0188	100	1
Copper				0.103	100	1
Lead				1.063	100	1
Nickel				2.604	100	1
Silver				0.0191	100	1
Zinc				0.979	100	1
Selenium				0.020	100	1
Outfall S24 Wet Weather						
Temperature				30.5	100	1
pH			a	9.0	100	1
Ammonia (as N) Summer				2.02	100	0
Ammonia (as N) Winter				3.84	100	1
Cyanide				0.022	100	1
Cadmium				0.0188	100	1
Copper				0.103	100	1
Lead				1.063	100	1
Nickel				2.604	100	1
Silver				0.0191	100	1
Zinc				0.979	100	1
Selenium				0.020	100	1
Outfall S06 Dry Weather						
Temperature				30.5	100	1
pH			a	9.0	100	1
Ammonia (as N) Summer				2.02	100	0
Ammonia (as N) Winter				3.84	100	1
Cyanide				0.022	100	1
Cadmium				0.0188	100	1
Copper				0.103	100	1
Lead				1.063	100	1
Nickel				2.604	100	1

Table 4.11. National Pollutant Discharge Elimination System compliance monitoring requirements and record for Y-12, 2024 (continued)

Effluent parameter	Daily average (lb)	Daily maximum (lb)	Monthly average (mg/L)	Daily maximum (mg/L)	Percentage of compliance	Number of samples
Silver				0.0191	100	1
Zinc				0.979	100	1
Selenium				0.020	100	1
Outfall S24 Dry Weather						
Temperature				30.5	100	1
pH			a	9.0	100	1
Ammonia (as N) Summer				2.02	100	0
Ammonia (as N) Winter				3.84	100	1
Cyanide				0.022	100	1
Cadmium				0.0188	100	1
Copper				0.103	100	1
Lead				1.063	100	1
Nickel				2.604	100	1
Silver				0.0191	100	1
Zinc				0.979	100	1
Selenium				0.020	100	1
Outfall C11 (Instream EFPC) Dry Weather						
Temperature				30.5	100	4
pH			a	9.0	100	4
Ammonia (as N) Summer			1.01	2.02	100	2
Ammonia (as N) Winter			1.92	3.84	100	2
Cyanide			0.0052	0.022	100	4
Cadmium			0.0043	0.0118	100	4
Copper			0.0407	0.064	100	4
Lead			0.0244	0.6265	100	4
Nickel			0.189	1.705	100	4
Silver				0.0081	100	4
Zinc			0.646	0.641	100	4
Selenium			0.0031	0.020	100	4
Total Residual Chlorine			0.011	0.019	100	4
Outfall C03 (Instream EFPC) Dry Weather						
Temperature				30.5	100	4
pH			a	9.0	100	4
Ammonia (as N) Summer			1.01	2.02	100	2
Ammonia (as N) Winter			1.92	3.84	100	2
Cyanide			0.0052	0.022	100	4

Table 4.11. National Pollutant Discharge Elimination System compliance monitoring requirements and record for Y-12, 2024 (continued)

Effluent parameter	Daily average (lb)	Daily maximum (lb)	Monthly average (mg/L)	Daily maximum (mg/L)	Percentage of compliance	Number of samples
Cadmium			0.0043	0.0118	100	4
Copper			0.0407	0.064	100	4
Lead			0.0244	0.6265	100	4
Nickel			0.189	1.705	100	4
Silver				0.0081	100	4
Zinc			0.646	0.641	100	4
Selenium			0.0031	0.020	100	4
Total Residual Chlorine			0.011	0.019	100	4
Outfall EFP (Station 17) Dry Weather						
Temperature				30.5	100	4
pH			[a]	9.0	100	4
Ammonia (as N) Summer			1.01	2.02	100	2
Ammonia (as N) Winter			1.92	3.84	100	2
Cyanide			0.0052	0.022	100	4
Cadmium			0.0043	0.0118	100	4
Copper			0.0407	0.064	100	4
Lead			0.0244	0.6265	100	4
Nickel			0.189	1.705	100	4
Silver				0.0081	100	4
Zinc			0.646	0.641	100	4
Selenium			0.0031	0.020	100	4
Total Residual Chlorine			0.011	0.019	100	4

[a] *Not applicable*

[b] *No discharge*

Acronyms:

IC_{25} = 25-percent inhibition concentration

PCB = polychlorinated biphenyl

4.5.2. Radiological Monitoring Plan and Results

Y-12 has a radiological monitoring plan to address compliance with DOE orders that was provided to TDEC as a matter of comity under NPDES Permit TN0002968. Y-12 submitted results from the radiological monitoring plan quarterly as an addendum to the NPDES discharge monitoring report. There were no discharge limits set by the NPDES permit for radionuclides; the requirement is to monitor and report. In October 2022, the new NPDES permit became effective, and the requirement for a radiological monitoring plan was removed. The radiological monitoring plan was developed based on an analysis of operational history, expected chemical and physical relationships, and historical monitoring results.

Under the existing plan, effluent monitoring is conducted at four types of locations: treatment facilities, other point source and area source discharges, instream locations, and storm water

runoff from production area roofs. Operational history and past monitoring results provide a basis for parameters routinely monitored under the plan, as listed in Table 4.12. Y/TS-1704, *Radiological Monitoring Plan for the Oak Ridge Y-12 National Security Complex: Surface Water* was revised and issued in 2020 (CNS 2020b). This revision added Outfall 109 and roof runoff from production areas.

Radiological monitoring during storm water events is part of the storm water monitoring program. Uranium is monitored at three major EFPC storm water outfalls, two instream monitoring locations, and an outfall on Bear Creek. In addition, the monthly 7-d composite sample for radiological parameters taken at Station 17 on EFPC likely includes rain events.

Radiological monitoring plan locations sampled in 2024 are noted on Figure 4.16. Table 4.13 identifies the monitored locations, the frequency of monitoring, and the sum of the percentages of the derived concentration standards for radionuclides measured in 2024. Radiological data were well below the allowable derived concentration standards.

Table 4.12. Radiological parameters monitored at Y-12

Parameters	Specific isotopes	Rationale for monitoring
Uranium isotopes	^{238}U, ^{235}U, ^{234}U, total U, weight % ^{235}U	These parameters reflect the major activity (uranium processing) throughout the history of Y-12 and are the dominant detectable radiological parameters in surface water.
Fission and activation products	^{90}Sr, ^{99}Tc, ^{137}Cs	These parameters reflect a minor activity at Y-12 (processing recycled uranium from reactor fuel elements from the early 1960s to the late 1980s) and will continue to be monitored as tracers for beta and gamma radionuclides, although their concentrations in surface water are low.
	^{3}H	Tritium is not expected to be high in fuel elements because tritium is produced primarily as an activation product in reactor coolants. Tritium is highly mobile and is detected in groundwater samples associated with the S-3 site.
Transuranium isotopes	^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}Pu$	These parameters are related to recycle uranium processing. Monitoring has continued because of their half-lives and presence in groundwater.
Other isotopes of interest	^{232}Th, ^{230}Th, ^{228}Th, ^{226}Ra, ^{228}Ra	These parameters reflect historical thorium processing and natural radionuclides necessary to characterize background radioisotopes.

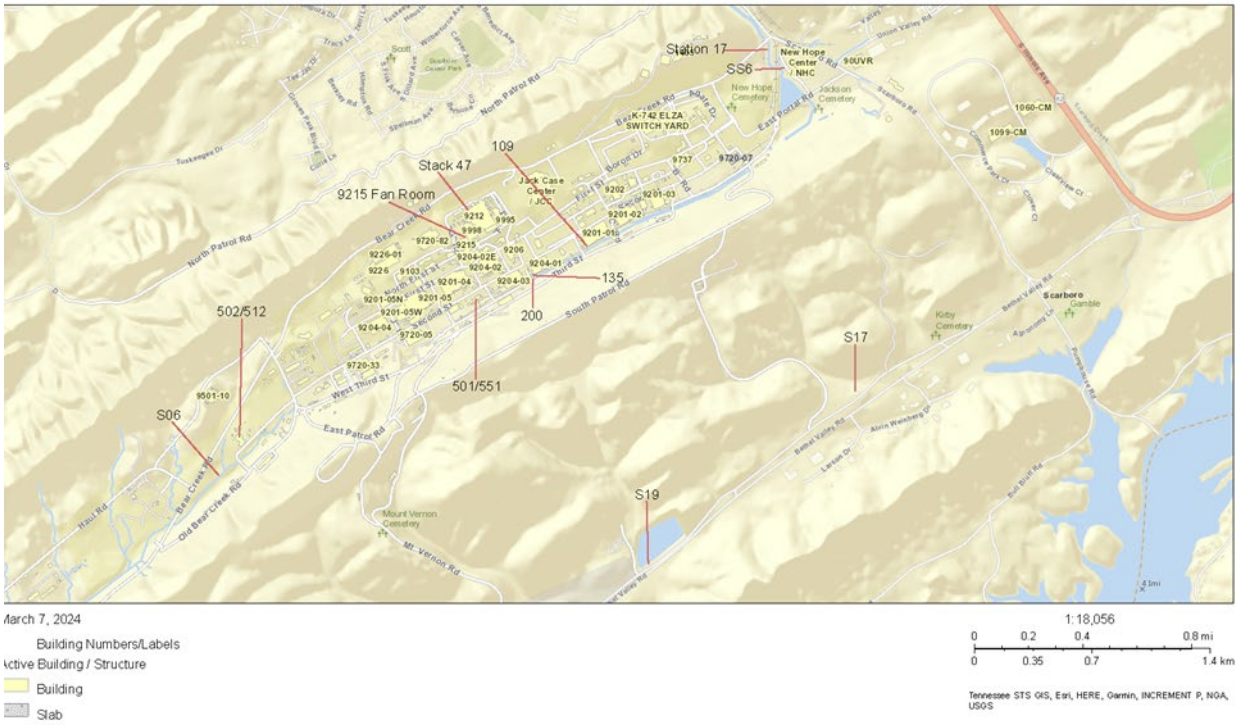


Figure 4.16. Radiological sampling locations at Y-12

Table 4.13. Summary of Y-12's radiological monitoring plan sample requirements and results, 2024

Location	Sample frequency	Sample type	Sum of derived concentration standards percentages
Y-12 wastewater treatment facilities			
Central Pollution Control Facility	1/batch	Composite during batch operation	No flow
West End Treatment Facility	1/batch	24-h composite	6.2
Groundwater Treatment Facility	4/yr	24-h composite	1.0
Central Mercury Treatment Facility	4/yr	24-h composite	1.6
Other Y-12 point and area source discharges			
Outfall 109	4/yr	24 h composite	0.31
Outfall 135	4/yr	24-h composite	0.53
Kerr Hollow Quarry	1/yr	24-h composite	0.10
Y-12 instream locations			
Outfall S24	1/yr	7-d composite	4.0
East Fork Poplar Creek, complex exit (east)	1/month	7-d composite	0.84
North/south pipes	1/month	24-h composite	1.70
Y-12 Production roof runoff			
9215 Fan Room	4/yr	Grab during rain	7.50
Stack 47	4/yr	Grab during rain	14.30

In 2024, the total mass of uranium and associated curies released from Y-12 at the easternmost monitoring station—Station 17 on Upper EFPC—was 118 kg or 0.092 Ci, as shown in Table 4.14.

Figure 4.17 illustrates a 6-year trend of these releases. The total release is calculated by multiplying the average concentration (g/L) by the average flow (million gal/d). Converting units and multiplying by 365 d/yr yields the calculated discharge.

Y-12 is permitted to discharge domestic wastewater to the City of Oak Ridge's publicly owned treatment works. Radiological monitoring of the sanitary sewer system discharge is conducted and reported to the city, although no city-established radiological limits exist. Alpha and beta levels are measured weekly, and subsequent uranium analyses are performed if the alpha or beta levels are above prescribed levels.

Table 4.14. Uranium release from Y-12 to the off-site environment as liquid effluent

Year	Quantity released	
	Ci[a]	kg
Station 17		
2014	0.061	90
2015	0.068	116
2016	0.045	88
2017	0.080	154
2018	0.084	205
2019	0.079	203
2020	0.082	173
2021	0.063	139
2022	0.071	167
2023	0.092	118
2024	0.177	192

[a] *1 Ci = 3.7E+10 Bq.*

Potential sources of radionuclides discharging to the sanitary sewer have been identified in previous studies at Y-12 as part of an initiative to meet goals to keep levels as low as reasonably achievable. Results of radiological monitoring were reported to the City of Oak Ridge in quarterly monitoring reports.

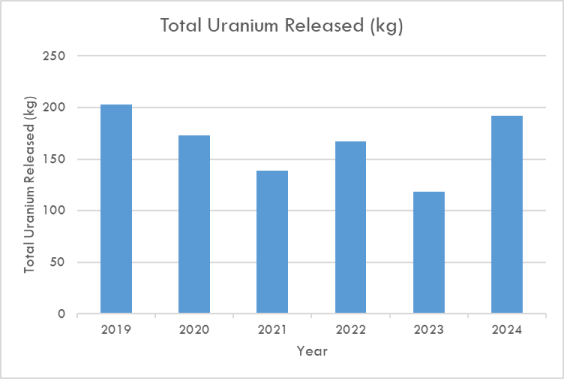


Figure 4.17. Y-12 uranium releases to East Fork Poplar Creek, 2019–2024

4.5.3. Storm Water Pollution Prevention

Y-12 has implemented a storm water pollution prevention program in alignment with the requirements of NPDES Permit TN0002968. program focuses primarily on storm water pollution prevention and continual improvement. It protects the quality of storm water runoff through identifying and properly managing outdoor storm water pollutant sources, implementing best management practices, sampling storm water and interpreting data to evaluate efficacy of pollutant controls, and conducting routine storm water inspections and surveillances.

For the Y-12 NPDES permit, storm water monitoring is performed at category outfalls and wet weather locations. These are described as follows:

- **Category 1 Storm Water Outfalls.** Annual monitoring of pH at Outfalls 002, 003, 004, 006, 007, 008, 009, 010, 011, 017, S17, S18, 019, 020, 033, 041, 044, 045, 046, 054, 057, 058, 062, 063, 064, 086, 087, 110, 114, 125, 126, 134.
- **Category 2 Storm Water Outfalls.** Annual monitoring of pH and total residual chlorine at Outfalls 034, 042, 071, 083, 088, 099, 113.
- **Sector AA Outfalls.** Annual monitoring of pH, nitrite plus nitrate (as N), total iron, total zinc, total aluminum, total mercury, and flow at Outfalls 014, 016, 047, 048, 067, 102, 135.
- **Other Wet Weather.** Annual monitoring as prescribed in the permit tables at Outfalls 200 and S30; Instream EFPC Locations C03, C11, EFP (Station 17); and Instream Bear Creek Locations S06 and S24.

Y-12 completed the storm water sampling scheduled for sampling year 2024. All storm water samples were collected as required in the current NPDES permit. The results were compared to the applicable permit table alert values and daily maximum benchmark values. The 2024 sampling year ran from October 2023 to the end of September 2024.

The following are the results for the storm water sampling conducted in 2024:

- **Category 1 Storm Water Outfalls.** All water sample results were within the typical NPDES permit range for pH of 6.0 and 9.0 standard units.
- **Category 2 Storm Water Outfalls.** All water sample results were within the typical NPDES permit range for pH of 6.0 and 9.0 standard units and were less than 0.05 mg/L for total residual chlorine.
- **Sector AA Storm Water Outfalls.** None of the results exceeded the applicable surface water daily maximum benchmarks as described in the permit.
- **Other Wet Weather Samples.** None of the results exceeded the applicable surface water daily maximum benchmarks or alerts as described in the permit.

An area of concern continues to be on-site construction activities; however, site surveillances continue to identify issues, and they are addressed before they cause an impact to storm water runoff. In addition, overall, the housekeeping and general

conditions that could impact storm water continue to improve. Based upon the results of the storm water sampling and site surveillances, the Y-12 storm water pollution prevention program is effective at protecting the surface waters at Y-12 from storm water pollution. Y-12 will continue to seek opportunities for additional improvement to storm water protections.

4.5.4. Ambient Surface Water Quality

A network of real-time monitors located at instream locations along Upper EFPC is used to monitor key indicators of water quality. The Surface Water Hydrological Information Support System is available for real-time water quality measurements, such as pH, temperature, dissolved oxygen, conductivity, and chlorine. The locations are shown in Figure 4.18. The system is used to indicate potential adverse conditions that could be causing an impact on water quality in Upper EFPC. It is operated as a best management practice.

Additional sampling of springs and tributaries is conducted in accordance with Y-12's Groundwater Protection Program to monitor trends throughout the three hydrogeologic regimes, as discussed in Section 4.6.

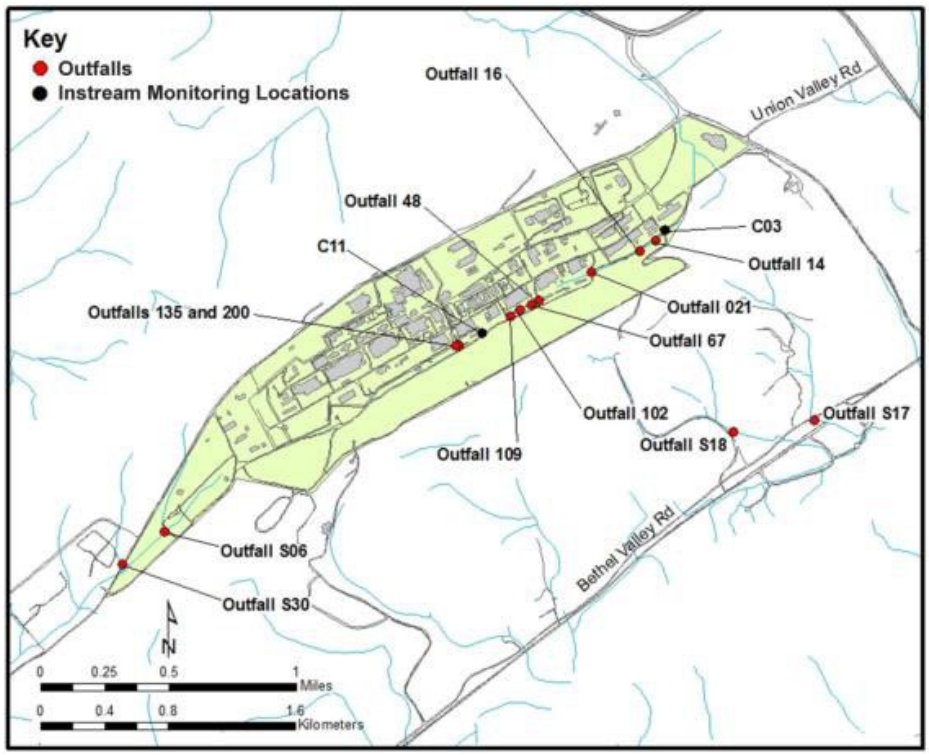


Figure 4.18. Y-12 storm water monitoring locations along East Fork Poplar Creek

4.5.5. Industrial Wastewater Discharge Permit

Industrial and Commercial User Wastewater Discharge Permit 1-91 defines requirements for discharging wastewaters to the sanitary sewer system as well as prohibitions for certain types of wastewaters. It prescribes requirements for monitoring certain parameters at the East End Sanitary Sewer Monitoring Station. The permit sets limits for most parameters.

Samples for gross-alpha and gross-beta are taken in a weekly 24-h composite sample. The sample is analyzed for uranium if the alpha or beta values exceed certain levels. Other parameters, including oil and grease, solids, and biological oxygen demand, are monitored on a monthly basis. Metals

and organic parameters are monitored once per quarter. Results of compliance sampling are reported quarterly. Flow is measured continuously at the monitoring station.

As part of the City of Oak Ridge's pretreatment program, city personnel use the east end monitoring station (also known as SS6) to conduct compliance monitoring as required by the pretreatment regulations. City personnel also conduct compliance inspections twice a year.

Monitoring results from 2024 are listed in Table 4.15. One permit limit was exceeded—the 2,100-gal/min instantaneous flow limit. To reduce storm water inflow and infiltration, a project is evaluating approximately 15,000 linear feet of the Y-12 sewage collection system via smoke tests and video inspection. The project also performs needed repairs identified during the evaluation, including manhole relining, pipe bursting, and installing cured-in-place piping. Repair work was completed in the B-449, C-409A, and B408A networks. Flow data evaluation indicates this project has reduced inflow and infiltration.

Table 4.15. Discharge point SS6 monitoring results, 2024

Effluent parameter	Number of samples	Average value	Daily maximum (gal/min)[a]	Monthly average (effluent limit)[a]	Number of limit exceedances
Max flow rate (gal/min)	Continuous	N/A	2,100	N/A	1
Flow (average kgpd) January through March	91	413	N/A	500[b]	0
Flow (average kgpd) April through June	91	365	N/A	500[b]	0
Flow (average kgpd) July through September	92	360	N/A	500[b]	0
Flow (average kgpd) October through December	92	371	N/A	500[b]	0
pH (standard units)	27	7.7	N/A	9 and 6[c]	0
Biochemical oxygen demand	12	59.7	N/A	300	0
Kjeldhal nitrogen	12	29.2	N/A	45	0
Phenols—total recoverable	12	<0.038	N/A	0.15	0
Oil and grease	12	<9.3	N/A	25	0
Suspended solids	14	108.9	N/A	200	0
Cyanide	12	<0.0032	N/A	0.006	0
Arsenic	4	<0.0012	N/A	0.01	0
Cadmium	4	<0.0005	N/A	0.0033	0
Chromium, hexavalent	4	0.005	N/A	0.053	0
Copper	4	0.0213	N/A	0.14	0
Iron	4	0.6125	N/A	10	0
Lead	4	<0.0025	N/A	0.049	0
Mercury	24	0.0052[d]	N/A	0.035[d]	0
Nickel	4	<0.005	N/A	0.021	0
Silver	4	0.0013	N/A	0.05	0
Zinc	4	0.0927	N/A	0.35	0
Molybdenum	4	0.0248	N/A	0.05[e]	N/A

Table 4.15. Discharge point SS6 monitoring results, 2024 (continued)

Effluent parameter	Number of samples	Average value	Daily maximum (gal/min)[a]	Monthly average (effluent limit)[a]	Number of limit exceedances
Selenium	4	<0.0025	N/A	0.01e	N/A
Toluene	4	0.002	N/A	0.005[e]	N/A
Ammonia	4	17.9	N/A	0.10[e]	N/A
Methanol	4	1.075	N/A	1.0[e]	N/A
Benzene	4	0.003	N/A	0.005[e]	N/A
1,1,1-Trichloroethane	4	0.003	N/A	0.005[e]	N/A
Ethylbenzene	4	0.003	N/A	0.005[e]	N/A
Carbon tetrachloride	4	0.003	N/A	0.005[e]	N/A
Chloroform	4	0.0047	N/A	0.005[e]	N/A
Tetrachloroethene	4	0.0034	N/A	0.005[e]	N/A
Trichloroethene	4	0.003	N/A	0.005[e]	N/A
trans-1,2-Dichloroethene	4	0.003	N/A	0.005[e]	N/A
Methylene chloride	4	0.004	N/A	0.005[e]	N/A

[a] *Industrial and commercial user wastewater permit limits.*

[b] *Average daily flow allowed in gal/d.*

[c] *Maximum and minimum value.*

[d] *Units are lb/d.*

[e] *This parameter does not have a permit limit. This value is the required detection limit. All units are mg/L unless noted otherwise.*

Acronyms: *kgpd = thousand gallons per day N/A = not applicable*

4.5.6. Quality Assurance and Quality Control

The Environmental Monitoring Management Information System is used to manage surface water monitoring data at Y-12. It uses standard sample definitions to ensure that samples are taken at the correct location at a specified frequency using the correct sampling protocol.

Field sampling QA encompasses many practices that minimize error and evaluate sampling performance. Some key quality practices include the following:

- Using standard operating procedures for sample collection and analysis
- Using chain-of-custody and sample identification, customized chain-of-custody documents, and sample labels provided by the Environmental Monitoring Management Information System
- Standardizing, calibrating, and verifying instruments
- Training sample technicians
- Preserving, handling, and decontaminating samples
- Using QC samples, such as field and trip blanks, duplicates, and equipment rinses

Surface water data are entered directly by the analytical laboratory into the Laboratory Information Management System on the day of approval. The Environmental Monitoring Management Information System routinely accesses the Laboratory Information Management System electronically to capture pertinent data. Generally, the system will store data in the form of concentrations.

A number of electronic data management tools automatically flag data points and allow monitoring and trending of data over time. Field information on all routine samples taken for surface water monitoring is entered in the Environmental Monitoring Management Information System, which also retrieves data nightly from the analytical laboratory. The system then performs numerous data checks, including comparing individual results against any applicable screening criteria, regulatory thresholds, compliance limits, best management practices, or other water quality indicators, and then produces required reports.

4.5.7. Biomonitoring Program

The NPDES permit for Y-12 (TN0002968, Part III, Section E) contains chronic toxicity testing requirements. These requirements specify that chronic toxicity testing (a 3-Brood *Ceriodaphnia dubia* survival and reproduction test and a 7-day fathead minnow larval survival and growth test) is required to determine whether the effluent is contributing chronic toxicity to the receiving water. The permit requires quarterly chronic testing of Outfall 200, which is performed using 100 percent effluent and the dilution series shown in Table 4.16.

Table 4.17 summarizes the results of the 2024 outfall biomonitoring tests in terms of the 25-percent inhibition concentration (IC_{25}), which is the concentration (i.e., a percentage of full-strength effluent diluted with laboratory control water) of each outfall effluent that causes a 25-percent reduction in the survival or reproduction of water fleas (*Ceriodaphnia dubia*) or the survival or growth of fathead minnow (*Pimephales promelas*) larvae (with respect to these same endpoints for these animals measured in control laboratory water). The lower the value of the IC_{25}, the more toxic the effluent. According to the NPDES permit, toxicity is demonstrated if the IC_{25} is less than or equal to the permit limit. The permit limit is 50-percent whole effluent for Outfall 200.

Table 4.16. Serial dilutions for whole effluent toxicity testing, as a percent of effluent serial dilutions for whole effluent toxicity testing, as a percent of effluent

Outfall 200	Control	0.25 x Permit limit	0.50 x Permit limit	Permit limit	(100+Permit limit)/2	100% Effluent
	0	12.5	25	50	75	100

Notes:

1. *Under permit effective Oct. 1, 2022.*
2. *The effluent water is diluted with control laboratory water.*

Table 4.17. Biomonitoring program summary information for Outfall 200, 2024

Toxicity testing dates	Test type	Test organism	End point	Metric[a]	IC_{25}[b] (%)
2/21/24–2/28/24	Chronic	Water fleas (*Ceriodaphnia dubia*)	Survival	IC_{25}	>100%
			Reproduction	IC_{25}	>100%
		Fathead minnow (*Pimephales promelas*)	Survival	IC_{25}	>100%
			Growth	IC_{25}	>100%
6/26/24–7/3/24	Chronic	Water fleas (*Ceriodaphnia dubia*)	Survival	IC_{25}	>100%
			Reproduction	IC_{25}	>100%
		Fathead minnow (*Pimephales promelas*)	Survival	IC_{25}	>100%
			Growth	IC_{25}	>100%
8/21/24–8/28/24	Chronic	Water fleas (*Ceriodaphnia dubia*)	Survival	IC_{25}	>100%
			Reproduction	IC_{25}	>100%
		Fathead minnow (*Pimephales promelas*)	Survival	IC_{25}	>100%
			Growth	IC_{25}	>100%
12/4/24–12/11/24	Chronic	Water fleas (*Ceriodaphnia dubia*)	Survival	IC_{25}	>100%
			Reproduction	IC_{25}	>100%
		Fathead minnow (*Pimephales promelas*)	Survival	IC_{25}	>100%
			Growth	IC_{25}	>100%

[a] *IC_{25} is summarized for the discharge monitoring location (Outfall 200).*

[b] *IC_{25} as a percentage of full-strength effluent from Outfall 200 diluted with laboratory control water. IC_{25} is the concentration that causes a 25-percent reduction in water fleas (*Ceriodaphnia dubia*) survival or reproduction or fathead minnow (*Pimephales promelas*) survival or growth.*

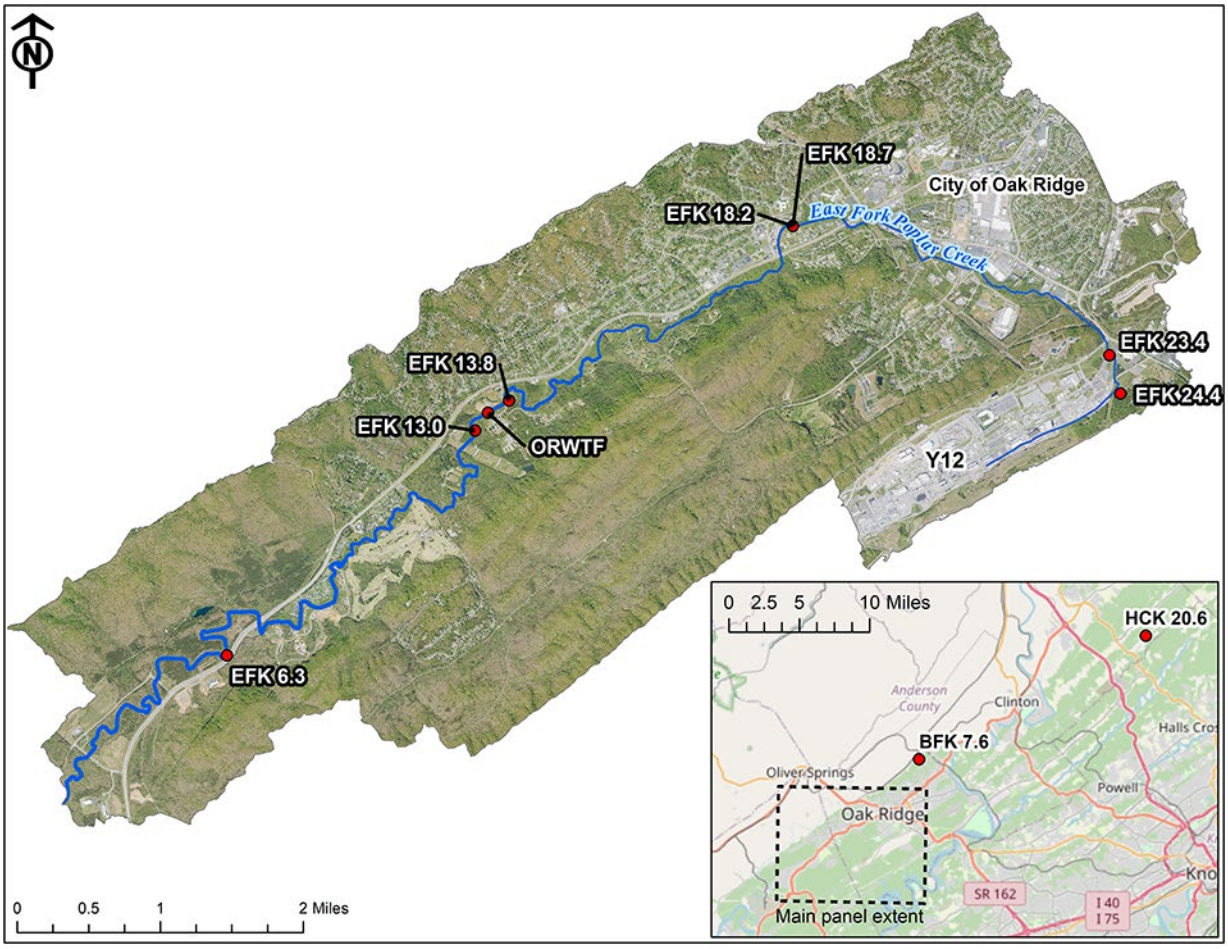
4.5.8. Biological Monitoring and Abatement Program

The NPDES permit issued for Y-12 mandates a biological monitoring and abatement program to demonstrate that the effluent limitations established for the facility protect the classified uses of the receiving stream—EFPC. The 2024 program sampling efforts follow the NPDES-required *Y-12 National Security Complex Biological Monitoring and Abatement Program Plan* (ORNL 2013).

Y-12's program, which has been monitoring the ecological health of EFPC since 1985, consists of three major tasks that reflect complementary approaches to evaluating the effects of Y-12 discharges on the aquatic integrity of EFPC—bioaccumulation studies, benthic macroinvertebrate community surveys, and fish community monitoring. Data collected on contaminant bioaccumulation and the composition and abundance of communities of aquatic organisms directly evaluate the effectiveness of abatement and remedial measures in improving ecological conditions in the stream.

Monitoring is conducted at seven primary EFPC sites (Figure 4.19), although sites may be excluded or added depending on the specific objectives of the various tasks. The primary sampling sites include the following:

- Upper EFPC at EFPC kilometers (EFKs) 24.4 and 23.4, located upstream and downstream of Lake Reality, respectively
- EFKs 18.7 and 18.2, located off ORR and below an area of intensive commercial and light industrial development, respectively
- EFKs 13.8 and 13.0, located upstream and downstream of the Oak Ridge Wastewater Treatment Facility, respectively
- EFK 6.3, located about 1.4 km downstream of the ORR boundary



Note: *BFK 7.6 and HCK 20.6 are reference sites.*

Acronyms:

BFK = Brushy Fork kilometer
EFK = East Fork Poplar Creek kilometer
HCK = Hinds Creek kilometer
ORWTF = Oak Ridge Wastewater Treatment Facility
Y12 = Y-12 National Security Complex

Figure 4.19. Biological monitoring sites in East Fork Poplar Creek relative to Y-12

Brushy Fork at kilometer 7.6 was used as a reference stream for the fish and macroinvertebrate community tasks until 2022 when the site was dropped because of limitations in site access and degraded ecological conditions.

Hinds Creek at kilometer 20.6 is used as a reference for the bioaccumulation as well as the macroinvertebrate and fish community monitoring tasks.

Generally, the number of invertebrate and fish species in EFPC has increased over the last three decades (primarily in the upstream sites), demonstrating that the overall ecological health of the stream continues to improve. However, since the end of flow augmentation in 2014, the richness of pollution-intolerant invertebrate and fish taxa at some sites in EFPC has declined. Further, the pace of improvement in Upper EFPC near Y-12 has slowed in recent years, and fish and invertebrate communities continue to have fewer species than the corresponding communities in reference streams.

4.5.8.1. Bioaccumulation Studies

Historically, mercury and PCB concentrations in fish from EFPC have been elevated relative to fish in uncontaminated reference streams. Fish in EFPC are monitored regularly for mercury and PCBs to assess spatial and temporal trends in bioaccumulation associated with ongoing remedial activities and Y-12 operations.

As part of this monitoring effort, redbreast sunfish (*Lepomis auritus*) and/or rock bass (*Ambloplites rupestris*) are collected from five sites throughout the length of EFPC and are analyzed twice a year for tissue concentrations of mercury (Figure 4.20) and annually for PCBs (Figure 4.21). Mercury concentrations remained higher in fish from EFPC in 2024 than in fish from reference streams. Elevated mercury concentrations in fish from the upper reach of EFPC indicate that Y-12 remains a continuing source of mercury to fish in the stream.

Figure 4.20 shows temporal trends for mercury concentrations in water collected from EFK 23.4 (Station 17) and in fish collected just upstream of this monitoring station at EFK 24.4. Waterborne mercury concentrations in the upper reach of EFPC have decreased substantially over the years in response to various remedial actions.

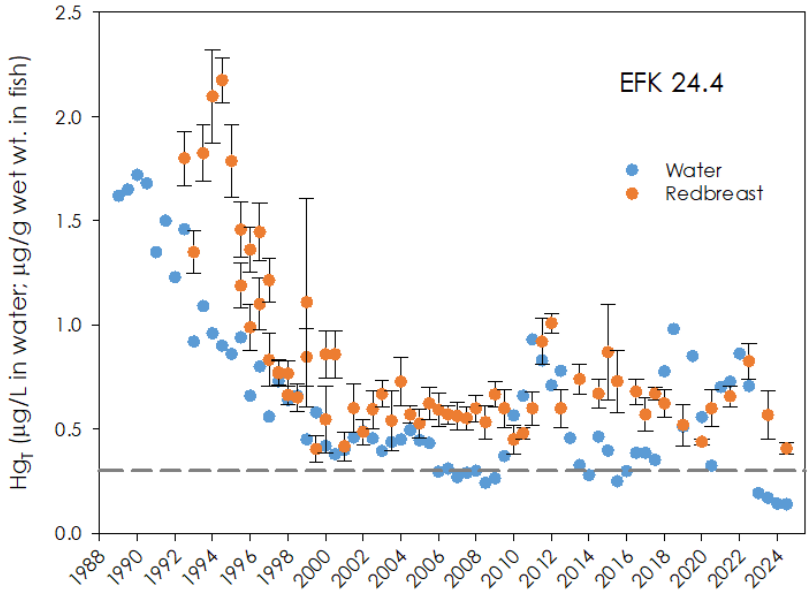
While the 1990s and early 2000s showed significant decreases in aqueous mercury concentrations at Station 17, various activities since 2009 (e.g., storm drain relining and cleanout) have led to significant fluctuations in aqueous mercury concentrations.

Aqueous mercury concentrations at Station 17 decreased significantly in 2024, and mean mercury concentrations in fish collected at EFK 24.4 decreased (0.41 µg/g) but remained above the EPA-recommended ambient water quality criterion for mercury (0.3 µg/g mercury as methylmercury in fish fillet).

The relationship between aqueous total mercury concentrations and fish tissue concentrations is complex. Aqueous mercury concentrations vary by orders of magnitude throughout the various watersheds across ORR, but fish tissue concentrations tend not to vary greatly (twofold to threefold). Multiple investigations are being conducted to better understand mercury bioaccumulation dynamics in EFPC and to better predict how remedial changes may impact mercury concentrations in fish in the future.

The mean total PCB concentration in sunfish fillets at EFK 23.4 was 0.25 µg/g in FY 2024, similar to concentrations seen in FY 2023 (0.26 µg/g) (Figure 4.21). Regulatory guidance and human health risk levels vary widely for PCBs, depending on the regulatory program and the assumptions used in the risk analysis. The Tennessee water quality criterion for both individual Aroclors and total PCBs is 0.00064 µg/L under the recreation designated-use classification and is the target for PCB-focused total maximum daily loads, including for local reservoirs, such as Melton Hill, Watts Bar, and Fort Loudoun (TDEC 2010a, 2010b, 2010c).

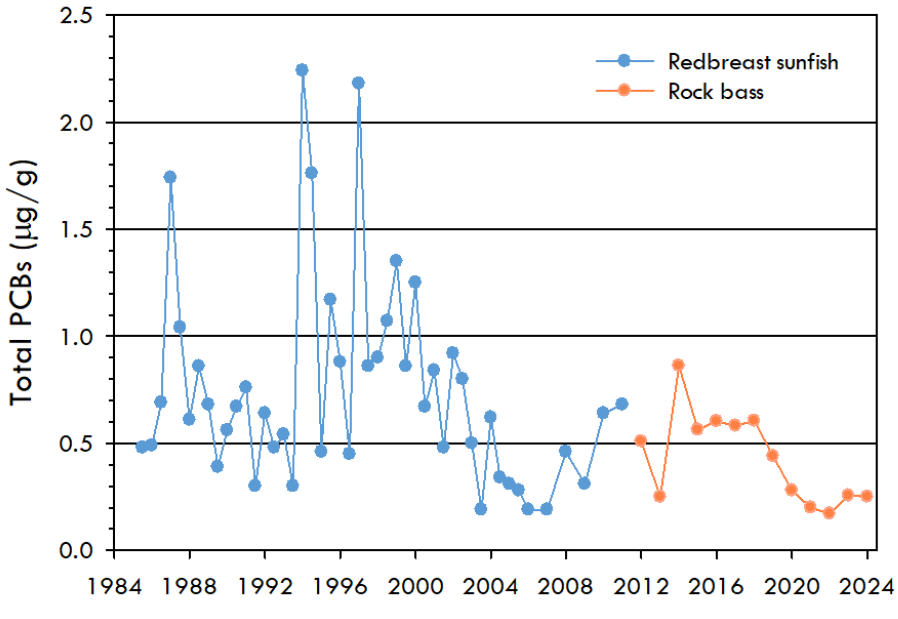
In the state of Tennessee, assessments of impairment for water body segments, as well as public fishing advisories, are based on fish tissue concentrations. Historically, the US Food and Drug Administration threshold limit of 2-µg/g PCBs in fish fillets was used for advisories. For many years, an approximate range of 0.8 to 1 µg/g was used, depending on the data available and factors such as the fish species and size. Most recently, the water quality criterion has been used to calculate the fish tissue concentration triggering impairment and a total maximum daily load (TDEC 2024b). This concentration is 0.02-µg/g PCBs in fish fillets (TDEC 2010a, 2010b, 2010c). The mean fish PCB concentration in Upper EFPC is well above this concentration.



Notes:

1. *Dashed gray line represents the ambient water quality criterion for methylmercury in fish fillets (0.3 µg/g).*
2. *Water: At East Fork Poplar Creek kilometer 23.4.*
3. *Fish: At East Fork Poplar Creek kilometer 24.4.*

Figure 4.20. Semiannual average mercury concentration in muscle fillets of redbreast sunfish and water from East Fork Poplar Creek, 1988–2024



Note: *At East Fork Poplar Creek kilometer 23.4.*

Acronym:

PCB = polychlorinated biphenyl

Figure 4.21. Annual mean concentrations of polychlorinated biphenyls in sunfish fillets, 1986–2024

4.5.8.2. Benthic Invertebrate Surveys

Monitoring the benthic macroinvertebrate community continued in the spring of 2024 at three sites in EFPC and at one reference stream (Hinds Creek). There have been long-term changes in the macroinvertebrate community at EFPC sites since monitoring began in 1986 (Figure 4.22).

Total taxa richness (number of taxa and sample) increased at EFK 24.4 from 1986 until the mid-2000s and then remained steady for approximately 14 years (Figure 4.22). After flow management ended in 2014, total taxa richness decreased at EFK 24.4 and has remained at these lower values since that time, with the exception of an increase in 2021 to a value similar to that measured before 2014, before decreasing again in 2022.

Total taxa richness at EFK 23.4 steadily increased since monitoring began, and values also decreased after flow management ceased (Figure 4.22). In 2024, total taxa richness declined from 2023 values at EFK 23.4, but still remains higher than the recent low value observed in 2021.

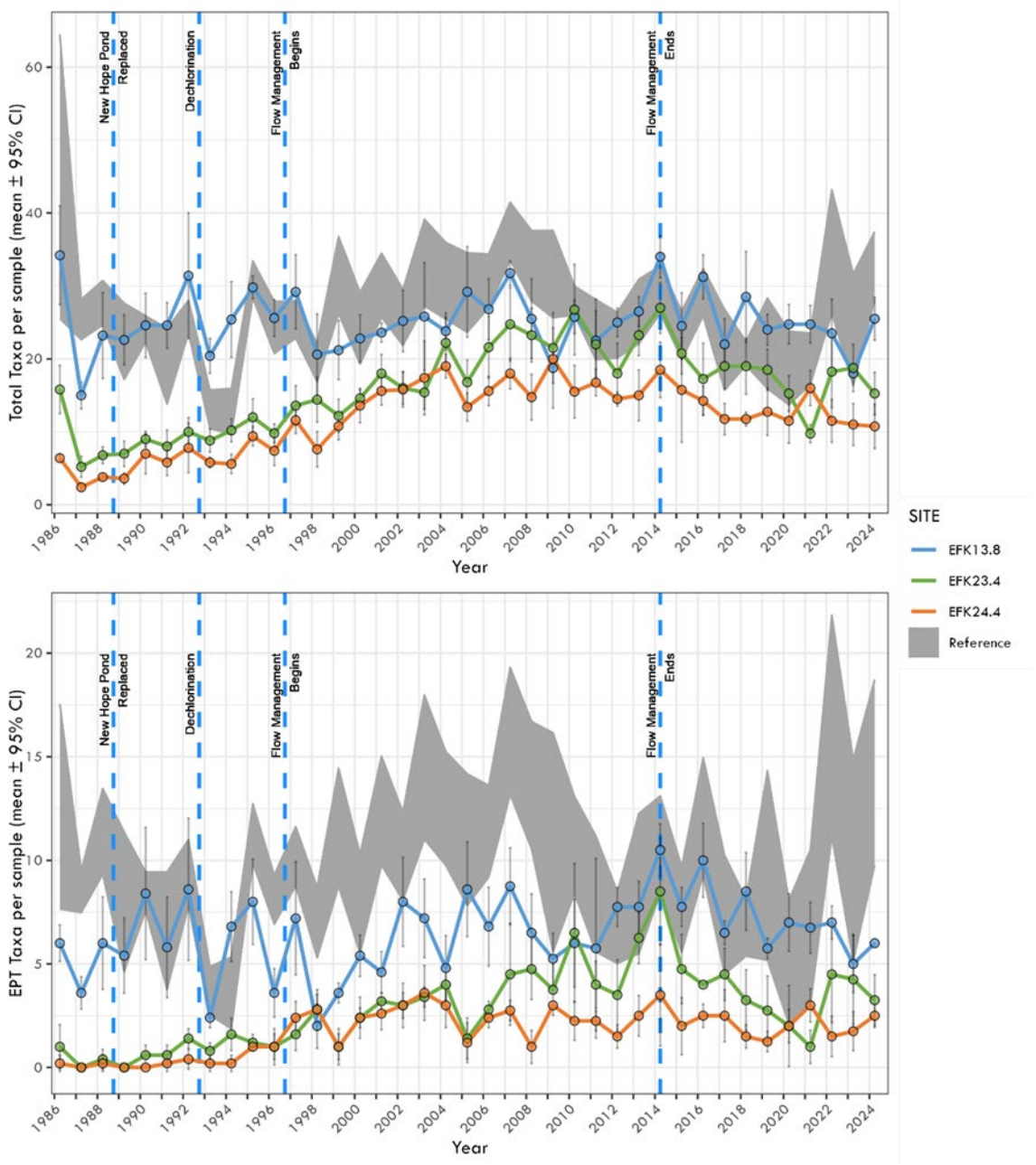
Total taxa richness at EFK 13.8 and the reference sites has been fairly consistent over the entire monitoring period. In 2024, total taxa richness increased relative to 2023, returning to a value more similar to the long-term average at the site (Figure 4.22).

Total taxa richness at EFK 24.4 has consistently been lower than at the reference sites throughout the monitoring period, while total taxa richness at EFK 13.8 has generally fallen within or above the 95-percent confidence interval of reference site values, especially in the past decade (Figure 4.22). Total taxa richness at EFK 23.4 was lower than the 95-percent confidence interval of the reference sites from 1986 to 2009, but since then total taxa richness has mostly been within the 95-percent confidence interval of the reference sites (Figure 4.22).

Temporal patterns in the number of pollution-intolerant taxa (Ephemeroptera, Plecoptera, and Trichoptera [EPT] taxa richness) were similar to those observed for total taxa richness (Figure 4.22). EPT taxa richness at EFK 24.4 was very low (less than 1 EPT taxa and sample) from 1986 until 1994 and then increased slightly (greater than 1 but less than 5 taxa per sample) until 2014. Since 2014, EPT taxa richness has generally been slightly lower, although this value did increase in 2024 (Figure 4.22).

EPT taxa richness at EFK 23.4 steadily increased since 1986 but decreased after flow management ended (Figure 4.22). In 2024, EPT taxa richness at EFK 23.4 decreased relative to values observed in 2023 and comparable to those observed from 2018 to 2019 following the lowest values observed in recent years in 2021 (Figure 4.22). EPT taxa richness at EFKs 24.4 and 23.4 has typically been lower than the 95-percent confidence interval of EPT taxa richness at the reference streams, indicative of degraded conditions.

The number of pollution-intolerant taxa at EFK 13.8 has remained fairly steady during the monitoring period, although with large interannual variation. EPT taxa richness values at EFK 13.8 have been within the reference site confidence limits since 2012, with the exception of 2022 and 2024, which were below the confidence limits (Figure 4.22).



Notes:

1. *Top: Total taxonomic richness (mean number of taxa per sample with 95 percent confidence interval).*
2. *Bottom: Taxonomic richness of the pollution-intolerant taxa (Ephemeroptera, Plecoptera, and Trichoptera [EPT]) (i.e., mean number of EPT taxa per sample with 95 percent confidence interval).*
3. *The timing of various activities within the watershed is shown with vertical blue lines.*
4. *Reference streams are Brushy Fork and Hinds Creek; however, Brushy Fork has not been sampled since 2021due to lack of access to the survey site.*

Acronyms:

EFK = East Fork Poplar Creek kilometer *EPT = Ephemeroptera, Plecoptera, and Trichoptera*

Figure 4.22. Benthic macroinvertebrate communities in three sites along East Fork Poplar Creek and the 95 percent confidence interval for two nearby reference streams

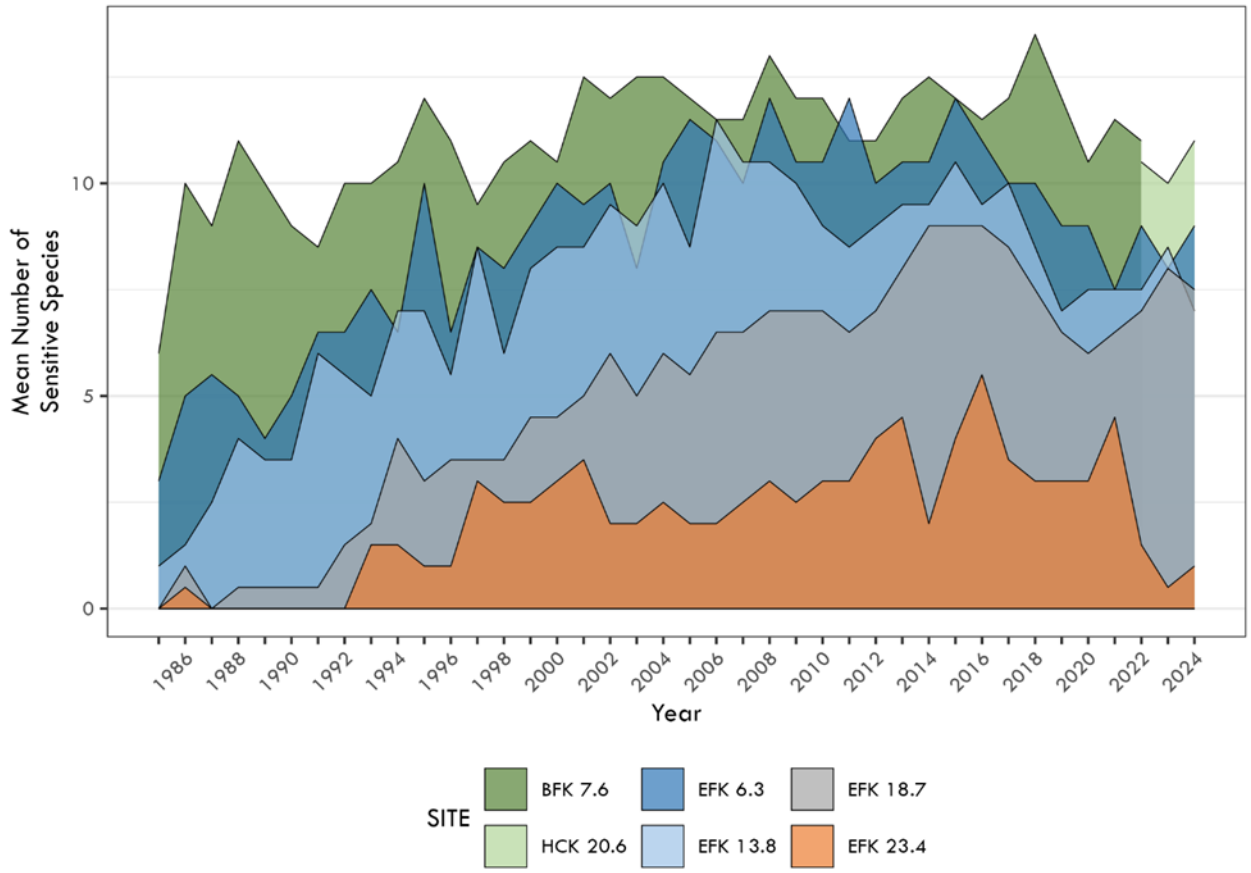
The implications of ending flow management in 2014 on invertebrate communities in EFPC are still uncertain. After flow augmentation ceased, EPT taxa richness at EFK 23.4 has consistently declined until 2022, although the improvement observed in 2022 may again be trending downward (Figure 4.22). EPT taxa richness at EFK 24.4 has also shown some minor variability since flow augmentation ended, but has generally remained similar to the last 10 years (Figure 4.22). The effects of ending flow augmentation on Lower EFPC (EFK 13.8) are less evident than at EFK 23.4, which makes sense as flow augmentation contributed a smaller percentage of total discharge at downstream sites. However, there has been a general downward trend over the past 10 years, although EPT taxa richness still remains higher at EFK 13.8 than either of the upstream sites. The long-term effects of ending flow management on the invertebrate community in EFPC will become more evident as conditions stabilize and additional data become available.

4.5.8.3. Fish Community Monitoring

Fish communities were monitored in the spring and fall of 2024 at sites along EFPC and at Hinds Creek, a comparable local reference stream. In the past three decades, overall species richness, density, biomass, and number of pollution-sensitive fish species improved at all sampling locations below Lake Reality. Some seasonal conditions, such as flooding and drought, can cause minor fluctuations in values but rarely cause long-term impacts on larger systems such as EFPC. However, some species of fish are considered sensitive, require very specific habitat conditions to survive, and can only tolerate a narrow range of environmental disturbance. The mean number of sensitive species at four sites in EFPC and the reference streams is shown in Figure 4.23, dramatically highlighting major improvements in the fish community in the middle to lower sections (EFKs 6.3 and 13.8) of the stream. However, the EFPC fish community continues to lag behind reference stream communities (Brushy Fork kilometer 7.6 and Hinds Creek kilometer 20.6) in the most important metrics of fish diversity and community structure, especially at the monitoring sites closest to Y-12 (EFKs 23.4 and 24.4).

Fish communities in Upper EFPC continued to fluctuate in density during 2024. Reduced stream flows associated with the termination of flow augmentation from Melton Hill in April 2014 and occasional unexpected fish kills are likely factors driving the decrease in fish densities in these upper sites (Figure 4.24). Upper EFPC experienced two fish kills in 2024. In June, an incident associated with a potable water line break resulted in the mortality of more than 8,000 fish, and in October, an incident associated with demolition activities resulted in the mortality of more than 1,200 fish.

Despite these impacts, fish richness values remained relatively consistent at most sites when sampled in September 2024. Very high densities are not always a positive indicator of fish health, and the most abundant species within these sites continue to be those that are considered tolerant. Continued monitoring in 2025 will provide additional insight into these variabilities and possible long-term impacts.



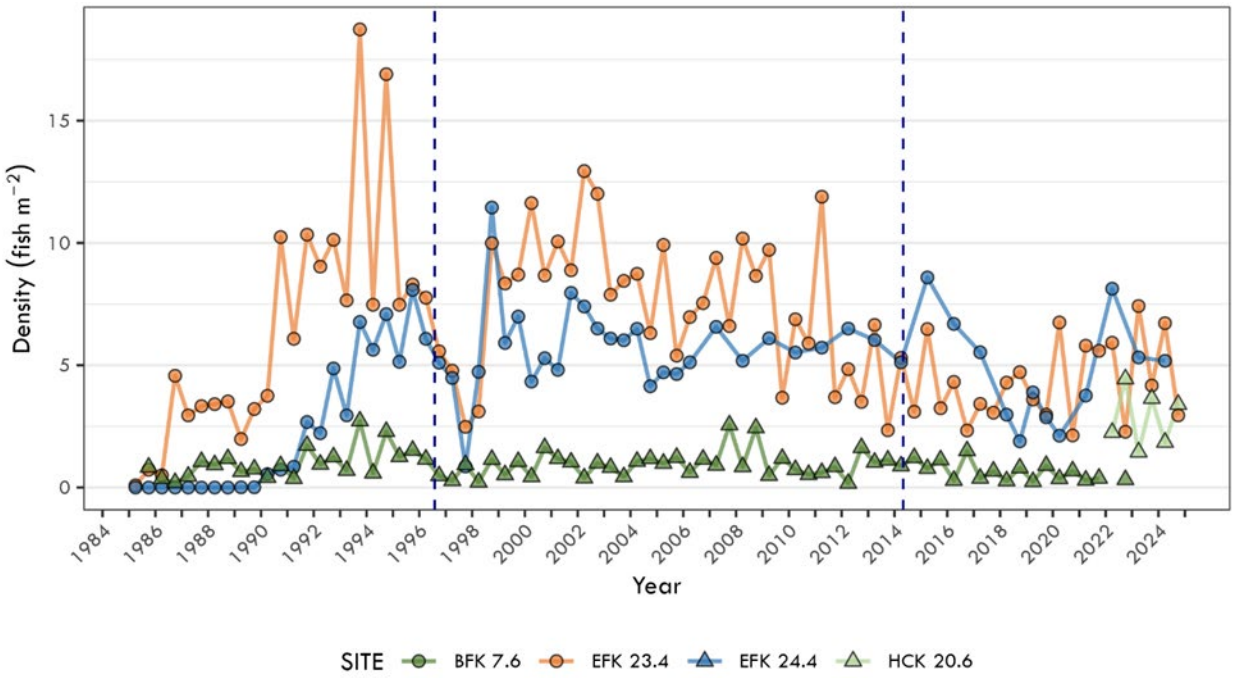
Notes:

1. *Mean sensitive species richness refers to the number of species.*
2. *Reference sites are Brushy Fork kilometer 7.6 and Hinds Creek kilometer 20.6.*
3. *No sensitive fish species have been observed at EFK 24.4 since monitoring began at this location.*

Acronyms:

BFK = Brushy Fork kilometer EFK = East Fork Poplar Creek kilometer HCK = Hinds Creek kilometer

Figure 4.23. Comparison of mean sensitive fish species richness collected from East Fork Poplar Creek and reference sites, 1985–2024



Notes:

1. *Access to the Brushy Fork site (BFK 7.6) has been restricted since 2022, and no samples have been collected. A comparable reference site was sampled beginning in spring 2022.*
2. *The interval of time between the dashed lines represents the period of flow management in East Fork Poplar Creek.*
3. *Fish density refers to the number of fish per m^2.*
4. *Reference sites are Brushy Fork (BFK 7.6) and Hinds Creek (HCK 20.6).*

Acronyms:

BFK = Brushy Fork kilometer EFK = East Fork Poplar Creek kilometer HCK = Hinds Creek kilometer

Figure 4.24. Fish density for two sites in Upper East Fork Poplar Creek and reference sites, 1985–2024

4.6. Groundwater at the Y-12 National Security Complex

Groundwater is monitored to comply with federal, state, and local requirements and to determine the environmental impact from legacy and current operations. There are approximately 190 known or potential sources of contamination identified in the Federal Facility Agreement for Y-12 (DOE 1992). Groundwater monitoring provides information on the nature and extent of contamination, which is used to identify actions needed to protect the worker, public, and environment. Figure 4.25 depicts major source areas where groundwater is monitored.

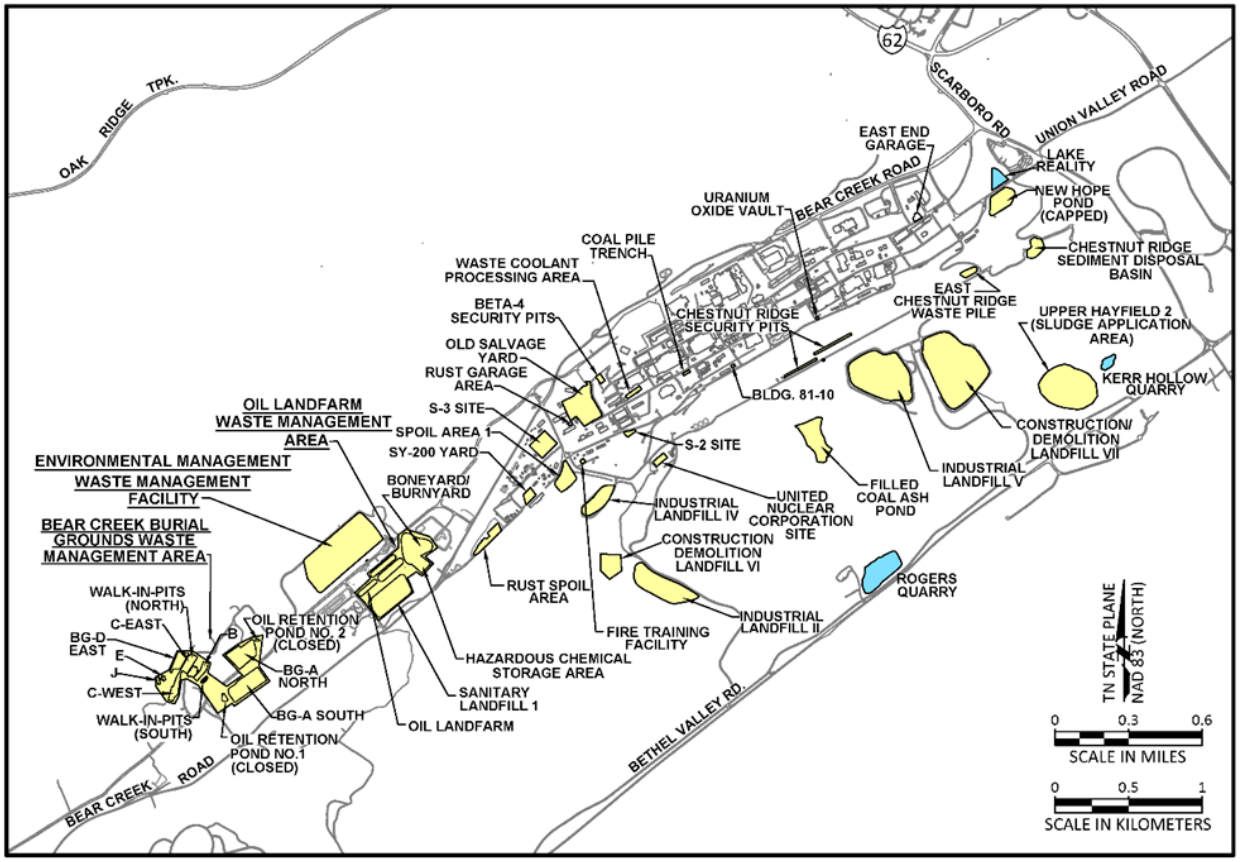


Figure 4.25. Known or potential contaminant source areas where groundwater is monitored at Y-12

4.6.1. Hydrogeologic Setting

Y-12 is divided into three hydrogeologic regimes—Bear Creek, Upper EFPC, and Chestnut Ridge (Figure 4.26). Most of the Bear Creek and Upper EFPC regimes are underlain by shale, siltstone, and sandstone bedrock, which act as an aquitard. An aquitard can contain water but does not readily yield that water to pumping wells. However, the southern portion of the Bear Creek and Upper EFPC regimes is underlain by the Maynardville Limestone, which is part of the Knox aquifer. (An aquifer more readily yields water to pumping wells.) The Chestnut Ridge regime is almost entirely underlain by the Knox aquifer.

In general, groundwater flow in the water table interval follows the topography; therefore, it flows off areas of higher elevation into the valleys and then flows parallel to the valley, along geologic strike (Figure 4.27). Shallow flow in the Bear Creek and Upper EFPC regimes diverges from a topographic and groundwater divide located near the western end of Y-12. In the Chestnut Ridge regime, a groundwater divide nearly coincides with the crest of the ridge. On Chestnut Ridge, shallow groundwater flow tends to be toward either flank of the ridge, with discharge primarily to surface streams and springs in Bethel Valley to the south and Bear Creek Valley to the north.

In Bear Creek Valley, groundwater in the intermediate and deep intervals moves through fractures in the aquitard, converging on and then moving through fractures and solution conduits in the Maynardville Limestone (Figure 4.26). Karst development in the Maynardville Limestone has a significant impact on groundwater flow in the water table and intermediate intervals. Groundwater flow rates in Bear Creek Valley vary; they are slow within the deep interval of the fractured non-carbonate rock (less than 10 ft/yr) but can be quite rapid within solution conduits in the Maynardville Limestone (10 to 5,000 ft/d).

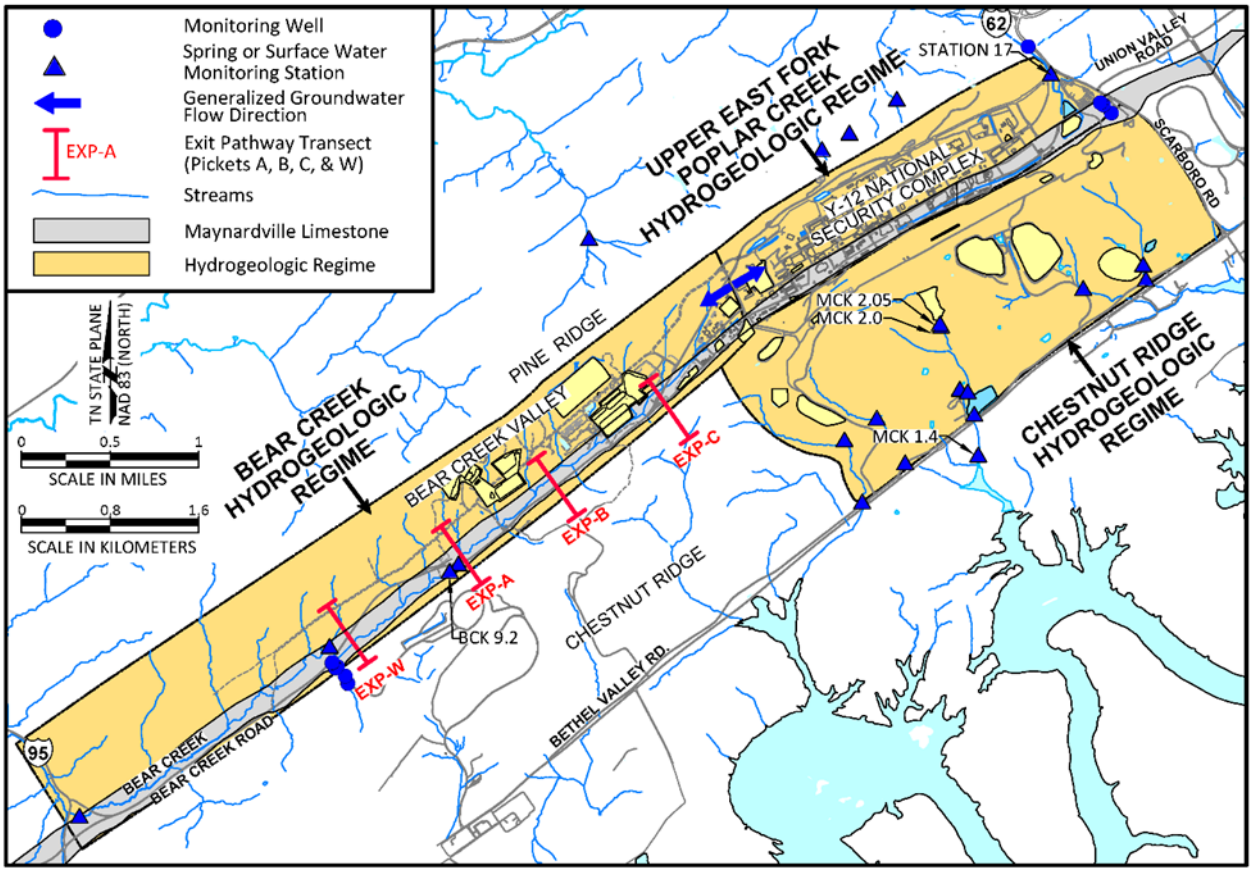


Figure 4.26. Hydrogeologic regimes, flow directions, perimeter/exit pathway locations, and position of Maynardville Limestone at Y-12

Contaminants are transported, along with flowing groundwater, through the pore spaces, fractures, or solution conduits of the hydrogeologic system. Strike-parallel transport of some contaminants can even occur within the aquitard units for significant distances, where they discharge to surface water tributaries or underground utility and storm water distribution systems in Y-12's industrial area. For example, elevated levels of nitrate (a contaminant from legacy waste disposals) within the fractured bedrock of the aquitard are known to extend east and west from the S-3 site for thousands of feet. Extensive VOC contamination from multiple sources is observed in both the Bear Creek and Upper EFPC regimes and to a lesser extent in the Chestnut Ridge regime. The VOCs (e.g., petroleum products, coolants, and solvents) in groundwater within the fractured bedrock of the aquitard units can remain close to source areas for long durations. This is because they tend to adsorb to the bedrock matrix, diffuse into pore spaces within the matrix, and very slowly diffuse back out of the matrix when concentration gradients change before migrating to exit pathways, where more rapid transport occurs for longer distances.

Groundwater flow in the Chestnut Ridge regime is through fractures and solution conduits in the Knox aquifer. Discharge points for intermediate and deep flow are not well-known. However, following the crest of the Chestnut Ridge, water table elevations decrease from west to east, demonstrating an overall easterly trend in groundwater flow.

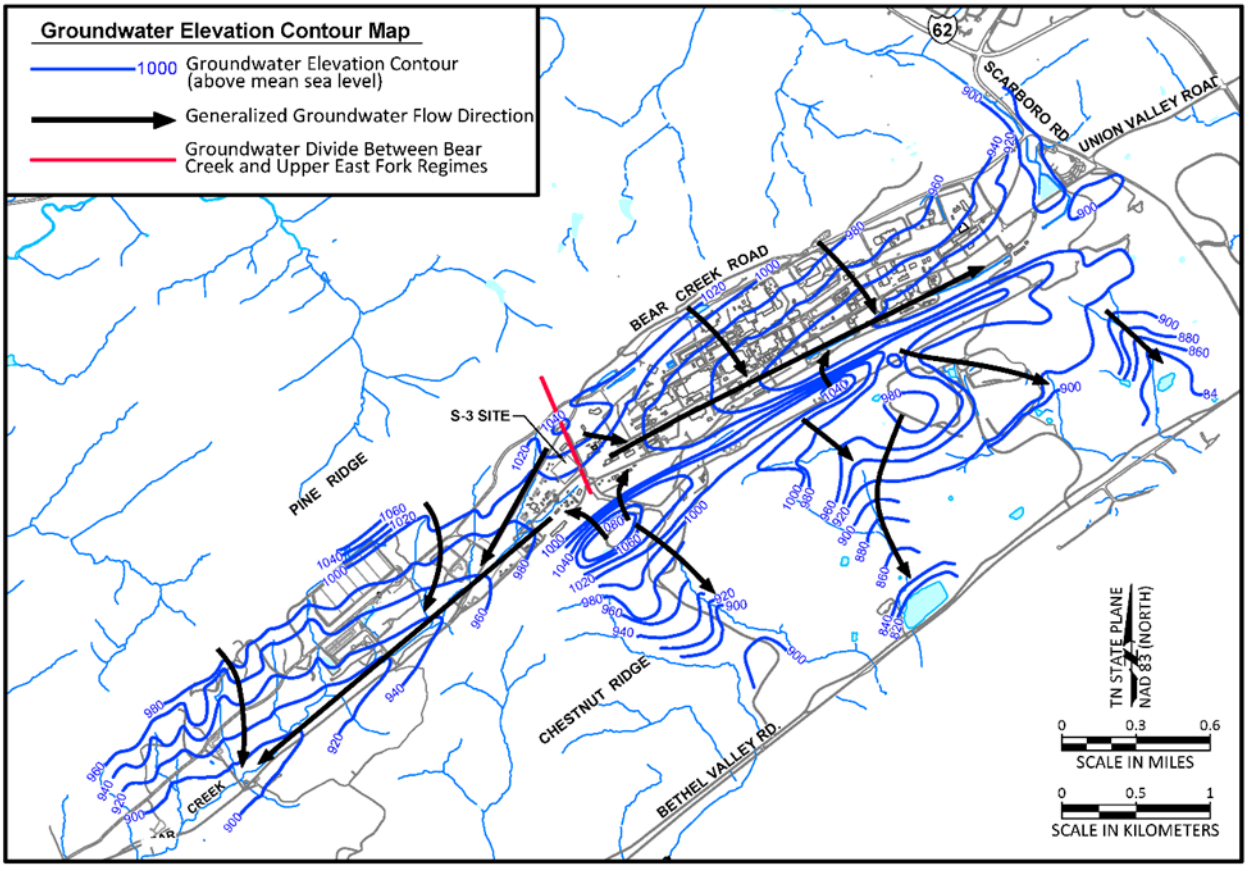


Figure 4.27. Groundwater elevation contours and flow directions at Y-12

4.6.2. Groundwater Monitoring

Groundwater monitoring in 2024 was performed as part of Y-12's Groundwater Protection Program, DOE EM programs such as the Water Resources Restoration Program, and other projects. Compliance requirements were met by monitoring 222 wells and 61 surface water locations and springs (Table 4.18). (Locations sampled for research projects are not included in the wells and locations monitored for compliance requirements.)

Specific wells of interest, based on 2024 data, are discussed later in this section. Figure 4.26 shows the locations of perimeter/exit pathway stations that are routinely monitored.

Table 4.18. Summary of groundwater monitoring at the Y-12 National Security Complex, 2024

	Restoration[a]	Waste management[b]	Surveillance[c]	Other[d]	Total
Purpose for which monitoring was performed					
Number of active wells	57	33	132	77	299
Number of other monitoring stations (e.g., springs, seeps, and surface water)	37	7	17	3	64
Number of samples taken[e]	315	315	175	82	887
Number of analyses performed	12,695	7,659	19,682	2,226	42,262
Percentage of analyses that are non-detects	64.6	87.2	70.6	NA	74.1
Ranges of results for positive detections, VOCs (µg/L)[f]					
Chloroethenes	0.15-2,040	3.76-7.39	0.35-93,900	NA	
Chloroethanes	0.16-200	57.78-73.8	0.39-1,930	NA	
Chloromethanes	0.2-1,100	0.76-1.32	0.46-574	NA	
Petroleum hydrocarbons	0.16-7,000	ND	1-490	NA	
Uranium (mg/L)	0.000037-0.36	0.0000161-0.0467	0.000501-0.26	NA	
Nitrates (mg/L)	0.057-3,700	ND	0.0349-9,250	NA	
Ranges of results for positive detections, radiological parameters (pCi/L)[g]					
Gross-alpha activity	0.79-350	1.45-13.2	0-36	NA	
Gross-beta activity	0.41-2,500	2.28-23.2	0-11,000	NA	

[a] *Monitoring to comply with CERCLA requirements.*

[b] *Solid waste landfill detection monitoring and CERCLA landfill detection monitoring.*

[c] *DOE Order surveillance monitoring.*

[d] *Research-related groundwater monitoring associated with activities of the DOE Oak Ridge Field Research Center and Ecosystems and Networks Integrated with Genes and Molecular Assemblies.*

[e] *The number of unfiltered samples, excluding duplicates, determined for unique location/date combinations.*

[f] *These ranges reflect concentrations of individual contaminants (not summed VOC concentrations):*

- *Chloroethenes—includes tetrachloroethene; trichloroethene; 1,2-dichloroethene (cis- and trans-); 1,1-dichloroethene; and vinyl chloride.*
- *Chloroethanes—includes 1,1,1-trichloroethane; 1,2-dichloroethane; and 1,1-dichloroethane.*
- *Chloromethanes—includes carbon tetrachloride, chloroform, and methylene chloride.*
- *Petroleum hydrocarbon—includes benzene, toluene, ethylbenzene, and xylene.*

[g] *pCi = 3.7 × 10^{-2} Bq*

Acronyms:

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act

NA = not analyzed

ND = not detected

VOC = volatile organic compound

Water quality results of groundwater monitoring activities are presented in the 2024 groundwater monitoring report (CNS 2025). The groundwater sampling technicians shown in Figure 4.28 are taking water quality samples from a well in the East Fork regime.

Monitoring efforts performed specifically for CERCLA baseline and remediation evaluation are published in the FYs 2024 and 2025 Water Resources Restoration Program sampling and analysis plans (UCOR 2023, 2024 respectively) and the annual CERCLA remediation effectiveness reports (DOE 2024a, 2025). Three groundwater monitoring wells were plugged and abandoned by the Groundwater Protection Program. One of these wells (GW-954) was plugged and abandoned due to damage sustained during construction activities by the Security Infrastructure Revitalization project. The other two wells (GW-760 and GW-761) were plugged and abandoned due to construction activities at the LPF site.

In 2024, two wells (GY-053 and GY-054) were installed at the Environmental Management Waste Management Facility, and two wells (GY-055 and GY-056) were installed at Environmental Management Disposal Facility by the Water Resources Restoration Program. Five monitoring wells were plugged and abandoned at Environmental Management Disposal Facility—GW-998, GW-999, GY-001, GY-002, and DC WELL.



Figure 4.28. Groundwater monitoring well sampling in the Upper East Fork regime at Y-12

4.6.3. Groundwater Quality

Historical monitoring shows that four primary contaminants adversely affect groundwater quality at Y-12: nitrate, VOCs, metals, and radionuclides. Of those, VOCs are the most widespread. Uranium and ^{99}Tc are the radionuclides of greatest concern. Trace metals (e.g., arsenic, barium, cadmium, chromium, and mercury), the least extensive groundwater contaminants, generally occur close to source areas because of their high adsorption characteristics. Data show that plumes from multiple source units have mixed with one another and that contaminants are not always easily associated with a single source.

4.6.3.1. Upper East Fork Poplar Creek Hydrogeologic Regime

Among the three hydrogeologic regimes, the Upper EFPC regime contains most of the known and potential sources of contamination. Contaminants from the S-3 site (nitrate and ^{99}Tc) and VOCs from multiple source areas are observed in groundwater in the western portion of the Upper EFPC regime, whereas groundwater in the eastern portion of the regime is predominantly contaminated with VOCs.

Plume delineation

Sources of contaminants monitored during 2024 include the S-2 site, Fire Training Facility, S-3 site, Waste Coolant Processing Facility, former petroleum underground storage tanks, New Hope Pond, Old Salvage Yard, and process/production buildings throughout Y-12.

The S-3 site is near the hydrologic divide that separates the Upper EFPC regime from the Bear Creek regime and has contributed groundwater contamination to both regimes. Contaminant plumes in both regimes (shown in orange shading on Figures 4.29, 4.31, 4.32, and 4.33) are elongated as a result of preferential transport of contaminants parallel to strike (parallel to the valley axis) in both the Knox aquifer and the fractured bedrock of the aquitard.

The plumes depicted reflect the average concentrations and radioactivity in groundwater between 2018 and 2022. The circular icons presented on the plume maps (Figures 4.29, 4.31, 4.32, and 4.33) represent 2024 monitoring results for the Upper EFPC regime (discussed in this section), the Bear Creek regime (discussed in Section 4.6.3.2), and the Chestnut Ridge regime (discussed in Section 4.6.3.3).

Nitrate

Nitrate is highly soluble and moves easily with groundwater. In the central and western portions of Upper EFPC, nitrate concentrations exceed the 10-mg/L drinking water standard. (A list of the national drinking water standards is presented in Appendix C.) The two primary sources of nitrate contamination are the S-2 and S-3 sites. In the past, these were ponds that received large quantities of nitric acid wastes. In 2024, there was a maximum nitrate concentration of 9,250 mg/L in well GW-275. This well is located approximately 396 m (1,300 ft) east of the S-3 site and is screened in the shallow-intermediate bedrock interval about 19 m (63 ft) below ground surface (Figure 4.29).

Increasing and indeterminate concentration trends are indicated by the respective time-series nitrate data for three wells in the East Fork Regime—55-2B, GW-270, and GW-275. These trends are illustrated by the time-series data for wells 55-2B and GW-270 shown in Figure 4.30. Recent data for GW-270 is beginning to show a decreasing trend, beginning in 2013, and an overall indeterminate trend through the sampling history. Future sampling will show if nitrate concentrations in well GW-270 continue to decline.

Considering the mobility of nitrate flowpaths in the Nolichucky Shale east of the S-3 site, this is consistent with both the heterogeneous transport characteristics of the groundwater flow systems as well as the conceptual model for contaminant transport for the S-3 site, whereby the center of the nitrate mass (and other intermixed contaminants) plume in the Nolichucky Shale east of the site continues to slowly move eastward (toward well GW-275) via permeable flowpaths (e.g., bedding plane fractures) that parallel geologic strike (DOE 1998).

As shown in Figure 4.30, nitrate trends in the groundwater at two well clusters in the East Fork Regime reflect differing conditions at different depth intervals at the same location. Divergent nitrate trends occur at wells GW-108/GW-109 (decreasing and indeterminate, respectively) and GW-274/GW-275 (decreasing and increasing, respectively). The monitoring depths of GW-108 and GW-109 are 49 and 114 ft below ground surface, respectively. The monitoring depths of GW-274 and GW-275 are 31 and 63 ft below ground surface, respectively. The decreasing trends at wells GW-108 and GW-274 likely reflect higher groundwater flow (e.g., flushing) in the shallow groundwater system.

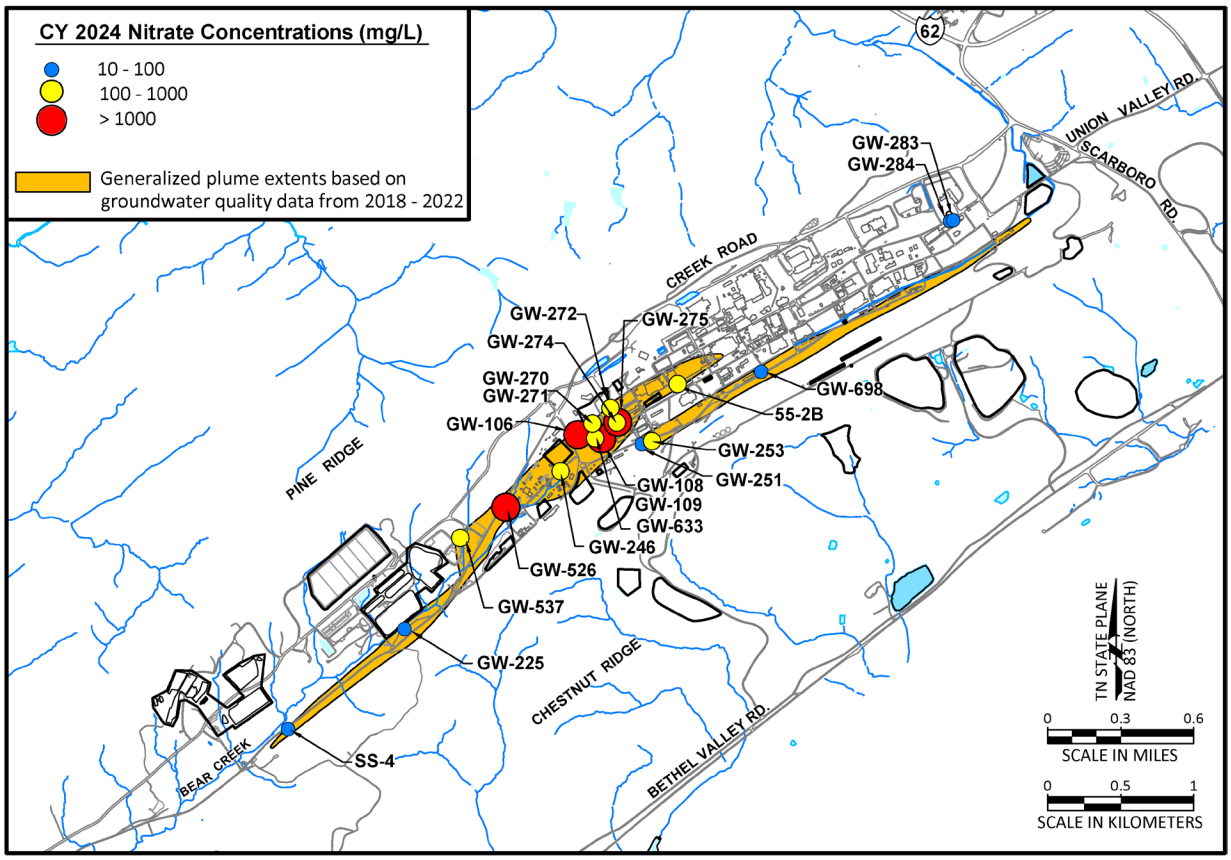


Figure 4.29. Nitrate in groundwater at Y-12

Trace metals

In 2024, barium, beryllium, cadmium, chromium, copper, nickel, thallium, and uranium exceeded primary drinking water standards in groundwater in the Upper EFPC regime. Uranium was found predominately downgradient of the S-2 and S-3 sites, and upgradient of the New Hope Pond site. Trace metal concentrations above standards occur adjacent to source areas because of their low solubility and high adsorption to the clay-rich soils and bedrock.

VOCs

VOCs, the most widespread contaminants in the Upper EFPC regime, consist of chlorinated and petroleum hydrocarbons. In 2024, the highest summed concentration of dissolved chlorinated hydrocarbons (108,574.7 µg/L) was again observed at well 55-3B in the western portion of Y-12, adjacent to currently inactive manufacturing facilities. The highest dissolved concentration of petroleum hydrocarbons was again seen at well GW-658 (11,361 µg/L) at the closed East End Garage.

Most monitoring results are consistent with data from previous years because a dissolved plume of legacy VOCs in the bedrock zone extends eastward from the S-3 site over the entire length of the regime (Figure 4.31). Additional sources are the Waste Coolant Processing Facility, fuel facilities (Rust Garage and East End Garage), and other waste disposal and production areas.

Chloroethene compounds (tetrachloroethene [PCE], trichloroethene [TCE], dichloroethene [DCE], and vinyl chloride) tend to dominate the VOC plume in the western and central portions of the Upper East Fork regime. However, PCE is almost ubiquitous throughout, indicating many source areas. Chloromethane compounds (carbon tetrachloride, chloroform, and methylene chloride) are the predominant VOCs in the eastern portion of the regime.

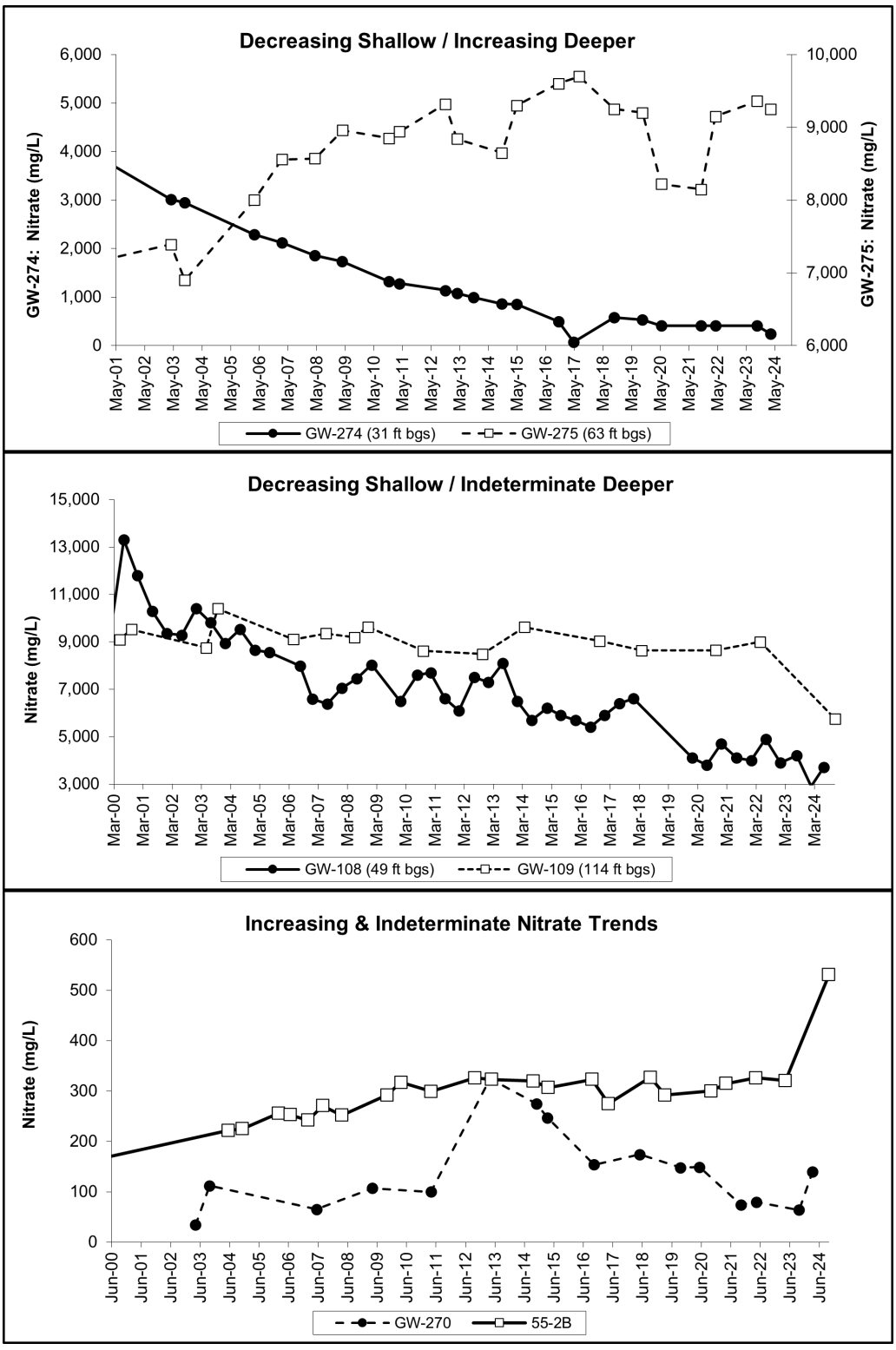


Figure 4.30. Nitrate concentration trends in surveillance monitoring wells 55-2B/GW-270 and GW-274/GW-275 in the East Fork regime

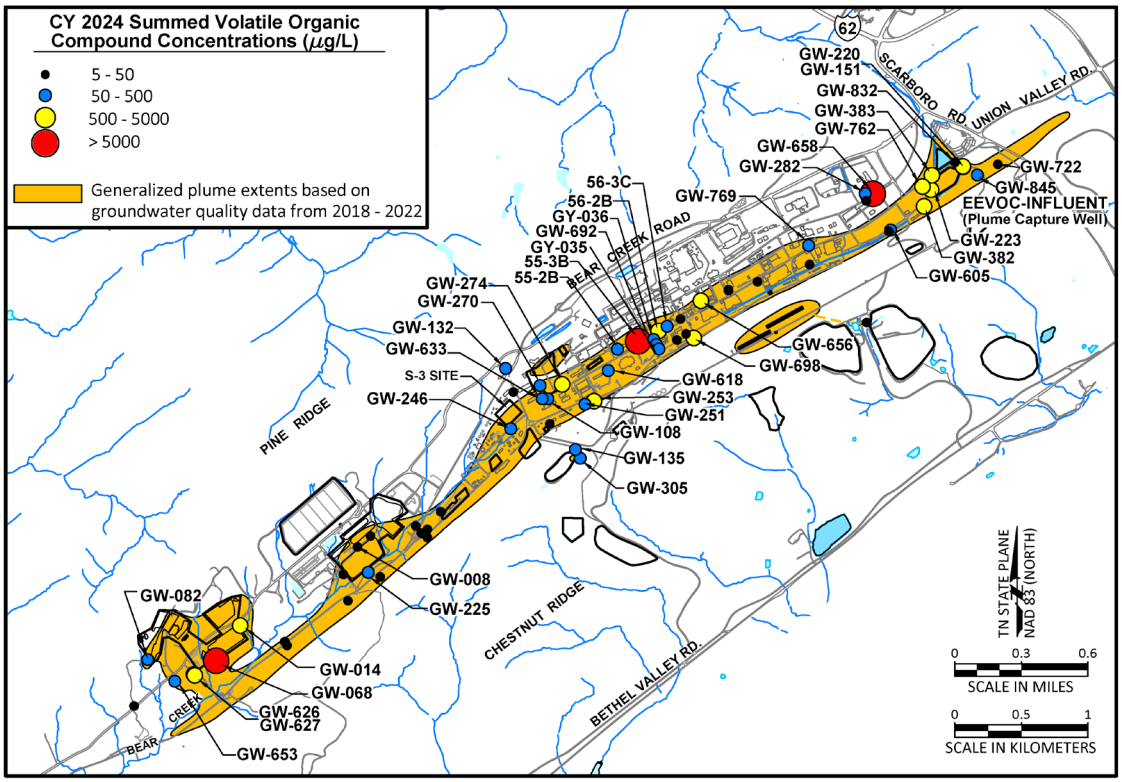


Figure 4.31. Summed volatile organic compounds in groundwater at Y-12

Variability in concentration trends of chlorinated and petroleum VOCs is seen within the Upper EFPC regime. Increasing trends have been observed in wells associated with the Rust Garage, Old Salvage Yard, and S-3 site, as well as some legacy sources at production/process facilities in central areas. While data from most monitoring wells have remained relatively constant since the late 1980s/early 1990s, some wells show trends in recovery from legacy contamination, especially where petroleum hydrocarbons are the predominant contaminant. For example, while GW-658 has the highest dissolved concentration of petroleum hydrocarbons in the regime, the concentration is an order of magnitude lower than measured in the same well in 1992 and 1993 (>100,000 mg/L).

Radionuclides

The primary alpha-emitting radionuclides found in the Upper EFPC regime during 2024 are isotopes of uranium. Exceedances of the drinking water standard for gross-alpha (15 pCi/L) have been observed near the S-3 site, Old Salvage Yard, and other western source areas; in the central areas near production facilities and the Uranium Oxide Vault; and in the east end near the former oil skimmer basin at the former inlet to New Hope Pond, which was capped in 1988. In 2024, the maximum occurrence of gross-alpha activity in groundwater in the Upper EFPC regime was 350 pCi/L, again at well GW-154 near the former oil skimmer basin as shown in Figure 4.32.

The primary beta-emitting radionuclides observed in the Upper EFPC regime are ^{99}Tc and isotopes of uranium. Historically, elevated gross-beta activity in groundwater shows a pattern similar to that observed for gross-alpha activity as shown in Figure 4.33.

Technetium-99 is the primary contaminant exceeding the gross-beta screening level of 50 pCi/L; the source is the S-3 site. The highest gross-beta activity in groundwater was observed during 2024 from well GW-108 (2,800 pCi/L), down from a maximum gross-beta (21,300 pCi/L) in 2008 in the same well.

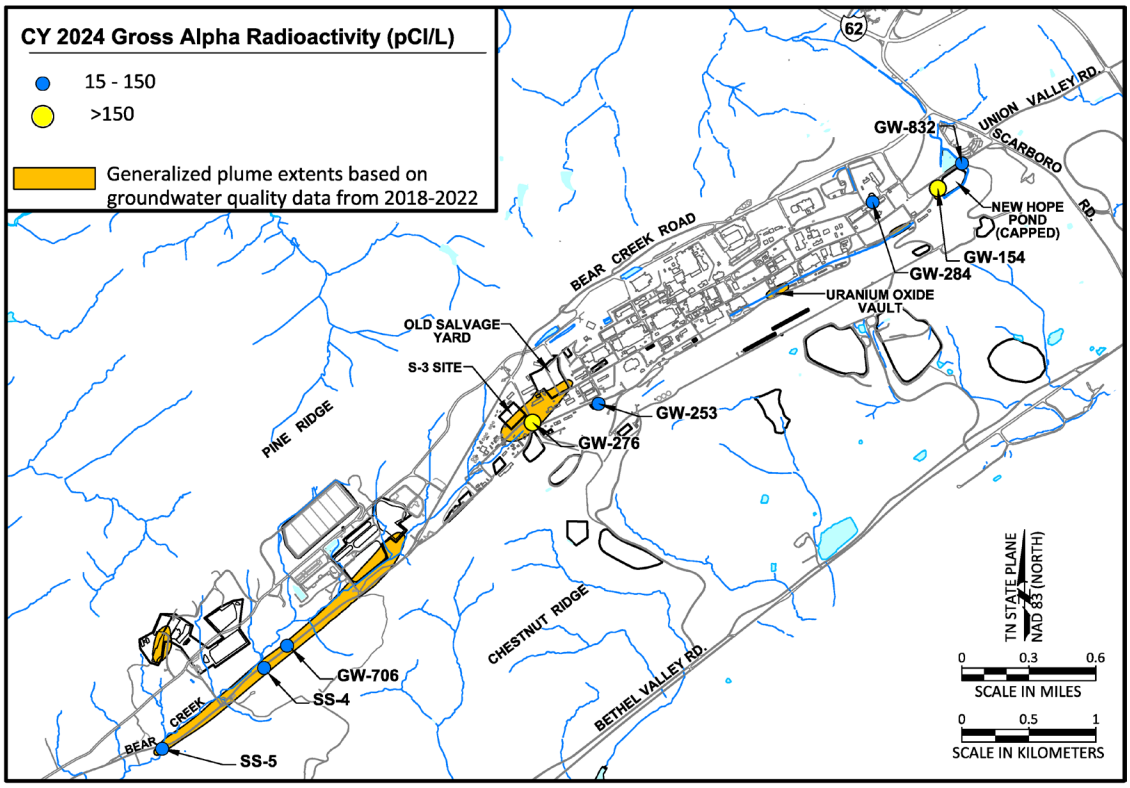


Figure 4.32. Gross-alpha activity in groundwater at Y-12

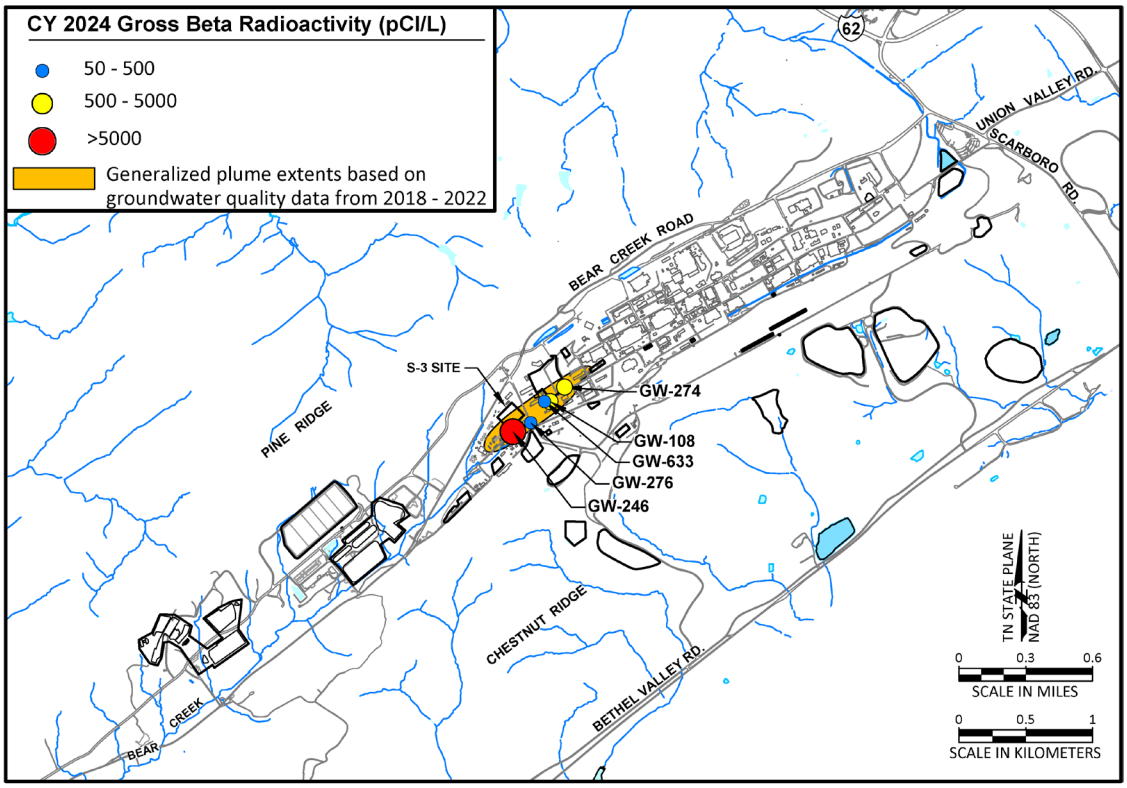


Figure 4.33. Gross-beta activity in groundwater at Y-12

Exit pathway and perimeter monitoring

In the Upper EFPC regime, VOCs have been observed at depths of up to 500 ft below ground surface. The deep fractures and solution channels in the Maynardville Limestone (the primary exit pathway) appear to be well connected and facilitate contaminant migration into Union Valley off-site to the east of Y-12.

Because of off-site migration of contaminants, a plume capture system (the East End VOC Treatment System) was constructed in and around well GW-845 (shown on Figure 4.31) and began continuous operation in October 2000. Groundwater is pumped from the Maynardville Limestone at about 95 L/min (25 gal/min), passes through a treatment system to remove the VOCs, and then discharges to Upper EFPC. The effectiveness of this system is reported annually in remediation effectiveness reports published by DOE EM (DOE 2024a, 2025).

Monitoring wells near the plume capture system continue to show an encouraging response. The trends near the East End VOC plume show that contaminants in shallow-intermediate wells located perpendicular to strike across lithologic units from the plume capture system installed in GW-845 may be mobilized by the system. However, downgradient detection of these compounds is limited. An example is observed in the Westbay system installed in well GW-722. This multiport well, located downgradient from the East End VOC Treatment System, allows sampling of several vertically discrete zones within the Maynardville Limestone. Monitoring results from GW-722 indicate reductions in VOCs due to the plume capture system, derived from summed VOC levels above 1,000 µg/L before the treatment system was installed to below 50 µg/L in the last 4 years.

Five zones in well GW-722 were sampled in 2024, with four zones showing summed VOCs greater than 5 µg/L. Four zones exceeded the drinking water standard for carbon tetrachloride, with the highest concentration (16 µg/L) measured at zone 722-20 (333 ft below ground surface). Zone 722-20 also exceeded the drinking water standard for PCE at 6.7 µg/L.

In addition to the deep system in the eastern portion of the Upper EFPC regime, VOCs have also been observed in shallow groundwater where it flows north-northeast (mimicking the flow of the creek) east of the New Hope Pond site and Lake Reality. In this area, GW-832 has been installed in a distribution channel underdrain associated with former New Hope Pond. During 2024, the summed concentrations of VOCs at the New Hope Pond distribution channel underdrain remained low (16.8-17.4 µg/L).

Upper EFPC flows north, exiting Y-12 through a gap in Pine Ridge. As mentioned previously, shallow groundwater mimics the creek and also moves through this exit pathway. A groundwater monitoring well in this pathway gap was monitored in 2024, and no groundwater contaminants were observed above primary drinking water standards.

Perimeter sampling locations continue to be monitored north and northwest of Y-12 to evaluate possible contaminant transport, even though those locations are considered unlikely contaminant exit pathways. One of the stations monitored is a tributary that drains the north slope of Pine Ridge and discharges into the adjacent Scarboro community. Another location monitors an upper reach of Mill Branch, which discharges into the residential areas along Wiltshire Drive. The remaining location monitors Gum Hollow Branch as it flows adjacent to the Country Club Estates community. There were no indications that contaminants were being discharged from ORR into those communities.

Union Valley monitoring

Groundwater monitoring data obtained in the early 1990s provided the first indication that VOCs were being transported off the ORR through the deep Maynardville Limestone exit pathway. The Upper EFPC remedial investigation (DOE 1998) discussed the nature and extent of VOC contamination in Union Valley.

In 2024, monitoring locations in Union Valley continued to show overall decreasing or low concentration stable trends. Vinyl chloride at 2.2 µg/L (above the maximum contaminant level of 2 µg/L) was detected at monitoring well GW-230, located in the University of Tennessee Arboretum (approximately 3,500 ft east of the ORR boundary). A groundwater flow divide west of GW-230, coincident with Scarboro Creek, Illinois Avenue, and a gap in Chestnut Ridge, probably restricts transport of VOCs from the ORR further east (MMES 1995). This would indicate that the VOCs observed in the well are from a source other than Y-12.

Under the terms of an interim Record of Decision, restrictions on potential future groundwater use have been established and maintained. Additionally, the previously discussed plume capture system (well GW-845) was installed to mitigate groundwater migration contaminated with VOCs into Union Valley (DOE 1997).

In July 2006, the Agency for Toxic Substances and Diseases Registry—the principal federal public health agency charged with evaluating the human health effects of exposure to hazardous substances in the environment—published *Public Health Assessment: Evaluation of Potential Exposures to Contaminated Off-Site Groundwater from the Oak Ridge Reservation*, in which groundwater contamination across the ORR was evaluated (ATSDR 2006). In the report, it was acknowledged that groundwater contamination exists throughout the ORR, but the authors concluded there is no public health hazard from exposure to contaminated groundwater originating on the ORR. At that time, the Y-12 East End VOC groundwater contaminant plume was acknowledged as the only confirmed, off-site, contaminant plume migrating across the ORR boundary. The report recognized that institutional and administrative controls established in the Record of Decision do not provide for reduction in toxicity, mobility, or volume of contaminants of concern, but it concluded the controls protect public health to the extent that they limit or prevent community exposure to contaminated groundwater in Union Valley.

4.6.3.2. Bear Creek Hydrogeologic Regime

Located west of Y-12 in Bear Creek Valley, the Bear Creek regime is bounded to the north by Pine Ridge and to the south by Chestnut Ridge. The regime encompasses the portion of Bear Creek Valley extending from the west end of Y-12 to State Highway 95.

Plume delineation

The primary contaminants in the Bear Creek regime are nitrate, trace metals, VOCs, and radionuclides. The S-3 site is a source of all four contaminants. The Bear Creek Burial Grounds and Oil Landfarm waste management areas are sources of uranium, other trace metals, and VOCs. Chlorinated hydrocarbons and PCBs have been observed in groundwater as deep as 82 m (270 ft) below the Bear Creek Burial Grounds (MMES 1990).

Contaminant plume boundaries are constrained by the bedrock formations (particularly the Nolichucky Shale) that underlie the waste disposal areas in the Bear Creek regime. This fractured aquitard unit is north of and adjacent to the exit pathway unit, the Maynardville Limestone. The elongated shape of the plumes in the Bear Creek regime is the result of preferential transport of the contaminants parallel to strike (parallel to the valley axis).

The plumes in the Bear Creek regime (Figures 4.29, 4.31, 4.32, and 4.33) represent the average concentrations and radioactivity between 2018 and 2022. The circular icons presented on the figures represent 2024 monitoring results.

Nitrate

Data from 2024 indicate nitrate in groundwater continues to exceed the drinking water standard (10 mg/L) in an area that extends west from the S-3 site. The highest nitrate concentration (3,080 mg/L) was observed at well GW-526 adjacent to the S-3 site at a depth of 123 ft below ground surface. Historically, elevated concentrations of nitrate (>1,000 mg/L) have been detected at greater depths (>700 ft below ground surface) near the S-3 site.

In 2024, concentrations of nitrate appear to be lower in the Bear Creek Regime. Concentrations exceeding the drinking water standard were detected in groundwater as far as 2,438 m (8,000 ft) west of the S-3 site, from spring location SS-4 (13 mg/L). Monitoring well GW-537, located 762 m (2,500 ft) from the S-3 site, showed elevated concentrations above the drinking water standard (114 mg/L) as shown in Figure 4.34.

Natural attenuation processes have reduced nitrate levels in the shallow groundwater downgradient of the site. These trends are shown in the time-series data for wells GW-246 and GW 537 in Figure 4.34. Decreasing nitrate levels in the groundwater from these wells primarily reflect the substantially reduced flux of nitrate in the subsurface after the S-3 site was closed and covered with a multilayer low permeability cap.

Despite the slightly elevated nitrate results for aquitard well GW-537 in 2023 and 2024, the overall decreasing trend in nitrate indicates more efficient natural attenuation of nitrate in the shallow flow system, including seasonal discharge of nitrate-contaminated groundwater to the surface drainage network in Bear Creek Valley, compared to the substantially slower attenuation of nitrate in less permeable groundwater flow/contaminant transport pathways deeper in the bedrock.

Under the conceptual model for contaminant transport in the valley, elevated nitrate concentrations in the shallow groundwater from well GW-537 (1,285 in 1992 and 8.44 mg/L in 2020) were sustained by nitrate-contaminated groundwater upwelling from deeper flowpaths in the Nolichucky Shale (DOE 1997b).

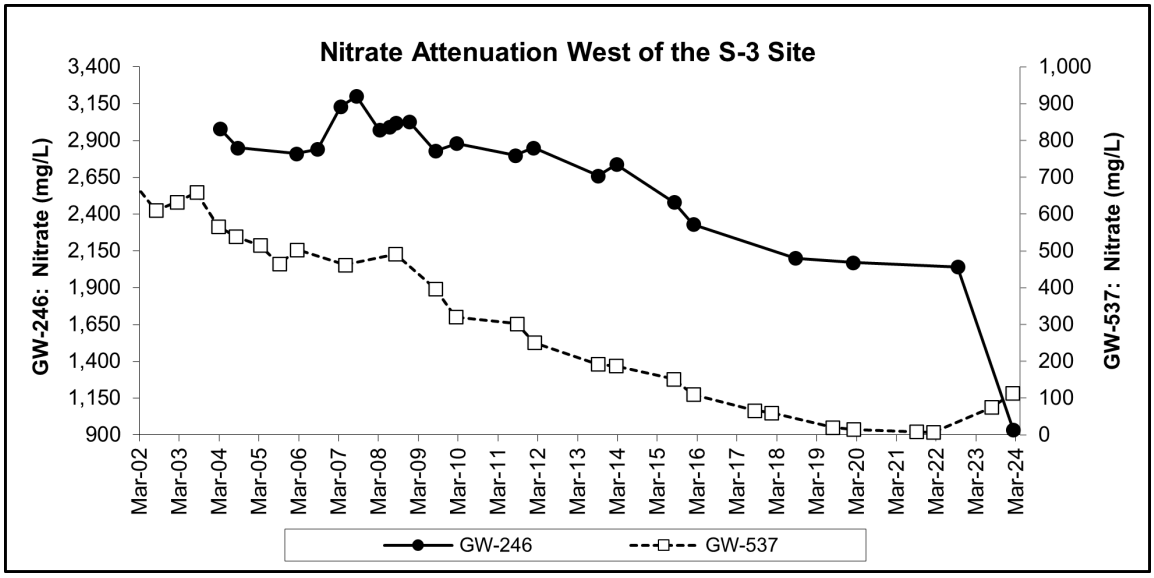


Figure 4.34. Nitrate trend in surveillance monitoring wells GW-246 GW-537, west of S-3 site, Bear Creek Regime, 2002–2024

Trace metals

During 2024, arsenic, barium, beryllium, cadmium, chromium, lead, nickel, and uranium were identified as trace metal contaminants in the Bear Creek regime that exceeded primary drinking water standards. Elevated concentrations of many of the trace metals were observed at shallow depths near the S-3 site.

Disposal of acidic liquid wastes at the site reduced the pH of the groundwater, which allows the metals to remain in solution longer and migrate further from the source area. In other areas of the Bear Creek regime, where natural geochemical conditions prevail, the trace metals may occur sporadically and in close association with source areas because conditions are typically not favorable for dissolution and migration.

The most prevalent trace metal contaminant is uranium. There has been a decrease in uranium in Bear Creek since 1990, as shown in Table 4.19; however, uranium concentrations in the upper reaches of Bear Creek have been stable, indicating that this contaminant still presents an impact to surface water and groundwater.

Table 4.19. Nitrate and uranium concentrations in Bear Creek

Bear Creek monitoring station (Distance from S-3 site)	Contaminant	Average concentration[a] (mg/L)			
		1990–1999	2000–2009	2010–2019	2020–2024
BCK[b]-11.84 to 11.97	Nitrate	91.9	75.2	43.4	24.8
(~0.5 miles downstream)	Uranium	1.61	0.124	0.183	0.164
BCK-09.20 to 09.47	Nitrate	12.4	11.3	4.8	2.9
(~2 miles downstream)	Uranium	0.096	0.115	0.061	0.058
BCK-04.55	Nitrate	3.8	2.5	0.96	0.98
(~5 miles downstream)	Uranium	0.033	0.028	0.018	0.016

[a] *Excludes results that do not meet data quality objectives.*

[b] *BCK = Bear Creek kilometer, measured upstream from the confluence with East Fork Poplar Creek.*

VOCs

VOCs are widespread in groundwater in the Bear Creek regime. The primary compounds are PCE; TCE; cis-1,2-DCE; vinyl chloride; and 1,1-dichoroethane. In most areas, they are dissolved in groundwater and can occur in bedrock at depths up to 92 m (300 ft) below ground surface. VOCs that occur in groundwater of the fractured bedrock aquitard units are found within about 305 m (1,000 ft) laterally of source areas.

The highest concentration observed in 2024 occurred in the Nolichucky Shale aquitard at the Bear Creek Burial Ground waste management area, with a maximum summed VOC concentration of 8,672.94 in well GW-068, which included cis-1,2-DCE (3,890 µg/L), 1,1-DCE (1,930 µg/L), benzene (965 µg/L), and vinyl chloride (904 µg/L).

As illustrated by respective time-series plots for wells GW-008, GW-225, and GW-626 shown in Figure 4.35, the summed VOC concentrations either show wide temporal concentrations fluctuations that do not display any consistently increasing or decreasing long-term trend or exhibit a generally stable trend that suggest little corresponding change in the overall flux of dissolved VOCs via the groundwater flow and transport pathways intercepted by the well.

In addition, data for each well show indeterminate trends for each of the VOCs detected above screening levels. The indeterminate trends likely reflect the combined influence of (1) the large volume of VOCs in the subsurface at each source area, (2) low permeability of the groundwater flow and transport pathways monitored by the wells, and/or (3) minimal natural attenuation of the VOCs during residence time or transport in the subsurface.

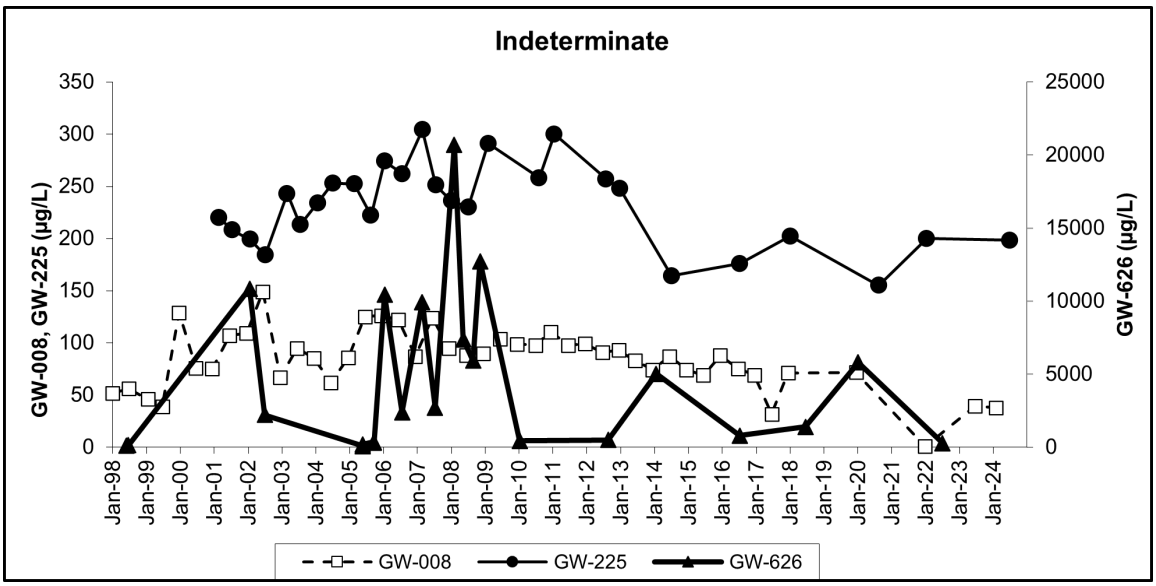


Figure 4.35. Indeterminate VOC trends in surveillance monitoring wells GW-008, GW-225, and GW-626

Radionuclides

As in the EFPC regime, the primary radionuclides identified in the Bear Creek regime are isotopes of uranium and ^{99}Tc. The extent of radionuclides in groundwater in the Bear Creek regime during 2024 was based primarily on measurements of gross-alpha and gross-beta activity. If the gross-alpha activity in a well exceeded 15 pCi/L (the drinking water standard for gross-alpha activity), then one or more of the alpha-emitting radionuclides (e.g., uranium) is assumed to be present and, at certain monitoring locations, is evaluated isotopically. A similar rationale is used for gross-beta activity that exceeds 50 pCi/L. Technetium-99, a more volatile radionuclide, is qualitatively screened by gross-beta activity analysis.

Groundwater in the Bear Creek regime with elevated gross-alpha activity occurs near the S-3 site and the Oil Landfarm waste management areas. In the bedrock interval, gross-alpha activity has exceeded 15 pCi/L in groundwater in the fractured bedrock of the aquitard units only near source areas (Figure 4.32).

In 2024, the highest gross-alpha activity observed in a monitoring well in the Bear Creek regime (111 pCi/L) was in GW-276, which is adjacent to the S-3 site (Figure 4.32). Although GW-276 has the highest concentration, gross-alpha activity is decreasing in the S-3 site plume. These trends are illustrated by the time-series data for wells GW-246 and GW-276 in Figure 4.36. These trends reflect reduced flux of uranium isotopes (and alpha-emitting daughter products) via the groundwater flow and transport pathways monitored by the wells.

In 2024, the highest gross-beta activity in groundwater in the Bear Creek regime was also at GW-246 at 11,000 pCi/L (Figure 4.33).

Exit pathway and perimeter monitoring

Bear Creek, which flows over the Maynardville Limestone (the primary exit pathway for groundwater) in much of the Bear Creek regime, is the principal exit pathway for surface water. Studies have shown the surface water in Bear Creek, the springs along the valley floor, and the groundwater in the Maynardville Limestone are hydraulically connected. Surveys have identified gaining (groundwater discharging into surface waters) and losing (surface water discharging into a groundwater system) reaches of Bear Creek. The western exit pathway monitoring well transect (EXP-W) serves as the perimeter well location for the Bear Creek regime (Figure 4.26).

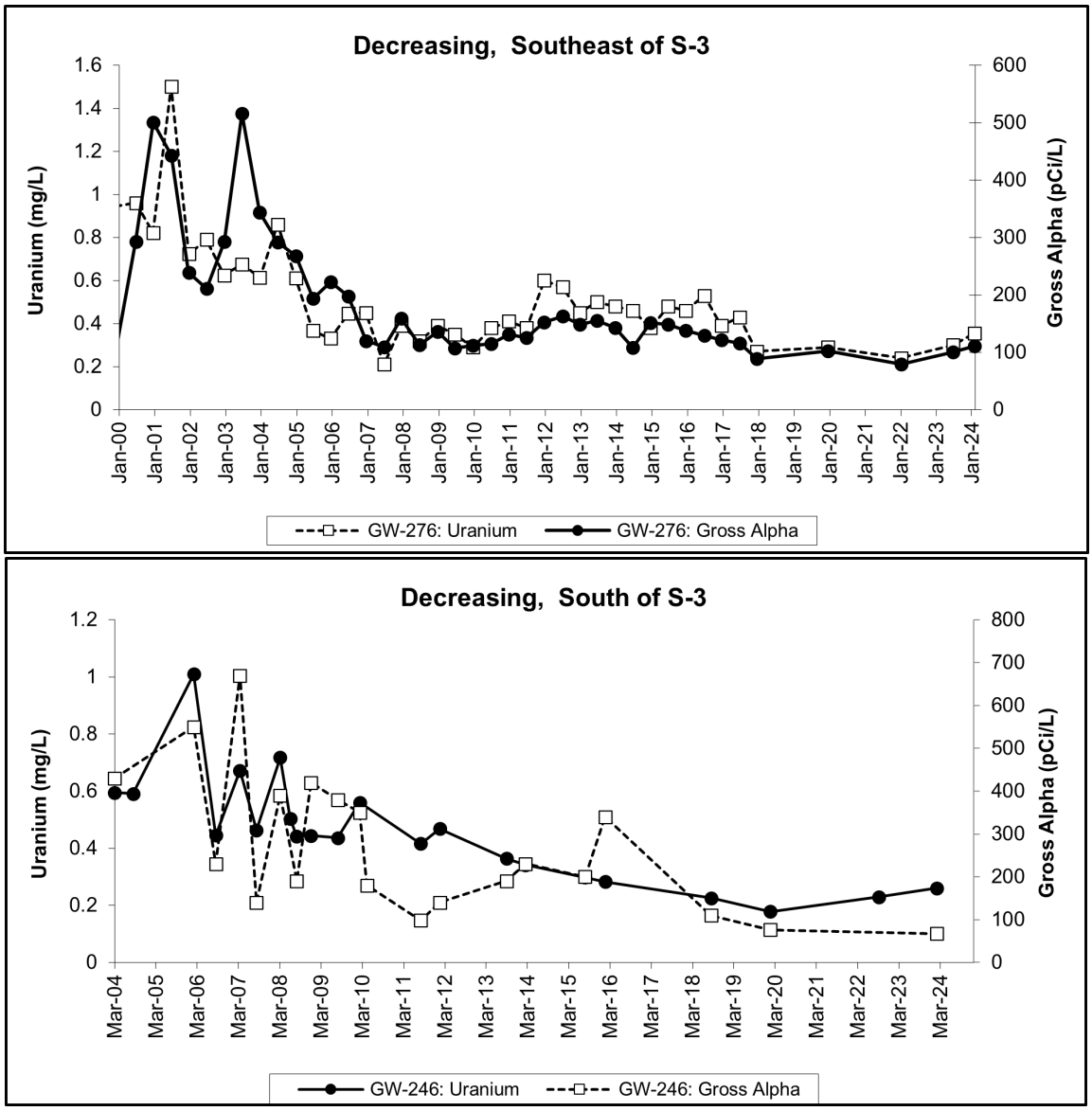
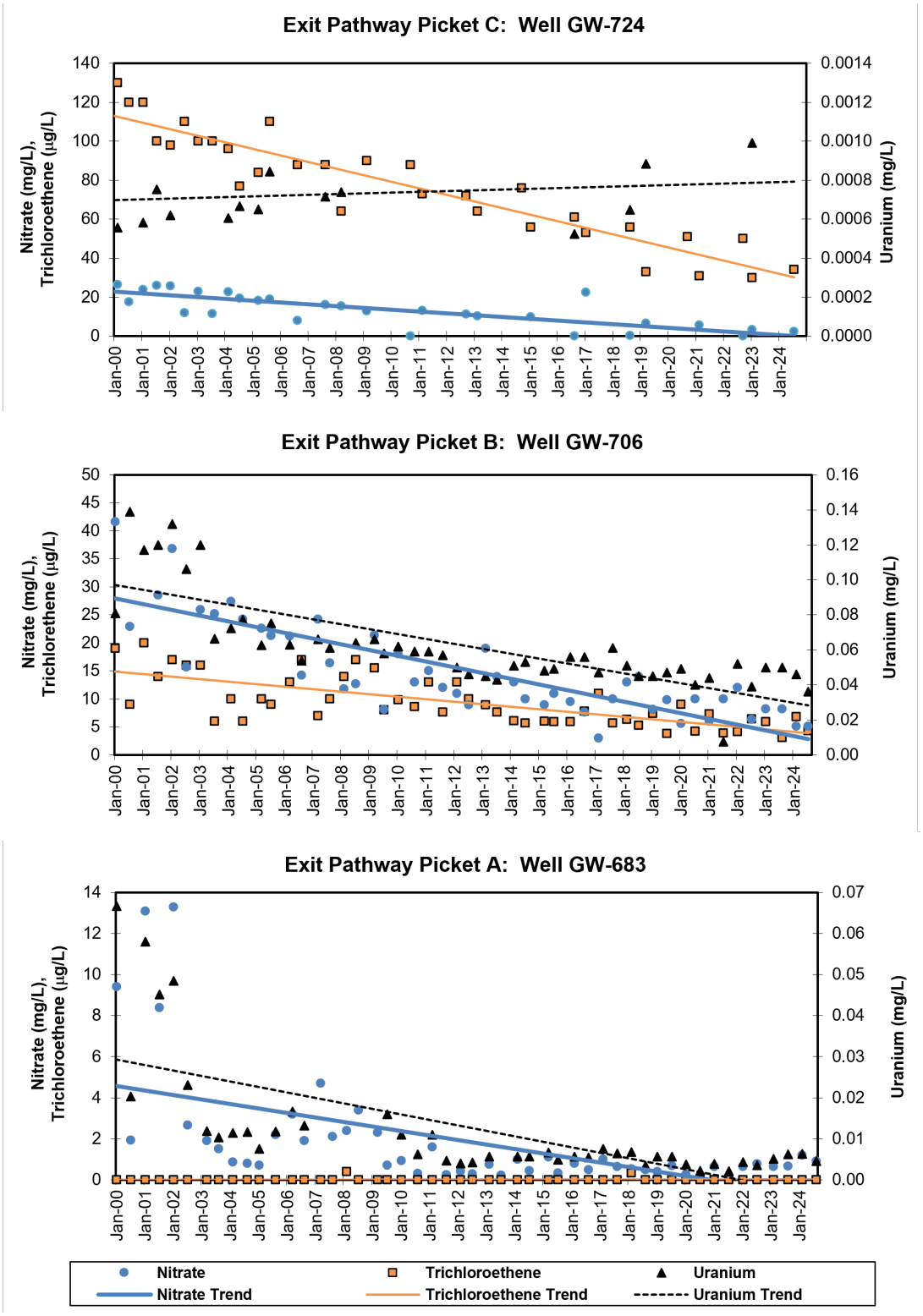


Figure 4.36. Gross alpha concentration trends in surveillance monitoring wells GW-246 and GW-276

Exit pathway monitoring continues at four exit pathway transects (A, B, C, and W; Figure 4.26) also referred to as pickets, and selected springs and surface water stations. Data obtained during 2024 indicate groundwater is contaminated above drinking water standards in the Maynardville Limestone as far as Picket W. The drinking water standard for uranium was exceeded (0.035 mg/L) in shallow well GW-715. Concentration trends throughout the exit pathway continue to be generally stable to decreasing, as shown in Figure 4.37.

In 2024, GW-710, GW-711, and GS-714 in exit pathway transect W showed trace concentrations of VOCs (below drinking water standards), thus indicating migration of contaminants potentially thousands of feet from likely sources areas to the east (e.g., Boneyard/Burnyard, the S-3 site, or Spoil Area 1). TCE is sporadically detected in transect W but has never been detected above drinking water standards.



Note: *Only nitrate and uranium results above the detection limit are plotted; non-detected trichloroethene results are plotted at zero.*

Figure 4.37. Concentrations of selected contaminants in exit pathway monitoring wells in the Bear Creek hydrogeologic regime

Surface water samples collected in 2024 indicate water in Bear Creek contains many of the same compounds found in the groundwater. Uranium concentrations exceeding the drinking water standard have been observed in surface water west of the Burial Grounds as far as Picket W. This location is 4,724 m (15,500 ft) west of the S-3 site. The concentrations in the creek generally decrease with distance downstream of the waste disposal sites (Table 4.19).

Exit pathway monitoring stations sampled in 2024 show that gross-alpha activity in the Maynardville Limestone exceeds the drinking water standard as far as 3,353 m (11,000 ft) west of the S-3 site at Spring SS-5 (15 pCi/L). The alpha activity at this spring recently shows a decreasing trend.

4.6.3.3. Chestnut Ridge Hydrogeologic Regime

The Chestnut Ridge hydrogeologic regime is flanked to the north by Bear Creek Valley and to the south by Bethel Valley Road (Figure 4.25). The regime encompasses the portion of Chestnut Ridge extending from Scarboro Road, east of the complex, to Dunaway Branch, located just west of Industrial Landfill II.

The Chestnut Ridge Security Pits area is the primary source of groundwater contamination in the regime. Contamination from the security pits is distinct and does not mingle with plumes from other sources.

Plume delineation

The extent of the VOC plume at the Chestnut Ridge Security Pits is reasonably well defined in the water table and shallow bedrock zones. With two possible exceptions, historical monitoring indicates the VOC plume from the Chestnut Ridge Security Pits has shown minimal migration in any direction (<305 m [<1,000 ft]).

Data obtained during 2022 indicate the western lateral extent of the VOC plume at the site has not changed significantly. VOC contaminants at a well about 458 m (1,500 ft) southeast and downgradient of the Chestnut Ridge Security Pits continue to show some migration of the eastern plume has occurred. Additionally, previously performed dye tracer test results and the intermittent detection of trace concentrations of VOCs (similar to those found in wells adjacent to the Chestnut Ridge Security Pits) at a natural spring about 2,745 m (9,000 ft) to the east and along geologic strike may suggest that Chestnut Ridge Security Pits contaminants have migrated further than the monitoring well network indicates. However, since 2021, no VOCs were detected at this spring.

The Chestnut Ridge Security Pits plume in the Chestnut Ridge regime (shown by orange shading on Figure 4.31) represents the average VOC concentrations between 2018 and 2022. The circular icons presented on the figure represent 2024 monitoring results.

Nitrate

Nitrate concentrations continue to be below the drinking water standard at all monitoring stations in the Chestnut Ridge regime in 2024.

Trace metals

Concentrations of arsenic above drinking water standards have been observed in two surface water monitoring locations downstream from the Filled Coal Ash Pond, which is monitored under a CERCLA Record of Decision (DOE 1996). Under the decision, migration of contaminated effluent from the Filled Coal Ash Pond is reduced by a constructed wetland area. In recent years, it became apparent the wetland efficiency was decreasing because, in part, of erosion channels forming around the wetland. During 2019, a maintenance activity was conducted at the site to improve the aquatic habitat for plant growth and to increase retention time for water within the wetland. The elevated arsenic levels were detected both upgradient (McCoy Branch kilometer [MCK] 2.05) and downgradient (MCK 2.0) of this wetland area. In 2024, the passive wetland treatment area continued to be effective in reducing arsenic.

VOCs

Overall, concentrations of VOCs in groundwater at the Chestnut Ridge Security Pits have decreased since 1988.

At Industrial Landfill IV, VOCs have been observed in the groundwater since 1992. Well GW-305, located immediately to the southeast of the facility (Figure 4.31), exhibited increasing trends of summed VOCs from 1992 to 2014 but have stabilized, with the 2024 concentration at 80.06 µg/L. GW-305 was sampled in January and July 2024 with results for 1,1 DCE of 4.14 µg/L and 6.26 µg/L, respectively. (The drinking water standard for this compound is 5 ug/L.)

Radionuclides

In 2024, no gross-alpha (15 pCi/L) or gross-beta (50 pCi/L) above the drinking water standards were observed in the Chestnut Ridge hydrogeologic regime.

Exit pathway and perimeter monitoring

Contaminant and groundwater flowpaths in the karst bedrock underlying the Chestnut Ridge regime have not been well characterized. Tracer studies have been conducted that show groundwater from Chestnut Ridge discharging into Scarboro Creek (approximately 9,000 ft from the Chestnut Ridge Security Pits) and other tributaries that feed into Melton Hill Lake. However, no springs or surface streams that represent discharge points for groundwater have been conclusively correlated to a waste management unit or operation at Y-12 that is a known or potential groundwater contaminant source. Springs along Scarboro Creek are monitored for water quality, and trace concentrations of VOCs are intermittently detected. The detected VOCs are suspected to originate from the Chestnut Ridge Security Pits; however, this has not been confirmed. In 2024, two springs along Scarboro Creek were sampled with no detected concentrations of VOCs.

Monitoring natural groundwater exit pathways is a basic monitoring strategy in a karst regime, such as that of Chestnut Ridge. Perimeter springs and surface water tributaries were monitored to determine whether contaminants are exiting the downgradient (southern) side of the regime. Six springs and three surface water monitoring locations were sampled during 2024. No contaminants at any of these monitoring stations were detected at levels above primary drinking water standards.

4.6.4. Emerging Contaminants

Per- and polyfluoroalkyl substances (PFAS) are emerging contaminants that constitute a large family of fluorinated chemicals. The persistence and mobility of some PFAS, combined with decades of widespread use in industrial processes, certain types of firefighting foams, and consumer products, have resulted in their being present in environmental media at trace levels across the globe. It was not until the early 2010s that analytical methods to detect a limited number of PFAS became widely available and had detection limits in water low enough to be commensurate with levels of potential human health effects. Toxicological studies have raised concerns regarding the bioaccumulative nature and potential health concerns of some PFAS.

The following actions and activities were conducted at Y-12 during 2024 to address these emerging contaminants of concern:

- Y-12 continues to maintain compliance with the DOE requirements pertaining to PFAS storage, use, and disposal (DOE 2021a, DOE 2021b). No PFAS-containing aqueous film-forming foam (AFFF) was used for training purposes, and no new AFFF systems were installed in 2024. One waste storage building (Building 9720-09) has an active AFFF fire suppression system that is only approved for fire emergencies. This system undergoes periodic maintenance and post-maintenance testing, which generate AFFF wastes that contain PFAS. There was one spill during post-maintenance testing, which was cleaned immediately with no release to the environment. Corrective actions were implemented following the event for future maintenance/testing cycles to prevent a similar release.

- Y-12 has a fire department and fire training facility. The Y-12 Fire Department has one firetruck with a foam induction system that uses a fluorine-free foam.
- Uses of PFAS or PFAS-related substances are tracked. No PFAS substances were used in excess of the Emergency Planning and Community Right-to-Know Act Toxics Release Inventory reporting threshold during 2024.
- No production-related activities, equipment, or processes are known to have generated or released PFAS to the environment; however, several products and/or chemicals containing PFAS have been used in small quantities, primarily in the Analytical Chemistry laboratories and in the Development facilities.
- Y-12 personnel sampled the drinking water system quarterly in 2024 to support the EPA Unregulated Contaminant Monitoring Rule 5 (EPA 2024). The Safe Drinking Water Act requires that, once every 5 years, the EPA issue a list of unregulated contaminants to be monitored by public water systems. The new rule requires that samples be collected for 30 chemical contaminants between 2023 and 2025 using standard analytical methods. Twenty-nine of these contaminants are PFAS. This action provides scientifically valid data on the national occurrence of these contaminants in drinking water to improve the agency's understanding of the frequency of detection and concentrations of PFAS in the nation's drinking water systems. The monitoring data on PFAS will help determine future regulations and other actions to protect public health. Results from sampling showed only one detected concentration (3.6 ng/L) of perfluorobutanesulfonioc acid (PFBS) above the detection limit. This result did not exceed the drinking water standard established for this PFAS chemical and was only observed during one quarter of sampling.

4.7. Quality Assurance Program

Y-12's QA Program establishes a quality policy and requirements for the Y-12 site. Internal procedures detail the methods used to carry out work processes safely and securely and in accordance with established procedures. They also describe mechanisms in place to identify and correct findings and prevent recurrences.

Many factors can potentially affect the results of environmental data collection activities, including sampling personnel, methods, and procedures; field conditions; sample handling, preservation, and transport; personnel training; analytical methods; data reporting; and recordkeeping. QA programs are designed to minimize these sources of variability and control all phases of the monitoring process.

Field sampling QA encompasses many practices that minimize error and evaluate sampling performance. The following are some key quality practices:

- Using work control processes and standard operating procedures for sample collection and analysis
- Using chain-of-custody and sample identification procedures
- Standardizing, calibrating, and verifying instruments
- Training sample technicians and laboratory analysts
- Preserving, handling, and decontaminating samples
- Using QC samples, such as field and trip blanks, duplicates, and equipment rinses

The Y-12 Environmental Sampling Services organization is responsible for field sampling activities, sample preservation and handling, chain-of-custody, and field QC sample transport in accordance with Y-12 Environmental Compliance procedures. Environmental Sampling Services developed a standards and calibration program

that conforms to ISO/IEC 17025, *General Requirements for the Competence of Testing and Calibration Laboratories* (ISO 2017), and provides a process for uniform standardization, calibration, and verification of measurement and test equipment. The program ensures measurements are made using appropriate documented methods, traceable standards, appropriate measurement and test equipment of known accuracy, trained personnel, and technical best practices.

Analytical results may be affected by a large number of factors inherent to the measurement process. Laboratories that support Y-12 environmental monitoring programs use internal QA/QC programs to ensure early detection of problems that may arise from contamination, inadequate calibrations, calculation errors, or improper procedure performance. Internal laboratory QA/QC programs include routine calibrations of counting instruments; yield determinations; frequent use of check sources and background counts, replicate and spiked sample analyses, and matrix and reagent blanks; and maintenance of control charts to indicate analytical deficiencies. These activities are supported by using standard materials or reference materials (e.g., materials of known composition that are used to calibrate instruments, methods standardization, spike additions for recovery tests, and other practices). Certified standards traceable to the National Institute of Standards and Technology, DOE sources, or EPA are used, when available.

Y-12's Analytical Chemistry organization has an internal manual that describes program elements; customer-specific requirements; certification program requirements; federal, state, and local regulations; and waste acceptance criteria. As a government-owned, contractor-operated laboratory that performs work for DOE, the Analytical Chemistry laboratory operates in accordance with DOE Order 414.1D, *Quality Assurance* (DOE 2011c).

Other internal practices used to ensure laboratory results represent of actual conditions and include training and managing staff; maintaining adequacy of the laboratory environment; ensuring safety; controlling the storage, integrity, and identity of samples; maintaining recordkeeping; maintaining and calibrating instruments; and using technically validated and properly documented methods.

Y-12's Analytical Chemistry organization participated in Mixed Analyte Performance Evaluation Program studies conducted in 2024 for water and soil matrices for metals, organics, and radionuclides. The overall acceptability rating from both studies was 95.25 percent.

Verification and validation of environmental data are performed as components of the data collection process, which includes planning, sampling, analyzing, and performing data review. Some level of verification and validation of field and analytical data collected for environmental monitoring and restoration programs is necessary to ensure that data conform to applicable regulatory and contractual requirements. Validation of field and analytical data is a technical review performed to compare data with established quality criteria to ensure that data are adequate for the intended use. The extent of project data verification and validation activities is based on project-specific requirements.

For routine environmental effluent monitoring and surveillance monitoring, data verification activities may include processes to check whether data have been accurately transcribed and recorded, appropriate procedures have been followed, electronic and hard copy data show one-to-one correspondence, and data are consistent with expected trends. Typically, routine data verification actions alone are sufficient to document the validity and accuracy of environmental reports. For restoration projects, routine verification activities are more contractually oriented and include checks for data completeness, consistency, and compliance with a predetermined standard or contract.

Certain projects may require a more-thorough technical validation of the data, as mandated by the project's data quality objectives. Sampling and analyses conducted as part of a remedial investigation to support the CERCLA process may

generate data that are needed to evaluate risk to human health and the environment, to document that no further remediation is necessary, or to support a multimillion-dollar construction activity and treatment alternative. In these cases, the data quality objectives of the project may mandate a thorough technical evaluation of the data against rigorous predetermined criteria.

The validation process may result in identifying data that do not meet predetermined QC criteria or in the ultimate rejection of data for their intended use. Typical criteria evaluated in the validation of contract laboratory program data include the percentage of surrogate recoveries, spike recoveries, method blanks, instrument tuning, instrument calibration, continuing calibration verifications, internal standard response, comparison of duplicate samples, and sample holding times.

A due diligence analysis is performed for facilities used for the treatment, storage, or disposal of radiological and hazardous waste to ensure that each facility is well operated and maintained; has minimal environmental issues and impacts; employs personnel who are properly trained, competent, and work safely; is in compliance with regulatory requirements; and is adequately insured against personal and environmental liabilities.

This evaluation includes a review of information on the facility's compliance history, design, operations, recordkeeping and reporting requirements, emergency response procedures, closure/post-closure plans, and insurance coverage, as well as any environmental issues, remediation, litigation or regulatory agency concerns related to the facility. Y-12 limits the number of facilities used and avoids or discontinues using facilities that present significant environmental and/or safety liability. This evaluation may rely on results of third-party accreditation assessments reported under the DOE Consolidated Audit Program. Table 4.20 lists treatment, storage, and disposal facilities used in 2024 for the disposition of radiological and hazardous waste.

Table 4.20. Treatment, storage, and disposal facilities used to disposition radiological and hazardous waste, 2024

Facility name	Location	Identification number
Clean Harbors Colfax Facility	Colfax, Louisiana	LAD981055791
Clean Harbors Baton Rouge	Baton Rouge, Louisiana	LAD010395127
Clean Harbors Deer Park Incineration Facility	La Porte, Texas	TXD055141378
Clean Harbors El Dorado Incineration Facility	El Dorado, Arkansas	ARD069748192
Clean Harbors Grassy Mountain Landfill Facility	Clive, Utah	UTD991301748
Clean Harbors La Porte Technical Services	La Porte, Texas	TXD982290140
Clean Harbors Lone Mountain Facility	Waynoka, Oklahoma	OKD065438376
Clean Harbors Reidsville	Reidsville, North Carolina	NCD000648451
Diversified Scientific Services, Inc.	Kingston, Tennessee	TND982109142
Energy*Solutions* Bear Creek Processing Facility	Kingston, Tennessee	TND982157570
Energy*Solutions* Clive Disposal Facility	Grantsville, Utah	UTD982598898
Nevada National Security Site	Mercury, Nevada	NV3890090001
Safety-Kleen Systems	Smithfield, Kentucky	KYD053348108
Veolia ES Technical Solutions	Port Washington, Wisconsin	WID988566543
Waste Control Specialists	Andrews, Texas	TXD988088464

4.8. Environmental Management and Waste Management Activities

The three sites on ORR have a rich history of research, innovation, and scientific discovery. Unfortunately, despite their vitally important missions, they are hindered by environmental legacies remaining from past operations. The contaminated portions of ORR are on the EPA National Priorities List, which includes hazardous waste sites across the nation that are to be cleaned up under CERCLA. Areas that require cleanup or further action on ORR have been clearly defined, and DOE EM is working to clean those areas under the Federal Facility Agreement with the EPA and TDEC. The *2024 Cleanup Progress: Annual Report on Oak Ridge Reservation Cleanup* (UCOR 2024a) provides detailed information on DOE EM cleanup activities.

4.8.1. Environmental Management Activities

At Y-12, DOE EM is addressing excess and contaminated facilities, removing mercury soil and groundwater contamination, and enabling modernization efforts that allow NNSA to continue its crucial national security and nuclear nonproliferation responsibilities.

Demolition begins on Alpha 2 Complex

Demolition is underway at one of the Manhattan Project-era complexes at Y-12. The main facility in the complex is Building 9201-2, also referred to as Alpha 2. The Alpha 2 facility occupies just over two acres of land. At nearly 325,000 ft^2, the 1940s-era Alpha 2 building is one of the largest high-risk excess contaminated facilities EM is addressing at Y-12.

Workers began deactivating the Alpha 2 complex in 2020 by removing the last of the hazardous waste, draining oil from equipment, and clearing various areas of the basement to allow it to be filled with controlled low-strength material that will provide structural support for the heavy equipment that will be on the slab during demolition.

While deactivation was going on inside Alpha 2, a separate project was underway to reroute utilities, including steam, instrument air, plant air, argon gas, nitrogen gas, and demineralized water, around the area. Workers installed four new structural steel bridges for the rerouted utilities across Second Street, which is the main road adjacent to Alpha 2. Each bridge weighs more than 2,000 lb and took more than a year to design and build.

Deactivation continues at former enrichment facilities

Deactivation activities continued at three large former uranium processing facilities throughout FY 2024—Building 9204-01, Building 9201-04, and Building 9204-4.

Building 9204-01 is a 210,500-ft^2, three-story, former uranium enrichment facility. Workers completed deactivation of the aboveground floors, and treated 5.7 million gal of water that was pumped from the basement. Weather-based water intrusion will continue to be mitigated. In addition, 100 linear ft of old thorium-contaminated piping was safely removed and prepared for disposal. Demolition is expected in 2026.

Activities during 2024 to bring Building 9201-04 closer to "cold and dark" status included addressing mercury vapors and supporting repackaging containers for eventual disposition of legacy waste. Roughly 50 percent of the facility's waste was characterized, and 227 legacy waste containers were shipped

Planning is underway to start work in Building 9204-4. Once all plans are reviewed and approved, crews will begin to move the facility toward the "cold and dark" state.

Progress continues at the Mercury Treatment Facility

Progress continued on construction of the Outfall 200 Mercury Treatment Facility. The facility is the linchpin for DOE EM's cleanup strategy at Y-12. This vital piece of infrastructure will open the door for demolishing Y-12's large, deteriorated, mercury-contaminated facilities and subsequent

soil remediation by providing a mechanism to limit potential mercury releases into the Upper EFPC.

In FY 2024, UCOR assumed construction responsibility for the facility and began construction of the treatment plant and headworks facility.

At the headworks site, workers are building concrete structures for handling normal flows and higher storm flows. They made progress throughout the year on these structures with approximately 600 yd^3 of concrete poured, bringing the total amount of concrete poured to date for the project to 2,400 yd^3 of concrete.

At the treatment site, workers completed construction of a gravity filter and installed additional tanks. The completion of the gravity filter allows workers to complete the structural steel and roofing of the eventual operations building.

Plans are being finalized for the next phases of construction.

When operational, the facility will be able to treat 3,000 gal of water per minute and help DOE meet regulatory limits in compliance with EPA and state of Tennessee requirements.

Soil remediation efforts being planned

Soil remediation is essential to ensuring environmental safety and allowing reuse of currently contaminated land. Several remediation efforts are underway in the Upper EFPC and Bear Creek areas.

DOE EM and UCOR meet regularly with the NNSA Y-12 Field Office and CNS to share information and develop a plan for addressing legacy soil contamination in the Y-12 main plant area.

The group is focused on understanding the probability and type of contamination in the soil at specific areas of the plant due to historical operations and processes. This includes areas that will become accessible once buildings are demolished. Additionally, Y-12 employees evaluate potential challenges associated with performing soil sampling and soil excavation work on an active site.

White Wing Scrap Yard. Planning is underway to transfer Self Sufficiency Parcel 2 in the ORR north-central area. The former White Wing Scrapyard occupies part of this parcel. The group held a data quality objectives session with EPA and TDEC to develop a site characterization plan. In addition, a remedial investigation work plan was prepared and submitted to EPA and TDEC for review. Due to DOE's intent to accelerate the parcel's transfer, initial surface soil sampling was completed within the scrapyard's footprint. This sampling provided initial site characterization data to inform follow-on sampling and support early remedial action planning.

Bear Creek Burial Ground. The Bear Creek Burial Ground is a former disposal area that received a variety of Y-12 industrial wastes from approximately 1955 to 1993. These wastes contained large amounts of uranium as well as chemical solvents, oils, and PCBs. DOE EM completed actions in 1994 to close disposal units and isolate the remaining waste. To reduce contamination discharges to nearby streams, crews have installed engineered caps and soil covers over waste disposal units, as well as leachate collection systems.

Numerous studies have shown that the site continues to contribute contaminants, including uranium and organic solvents, to surface water and groundwater. In 2024, DOE EM and UCOR began developing a plan to conduct a comprehensive remedial investigation to characterize current conditions, assess risk to human health and the environment, and develop and evaluate alternatives to remediate the contaminant sources working toward a final remedy. A preliminary field investigation was completed in FY 2024 on current contaminant levels in Bear Creek Burial Ground tributaries and groundwater. Results of that investigation support the remedial investigation work plan.

North Tributary 8. In September 2024, DOE EM and UCOR submitted an action memorandum for North Tributary 8 (DOE 2024c). The tributary

carries runoff and contaminants from the western end of the Bear Creek Burial Ground to Bear Creek. Uranium discharges in Bear Creek from the area have exceeded the surface water goals in the Record of Decision for Phase I activities in Bear Creek Valley since 2001 (DOE 2000).

Previous investigations confirmed the eastern branch of North Tributary 8 is the principal source of uranium, making this a trackable issue under the 2016 remediation effectiveness report evaluation requiring a final resolution (DOE 2016). The Federal Facility Agreement parties agreed to conduct a non-time-critical removal action to address these releases. The action memorandum documents the selection of the non-time-critical interim removal action, which includes a geomembrane cap, surface water diversion controls, and surface water monitoring.

Bear Creek Valley Mercury Sources Remedial Site Evaluation. In 2024, DOE EM and UCOR conducted a remedial site evaluation to support the mercury management approach outlined for Bear Creek in the Environmental Management Disposal Facility Record of Decision (DOE 2022b). This evaluation did not identify a mercury source that significantly contributes to the Bear Creek mercury contamination or that would warrant active remediation. To identify potential source areas for mercury and methylmercury in the environment and determine if active remediation was warranted, DOE EM and UCOR sampled surface water, channel sediment, and stream bank and floodplain soils at 15 locations along Bear Creek and an off-site reference location. Routine fish tissue sample data was also evaluated. Although mercury was detected in the media sampled, concentrations are low compared to other ORR mercury-contaminated sites, and fish tissue mercury concentrations continue to decrease.

4.8.2. Waste Management Activities

Waste management is performed at multiple locations on the ORR for both solid and liquid wastes, including landfills and water treatment facilities.

4.8.2.1. CERCLA Waste Disposal

Most of the waste generated during FY 2024 cleanup activities in Oak Ridge went to disposal facilities on the ORR. The Environmental Management Waste Management Facility received 1,526 waste shipments, totaling 12,978 yd^3, from cleanup projects at ETTP and ORNL. This engineered landfill consists of six disposal cells that only accept low-level radioactive and hazardous waste meeting specific criteria. These wastes include soil, dried sludge and sediment, building debris, and personal protective equipment.

4.8.2.2. Solid Waste Disposal

DOE operates and maintains solid waste disposal facilities known as the ORR Landfills. In FY 2024, these three active landfills received 9,959 waste shipments, totaling 153,217 yd^3 of waste.

4.8.2.3. Wastewater Treatment

Safe and compliant treatment of more than 50 million gallons of wastewater and groundwater generated from both production and environmental cleanup activities was provided at various facilities during 2024:

- The West End Treatment Facility and the Central Pollution Control Facility processed approximately 329,550 gal of wastewater, primarily in support of NNSA operational activities.
- The Big Springs Water Treatment System treated more than 29.5 million gal of mercury-contaminated groundwater.
- The East End VOC Treatment System treated 16.1 million gal of VOC-contaminated groundwater.
- The Liquid Storage Facility and Groundwater Treatment Facility treated more than 1.9 million gal of leachate from burial grounds and well purge waters from remediation areas.

- The Central Mercury Treatment System treated approximately 2.1 million gal of mercury-contaminated sump waters from Building 9201-04.

4.9. References

10 CFR 1021. *National Environmental Policy Act Implementing Procedures. US Code of Federal Regulations.* US Department of Energy. Washington, DC.

40 CFR 60, *Standards of Performance for New Stationary Sources. US Code of Federal Regulations.* US Environmental Protection Agency, Washington, DC.

40 CFR 61. *National Emission Standards for Hazard Air Pollutants. US Code of Federal Regulations.* US Environmental Protection Agency, Washington, DC.

40 CFR 63. *National Emission Standards for Hazardous Air Pollutants for Major Sources: Industrial, Commercial, and Institutional Boilers and Process Heaters. US Code of Federal Regulations.* US Environmental Protection Agency, Washington DC.

40 CFR 63 Subpart GGGGG. *National Emission Standard for Hazardous Air Pollutants: Site Remediation*. US Environmental Protection Agency, Washington DC.

40 CFR 82, *Protection of Stratospheric Ozone. US Code of Federal Regulations*. Environmental Protection Agency, Washington, DC.

40 CFR 84, *Phasedown of Hydrofluorocarbons. US Code of Federal Regulations*. Environmental Protection Agency, Washington, DC.

40 CFR 98. *Mandatory Reporting of Greenhouse Gases. US Code of Federal Regulations*. Environmental Protection Agency, Washington, DC.

49 CFR 173. *Shippers—General Requirements for Shipments and Packaging. US Code of Federal Regulations.* US Department of Transportation, Washington, DC.

AIM 2020. *American Innovation and Manufacturing Act of 2020.* 42 U.S.C. 7675. US Government.

ATSDR 2006. *Public Health Assessment: Evaluation of Potential Exposures to Contaminated Off-Site Groundwater from the Oak Ridge Reservation*. Agency for Toxic Substances and Diseases Registry, Atlanta, Georgia. https://wwwn.cdc.gov/tsp/pha/PHAHTMLDisplay.aspx?docid=1371&pg=0.

BWXT 2003. *Y-12 National Security Complex National Historic Preservation Act Historic Preservation Plan.* Y/TS-1983. BWXT Y-12, L.L.C., Y-12 National Security Complex, Oak Ridge, Tennessee.

CAA 1970. *Clean Air Act.* 42 U.S.C. §7401 et seq. US Government.

CERCLA 1980. *Comprehensive Environmental Response, Compensation, and Liability*. 42 US Code 103. US Government.

CNS 2020a. *Y-12 Plant Quality Assurance Project Plan for National Emission Standards for Hazardous Air Pollutants (NESHAP) Radionuclide Emission Measurements*. Y/TS-874, Revision 5. Consolidated Nuclear Security, LLC, Y-12 National Security Complex, Oak Ridge, Tennessee. October.

CNS 2020b. *Radiological Monitoring Plan for the Oak Ridge Y-12 National Security Complex: Surface Water*. Y/TS-1704/R4. Consolidated Nuclear Security, LLC, Y-12 National Security Complex, Oak Ridge, Tennessee. October.

CNS 2024. *Spill Prevention, Control, and Countermeasure Plan for the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee*. Y/SUB/02-001091/9. Consolidated Nuclear Security, LLC, Y-12 National Security Complex, Oak Ridge, Tennessee. September.

CNS 2025. *Calendar Year 2024 Groundwater Monitoring Report.* Y/SUB/25-173959/1. US Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee.

CWA 1972. *Clean Water Act*. 33 US Code §1251 et seq. US Government.

DOE 1992. *Federal Facility Agreement for the Oak Ridge Reservation*. FFA-PM/18-011, DOE/OR-014, January 1, 1992, including appendixes. US Environmental Protection Agency Region IV, US Department of Energy, and Tennessee Department of Environment and Conservation. Oak Ridge, Tennessee. https://ucor.com/regulatory-agreements-for-the-oak-ridge-reservation/.

DOE 1996. *Record of Decision for Chestnut Ridge Operable Unit 2 (Filled Coal Ash Pond and Vicinity), Oak Ridge, Tennessee*. DOE/OR/02-1410&D3. US Department of Energy, Office of Environmental Management, Oak Ridge, Tennessee. https://doeic.science.energy.gov/uploads/F.0602.031.0039.pdf

DOE 1997. *Record of Decision for an Interim Action for Union Valley, Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee*. DOE/OR/02-1545&D2. US Department of Energy, Office of Environmental Management, Oak Ridge, Tennessee. https://doeic.science.energy.gov/uploads/F.0603.031.0241.pdf

DOE 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*. DOE/OR/01-1641/V1-V4&D2. US Department of Energy, Office of Environmental Management, Oak Ridge, Tennessee.

DOE 2000. *Record of Decision for the Phase I Activities in Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*. DOE/OR/01-1750&D4. US Department of Energy Office of Environmental Management, Oak Ridge, Tennessee. May. https://doeic.science.energy.gov/uploads/F.0601.031.0009.pdf.

DOE 2011a. *Final Site-Wide Environmental Impact Statement for the Y-12 National Security Complex.* DOE/EIS-0387. US Department of Energy, National Nuclear Security Administration, Y-12 Site Office, Oak Ridge, Tennessee. February.

DOE 2011b. *Radiation Protection of the Public and the Environment.* DOE Order 458.1. Approved February 11, 2011, Chg. 5 approved in January 2025. US Department of Energy, Washington, DC.

DOE 2011c. *Quality Assurance.* DOE Order 414.1D, approved April 25, 2011, Chg. 2 approved September 15, 2020, US Department of Energy, Washington, DC.

DOE 2012. *Compliance Agreement Between the United States Department of Energy and the United States Environmental Protection Agency Region 4.* ORR-PCB-FFCA, Revision 5. US Department of Energy, Office of Environmental Management, Oak Ridge, Tennessee. May. https://ucor.com/regulatory-agreements-for-the-oak-ridge-reservation/.

DOE 2016. *2016 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee, Data and Evaluations*. DOE/OR/01-2707&D1. US Department of Energy Office of Environmental Management, Oak Ridge, Tennessee. March. https://doeic.science.energy.gov/uploads/A.0100.064.2399.pdf.

DOE 2020a. *Compliance Plan, National Emission Standards for Hazardous Air Pollutants for Airborne Radionuclides on the Oak Ridge Reservation, Oak Ridge, Tennessee.* DOE/ORO/2196, Revision 2. US Department of Energy, Washington, DC.

DOE 2021a. *Memorandum for Heads of Departmental Elements: Addressing Per- and Polyfluoroalkyl Substances at the Department of Energy.* NNSA-2021-004992. US Department of Energy, Washington, DC, David M. Turk, Deputy Secretary of Energy. September 16, 2021. https://www.energy.gov/sites/default/files/2021-12/Attachment_1_EXEC-2021-004118_Distribution_Memo_from_S2_Turk_Addressing_Per-and_Polyfluoroalkyl_Substances_at_DOE_S2_Signed_9-16-21_508.pdf.

DOE 2021b. *Memorandum for Distribution: Direction to Implement Department of Energy Policy on Per- and Polyfluoroalkyl Substances*. US Department of Energy, Washington, DC, James J. McConnell, Associate Administrator for Safety, Infrastructure, and Operations, October 26, 2021.

DOE 2022a. *DOE PFAS Strategic Roadmap: DOE's Commitments to Action 2022-2025*. US Department of Energy, Washington, DC, August. https://www.energy.gov/pfas/articles/pfas-strategic-roadmap-doe-commitments-action-2022-2025

DOE 2022b. *Record of Decision for Comprehensive Environmental Response, Compensation, and Liability Act Oak Ridge Reservation Waste Disposal at the Environmental Management Disposal Facility, Oak Ridge, Tennessee*. DOE/OR/01-2794&D2/R2. US Department of Energy Oak Ridge Office of Environmental Management, Oak Ridge, Tennessee. September. https://doeic.science.energy.gov/uploads/F.0615.031.0263.pdf

DOE 2024a. *2024 Remediation Effectiveness Report for the US Department of Energy, Oak Ridge Reservation, Oak Ridge, Tennessee*. DOE/OE/01-2960&D1. US Department of Energy, Office of Environmental Management, Oak Ridge, Tennessee. https://doeic.science.energy.gov/uploads/A.0100.064.2878.pdf.

DOE 2024b. *East End Substation Construction,* NEPA 5092. US Department of Energy. Oak Ridge, Tennessee. April.

DOE 2024c. *Action Memorandum for North Tributary 8 at the Y-12 National Security Complex Bear Creek Burial Grounds, Oak Ridge, Tennessee.* US Department of Energy Office of Environmental Management, Oak Ridge, Tennessee. September. https://doeic.science.energy.gov/uploads/F.0601.025.0669.pdf.

DOE 2025. *2025 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Site, Oak Ridge, Tennessee*. DOE/OR/01-2989&D1. US Department of Energy, Office of Environmental Management, Oak Ridge, Tennessee.

EA 2020. *The Energy Act of 2020.* Public Law 116-260. US Government.

EISA 2007. *Energy Independence and Security Act of 2007*. Public Law 110-140. US Government.

EPA 1995, 1998. *Compilation of Air Pollutant Emission Factors from Stationary Sources.* AP-42, Fifth Edition. *Volume 1: Stationary Point and Area Sources*. US Environmental Protection Agency, Research Triangle Park, North Carolina, January 1995, September 1998.

EPA 2024. *Fifth Unregulated Monitoring Rule*. US Environmental Protection Agency, Washington, DC. https://www.epa.gov/dwucmr/fifth-unregulated-contaminant-monitoring-rule.

EPCRA 1986. *Emergency Planning and Community Right-to-Know*. 42 US Code Chapter 116. US Government.

FFCA 1992. *Federal Facility Compliance Act.* 42 US Code 6961(a). US Government. https://ucor.com/wp-content/uploads/2021/07/ffa.pdf.

HPS 2013. *Surface and Volume Radioactivity Standards for Clearance.* ANSI/HPS N13.12. Health Physics Society, Herndon, Virginia. January.

ISO 2015. *Environmental management systems—Requirements with guidance for use*. ISO 14001:2015. International Organization for Standardization, Geneva, Switzerland, September.

ISO 2017. *General Requirements for the Competence of Testing and Calibration Laboratories.* ISO/IEC 17025:2017. International Organization for Standardization, Geneva, Switzerland.

MMES 1990. *Report and Preliminary Assessment of the Occurrence of Dense, Nonaqueous Phase Liquids in the Bear Creek Burial Grounds Hazardous Waste Disposal Unit at the Oak Ridge Y-12 Plant.* Y/TS-960. Martin Marietta Energy Systems, Inc., Oak Ridge, Tennessee.

MMES 1995. *Calendar Year 1994 Groundwater Quality Report for the Upper East Fork Poplar Creek Hydrogeologic Regime, Y-12 Plant, Oak Ridge, Tennessee.* Y/SUB/95-EAQ10C/2/P2. Martin Marietta Energy Systems, Inc., Oak Ridge, Tennessee. October. https://www.osti.gov/servlets/purl/164949.

NCRP 1996. *Screening Models for Releases of Radionuclides to Atmosphere, Surface Water, and Ground – Vol. I and Vol II*. NCRP Report No. 123. National Council on Radiation Protection and Measurements, Bethesda, MD.

NEPA 1969. *National Environmental Policy*. Title 42, US Code Chapter 55. US Government.

NHPA 1966. *National Historic Preservation Act.* Public Law 89-665; Title 54 US Code §300101 et seq. US Government.

NNSA 2016. *Supplement Analysis for the Site-Wide Environmental Impact Statement for the Y-12 National Security Complex*. DOE/EIS-0387-SA-01. National Nuclear Security Administration, NNSA Production Office, Oak Ridge, Tennessee. April.

NNSA 2018. *Supplement Analysis for the Site-Wide Environmental Impact Statement for the Y-12 National Security Complex*. DOE/EIS-0387-SA-03. National Nuclear Security Administration, NNSA Production Office, Oak Ridge, Tennessee. August.

NNSA 2020. *Final Supplement Analysis for the Final Site-Wide Environmental Impact Statement for the Y-12 National Security Complex, Earthquake Accident Analysis.* DOE/EIS-0387-SA-04. National Nuclear Security Administration, NNSA Production Office, Oak Ridge, Tennessee. June.

NNSA 2021. "NNSA Production Office Approval to Use Pre-Approved Authorized Limits for the Release and Clearance of Volumetric Radioactivity of Personal Property." COR-NP0-60 ESH-7.20.2021-919599. National Nuclear Security Administration, NNSA Production Office, Oak Ridge, Tennessee. July 20, 2021.

NNSA 2024a. *Environmental Assessment for Activities in Support of the Y-12 National Security Complex Materials Manufacturing Mission.* DOE/EA-2218. National Nuclear Security Administration, NNSA Production Office, Oak Ridge, Tennessee. January.

NNSA 2024b. *Finding of No Significant Impact for the Environmental Assessment for Activities in Support of the Y-12 National Security Complex Materials Manufacturing Mission.* DOE/EA-2218. National Nuclear Security Administration, NNSA Production Office, Oak Ridge, Tennessee. January.

NNSA 2024c. *Environmental Assessment for Off-Site Depleted Uranium Manufacturing.* DOE/EA-2252. National Nuclear Security Administration, NNSA Production Office, Oak Ridge, Tennessee. October.

NNSA 2024d. *Finding of No Significant Impact for the Environmental Assessment for Off-Site Depleted Uranium Manufacturing.* DOE/EA-2252. National Nuclear Security Administration, NNSA Production Office, Oak Ridge, Tennessee. November.

NRC 2000. *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*. NUREG-1575, Revision 1/EPA 402-R-97-016, Revision 1/DOE/EH-0624, Revision 1. US Nuclear Regulatory Commission, Washington, DC. August.

NRC 2009. *Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual (MARSAME)*. NUREG-1575, Supplement 1/EPA 402-R-09-001/DOE/HS-0004. US Nuclear Regulatory Commission, Washington, DC. January.

ORNL 2013. *Y-12 National Security Complex Biological Monitoring and Abatement Program Plan*. ORNL/TM-2013/171. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

RCRA 1976. *Resource Conservation and Recovery Act.* 40 CFR 239–282. US Government.

TDEC 2010a. *Proposed Total Maximum Daily Loads (TMDLs) for Polychlorinated Biphenyls (PCBs) and Chlordane in Melton Hill Reservoir: Lower Clinch River Watershed (HUC 06010207), Anderson, Knox, Loudon, and Roane Counties, Tennessee*. Tennessee Department of Environment and Conservation, Nashville, TN. 2010.

TDEC 2010b. *Proposed Total Maximum Daily Loads (TMDLs) for Polychlorinated Biphenyls (PCBs) and Chlordane in Watts Bar Reservoir: Watts Bar Lake Watershed (HUC 06010201), Lower Clinch River Watershed (HUC 06010207), and Emory River Watershed (HUC 06010208), Loudon, Meigs, Morgan, Rhea, and Roane Counties, Tennessee*. Tennessee Department of Environment and Conservation, Nashville, TN. 2010.

TDEC 2010c. *Proposed Total Maximum Daily Loads (TMDLs) for Polychlorinated Biphenyls (PCBs) and Chlordane in Fort Loudon Reservoir: Fort Loudon Lake Watershed (HUC 06010201), Blount, Knox, and Loudon Counties, Tennessee.* Tennessee Department of Environment and Conservation, Nashville, TN. 2010.

TDEC 2019. "Public Water Systems." Chapter 0400-45-01. Tennessee Department of Environment and Conservation, Division of Water Pollution Control, Nashville, TN. Approved February 2019.

TDEC 2022. "Emission Standards for Hazardous Air Pollutants." TDEC Regulation 0400-30-38, Tennessee Department of Environment and Conservation, Division of Air Pollution Control, Nashville, TN. Approved December 2022.

TDEC 2024a. "Administrative Fees Schedule." TDEC Regulation 1200-03-26. Tennessee Department of Environment and Conservation, Division of Air Pollution Control, Nashville, TN. Revised December 2024.

TDEC 2024b. "General Water Quality Criteria." Chapter 0400-40-03. Tennessee Department of Environment and Conservation, Division of Water Pollution Control, Nashville, TN. Revised March 2024.

TDEC 2024c. *Site Treatment Plan for Mixed Wastes on the U.S. Department of Energy Oak Ridge Reservation*. TDEC-VER. 29.0. US Department of Energy, Oak Ridge Reservation, Oak Ridge, Tennessee. October.

TDEC 2024d. "Construction and Operating Permits." TDEC Regulation 1200-03-09. Tennessee Department of Environment and Conservation, Division of Air Pollution Control, Nashville, TN. Revised December 2024.

TSCA 1976. *Toxic Substances Control Act*. Title 15 US Code §2601 et seq. US Government.

UCOR 2023. *Sampling and Analysis Plan for the Water Resources Restoration Program for Fiscal Year 2024 Oak Ridge Reservation, Oak Ridge, Tennessee*, UCOR-4587-R9. United Cleanup Oak Ridge, LLC, Oak Ridge, Tennessee.

UCOR 2024a. *2024 Cleanup Progress: Annual Report on Oak Ridge Reservation Cleanup.* OREM-24-7651. United Cleanup Oak Ridge, Oak Ridge, Tennessee.

UCOR 2024b. *Sampling and Analysis Plan for the Water Resources Restoration Program for Fiscal Year 2025 Oak Ridge Reservation, Oak Ridge, Tennessee*, UCOR-4587/R10. United Cleanup Oak Ridge, LLC, Oak Ridge, Tennessee.



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

Photo by Carlos Jones

5

Oak Ridge National Laboratory

At ORNL, DOE's largest multidisciplinary laboratory, researchers apply unique facilities, sophisticated tools, and signature strengths in key scientific and technological areas to benefit science and society, enabling ORNL to do the following:

- Advance understanding, design, and use of new materials and chemical processes
- Reveal unmatched insights through computing and data
- Ensure safe nuclear power and secure nuclear materials
- Produce rare isotopes for medicine, industry, security, research, and space exploration
- Increase and exploit understanding of biological and environmental systems

ORNL is managed by UT-Battelle, LLC, a partnership between the University of Tennessee and Battelle Memorial Institute. Other DOE contractors that conducted activities at ORNL in 2024 included UCOR and Isotek Systems, LLC (Isotek).

5.1. Description of Site, Missions, and Operations

ORNL lies in the southwest corner of ORR (Figure 5.1) and includes facilities in two valleys (Bethel and Melton) and on Chestnut Ridge. ORNL was established in 1943 as part of the secret Manhattan Project to pioneer a method for producing and separating plutonium. During the 1950s and 1960s, and with the creation of DOE in the 1970s, ORNL became an international center for the study of nuclear energy and related research in the physical and life sciences. By the turn of the century, the laboratory was supporting 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.

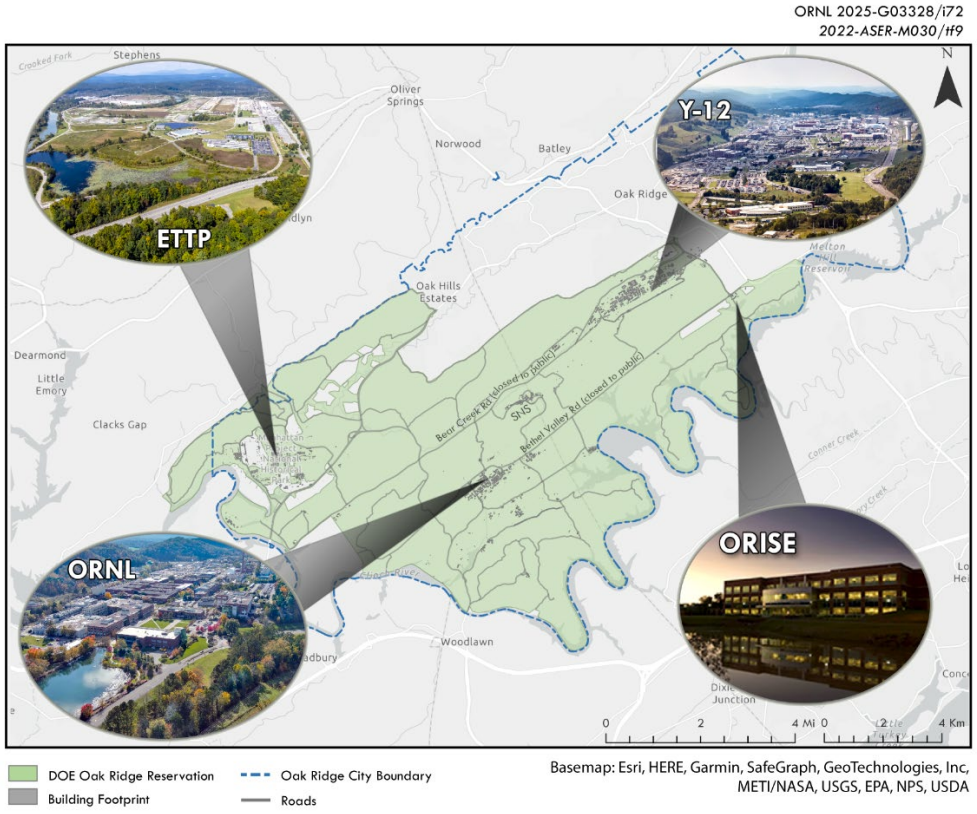
Leveraging the talents of its world-class researchers and exceptional support staff, ORNL is helping solve critical scientific and technical challenges and in doing so is creating economic opportunity for the nation. ORNL's unique facilities, laboratories, and equipment draw thousands of visiting researchers each year and enable the development of scientific and technological solutions in these areas:

- Biology and environment
- Materials
- Clean energy
- National security
- Fusion and fission
- Neutron science
- Isotopes
- Supercomputing

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

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

Isotek is responsible for the Building 3019 Complex at ORNL, where the national repository of ^{233}U has been kept since 1962. Recommendations in the Final Draft ^{233}U Alternatives Analysis Phase I Report (DOE 2011a) have been completed. Phase I recommendations included (1) transfer of Zero-Power Reactor plate canisters to the National Nuclear Security Administration and disposal of Consolidated Edison Uranium Solidification Project material canisters and (2) completion of a Phase II alternatives analysis for processing the remaining 50 percent of the inventory. The transfer of the reactor plate canisters was completed in 2012. Disposal of the Consolidated Edison Uranium Solidification Project material canisters began in 2015 and was completed in 2017.



Acronyms:

ETTP = East Tennessee Technology Park
ORISE = Oak Ridge Institute for Science and Education
ORNL = Oak Ridge National Laboratory
Y-12 = Y-12 National Security Complex

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

Isotek has been responsible for Building 2026 since May 2017. Isotek finished processing ^{233}U material inside glove boxes in Building 2026 in 2021. Processing the remaining ^{233}U inventory began in 2022 and is expected to be completed in 2030. This work is performed in shielded hot cells because of the high radiation levels of the material and produces a solidified, low-level radioactive waste (LLW) form that is acceptable for disposal. Additionally, Isotek is extracting ^{229}Th from the ^{233}U material and transferring it to a customer for use as source material to produce vital medical isotopes ideal for targeted alpha therapy, a promising new cancer treatment.

UCOR is the DOE ORR cleanup contractor for the DOE Oak Ridge Office of Environmental Management (OREM). UCOR activities at ORNL include operation of the Transuranic Waste Processing Center (TWPC) and the long-term surveillance, maintenance, and management of inactive waste disposal sites, structures, and buildings. The *FY 2024 Cleanup Progress: Annual Report on Oak Ridge Reservation Cleanup* (UCOR 2024) **here** provides detailed information on UCOR activities at ORNL.

In October 2022, UCOR assumed responsibility for operations at TWPC, which is located on about 26 acres of land adjacent to the Melton Valley Storage Tanks along State Route 95. UCOR's mission at TWPC is to receive, process, treat, and repackage transuranic (TRU) wastes for shipment to designated facilities for final disposal. TWPC consists of a waste-processing facility, a personnel building, and numerous support buildings and storage areas. TWPC began processing supernatant liquid from the Melton Valley Storage Tanks in 2002, contact-handled debris waste in December 2005, and remotely handled debris

waste in May 2008. Based on the definition of TRU waste, some waste being managed as TRU is later determined to be LLW or mixed LLW. UT-Battelle provides water quality monitoring for operations at TWPC, and results are included in water-monitoring discussions in Section 5.5. 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 are incorporated into air-monitoring discussions in this chapter.

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

NTRC is DOE's only user facility dedicated to transportation. 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 cybersecurity, and intelligent transportation systems.

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

- Power and energy systems
- Vehicle and buildings science
- Power electronics
- Energy storage
- Sensors and controls
- Data science and modeling
- Cybersecurity

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

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

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

5.2. Environmental Management Systems

ORNL prioritizes demonstration of environmental excellence through high-level policies that clearly state expectations for continual improvement and compliance with regulations and other requirements. UT-Battelle, UCOR, and Isotek have implemented environmental management

systems (EMSs) modeled after the International Organization for Standardization (ISO) 14001 standard to measure, manage, and control environmental impacts (ISO 2015). An EMS is a continuing cycle of planning, implementing, evaluating, and improving processes and actions undertaken to achieve environmental goals. The UT-Battelle and Isotek EMSs are discussed in the following sections, and the UCOR EMS is discussed in Chapter 3.

5.2.1. UT-Battelle Environmental Management System

UT-Battelle's contract with DOE requires an EMS designed to comply with all applicable requirements and to improve ORNL's environmental performance continually. Annual internal independent audits are performed to confirm that the UT-Battelle EMS conforms to the ISO 14001:2015 framework.

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

5.2.1.1. Integration with the Integrated Safety Management System

The objective of the UT-Battelle Integrated Safety Management System (ISMS) is to systematically integrate ESH&Q requirements and controls into all work activities and to protect workers, the environment, and the public. The UT-Battelle EMS and 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 ESH&Q 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 ESH&Q, including pollution prevention, waste minimization, and resource conservation. Therefore, the guiding principles and core functions in the ISMS include protection of the environment. The UT-Battelle EMS is consistent with the ISMS and includes all the elements in the ISO 14001:2015 standard.

5.2.1.2. UT-Battelle Environmental Policy for ORNL

UT-Battelle's environmental policy for ORNL, which can be found **here**, includes expectations and commitments to continual improvement and compliance with regulations and other requirements.

5.2.1.3. Environmental Management System Planning

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

UT-Battelle environmental aspects

Environmental aspects are elements of an organization's activities, products, or services that can interact with the environment. Environmental aspects associated with UT-Battelle activities, products, and services have been identified at the line organization level and the laboratory level. Activities that are relative to any of the aspects are carefully controlled to minimize or eliminate impacts to the environment. Nine significant environmental aspects (listed on the ORNL website **here**) have been identified as potentially having 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; DOE orders; UT-Battelle contract clauses; and waste acceptance criteria. 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 establishes laboratory-level and line organization–level objectives that support the laboratory mission and, where practical, are measurable.

UT-Battelle programs

UT-Battelle has established an organizational structure to ensure that environmental programs are led by experts in environmental protection and compliance, energy and resource conservation, waste minimization, pollution prevention, and waste management and to ensure that laboratory activities are conducted in accordance with the environmental policy (see Section 5.2.1.2). Information on UT-Battelle's 2024 compliance status, activities, and accomplishments is presented in Section 5.3.

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

- Waste management
- Solid and hazardous waste compliance
- National Environmental Policy Act (NEPA 1969) compliance
- Air quality compliance
- Water quality compliance
- US Department of Agriculture (USDA) compliance
- Environmental sampling and data evaluation
- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA 1980) interface

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

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

5.2.1.4. Operational Efficiency and Energy Management Overview

The Facilities and Operations Directorate at ORNL manages an extraordinary set of distinctive scientific facilities, systems, and equipment for DOE. ORNL's vast portfolio of research facilities must be maintained and upgraded to protect the country's investment in scientific analysis. Designed to ensure the reliability and maintainability of these complex scientific facilities and systems, the Facilities and Operations Directorate's operational processes enable more effective and efficient execution of ORNL's science and technology mission. Implementing efficient operational practices involves identifying opportunities to continually improve operational results and remaining diligent in energy and environmental stewardship.

ORNL is expected to contribute toward DOE initiatives, including those directed by 42 U.S.C. 17143, "Government Efficiency Status Reports," and to identify strengths that can potentially be adapted as agencywide best practices. Other federal laws covering the operational efficiency of government-owned facilities include the Energy Independence and Security Act of 2007 (EISA 2007), Section 432, "Management of Energy and Water Efficiency in Federal Buildings," whose reporting requirements are summarized **here**; the Energy Act of 2020 (EAct 2020), Section 1002, "Use of Energy and Water Efficiency Measures in Federal Buildings," whose requirements for energy and water efficiency measures are summarized **here**; and 42 U.S.C. 8253, "Energy and Water Management Requirements."

Considerable progress has been made toward reducing ORNL's energy use by targeting readily applied energy conservation measures (ECMs) in existing buildings. As these opportunities become less prevalent, ORNL projects with the potential to reduce energy consumption will need to be identified and evaluated on several operational efficiency priorities, including energy, water, and cost savings from ECMs and enhanced operational resilience.

ORNL continues to promote awareness of energy efficiency and to incorporate it in daily operations. It is important that all decision-making processes include energy efficiency considerations and life cycle cost analyses.

Operational efficiency and energy reporting

DOE compiles consolidated annual government efficiency reports (available **here**) covering the status of DOE's implementation of initiatives to improve energy efficiency, reduce energy costs, and provide savings for US taxpayers. Performance data from each DOE site are combined to show the progress of each program office and comprehensive progress for the agency. As part of this effort, ORNL provides annual performance data capturing energy usage and progress on initiatives for entry into DOE reporting systems. In addition to providing information on energy usage, these data provide an overview of ORNL's planned actions and of efforts and accomplishments during the reporting period. Table 5.1 summarizes operational efficiency progress and performance data for DOE goals related to energy and water management, waste avoidance, and utility savings.

To implement operational efficiency goals at ORNL, UT-Battelle identifies opportunities for continuous improvement in operational and business processes, implements practices to maximize the return on investment in modernizing facilities and equipment, and reports information about initiatives and energy use data to the DOE Office of Asset Management. The Office of Asset Management assists program offices in safeguarding their missions, freeing up resources by reducing waste, avoiding excess expenditures on utilities, maximizing productivity, and improving the efficiency of facilities and processes. By focusing on mission needs, programs and associated DOE sites can help the agency meet efficiency and savings goals outlined in federal statutory and regulatory requirements. Updates in annual reporting directions help minimize and streamline reporting and address updated federal requirements and DOE priorities.

Table 5.1. ORNL FY 2024 performance status and planned actions and contributions

DOE goal	Current performance status	Planned actions and contribution
	Energy management	
Reduce energy intensity (British thermal units per gsf) in goal-subject buildings by 50% by the end of FY 2030.	ORNL's FY 2024 calculated EUI was 250,387 Btu/gsf. This is a cumulative reduction of 31.2% since FY 2003 and a reduction of 39.1% from the FY 2021 baseline but is an increase of 5.42% from FY 2023. ORNL continues to improve identification of energy-consuming facilities as the mission expands.	Continued EUI reduction for goal-subject facilities is seen as attainable by concentrating on the best mix of ECM projects for energy savings and by identifying and prioritizing maintenance issues, including some that may have energy efficiency impacts on buildings.
Perform EISA Section 432 continuous (4-year cycle) energy and water evaluations.	In FY 2024, ORNL started the fourth year of the 4-year energy audit cycle by conducting 21 building audits throughout the year to cover a quarter of the buildings that are qualified for audit inclusion.	In FY 2025, ORNL will start the first year of a new 4-year energy audit cycle. ORNL will continue to use the building energy audit evaluation tool and conduct FCAs.
Meter individual buildings for electricity, natural gas, steam, and water to adhere to federal metering guidance.	In FY 2024, ORNL added 27 new advanced utility meters (including computational and electrical utility distribution meters), migrated one new data stream from other systems across the lab, and replaced seven meters. ORNL meter installations have included electrical, steam/hot water, natural gas, chilled water, and potable water.	ORNL will continue to use the metering–tracking process for guidance in the installation of additional advanced utility meters on all utilities per new federal metering guidance.
	Water management	
Reduce potable water use intensity (gallons per gsf).	Annual water consumption resulted in a WUI of 155.7 gal/gsf in FY 2024, which is an increase of 5.0% from FY 2023 and is 15.0% higher than the FY 2021 baseline. (The target is a 50% reduction by FY 2030.) Continued improvements in the identification of water-consuming facilities yielded a 2.8% decrease in gsf in support of the WUI calculation.	ORNL's WUI is subject to rise because of increased demands for cooling tower makeup water to support the growth of high-performance computing systems. With continued modernization activities that include the elimination of old facilities and the addition of new facilities, ORNL will consider more water-efficient systems and focus on water management best practices to meet future WUI reduction goals.
	Fleet management	
Increase alternative fuel consumption.	Presently, 80% of all ORNL vehicles are AFVs, and 86% of all replacements since FY 2020 have been AFVs or EVs. Also, 77% of light-duty vehicles operate on alternative fuels.	ORNL will continue to align its use of AFVs with statutory and regulatory requirements and guidance.
	Investments: improvement measures, workforce, and community	
Implement life cycle cost-effective efficiency and conservation measures with appropriated funds and/or performance contracts.	DOE has an ESPC with JCI for ORNL. The delivery order was awarded on July 31, 2008. It includes ECMs consisting of steam system decentralization, building management system improvements, advanced meter installations, energy-efficient lighting upgrades, and domestic water conservation.	ORNL's ECMs need to be evaluated to determine which are life cycle cost-effective. Those found to be so need to be funded and implemented to the maximum extent possible with approved funding. ORNL plans on expanding the auditing process and integrating this process with the FCAs. ORNL will then continue to investigate the best potential funding strategies as the life cycle cost-effective ECM list grows.

Table 5.1. ORNL FY 2024 performance status and planned actions and contributions (continued)

DOE goal	Current performance status	Planned actions and contribution
	Electronic stewardship	
Increase acquisition of certified electronics and promote operational efficiencies and end-of-life practices.	ORNL maintained 100% compliance in the acquisition of environmentally certified products. ORNL actively maintained power management features on 100% of eligible IT devices. Disposition of 100% of end-of-life electronics was performed through government reuse programs and certified recyclers.	ORNL plans to maintain 100% compliance with all electronic stewardship goals and categories. No obstacles to the goal are foreseen.

Acronyms:
AFV = alternative fuel vehicle
DOE = US Department of Energy
ECM = energy conservation measure
EISA = Energy Independence and Security Act of 2007
ESPC = Energy Savings and Performance Contract
EUI = energy use intensity
EV = electric vehicle
FCA = facility condition assessment
FY = fiscal year
gsf = gross square feet
JCI = Johnson Controls Inc.
ORNL = Oak Ridge National Laboratory
WUI = water use intensity

Monitoring and assessments of utility consumption and costs

The foundation of the ORNL energy management program is the comprehensive understanding of utility consumption obtained through ongoing monitoring and assessments of all energy and water usage. Site utilities include electrical power, natural gas, fuel oil, steam, chilled water, and potable/process water to support ORNL's mission and research programs. ORNL's utility consumption and costs reflect various research and support facilities on the ORNL main campus, including those owned by the DOE Office of Science and OREM; the Spallation Neutron Source (SNS) site; and leased spaces, primarily NTRC at the HVC. Table 5.2 outlines ORNL's utility consumption and costs for fiscal year (FY) 2024.

Table 5.2. ORNL FY 2024 utility consumption and costs

Utility	Consumption	Cost
Electricity	564,744 MWh	$35,815,000
Natural gas	635,285 MCF	$3,812,000
Fuel oil	56 kgal	$164,000
Potable water	693.074 Mgal	$1,386,000

Acronyms:
FY = fiscal year
ORNL = Oak Ridge National Laboratory
MCF = thousand cubic feet

Figure 5.2 breaks down ORNL's energy consumption for FY 2024. Electricity, including that used for basic power needs, chilled water service, and direct cooling applications, accounted for 74.5 percent of ORNL's total energy consumption. Electricity dominated ORNL's energy consumption primarily because of high-energy mission-specific facilities, which house critical, energy-intensive operations that create unique energy efficiency challenges. Electricity accounts for 87 percent of the utility provider commodity budget at ORNL.

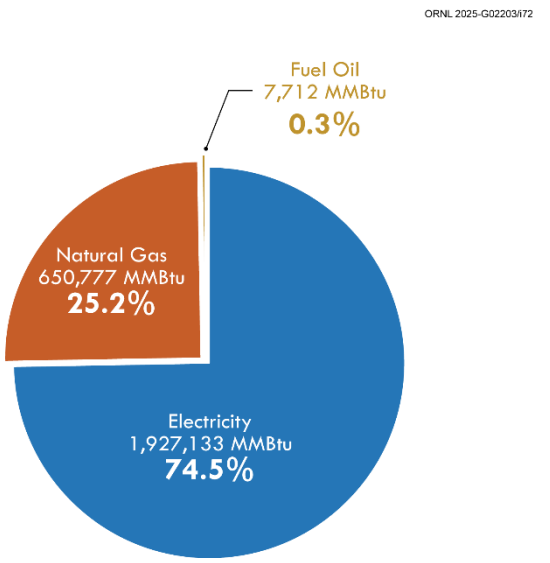


Figure 5.2. FY 2024 total energy consumption breakdown

Heating energy generated from natural gas and fuel oil accounted for 25.2 and 0.3 percent, respectively, of energy consumption at ORNL in FY 2024. Natural gas is the primary fuel used for steam generation at the ORNL main campus steam plant and the Melton Valley Steam Plant and for hot water generation at the Central Utilities Building supporting SNS. Natural gas is also used in direct heating and research applications. Fuel oil is used for steam generation during curtailment and maintenance periods and for heating at the Energy System Test Complex.

ORNL will continue to analyze building operations data from existing systems, including the building automation system and metering systems, to identify opportunities for enhancing operational efficiency. New sensors and meters will be added in strategic locations, and new capabilities will be built out in existing systems or layered with new systems, as necessary. ORNL will focus on developing tools for operations staff to maintain building systems in a way that supports reliability, meets the needs of building occupants, and achieves energy efficiency. The Utilities Division will continue to evaluate utility systems for opportunities to improve operations, improve reliability, and reduce maintenance costs. The knowledge gained by analyzing past and current energy consumption will better position ORNL to develop plans for improving energy efficiency and reducing greenhouse gases in facility operations.

Facility metering

Meters are used to track the use of energy, fuel, and water for various data-reporting requirements and to help identify problems and potential conservation opportunities throughout the ORNL campus. In FY 2024, ORNL added 27 new advanced utility meters (including computational meters and electrical utility distribution meters), migrated 1 new data stream from other systems across the lab, and replaced 7 meters. Meters have been installed at ORNL for electrical, steam/hot water, natural gas, chilled water, and potable water systems. The meters were connected to ORNL's Central Energy Data System (CEDS), a network of systems used for data archiving and analysis. CEDS securely collects, archives, and displays advanced utility meter data from the network of utility meters installed throughout the laboratory. CEDS logs multiple parameters from each meter on a standard 15 min interval. This system also enables trend analysis and consumption reporting and includes an energy awareness dashboard. Data can be exported from CEDS for use in other analyses.

One of the tools used in CEDS is Resource Advisor. Resource Advisor's advanced configuration capabilities have been used to easily calculate and quickly display total building energy consumption using data from the advanced utility meters. Resource Advisor includes a comprehensive dashboard and energy analysis capabilities that support ORNL's continued maturation in energy data utilization. Resource Advisor also directly feeds metered energy data into ENERGY STAR for benchmarking.

Energy savings performance contracts

An energy savings performance contract (ESPC) between ORNL and Johnson Controls Inc. (JCI) has been the primary mechanism for achieving the goals established to comply with Energy Policy Act of 2005 (EPAct 2005) directives. A delivery order with JCI was awarded in July 2008 and accepted in

July 2012 and has created opportunities for ORNL to deepen its experience in performance contracting and to better understand the most effective use of ESPCs. Total ESPC savings of $13,696,000 were realized in the 11th year of the contract and included $10,507,000 (762 million Btu) of electricity, natural gas, and fuel oil savings; $449,000 (197 million gal) of water savings; and $2,740,000 of operations and maintenance savings.

As part of the ESPC, a dual-fuel natural gas/fuel oil boiler replaced the biomass gasification system and became operational in FY 2016. The new boiler has reduced natural gas and fuel oil consumption. Steam distribution decentralization and steam production efficiency improvements have further improved ORNL's steam service and reliability.

Other ESPC improvements include lighting upgrades and water conservation measures. Equipment upgrades, a building management system, and modernized HVAC control systems provide the means to significantly reduce or eliminate energy-intensive simultaneous heating and cooling in several large air-handling units.

In accordance with the ORNL–JCI ESPC, measurement and verification (M&V) of the ECMs completed under the contract are ongoing. JCI employs an on-site performance assurance engineer who leads the M&V effort. M&V activities are reviewed by the ORNL DOE Site Office contracting officer's representative, who obtains input from UT-Battelle staff. JCI holds monthly ESPC performance reviews with ORNL DOE Site Office management and ORNL personnel. The same parties conduct an annual M&V report review and comment resolution process.

Pollution prevention and waste minimization

Source reduction efforts at ORNL include increasing the use of acceptable nontoxic or less-toxic alternative chemicals and processes while minimizing the acquisition of hazardous chemicals and materials via material substitution, operational assessments, and inventory management. In cases where the complete elimination of a particular hazardous material is not possible, a combination of actions is pursued, including implementing controls to limit use, procuring alternative materials, and using recycling processes to mitigate the environmental impact. These efforts comply with state and federal regulatory requirements. Efficient waste minimization is integrated across ORNL by procuring and using sustainable products.

During 2024, UT-Battelle implemented 28 ongoing and new waste minimization and pollution prevention projects. These cost-effective projects and ongoing reuse and recycle efforts eliminated more than 2.6 million kg of waste. Researchers at ORNL implement traditional recycling options when feasible and investigate new options when a need is identified.

Efforts to reduce and divert the amount of material going to the landfill also include the development of contract language requiring construction contractors to recycle as much construction debris as possible. Furthermore, training and outreach encourage source reduction and recycling by all associates. ORNL shares the lessons learned from its waste minimization successes with other DOE sites and the public through several avenues, including its public website, ORR virtual and in-person meetings, DOE-organized webinars and meetings, and appropriate external conferences.

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

EISA Section 438 stipulates the following:

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

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

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

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

Implementing this revised approach to EISA-438 compliance, as opposed to claiming technical infeasibility, demonstrates ORNL's commitment to environmental stewardship. When possible, this approach is implemented on an area basis at ORNL. Addressing EISA-438 on an area basis, instead of a project-by-project basis, allows for the following:

- Storm water runoff from adjacent areas can be diverted around developed areas to keep water quality high.
- Water quality structures and devices that manage runoff, filter pollutants, and slow down water flow from developed areas can be installed, potentially reducing the overall need for downstream water quality structures and devices.
- Individual projects are not burdened with the costs associated with addressing EISA-438 requirements.

If projects take place in existing contaminated areas or where an area approach is not feasible, technical infeasibility is claimed to prevent potential movement of contamination within soil or groundwater.

In 2024, no water quality improvements for projects subject to EISA-438 were completed.

5.2.1.6. Emergency Preparedness and Response

The UT-Battelle Emergency Management Program supplies the resources and capabilities to provide emergency preparedness and emergency response services. The on-site emergency management organization provides emergency call answering and dispatch, emergency medical care and transport, firefighting capability, technical rescue services, and hazardous materials release mitigation. Emergency management personnel perform hazard surveys and hazard assessments to identify potential emergency situations. Procedures and plans have been developed to prepare for and respond to a wide variety of potential emergency situations. Training is provided to ensure appropriate response and performance during emergency events. Frequent exercises and drills are scheduled to ensure the effective execution of the procedures and plans. Emergency responders to expanding and complex incidents are supported by an emergency operations center consisting of laboratory leaders and SMEs. An environmental SME is a member of the emergency response organization. The environmental SME participates in real events, drills, and exercises to ensure that environmental requirements are met and that environmental impacts are mitigated.

5.2.1.7. Environmental Management System Performance Evaluation

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

Monitoring and measurement

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

UT-Battelle environmental management system assessments

UT-Battelle uses several methods to evaluate compliance with legal and other environmental requirements. Most compliance evaluation activities are implemented through the EMS or participation in line-organization assessment activities. If a nonconformance is identified, the ORNL issues management process requires identifying the cause and developing corrective and/or preventive actions. These actions are then implemented and tracked to completion.

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

UT-Battelle also uses the results from numerous external compliance inspections conducted by regulators to verify compliance with requirements. In addition to regulatory compliance assessments, an internal EMS assessment is performed annually to ensure that the UT-Battelle EMS continues to conform to ISO 14001:2015 requirements. An independent internal audit conducted in 2024 verified that the EMS conforms to ISO 14001:2015. In addition to verifying conformance, these management system assessments also identify continual improvement opportunities.

5.2.2. Environmental Management System for Isotek

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

Project procedures provide a systematic approach to integrating environmental considerations into all aspects of Isotek's activities at ORNL. The Isotek EMS includes a procedure for identifying environmental aspects associated with the Uranium-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 Uranium-233 Disposition Project has a well-established recycling program that is implemented at all Isotek-managed facilities and includes Building 3017, the Building 3019

Complex, Building 2026, and Building 3137. Materials Isotek currently recycles 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 to continually improve the EMS.

5.3. Compliance Programs and Status

During 2024, UT-Battelle, UCOR, and Isotek operations were conducted to comply with contractual and regulatory environmental requirements. Table 5.3 summarizes environmental audits conducted at ORNL in 2024. The following discussions summarize the major environmental programs and activities carried out at ORNL during 2024 and provide an overview of the compliance status for the year. Summary information on 2024 noncompliances at ORNL is also available under Federal Services Registry ID number 110002040201 on EPA's Enforcement and Compliance History Online website **here**.

5.3.1. Environmental Permits

Table 5.4 lists the environmental permits that were in effect in 2024 at ORNL.

5.3.2. National Environmental Policy Act/National Historic Preservation Act

The NEPA process is used to evaluate the potential environmental impact of proposed federal activities and to examine alternatives to those actions. UT-Battelle, UCOR, 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 5.5 summarizes NEPA activities conducted at ORNL during 2024.

During 2024, UT-Battelle and UCOR 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, DOE has approved generic categorical exclusion determinations that cover proposed bench-scale and pilot-scale research activities and generic categorical exclusions that cover proposed nonresearch activities (e.g., maintenance activities, facilities upgrades, personnel safety enhancements). A categorical exclusion is one of a category of actions defined in 40 *Code of Federal Regulations* (CFR) Part 1508.4 that does not individually or cumulatively have a significant effect on the human environment and for which neither an environmental assessment nor an environmental impact statement is normally required.

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

Compliance with the National Historic Preservation Act (NHPA 1966) is achieved and maintained at ORNL in conjunction with NEPA compliance. The scope of proposed actions is reviewed in accordance with the *Cultural Resource Management Plan* (Souza et al. 2001).

Table 5.3. Summary of regulatory environmental audits, evaluations, inspections, and assessments conducted at ORNL, 2024

Date	Reviewer	Subject	Issues
March 4–5	TDEC	Hazardous Waste Compliance Evaluation Inspection (including UT-Battelle, TWPC, and UCOR)	0
March 26	City of Oak Ridge	CFTF Wastewater Pretreatment Permit Inspection	0
April 3	KCDAQM	Hardin Valley Campus Clean Air Act Inspection	0
September 23	City of Oak Ridge	CFTF Wastewater Pretreatment Permit Inspection	0
August 9	TDEC	TWPC Clean Air Act Inspection	0
December 4	TDEC	Clean Air Inspection for ORNL	0

Acronyms:
CFTF = Carbon Fiber Technology Facility
KCDAQM = Knox County Department of Air Quality Management
ORNL = Oak Ridge National Laboratory
TDEC = Tennessee Department of Environment and Conservation
TWPC = Transuranic Waste Processing Center
UCOR = United Cleanup Oak Ridge LLC

Table 5.4. Environmental permits in effect at ORNL, 2024

Regulatory driver	Permit title/description	Permit number	Owner	Operator	Responsible contractor
CAA	Title V Major Source Operating Permit, ORNL	571359	DOE	UT-B	UT-B
CAA	Operating Permit, NTRC	22-0941R2	DOE	UT-B	UT-B
CAA	Operating Permit, TRU	071009P	DOE	UCOR	UCOR
CAA	Construction Permit, 3525 Area Off Gas System	971543P	DOE	UT-B	UT-B
CAA	Permit-by-Rule, TRU Emergency Generators	R80800	DOE	UCOR	UCOR
CAA	Title V Major Source Operating Permit, ORNL	578132	DOE	UCOR	UCOR
CAA	CFTF CAA Operating Permit (Conditional Major)	474951	DOE	UT-B	UT-B
CAA	Construction Permit, NTRC[a]	C-21-0941-02-01	DOE	UT-B	UT-B
CAA	CAA Title V Operating Permit for Isotek operations at ORNL	576448	DOE	Isotek	Isotek

Table 5.4. Environmental permits in effect at ORNL, 2024 (continued)

Regulatory driver	Permit title/description	Permit number	Owner	Operator	Responsible contractor
CAA	Construction Permit, ^{233}U Processing at Building 2026	982390	DOE	Isotek	Isotek
CAA	Construction Permit, SNS 8915 Upgrade	980182	DOE	UT-B	UT-B
CWA	ORNL NPDES Permit (ORNL sitewide wastewater discharge permit)	TN0002941	DOE	DOE	UT-B, UCOR, Isotek
CWA	Industrial and Commercial User Wastewater Discharge Permit (CFTF)	1-12	UT-B	UT-B	UT-B
CWA	General NPDES Permit for Storm Water Discharges Associated with Craft Resources Support Facility Construction Activities	TNR136355	DOE	UT-B	UT-B
CWA	General NPDES Permit for Storm Water for ORNL Experimental Gas Cooled Reactor Parking Lot[a]	TNR136470	DOE	UT-B	UT-B
CWA	Tennessee Operating Permit, Holding Tank/Haul System for Domestic Wastewater	SOP-07014	UCOR	UCOR	UCOR
CWA	Tennessee Operating Permit (sewage)	SOP-02056	DOE	DOE	UCOR
CWA	Notice of Coverage under the General NPDES Permit for Storm Water for TRC Project	TNR136285	DOE	UT-B	UT-B
RCRA	Hazardous Waste Transporter Permit	TN1890090003	DOE	UT-B	UT-B, UCOR
RCRA	Hazardous Waste Corrective Action Permit	TNHW-164	DOE	DOE/all	DOE/all
RCRA	Hazardous Waste Storage and Treatment Permit	TNHW-145	DOE	DOE/ UCOR	UCOR
RCRA	Hazardous and Mixed Waste Storage Permit	TNHW-178	DOE	DOE/UT-B	UT-B
PCB	PCB Risk Based Agreement between UT-B and EPA	TN1890090003	DOE	UT-B	UT-B
PCB	PCB Risk Based Agreement between UCOR and EPA	TN1890090003	DOE	UCOR	UCOR
CWA	ARAP—Construction of a New Outfall Consisting of a Headwall and Riprap Apron	NR2203.208	DOE	UT-B	UT-B
CWA	General NPDES Permit for Storm Water Discharges Associated with 1000 Area Parking Lot Improvements	TNR137699	DOE	UT-B	UT-B
CWA	Tennessee Operating Permit, No-Discharge Wastewater Collection System for New GEARS Facility	SOP-22033	DOE	UT-B	UT-B
MBTA	US Fish and Wildlife Service Permit for Canada Geese	MB836291	UT-B	UT-B	UT-B
TCA 70	TWRA Scientific Collection Permit for Sunfish and Catfish	TWRA 1630	UT-B	UT-B	UT-B

Table 5.4. Environmental permits in effect at ORNL, 2024 (continued)

Regulatory driver	Permit title/description	Permit number	Owner	Operator	Responsible contractor
TCA 70	TWRA Scientific Collection Permit for Canada Geese	TWRA 1631	UT-B	UT-B	UT-B
CWA	General NPDES Permit for Storm Water Discharges Associated with Stable Isotope and Production Research Center Site Prep	TNR136958	DOE	UT-B	UT-B
CWA	General Permit for Storm Water Discharges Associated with the ORNL 6000E Parking Lots	TNR137306	DOE	UT-B	UT-B
CWA	ARAP—Fifth Creek Culvert Maintenance Activities	NR2103.308	DOE	UT-B	UT-B
CWA	General NPDES Permit for Storm Water Discharges Associated with Graphite Reactor and 2040 Parking Lot Improvements	TNR137673	DOE	UT-B	UT-B
CWA	General NPDES Permit for Storm Water Discharges Associated with Spallation Neutron Source Second Target Station	TNR137697	DOE	UT-B	UT-B
CWA	General Permit for Minor Alterations to Wetlands (installation of new fiber optic lines onto existing power poles—one of the power poles, Q011, is located within a wetland)	ARAP-NR2403.026	DOE	UT-B	UT-B
CWA	ARAP—Construction of Intake and Outfall Structures at NPDES Outfall 302	NR2303.163	DOE	UT-B	UT-B

[a] *Permit terminated during 2024.*

Acronyms:

ARAP = Aquatic Resources Alteration Permit
CAA = Clean Air Act
CFTF = Carbon Fiber Technology Facility
CWA = Clean Water Act
DOE = US Department of Energy
EPA = US Environmental Protection Agency
GEARS = Global Evaluation, Analysis, Research, and Security
Isotek = Isotek Systems, LLC
MBTA = Migratory Bird Treaty Act of 1918
NPDES = National Pollutant Discharge Elimination System
NTRC = National Transportation Research Center
ORNL = Oak Ridge National Laboratory
PCB = polychlorinated biphenyl
RCRA = Resource Conservation and Recovery Act
SNS = Spallation Neutron Source
TCA 70 = T.C.A. 70-2-213
TRC = Translational Research Capability
TRU = transuranic
TWRA = Tennessee Wildlife Resources Agency
UCOR = United Cleanup Oak Ridge LLC
UT-B = UT-Battelle, LLC

Table 5.5. National Environmental Policy Act activities, 2023–2024

Types of NEPA documentation	Number of instances
UT-Battelle, LLC	
Environmental assessments	0
Approved under general actions or generic CX determinations[a]	152
Project-specific CX determinations[b]	0
UCOR	
Approved under general actions[a] or generic CX determinations	0

[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

UCOR = United Cleanup Oak Ridge LLC

5.3.3. Clean Air Act Compliance Status

The Clean Air Act (CAA 1970), passed in 1970 and amended in 1977 and 1990, forms the basis for the national air pollution control effort. This legislation establishes 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 Rad-NESHAPs.

Airborne discharges from DOE Oak Ridge facilities, both radioactive and nonradioactive, are subject to regulation by EPA and the Tennessee Department of Environment and Conservation (TDEC) Division of Air Pollution Control. The most recent sitewide UT-Battelle Title V Major Source Operating Permit was issued in December 2023. The Title V Major Source Operating Permit for the 3039 stack, operated by UCOR, was issued in January 2022. To demonstrate compliance with the Title V Major Source Operating Permits, more than 1,500 data points are collected and reported every year. In addition, nitrogen oxides, a family of poisonous, highly reactive gases defined collectively as a criteria pollutant by EPA (EPA 2024), are monitored continuously at one location. Samples are collected continuously from 8 major radionuclide sources and periodically from 14 minor radionuclide sources. There are numerous other demonstrations of compliance with generally applicable air quality protection requirements (e.g., asbestos, stratospheric ozone).

NTRC and the CFTF are two off-site CAA-regulated facilities maintained and operated by UT-Battelle. In December 2022, Knox County issued an operating permit for two emergency generators located at NTRC. The CFTF operates under a conditional major operating permit issued to UT-Battelle by TDEC in 2022.

In summary, no UT-Battelle, Isotek, or UCOR CAA violations or exceedances occurred in 2024. Section 5.4. provides detailed information on 2024 activities conducted by UT-Battelle in support of the CAA.

5.3.4. Clean Water Act Compliance Status

The Clean Water Act (CWA 1972) is the primary federal statute governing the restoration, maintenance, and protection of the integrity of the nation's waters. The CWA establishes several major integrated regulatory programs, standards, and plans, including the National Pollutant Discharge Elimination System (NPDES) program, national and local pretreatment programs, storm water management program, Section 404 dredge

or fill discharge program, biosolids program, and oil spills and spill prevention program.

As part of the CWA, EPA developed the NPDES permit program to address water pollution by regulating point sources that discharge pollutants to US waters. (See Appendix C for water quality reference standards.) 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 permit program to the State of Tennessee. The pretreatment program is a component of the NPDES program. This program is designed to reduce the level of toxic pollutants discharged by industry and other nondomestic wastewater sources into municipal sewer systems and treatment facilities. Local municipalities with approved pretreatment programs control sources of nondomestic discharges through permitting and are responsible for conducting inspections, sampling, and enforcement in Tennessee.

Wastewater discharges from ORNL facilities are subject to regulation by EPA and the TDEC Division of Water Resources. DOE received a renewed ORNL NPDES permit in May 2019 from TDEC. Several conditions in the permit were appealed, and others were addressed in permit modifications issued in December 2022 and February 2023. Another minor modification was scheduled to become effective on March 1, 2023, but some conditions were appealed and remained unresolved in 2023. An NPDES permit renewal application was submitted to TDEC in June 2023, and until a new permit is issued, the February 2023 permit, which expired December 31, 2023, has been administratively extended.

In 2024, compliance with the ORNL NPDES permit was calculated based on a total of 1,736 laboratory analyses and field measurements. The wastewater treatment facilities achieved a numeric permit compliance rate of 100 percent in 2024 (see Table 5.6). The CFTF also achieved 100 percent compliance with the UT-Battelle City of Oak Ridge Industrial and Commercial User Discharge Pre-Treatment Permit in 2024.

Table 5.6. National Pollutant Discharge Elimination System (TN0002941) compliance at ORNL, January through December 2024

Effluent parameters[a]	Number of numeric noncompliances	Number of compliance measurements[b]	Compliance rate (%)[c]
X01 (Sewage Treatment Plant)			
IC_{25} static renewal 7-day chronic *Ceriodaphnia dubia* (%)[d]	0	1	100
IC_{25} static renewal 7-day chronic *Pimephales promelas* (%)[d]	0	1	100
Ammonia, as N (summer)	0	26	100
Ammonia, as N (winter)	0	27	100
Carbonaceous biological oxygen demand	0	52	100
Dissolved oxygen	0	52	100
Escherichia coliform (col/100 mL)	0	53	100
Peracetic acid	0	0	100
pH (standard units)	0	52	100
Total suspended solids	0	53	100

Table 5.6. National Pollutant Discharge Elimination System (TN0002941) compliance at ORNL, January through December 2024 (continued)

Effluent parameters[a]	Number of numeric noncompliances	Number of compliance measurements[b]	Compliance rate (%)[c]
X12 (Process Waste Treatment Complex)			
IC_{25} static renewal 7-day chronic *Ceriodaphnia dubia* (%)[d]	0	1	100
IC_{25} static renewal 7-day chronic *Pimephales promelas* (%)[d]	0	1	100
Oil and grease	0	4	100
pH (standard units)	0	52	100
Temperature (°C)	0	52	100
X16 through X27 (12 instream monitoring locations)			
Total residual oxidant	0	288	100
X28 and X29 (two additional instream monitoring locations)			
Peracetic acid	0	0	100
Hydrogen peroxide	0	0	100

[a] *Only permit parameters with a numerical limit are listed.*
[b] *Total number of readings taken in the year by an approved method for the given parameter.*
[c] *Compliance rate = 100 − [(number of noncompliances/number of samples) × 100].*
[d] *The inhibition concentration (IC_{25}) is the concentration (as a percentage of full-strength wastewater) that reduces survival or reproduction of the test species by 25 percent when compared to a control treatment.*

5.3.5. Safe Drinking Water Act Compliance Status

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

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

The fifth Unregulated Contaminant Monitoring Rule, published on December 27, 2021, requires sample collection and analyses for 30 chemical contaminants between 2023 and 2025 using methods developed by EPA and consensus organizations. Sample collection at ORNL for the fifth Unregulated Contaminant Monitoring Rule began in 2023 and will continue through 2026. Samples were taken five times in 2023 (January, April, July, October, and December) at the entry point of the distribution system. No sampling was required in 2024.

EPA issued a new lead and copper rule for water systems that became final on December 17, 2021. In accordance with 40 CFR 141.86, the rule required that lead service line inventories be developed for all drinking water systems and submitted to TDEC no later than October 16, 2024. Potential lead exposure risk notices for facility service lines that were not identified and were assigned an *unknown* status in the lead service line inventory were sent to facility managers by November 15, 2024. TDEC is expected to provide further information and incorporate additional new rules regulating lead and copper.

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. The City of Oak Ridge is currently managing the construction of a new water treatment plant to replace the antiquated water treatment plant currently in service.

In 2024, sampling results for ORNL's water system residual chlorine levels, bacterial constituents, disinfectant by-products, and lead and copper were all within acceptable limits.

5.3.6. Resource Conservation and Recovery Act Compliance Status

The hazardous waste program under the Resource Conservation and Recovery Act (RCRA 1976) establishes a system for regulating hazardous wastes from the initial point of generation through final disposal. In Tennessee, TDEC has been delegated authority by EPA to implement the hazardous waste program; EPA retains an oversight role. In 2024, 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 2024.

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 5.7. In 2024, UT-Battelle and UCOR were permitted to transport hazardous wastes under the EPA ID number issued for ORNL activities. TNHW-164 is a set of conditions pertaining to the current status of all solid waste management units and areas of concern at ETTP, ORNL, and the Y-12 Complex. The corrective action conditions require that the solid waste management units and areas of concern be investigated and, as necessary, remediated.

Reporting is required for hazardous waste activities on 12 active waste streams at ORNL, some of which involve mixed wastes. The quantity of hazardous/mixed waste generated at ORNL in 2024 was 544,316 kg, of which 169,234 kg was mixed wastewater.

ORNL generators treated 3,374 kg of hazardous waste by elementary neutralization. The quantity of hazardous/mixed waste treated in permitted treatment facilities at ORNL in 2024 was 169,740 kg. This includes waste treated by macroencapsulation, size reduction, and stabilization/solidification as well as wastewater treatment at the Process Waste Treatment Complex (PWTC). In 2024, 360,806 kg of hazardous/mixed waste was shipped off-site to commercial treatment, storage, and disposal facilities.

In March 2024, the TDEC Division of Solid Waste Management conducted a hazardous waste compliance evaluation inspection of the following:

- ORNL generator areas
- Used-oil collection areas
- Universal waste collection areas
- RCRA-permitted treatment, storage, and disposal facilities
- Hazardous waste training records
- Site-specific contingency plans
- Hazardous waste reduction plan and annual progress report, updated March 2023
- *2023 Hazardous Waste Annual Report*
- Active mutual aid agreements and memorandums of agreement with local authorities
- Waste determination records
- RCRA records

TDEC also reviewed the Hazardous Waste Transporter Permit and hazardous waste manifests. No violations were observed.

Table 5.7. ORNL Resource Conservation and Recovery Act operating permits, 2024

Permit number	Storage and treatment/description
	Oak Ridge National Laboratory
TNHW-178	Building 7651 Mixed Waste Container Storage Unit Building 7652 Hazardous Waste Container Storage and Treatment Unit Building 7653 Chemical Waste Container Storage Unit Building 7654 Mixed Waste Container Storage and Treatment Unit
TNHW-145	Building 7572 Contact-Handled Transuranic Waste Storage Facility Building 7574 Transuranic Storage Facility Building 7855 Remote-Handled Transuranic Retrievable Storage Facility Building 7860A Remote-Handled Transuranic Retrievable Storage Facility Building 7879 Transuranic/Low-Level Waste Storage Facility Building 7883 Remote-Handled Transuranic Storage Bunker Building 7831F Flammable Storage Unit[a] Transuranic Waste Processing Center (TWPC)-1 Contact-Handled Storage Area TWPC-2 Waste Processing Building Second Floor TWPC-3 Drum Aging Criteria Area TWPC-4 Waste Processing Building First Floor TWPC-5 Container Storage Area TWPC-6 Contact-Handled Marshaling Building TWPC-7 Drum-Venting Building TWPC-8 Multipurpose Building T-1 Macroencapsulation Treatment[a] T-2 Solidification/Stabilization Treatment[a] T-3 Amalgamation Treatment[a] T-4 Groundwater Absorption Treatment[a] T-5 Size Reduction[a] T-6 Groundwater Filtration Treatment[a] T-7 Neutralization[a] T-8 Oxidation/Deactivation[a] T-9 Puncturing Potentially Pressurized Containers[a]
	Oak Ridge Reservation
TNHW-164	Hazardous Waste Corrective Action Document

[a] *Treatment methodologies within Transuranic Waste Processing Center facilities.*

In June 2023, DOE and UT-Battelle operations at the HVC changed generator category from a very small quantity generator to small quantity generator. The HVC does not generate mixed waste. Hazardous wastes are accumulated in satellite accumulation areas or in less-than-180-day accumulation areas. Reporting is required for hazardous waste activities in nine active waste streams at the HVC. During 2024, the HVC generated 3,157 kg of hazardous waste and shipped 3,175 kg of hazardous waste for treatment and disposal.

The CFTF was categorized as a very small quantity generator in 2024, meaning that less than 100 kg of hazardous waste was generated per month.

In 2024, no hazardous/mixed wastes were generated, accumulated, or shipped by DOE or UT-Battelle from the Jones Island Road 0800 Area, Property Sales, or the DOE Office of Scientific and Technical Information.

5.3.7. ORNL RCRA-CERCLA Coordination

The *Federal Facility Agreement for Oak Ridge Reservation* (DOE 1992) is intended to coordinate the corrective action processes of RCRA required under the Hazardous and Solid Waste Amendments permit with CERCLA response actions. Annual updates for 2024 for ORNL's solid waste management units and areas of concern were consolidated with updates for ETTP, the

Y-12 Complex, and ORR and were reported to TDEC and DOE in January 2025.

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

5.3.7.1. RCRA Underground Storage Tanks

Underground storage tanks (USTs) containing petroleum and hazardous substances are regulated under RCRA Subtitle I (40 CFR 280). EPA has granted TDEC the authority to regulate USTs containing petroleum under TDEC Rule 400-18-01 (TDEC 2021a); however, EPA still regulates hazardous substance USTs.

ORNL has two USTs registered with TDEC under Facility ID 0-730089. These USTs are in service (for petroleum storage) and meet the current UST standards. TDEC conducted a compliance inspection on December 12, 2024, and a minor violation was issued. The violation was immediately resolved and was closed by TDEC on January 14, 2025.

5.3.8. CERCLA Compliance Status

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

In 1989, ORR was placed on the National Priorities List. In 1992, the ORR Federal Facility Agreement became effective among EPA, TDEC, and DOE and established the framework and schedule for developing, implementing, and monitoring remedial actions (RAs) on ORR. UCOR operates the on-site CERCLA Environmental Management Waste Management Facility (EMWMF) for DOE. Located in Bear Creek Valley, the EMWMF is used for disposal of waste resulting from CERCLA cleanup actions on ORR, including ORNL. The EMWMF is an engineered landfill that accepts low-level radioactive, hazardous, asbestos, and polychlorinated biphenyl (PCB) wastes and combinations of these 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 Substances Control Act (TSCA 1976). PCB waste generation, transportation, and storage at ORNL are reported under EPA ID TN1890090003. In 2024, ORNL contractors operated four PCB waste storage areas. When longer-term storage was necessary, PCB/radioactive wastes were stored in RCRA-permitted storage buildings at ORNL. One of the PCB waste storage areas was operated at a UT-Battelle facility in the Y-12 Complex. The continued use of authorized PCBs in electrical systems and equipment (e.g., transformers, capacitors, rectifiers) is regulated at ORNL. Most of the equipment at ORNL that required regulation under the Toxic Substances Control Act has been dispositioned. However, some of the ORNL facilities at the Y-12 Complex continue to use (or store for future reuse) PCB equipment.

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

the compliance issues related to these unauthorized uses and to allow for continued use pending decontamination or disposal. As a result of that agreement, DOE continues to notify EPA when additional unauthorized uses of PCBs, such as in paint, adhesives, electrical wiring, or floor tile, are identified at ORNL. No new unauthorized uses of PCBs were identified during 2024.

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

The Emergency Planning and Community Right-to-Know Act (EPCRA 1986) and Title III of SARA require that facilities report inventories and releases of certain chemicals that exceed specific release thresholds. The inventory report is submitted to the Emergency Response Information System (E-Plan), which is an electronic database managed by the University of Texas at Dallas and funded by the US Department of Homeland Security. The State of Tennessee Emergency Response Commission has access to ORNL EPCRA data via the E-Plan system.

Table 5.8 describes the main elements of EPCRA. UT-Battelle complied with these requirements in 2024 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.

In 2024, ORNL had no releases of extremely hazardous substances as defined by EPCRA. Releases of toxic chemicals that were greater than the reportable threshold quantities designated in Section 313 are discussed in Section 5.3.10.2.

Table 5.8. Main elements of the Emergency Planning and Community Right-to-Know Act

Title	Description
Sections 302 and 303, Planning Notification	Requires that the 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 and 312, Safety Data Sheet/Chemical Inventory	Requires that either safety data sheets or lists of hazardous chemicals for which they are required be provided to state and local authorities for emergency planning. Requires that an inventory of hazardous chemicals maintained in quantities over thresholds be reported annually to EPA
Section 313, Toxic Chemical Release Reporting	Requires that releases of toxic chemicals be reported annually to EPA

Acronyms:
EPA = US Environmental Protection Agency
EPCRA = Emergency Planning and Community Right-to-Know Act

5.3.10.1. Safety Data Sheet/Chemical Inventory (EPCRA Sections 311 and 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 2024, 46 hazardous and 11 extremely hazardous substances at ORNL met EPCRA reporting criteria.

Private-sector lessees were not included in the 2024 submittals. Under the terms of their leases, lessees must evaluate their own inventories of hazardous and extremely hazardous chemicals and submit information as required by the regulations.

The ORNL chemical safety SME participated in a Battelle environmental subgroup meeting in March 2024 to discuss and benchmark the participating sites' chemical management systems. ORNL qualified health and safety professionals also participated in the 2024 spring and fall Energy Facility Contractors Group Industrial Hygiene, Safety, and Chemical Management

conferences, which provided opportunities to share information and lessons learned.

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 into the environment and/or managed through recycling, energy recovery, and treatment. (A release of a chemical means that it is emitted into 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, processed, or otherwise used. Releases and other waste management activities were determined for each chemical that exceeded one or more threshold.

In 2024, ORNL exceeded the reporting threshold for nitrate compounds and reported on their manufacture. Nitrate compounds were coincidentally manufactured as by-products of on-site sewage treatment.

5.3.11. US Department of Agriculture/Tennessee Department of Agriculture

USDA, through Animal and Plant Health Inspection Services, issues permits for the import, transit, and controlled release of regulated animals, animal products, veterinary biologics, plants, plant products, pests, organisms, soil, and genetically engineered organisms. The Tennessee Department of Agriculture issues agreements and jointly regulates domestic soil with USDA. In 2024, UT-Battelle personnel had 31 permits and agreements for the receipt, movement, or controlled release of regulated articles.

5.3.12. Wetlands

Wetland delineations facilitate compliance with TDEC and US Army Corps of Engineers wetland protection requirements. In 2024, two wetlands were delineated on the ORNL campus to ensure project activities did not have negative impacts on wetlands. One was included in an Aquatic Resource Alteration Permit.

5.3.13. Radiological Clearance of Property at ORNL

DOE Order 458.1, *Radiation Protection of the Public and the Environment* (DOE 2020), 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 into the environment, the release of property containing residual radioactive material is a potential contributor to the dose received by the public, and DOE Order 458.1 established requirements for clearance of property from DOE control and for public notification of clearance of property.

5.3.13.1. Graded Approach to Evaluate Material and Equipment for Release

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

- Documents, mail, diskettes, compact disks, and other office media
- Nonradioactive items or materials received that are immediately (within the same shift) determined to have been delivered in error or damaged
- Personal items or materials
- Paper, plastic products, aluminum beverage cans, toner cartridges, and other items released for recycling
- Office trash
- Housekeeping materials and associated waste

- Breakroom, cafeteria, and medical wastes
- Compressed gas cylinders and fire extinguishers
- Medical and bioassay samples
- Other items with an approved release plan

Items that are not in the listed categories and that originate from nonradiological areas within ORNL's controlled areas are surveyed before release to the public, or a process knowledge evaluation is conducted to ensure that the material has not been exposed to radioactive material or beams of radiation capable of creating radioactive material. In some cases, both a radiological survey and a process knowledge evaluation are performed (e.g., a radiological survey is conducted on the outside of the item, and a process knowledge form is signed by the custodian for inaccessible surfaces). A similar approach is used for material released to state-permitted landfills on ORR. The only exception is for items that could be internally contaminated; samples from those items undergo 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 is known and that the item is known to be free of contamination. This process knowledge certification is more stringent than what is required by DOE Order 458.1 (DOE 2020) in that ORNL requires an individual to take personal responsibility and accountability for knowing the complete history of an item before it can be cleared using process knowledge alone. DOE Order 458.1 allows use of procedures for evaluating operational records and operating history to make process knowledge release decisions, but UT-Battelle has chosen to continue to require personal certification of the status of an item. This requirement ensures that each individual certifying the item is aware of the significance of this decision and encourages the individual to obtain a survey of the item if he or she is not confident that the item can be certified as being free of contamination.

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

In accordance with DOE Order 458.1, Section k.(6)(f)2 b, "Pre-Approved Authorized Limits," UT-Battelle continues to use the preapproved authorized limits for surface contamination originally established in Table IV-1 of DOE Order 5400.5 (canceled 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 2024, UT-Battelle cleared more than 20,891 items through the excess items and property sales processes. A summary of items requested for release through these processes is shown in Table 5.9.

Table 5.9. Excess items requested for release or recycling, 2024

Item	Process knowledge	Radiologically surveyed
Release request totals for 2024		
Totals	19,537	1,354
Recycling request totals for 2024		
Cardboard (lb)	377,096	
Scrap metal (nonradiological areas) (tons)	567.2094	

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

The SNS and High Flux Isotope Reactor (HFIR) facilities provide unique neutron scattering experiment capabilities that allow researchers to explore the properties of various materials by exposing samples to well-characterized neutron beams. Because materials exposed to neutrons can become radioactive, a process has been developed to evaluate and clear samples for release to off-site facilities. DOE regulations and orders governing radiological release of material do not specifically cover items that may have radioactivity distributed throughout the volume of the material. To address sample clearance, activity-based limits were established using the authorized limits process defined in DOE Order 458.1 (DOE 2020) and associated guidance. The sample clearance limits are based on an assessment of potential doses against a threshold of 1 mrem/year to an individual and evaluation of other potentially applicable requirements (e.g., Nuclear Regulatory Commission licensing regulations). Implementation of the clearance limits involves using unique instrument screening and methods to predict sample activity to provide an efficient and defensible process for releasing neutron scattering experiment samples to researchers without further DOE control.

In 2024, ORNL cleared a total of 11 samples from neutron scattering experiments using the sample authorized limits release process. Five samples were released from SNS, and six samples were released from HFIR.

5.4. Air Quality Program

Permits issued by the State of Tennessee convey the clean air requirements that are applicable to ORNL. These permits and the results of 2024 air monitoring activities are summarized in the following sections.

5.4.1. Construction and Operating Permits

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

The CFTF was constructed at an off-site location in the Horizon Center Business Park in Oak Ridge, Tennessee. UT-Battelle applied for and received two construction permits for construction of the CFTF (Permit No. 965013P in 2012 and Permit No. 967180P in 2014). The initial start-up of the CFTF occurred in March 2013. The most recent Conditional Major Source Operating Permit for the facility was issued in September 2023 (Permit No. 474951).

DOE/UCOR has one non-Title V Major Source Operating Permit for one emission source at TWPC (Permit No. 071009P and Permit-by-Rule R80800). During 2024, no permit limits were exceeded. Isotek has a Title V Major Source Operating Permit (576448) for the Radiochemical Development Center (Building 3019 Complex). During 2024, no permit limits were exceeded. UCOR was issued a Title V Major Source Operating Permit (569768) on September 18, 2015, for the Building 3039 Process Off-Gas and Hot Cell Ventilation System. Construction Permit 974744 was issued on November 19, 2018, to implement several proposed modifications to the Title V Operating Permit, and Significant Modification #1

to the Title V Operating Permit was issued on April 5, 2019, incorporating those modifications. The current operating permit (578132) was issued in July 2022. During 2024, no permit limits were exceeded.

5.4.2. National Emission Standards for Hazardous Air Pollutants—Asbestos

Numerous facilities, structures, facility components, and pieces of equipment at ORNL have asbestos-containing material. UT-Battelle's Asbestos Management Program manages the compliance of work activities involving the removal and disposal of asbestos-containing material. This program includes notifications to TDEC for all demolition activities and required renovation activities, approval of asbestos work authorization requests, implementation of engineering controls and work practices, inspections, air monitoring, and waste tracking of asbestos-contaminated waste material. During 2024, no deviations or releases of reportable quantities of asbestos-containing material occurred.

In 2024, activities related to the Asbestos Management Program included the following:

- One Notification of Demolition and/or Asbestos Renovation was submitted to TDEC in December 2024 for the "FY25 HFIR Shed Demo and Laydown Yard Cleanup Task" project, which included demolition work activities for Buildings 7986, 7980A, 7980B, and 0808T and three unnumbered sheds. This task did not involve regulated asbestos-containing materials, and an asbestos work authorization was not required.
- The Building 2523 laundry facility was demolished in accordance with CERCLA requirements. This demolition included the removal of 5 ft of regulated asbestos-containing materials and 330 ft^2 of Category I and II nonfriable materials such as window glazing, electrical wiring, caulking/filler materials, transite wall panels, and roofing materials.
- Revised friable asbestos removal annual estimates for calendar year 2024 were submitted on November 21, 2024. The revised estimates were 900 ft, 6 ft^2, and 18 ft^3.
- Estimates for calendar year 2025 friable asbestos removal (1,035 ft, 260 ft^2, and 50 ft^3) were submitted on December 12, 2024.
- During 2024, a total of 89 work authorizations for asbestos removal work activities were completed, primarily for asbestos pipe insulation and floor tile materials.

5.4.3. Radiological Airborne Effluent Monitoring

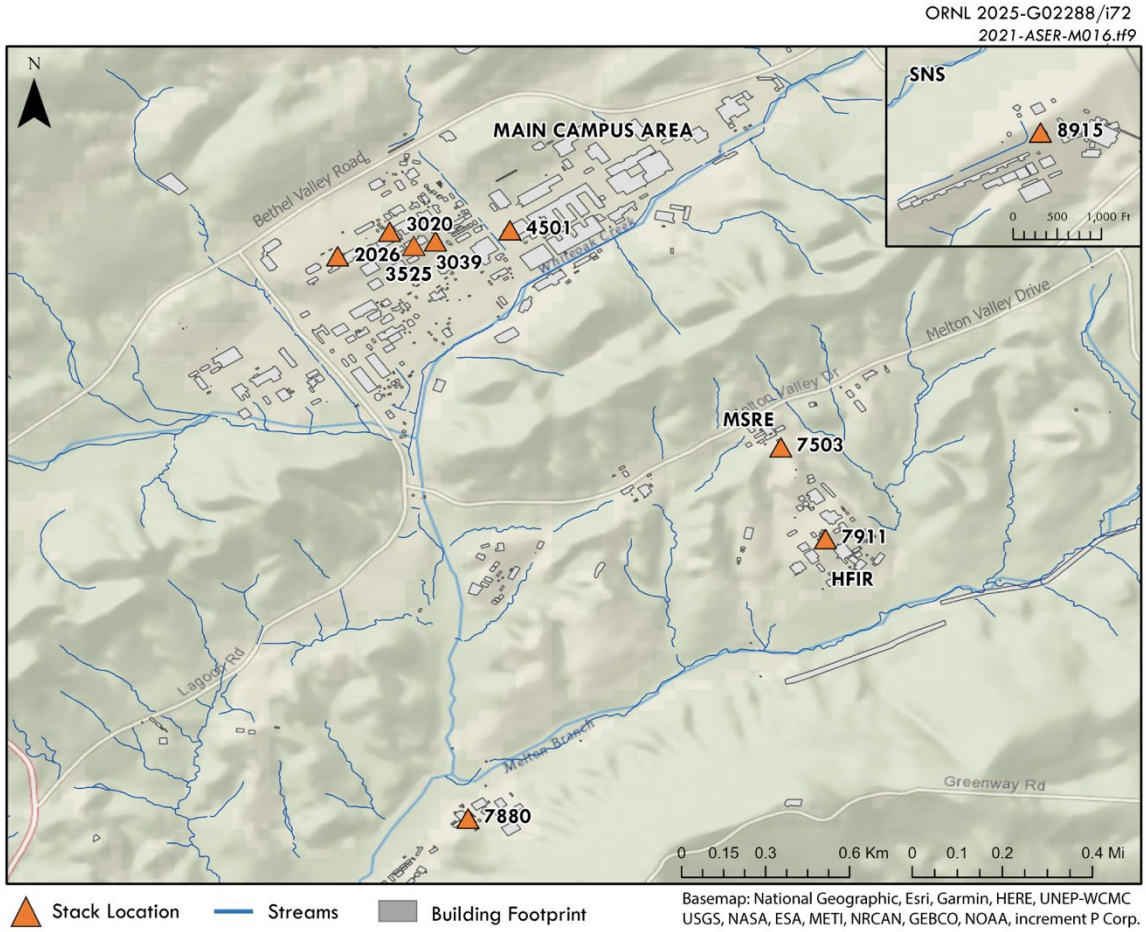
Radioactive airborne discharges at ORNL are subject to Rad-NESHAPs and consist primarily of ventilation air from radioactively contaminated or potentially contaminated areas, vents from tanks and processes, and ventilation for hot cell operations and reactor facilities. The airborne emissions are treated and then filtered with high-efficiency particulate air filters and/or charcoal filters before discharge. Radiological airborne emissions from ORNL consist of solid particulates, ^3H, adsorbable gases (e.g., iodine), and nonadsorbable gases (e.g., noble gases).

The major radiological emission point sources for ORNL consist of the following nine stacks. Seven are located in Bethel and Melton Valleys, and one, the SNS Central Exhaust Facility stack, is located on Chestnut Ridge (Figure 5.3):

- 2026 Radioactive Materials Analytical Laboratory
- 3020 Radiochemical Development Facility
- 3039 central off-gas and scrubber system, which includes the 3025/3026 cell ventilation system, 3042 ventilation system, and 3092 central off-gas system
- 3525 Irradiated Fuels Examination Laboratory area off-gas system
- 4501 Radiochemistry Laboratory area off-gas system
- 7503 Molten Salt Reactor Experiment Facility

- 7880 TWPC
- 7911 Melton Valley complex, which includes HFIR and the Radiochemical Engineering Development Center
- 8915 SNS Central Exhaust Facility stack

In 2024, emission calculations/estimates were made for each of the 15 minor point/group sources.



Acronyms:

HFIR = High Flux Isotope Reactor MSRE = Molten Salt Reactor Experiment SNS = Spallation Neutron Source

Figure 5.3. Locations of major radiological emission points at ORNL, 2024

5.4.3.1. Sample Collection and Analytical Procedure

Three of the major point sources (stacks 3020, 3039, and 7503) are equipped with in-stack source-sampling systems that comply with criteria in the American National Standards Institute (ANSI) standard ANSI N 13.1-1969R (ANSI 1969). Each sampling system generally comprises a multipoint in-stack sampling probe, a sample transport line, a particulate filter, activated charcoal cartridges (or canister), a silica gel cartridge (if required), flow measurement and totalizing instruments, a sampling pump, and a return line to the stack.

The 2026 (Radioactive Materials Analytical Laboratory), 3525 (Irradiated Fuels Examination Laboratory), 4501 (Radiochemistry Laboratory), 7911 (Melton Valley complex), and 7880 (TWPC) stacks are equipped with in-stack source-sampling systems that comply with criteria in the

ANSI–Health Physics Society standard ANSI/HPS N13.1-1999 (ANSI 1999). The 2026, 3525, 4501, and 7911 sampling systems have the same components as the ANSI 1969 sampling systems used for the four major point sources but use stainless-steel-shrouded probes instead of multipoint in-stack sampling probes.

The 7911 sampling system also includes 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 8915 (SNS Central Exhaust Facility) stack is equipped with an in-stack radiation detector that complies with criteria in ANSI/HPS N13.1-1999 (ANSI 1999). The detector monitors radioactive gases flowing through the exhaust stack and provides a continual readout of activity detected by a scintillator probe. The detector is calibrated to correlate with isotopic emissions.

Velocity profiles are performed quarterly at major sources (except for the 3039 stack) and at some minor sources; the criteria in EPA Method 2 (40 CFR 60, Appendix A-1, Method 2) are followed. The profiles provide accurate stack flow data for subsequent emission rate calculations. An annual leak check program is implemented to verify the integrity of the sample transport system. Results obtained from the effluent flow rate totalizer and from EPA Method 2 are compared annually for the 7880 stack. 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 rotameter tests.

Starting in 2017, the 3039 emissions were calculated using a fixed stack flow rate. A fixed stack flow rate was used because the stack velocity at the sampling level was at or below the sensitivity of standard methods for measuring the velocity, and therefore stack flow rates could not be determined. The reduction in velocity was due to stack flow reductions resulting from the removal of facilities exhausting through the stack. The EPA Region 4 office approved a request to use an alternative to fixed stack flow for emission calculations for the 3039 stack in a letter dated April 27, 2017 (V. Anne Heard, acting regional administrator, United States Environmental Protection Agency Region 4 to Raymond J. Skwarek, environmental safety, health and quality assurance manager, UCOR, April 27, 2017). The 3039 stack velocity was successfully measured with new equipment in November 2019 and in July 2020. Both results were below the fixed stack flow rate; the stack velocity result obtained in 2020 has been used for subsequent emission calculations. In addition to the major sources, ORNL has several minor sources that have the potential to emit radionuclides into 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 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 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 and canisters, particulate filters, and silica gel traps are collected weekly to biweekly. The use of charcoal cartridges (or canisters) is a standard method for capturing and quantifying radioactive iodine in airborne emissions. Gamma spectrometric analyses of the charcoal samples are performed weekly to biweekly to quantify the adsorbable gases.

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 composited quarterly or semiannually and are analyzed for alpha-, beta-, and gamma-emitting isotopes. At stack 7880, the filters are collected monthly and analyzed for alpha-, beta-, and gamma-emitting isotopes. The sampling system on stack 7880 requires no other type of radionuclide collection media. Monthly sampling provides a better opportunity for quantification of the low-concentration isotopes. Silica gel traps are used to capture water vapor that may contain ^{3}H. Analysis is performed weekly to biweekly.

At the end of the year, the sample probes for all 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, and contaminant deposits are not expected to collect on the scintillator probe. A probe-cleaning program for 7880 has established that rinse analysis has historically shown no detectable contamination. Therefore, the frequency of probe rinse collection and analysis is not more often than every 3 years unless particulate emissions increase, detectable radionuclides in the sample media increase, or process modifications occur.

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

5.4.3.2. Results

Annual radioactive airborne emissions for ORNL in 2024 are presented in Appendix G.

Historical trends for ^{3}H and ^{131}I are presented in Figures 5.4 and 5.5. For 2024, ^{3}H emissions totaled about 1,001 Ci (Figure 5.4), comparable to what was seen in 2023; ^{131}I emissions totaled 0.07 Ci (Figure 5.5), a decrease from what was seen in 2023. For 2024, of the 320 radionuclides (excluding radionuclides with multiple solubility types) released from ORNL operations and evaluated, the isotopes that contributed 10 percent or more to the off-site dose from ORNL included ^{212}Pb, which contributed about 69 percent, and ^{237}Np, which contributed about 11 percent to the total ORNL dose.

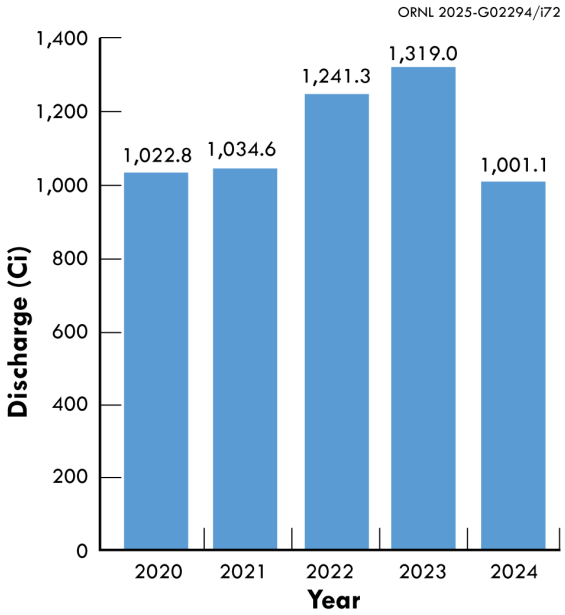


Figure 5.4. Total curies of ^{3}H discharged from ORNL to the atmosphere, 2020–2024

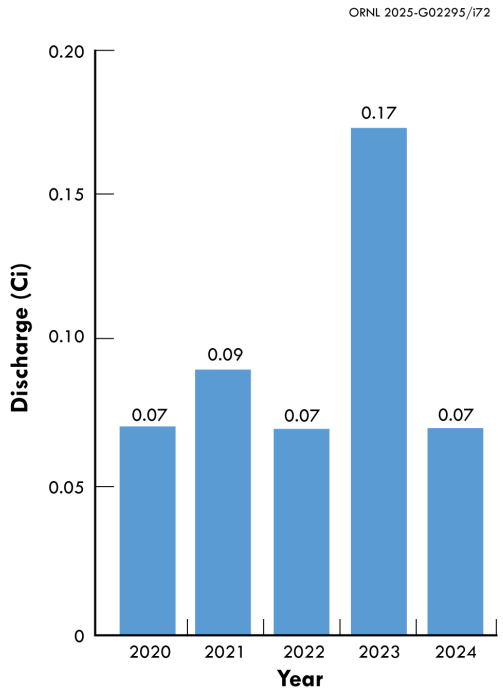


Figure 5.5. Total curies of ^{131}I discharged from ORNL to the atmosphere, 2020–2024

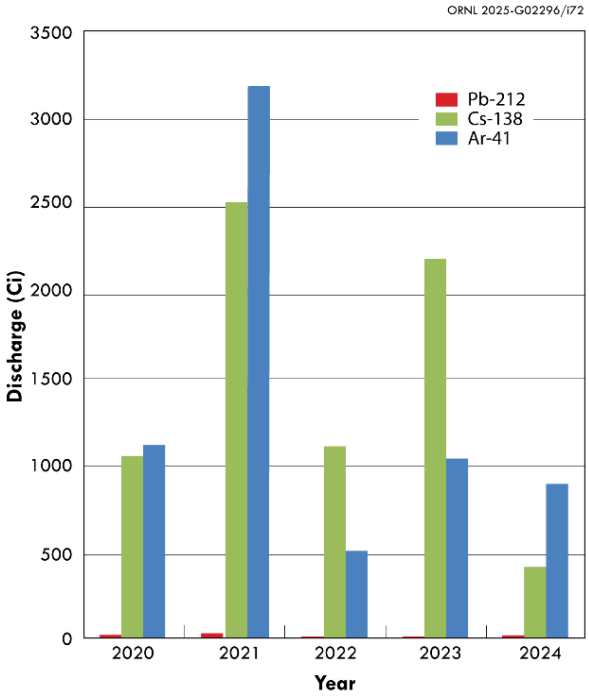


Figure 5.6. Total curies of ^{41}Ar, ^{138}Cs, and ^{212}Pb discharged from ORNL to the atmosphere, 2020–2024

Emissions of ^{212}Pb result from research activities and from the radiation decay of legacy material stored on-site and from areas containing ^{228}Th, ^{232}Th, and $^{232/233}$U. Emissions of ^{212}Pb were from the following stacks: 2026, 3020, 3039, 3525, 4501, 7503, 7856, 7911, and 4000 area laboratory hoods. Emissions of ^{237}Np result from 3000, 4000, and 7000 area laboratory hood research activities. For 2024, ^{212}Pb emissions totaled 12.46 Ci, ^{138}Cs emissions totaled 412.0 Ci, and ^{41}Ar emissions totaled 891.3 Ci (Figure 5.6).

The calculated radiation dose to the maximally exposed individual from all radiological airborne release points at ORR during 2024 was 0.6 mrem. The dose contribution to the maximally exposed individual from all ORNL radiological airborne release points was 13 percent of the ORR dose. This dose is well below the Rad-NESHAPs standard of 10 mrem and is equal to approximately 0.2 percent of the roughly 300 mrem that the average individual receives from natural sources of radiation. (See Section 7.1.2 for an explanation of how the airborne radionuclide dose was determined.)

5.4.4. Stratospheric Ozone Protection and Hydrofluorocarbon Phasedown

As required by the CAA Title VI Amendments of 1990 and in accordance with 40 CFR 82, actions have been implemented to comply with the prohibition against intentionally releasing ozone-depleting substances during maintenance activities performed on refrigeration equipment. Regulations of substitutes for ozone-depleting substances are included in 40 CFR 82 Subpart F. In 2021, EPA began implementing the hydrofluorocarbons phasedown requirements of the American Innovation and Manufacturing Act (AIM 2020), which seeks to reduce hydrofluorocarbon consumption and production to 15 percent of a 2011–2013 baseline by 2036. (*Phasedown of Hydrofluorocarbons: Establishing the Allowance Allocation and Trading Program under the AIM Act* [EPA 2022a] is available **here**.) Sitewide use and purchase of hydrofluorocarbon-containing appliances are being tracked to remain in compliance with the AIM Act phasedowns in accordance with 40 CFR 84 Subparts B and C.

5.4.5. Ambient Air

Station 7 in the ORNL 7000 maintenance area is the site-specific ambient air monitoring location. During 2024, the sampling system at Station 7 was used to quantify levels of ^{3}H; 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 an annual composite was submitted for laboratory analysis. A silica gel column was used for collection of ^{3}H as tritiated water. The silica gel was collected biweekly or weekly, depending on ambient humidity, and was composited quarterly for ^{3}H analysis. Station 7 sampling data (Table 5.10) were compared with the derived concentration standards (DCSs) for air established by DOE as guidelines for controlling exposure to members of the public (DOE 2021). During 2024, average radionuclide concentrations at Station 7 were less than 1 percent of the applicable DCSs in all cases.

Table 5.10. Radionuclide concentrations measured at ORNL air monitoring Station 7, 2024[a]

Parameter	Concentration (pCi/mL)[b]
Alpha	7.4×10^{-9}
^{7}Be	2.3×10^{-8}
Beta	3.1×10^{-8}
^{40}K	-2.3×10^{-9}
^{3}H[c]	9.1×10^{-6}
$^{233/234}U$	3.4×10^{-11}
$^{235/236}U$	1.7×10^{-12}
^{238}U	3.0×10^{-11}

[a] *Except for ^{3}H, each concentration value is based on a single result from annual composites of low-volume filters.*

[b] *1 pCi = 3.7×10^{-2} Bq.*

[c] *Silica gels are composited quarterly for ^{3}H analysis. The ^{3}H concentration is the calculated annual average.*

5.5. ORNL Water Quality Program

NPDES Permit TN0002941—issued to DOE for the ORNL site, reissued by the State of Tennessee in 2019, and modified in 2022 and again in 2023—includes requirements for discharging wastewaters from the two ORNL on-site wastewater treatment facilities and from more than 150 category outfalls (outfalls with nonprocess wastewaters such as cooling water, condensate, and storm water) and requirements for developing and implementing a water quality protection plan (WQPP). The permit calls for a WQPP to "efficiently utilize the facility's financial resources to measure its environmental impacts." Rather than prescribing rigid monitoring schedules, the ORNL WQPP is flexible and focuses on significant findings. It is implemented using an adaptive management approach whereby results of investigations are routinely evaluated, and strategies for achieving goals are modified based on those evaluations. The goals of the WQPP are to meet the requirements of the NPDES permit, improve the quality of aquatic resources on the ORNL site, prevent further impacts to aquatic resources from current activities, identify the stressors that contribute to impairment of aquatic resources, use available resources efficiently, and communicate outcomes with decision-makers and stakeholders.

The ORNL WQPP was developed by DOE and approved by TDEC in 2008, and WQPP monitoring was initiated in 2009. The WQPP originally incorporated several control plans that were required under the previous NPDES permit, including a biological monitoring and abatement plan, a chlorine control strategy, a storm water pollution prevention plan, a non–storm water best management practices plan, and a radiological monitoring plan. Radiological monitoring requirements were removed in the February 2023 permit modification, but some radiological monitoring is still performed to comply with DOE Order 458.1.

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

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

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

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

5.5.1. Treatment Facility Discharges

The ORNL Sewage Treatment Plant (STP) and the ORNL PWTC appropriately treat the various R&D, operational, and domestic wastewaters generated by site staff and research activities. Both are permitted to discharge treated wastewater and are monitored under NPDES Permit TN0002941, issued by TDEC to DOE for the ORNL site. The ORNL NPDES permit requirements include monitoring the two ORNL wastewater treatment facility effluents for conventional and water quality–based constituents and for effluent toxicity with numeric parameter-specific compliance limits established by TDEC in the permit. The results of field measurements and laboratory analyses to assess compliance for the parameters required by the NPDES permit and rates of compliance with numeric limits established in the permit are provided in Section 5.3.4 (Table 5.6). Compliance with permit limits for ORNL wastewater treatment facilities was 100 percent in 2024.

Toxicity testing provides an assessment of any potential harmful effects from the total combined constituents in discharges from ORNL wastewater treatment facilities. The NPDES permit has required testing of effluents from the STP for toxicity to aquatic species since 1986, and effluents from the PWTC have been tested since it went into operation in 1990. Test species have been *Ceriodaphnia dubia*, an aquatic invertebrate, and fathead minnow (*Pimephales promelas*) larvae. Tests have been conducted using EPA chronic or acute test protocols at frequencies ranging from one to four times per year.

Toxicity test requirements under the current NPDES permit include annual testing for chronic toxicity from the ORNL STP and PWTC. In 2024 no toxicity was observed in any of the tests at either of the wastewater treatment facilities.

5.5.2. Residual Bromine and Chlorine Monitoring

ORNL receives potable water from the City of Oak Ridge Department of Public Works, which uses chlorine as a final disinfectant. On the ORNL site, potable water is used for drinking, sanitary, and housekeeping purposes as well as for research processes and in cooling systems. After the water is used, residual chlorine remains and can be toxic to fish and other aquatic life if discharged to surface water. Residual chlorine in wastewater routed to the STP is generally consumed in reactions with other substances within the collection and treatment system, and any residual chlorine in wastewater routed to the PWTC is removed by final activated carbon filtration.

The NPDES permit requires monitoring total residual oxidant (TRO) levels at 12 different instream locations twice a month. In addition, oxidant levels at outfalls with potential

chlorine/bromine sources are routinely monitored via the WQPP TRO control strategy (also referred to as the chlorine control strategy). The NPDES permit establishes an action level of 1.2 g/day for TRO loading at all outfalls. A root cause analysis is performed for action level exceedances, and corrective actions are taken to reduce chlorine/bromine loading to less than 1.2 g/day.

In 2024, TRO levels were monitored twice a month at outfalls that receive cooling tower discharges and once-through cooling water. Less frequent monitoring was conducted at other outfalls (semimonthly, monthly, quarterly, or semiannually if flow was present). A total of 396 TRO measurements were taken at 26 locations, in addition to 288 semimonthly instream measurements. TRO levels at or above the end-of-pipe action level were detected on 33 occasions during 2024 but were never detected at any of the 12 instream monitoring points (Table 5.11).

Table 5.11. Overview of 2024 chlorine control strategy

Total residual oxidant sampling events	684
Below detection (<0.05 mg/L)	606
Instream total residual oxidant exceedances	0
Outfall detections	33
Outfall action level detections (>1.2 g/day)	33
Number of outfalls with action level detections	9

5.5.2.1. Monitoring Results and Corrective Actions

Actions in response to point source TRO monitoring include source investigations, source elimination, addition of pretreatment dechlorination systems, emergency repairs, and dechlorination system adjustments. Inspections of the sodium sulfite tablet feeders are also conducted to ensure that they are refilled and in good condition and that any fouled tablets are removed for disposal. In addition, as a storm water best management practice, potential residual chlorine/bromine sources or leaks are dechlorinated prior to discharge in the WOC watershed to reduce risk of harm to aquatic life and the environment.

Table 5.12 summarizes 2024 TRO detections greater than 1.2 g/day and any additional investigation actions or repairs.

Table 5.12. Total residual oxidant mitigation summary: emergency repairs, 2024

Outfall	Date	TRO (mg/L)	Flow (gpm)	Load (g/day)	Receiving stream	Downstream water kilometer	Downstream instream monitoring point	Source/notes/actions
210	1/4/2024	0.84	40	183.15	WOC	WCK 4.1	X18	Once-through cooling liquid dechlorination system was inoperable in the first half of 2024 due to pump failure. Dechlorination was facilitated with sodium sulfite tablets until the pump was returned to service.
210	1/29/2024	1.13	25	153.99	WOC	WCK 4.1	X18	
210	2/15/2024	1.96	30	320.52	WOC	WCK 4.1	X18	
210	3/4/2024	1.55	30	253.47	WOC	WCK 4.1	X18	
210	4/18/2024	1.37	12	89.61	WOC	WCK 4.1	X18	
210	6/20/2024	1.28	25	174.43	WOC	WCK 4.1	X18	
211	7/24/2024	0.4	45	98.12	WOC	WCK 4.4	X22	Once-through cooling water is present in this drainage network. Flows are dechlorinated at the end of the pipe with tablets. Source investigations are underway in this drainage network due to the unusual trend in detections.
211	2/22/2024	1.1	50	299.80	WOC	WCK 4.4	X22	
211	4/18/2024	0.37	40	80.67	WOC	WCK 4.4	X22	
211	5/10/2024	1.22	50	332.51	WOC	WCK 4.4	X22	
211	5/23/2024	0.58	50	158.08	WOC	WCK 4.4	X22	
211	6/14/2024	1.5	40	327.06	WOC	WCK 4.4	X22	
211	6/20/2024	0.34	60	111.20	WOC	WCK 4.4	X22	
211	7/15/2024	0.9	40	196.24	WOC	WCK 4.4	X22	
211	7/22/2024	1.19	50	324.33	WOC	WCK 4.4	X22	
211	8/1/2024	1.43	45	350.77	WOC	WCK 4.4	X22	
211	8/26/2024	1.4	45	343.41	WOC	WCK 4.4	X22	
211	9/12/2024	0.98	40	213.68	WOC	WCK 4.4	X22	
211	10/17/2024	1.06	40	231.12	WOC	WCK 4.4	X22	
211	12/5/2024	0.2	30	32.71	WOC	WCK 4.4	X22	
211	12/19/2024	0.89	50	242.57	WOC	WCK 4.4	X22	
227	7/22/2024	1.18	50	321.61	WOC	WCK 4.4	X25	Cooling tower blowdown is discharged at this outfall. Dechlorination boxes were checked and adjusted.
227	10/28/2024	1.51	40	329.34	WOC	WCK 4.4	X25	

Table 5.12. Total residual oxidant mitigation summary: emergency repairs, 2024 (continued)

Outfall	Date	TRO (mg/L)	Flow (gpm)	Load (g/day)	Receiving stream	Downstream water kilometer	Downstream instream monitoring point	Source/notes/actions
231	11/25/2024	1.9	75	776.77	WOC	WCK 4.4	X25	Potassium bisulfite quill was replaced in the 5800X cooling tower dechlorination system.
267	6/14/2024	0.21	20	22.89	FFK	FFK 0.1	X20	Source is under investigation following potable water outages near Building 3144.
267	8/1/2024	0.19	30	31.07	FFK	FFK 0.1	X20	
267	12/5/2024	0.3	8	13.08	FFK	FFK 0.1	X20	
314	7/22/2024	30	0.31	50.69	WOC	WCK 4.4	X26	Dechlorination box was checked and adjusted.
314	12/5/2024	75	0.6	245.29	WOC	WCK 4.4	X26	
363	7/22/2024	45	0.74	181.52	FFK	FFK 0.1	X20	Cooling tower blowdown is discharged at this outfall. In both instances, high storm flows had washed out the backup dechlorination tablets, which were replaced.
363	12/19/2024	10	0.61	33.25	FFK	FFK 0.1	X20	
4510 Box (014)	6/14/2024	1.5	60	490.59	WOC	WCK 4.4	X23	Tablet box was adjusted.
4510 Box (014)	7/22/2024	2.24	50	610.51	WOC	WCK 4.4	X23	A defective foot valve was identified on the dechlorination chemical pump, which was repaired.

Acronyms:
FFK = Fifth Creek kilometer
TRO = total residual oxidant
WCK = White Oak Creek kilometer
WOC = White Oak Creek

5.5.3. Radiological Monitoring

At ORNL, monitoring of liquid effluents and selected instream locations for radioactivity is conducted per DOE Order 458.1. Table 5.13 details the analyses performed on samples collected in 2024 at 2 treatment facility outfalls, 4 instream monitoring locations, and 16 category outfalls (outfalls that are categorized into groups with similar effluent characteristics for the purposes of setting monitoring and reporting requirements in the site NPDES permit). Dry-weather discharges from category outfalls are primarily cooling water, groundwater, and condensate. Low levels of radioactivity can be discharged from category outfalls in areas where groundwater contamination exists and where contaminated groundwater enters category outfall collection systems by direct infiltration and from building sumps, facility sumps, and building footer drains. In 2024, dry-weather grab samples were collected at 11 of the 16 category outfalls targeted for sampling. Five category outfalls were not sampled because no discharge was present during sampling attempts.

The two ORNL treatment facility outfalls that were monitored for radioactivity in 2024 were the STP outfall (Outfall X01) and the PWTC outfall (Outfall X12). The four instream locations that were monitored were the WOC headwaters, X13 on Melton Branch, X14 on WOC, and X15 at White Oak Dam (WOD) (Figure 5.7). At each treatment facility outfall and instream monitoring location, monthly flow-proportional composite samples were collected using dedicated automatic water samplers.

A DCS for each radioisotope is used to evaluate discharges of radioactivity from DOE facilities (DOE 2021). DCSs were developed for evaluating effluent discharges and are not intended to be applied to instream values, but the comparisons can provide a useful frame of reference. Four percent of the DCS is used as a comparison point. The annual average concentration of at least one radionuclide met or exceeded 4 percent of the relevant DCS concentration in dry-weather discharges from Outfalls X01, X12, 085, 207, 302, and 304 (Figure 5.8).

In 2024, dry-weather discharges from Outfalls 304 and 085 had annual mean radioactivity concentrations greater than 100 percent of the DCS for $^{89/90}$Sr. Concentrations at Outfall 304 have historically been affected by pump failures in a groundwater suppression sump near the OREM low-level liquid waste tank WC-9, which is within a CERCLA soil and groundwater contamination area. When pump failures occur, contaminated groundwater in the WC-9 tank area can enter 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. The pipe was subsequently bypassed and taken out of service. Before the leaking pipe was bypassed, the $^{89/90}$Sr concentration at Outfall 304 peaked at 29,000 pCi/L in 2015, exceeding the DCS of 1,700 pCi/L. Since the bypass was implemented, $^{89/90}$Sr levels in the outfall effluent have trended downward. Concentrations of $^{89/90}$Sr rose above the DCS in early 2024 and remained there throughout the year. The reason for the increase is uncertain but is under investigation by UCOR.

Levels 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 water leaked from a pipe in the building's fire suppression system that ruptured when it froze in the early morning hours of February 23, 2015. Leaked water is believed to have mobilized underground contamination to a location where it could enter the building foundation drain. Concentrations began declining in April 2015, and the rate of decline slowed in the latter part of 2016. Concentrations of $^{89/90}$Sr began to increase again in early 2024 and appear to have peaked in October 2024 at 4,400 pCi/L before declining to

3,300 pCi/L in December 2024. The cause of the increasing $^{89/90}$Sr is not known but is under investigation by UCOR.

The total annual discharges (or amounts) of radioactivity measured in stream water at WOD, the final monitoring point on WOC before the stream flow leaves ORNL, were calculated from concentration and flow. Results of those calculations for each of the past 5 years are shown in Figures 5.9 through 5.13. Because discharges of radioactivity are somewhat correlated to stream flow, annual flow volumes measured at the WOD monitoring station are given in Figure 5.14. Discharges of radioactivity at WOD in 2024 were similar to discharges during other recent years, particularly when differences in annual flow volume are considered, and continue to be generally lower than in the years preceding completion of the waste area caps in Melton Valley (substantially complete by 2006).

5.5.4. Mercury in the White Oak Creek Watershed

During the mid-1950s, mercury (Hg) was used for pilot-scale isotope separation work in Buildings 3592, 4501, and 4505 and in spent-fuel reprocessing in Building 3503. By 1963, this work had transferred to Y-12. Buildings 4501 and 4505, located east of Fifth Creek and north of WOC, are still active research facilities. In the 1990s, two settling ponds for process wastewaters from these buildings were removed, and discharges were rerouted to the PWTC for treatment. Figure 5.15 depicts outfalls and associated storm drain connections that are legacy Hg sources.

In 1996, the Building 4501 foundation sump was found to contain legacy Hg because of its volatility and from its use and spills in the 1950s. The foundation sump discharged to storm Outfall 211 (Figure 5.15) on WOC; a smaller foundation sump in the building discharged to Outfall 263 on Fifth Creek. By 2008, the foundation sump had been rerouted to the PWTC, and by 2011, an Hg pretreatment system had been installed on the larger sump. Discharges from the foundation sumps in Buildings 4501 and 4500N and from the smaller sump in Building 4501 had also been rerouted to the PWTC along with the smaller sump and a 4500N foundation sump. Outfall 211 and Outfall 363 storm piping still receives other sources of storm water, cooling water, and steam condensate discharges. Buildings 3592 and 3503 were demolished under the CERCLA remedial process in 2011 and 2012, respectively; their footprints and associated storm water drains remain in the Outfall 207 storm water drainage system. Because of the persistence of legacy elemental Hg, its volatility, and the complexity of its interactions in piping and soil, legacy Hg continues to be monitored and assessed at these storm outfalls. Legacy Hg associated with process infrastructure has also been found in other areas, such as north of the Fifth Street and Central Avenue intersection and in the Outfall 304 drainage area.

Table 5.13. Radiological outfall and instream monitoring conducted at ORNL, 2024

Location	Frequency	Gross alpha/beta	Gamma scan	^{3}H	^{14}C	$^{89/90}Sr$	Isotopic uranium	Isotopic plutonium	^{241}Am	$^{243/244}Cm$	^{99}Tc
Outfall 001	Annually	X									
Outfall 080[a]	Annually										
Outfall 081	Annually	X		X							
Outfall 085	Monthly	X	X			X	X	X			
Outfall 203[a]	Annually										
Outfall 207	Monthly	X	X			X					
Outfall 211	Annually	X	X			X					
Outfall 234[a]	Annually										
Outfall 281	Quarterly	X		X							
Outfall 282	Annually	X									
Outfall 302	Monthly	X	X	X		X	X	X	X	X	
Outfall 304	Monthly	X	X	X		X	X	X	X	X	
Outfall 365	Annually	X									
Outfall 368[a]	Annually										
Outfall 383	Annually	X		X							
Outfall 484[a]	Annually										
WOCHW	Monthly	X	X	X	X	X					
STP (X01)	Monthly	X	X	X	X	X					
PWTC (X12)	Monthly	X	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 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
WOCHW = White Oak Creek headwaters
WOD = White Oak Dam

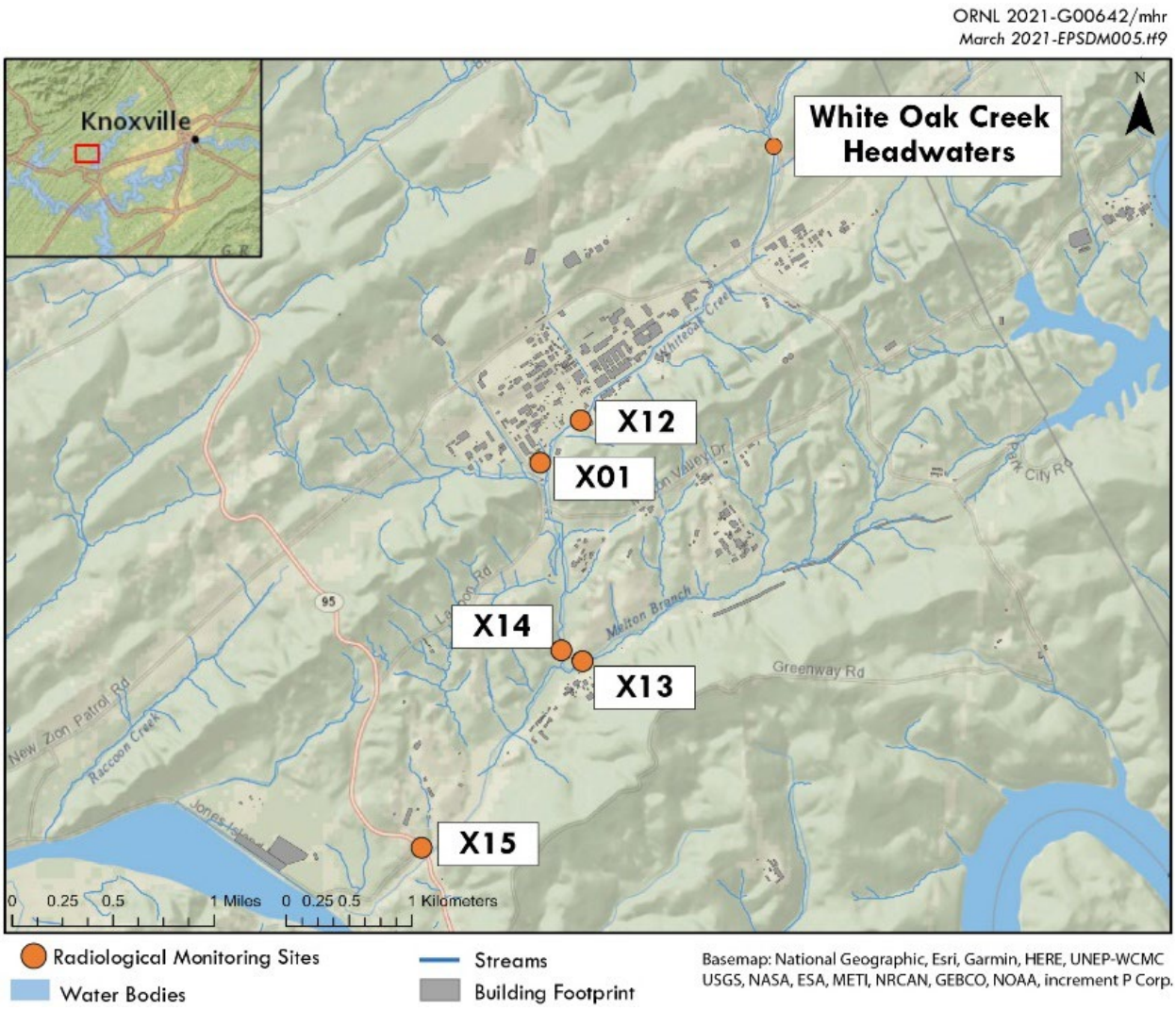


Figure 5.7. Selected surface water, National Pollutant Discharge Elimination System, and reference sampling locations at ORNL

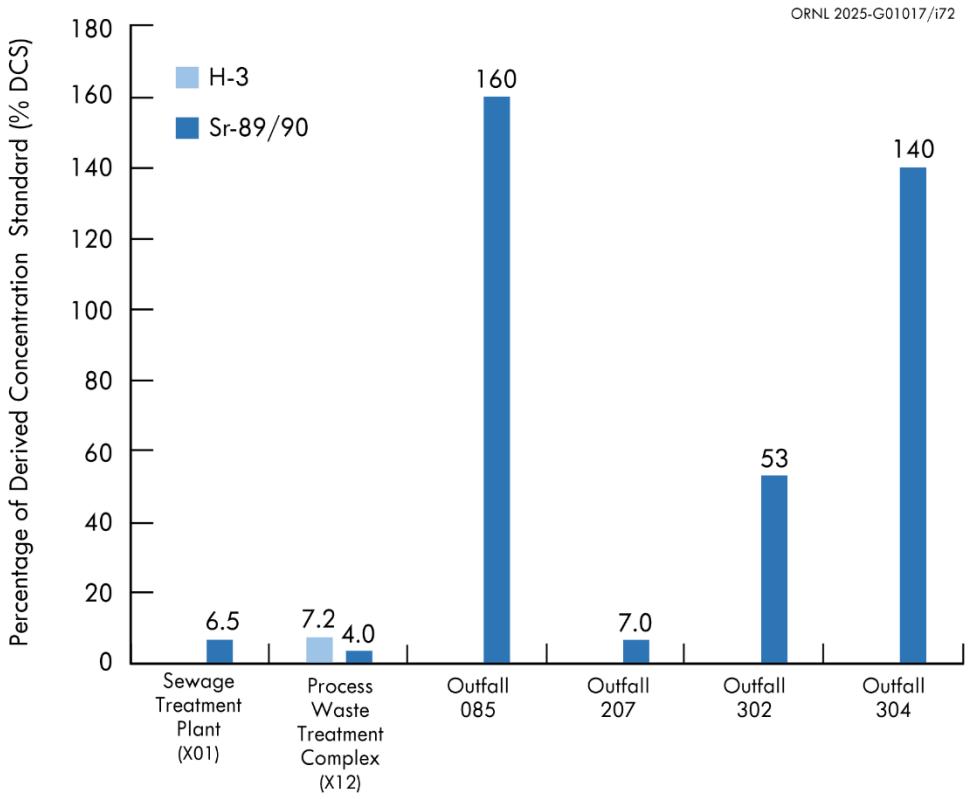


Figure 5.8. Outfalls and instream locations at ORNL with average radionuclide concentrations greater than 4 percent of the relevant derived concentration standards, 2024

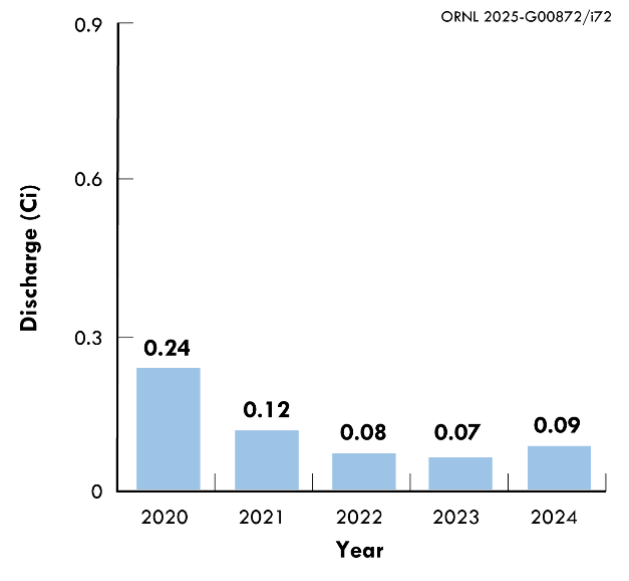


Figure 5.9. Cesium-137 discharges at White Oak Dam, 2020–2024

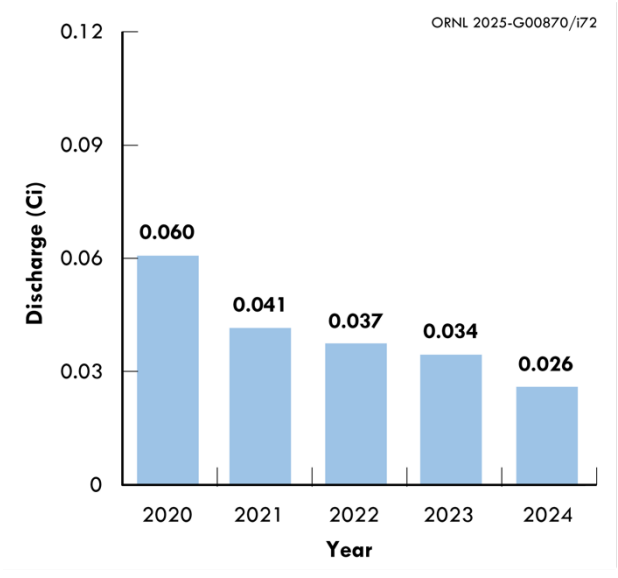


Figure 5.10. Gross alpha discharges at White Oak Dam, 2020–2024

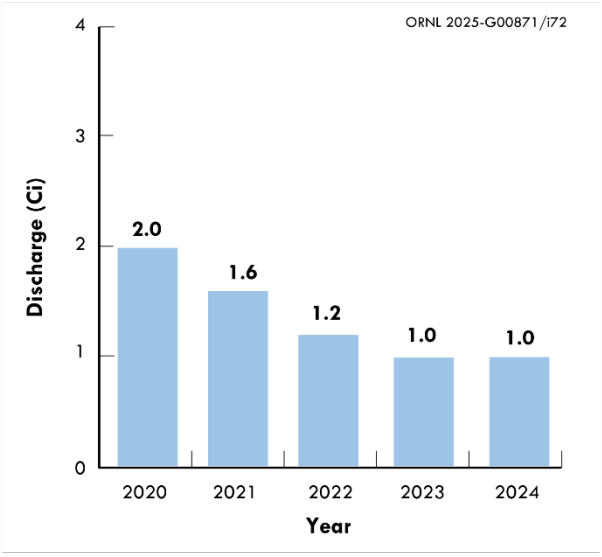


Figure 5.11. Gross beta discharges at White Oak Dam, 2020–2024

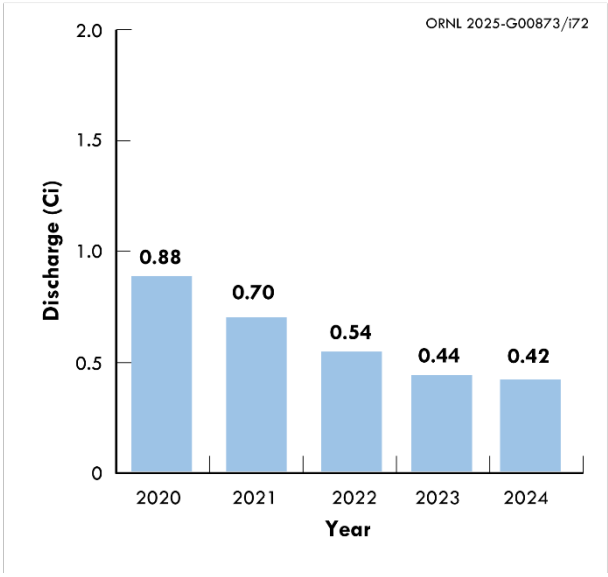


Figure 5.12. Total radioactive strontium discharges at White Oak Dam, 2020–2024

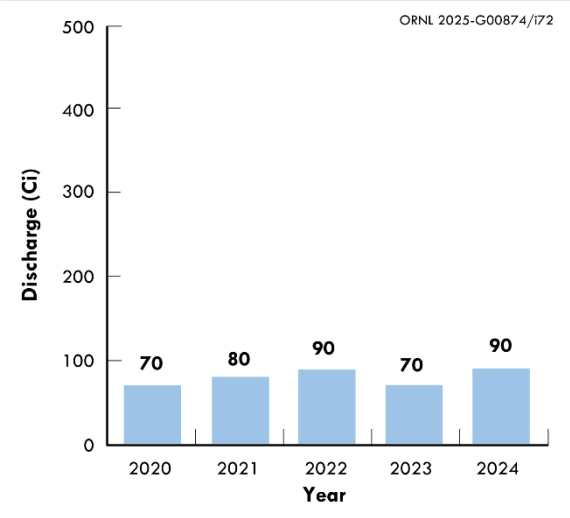


Figure 5.13. Tritium discharges at White Oak Dam, 2020–2024

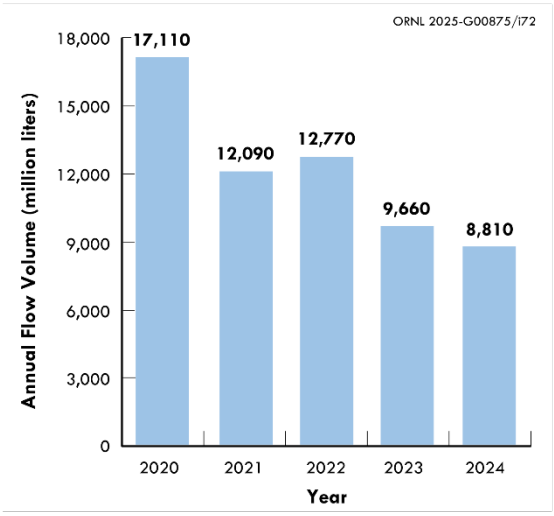


Figure 5.14. Annual flow volume at White Oak Dam 2020–2024

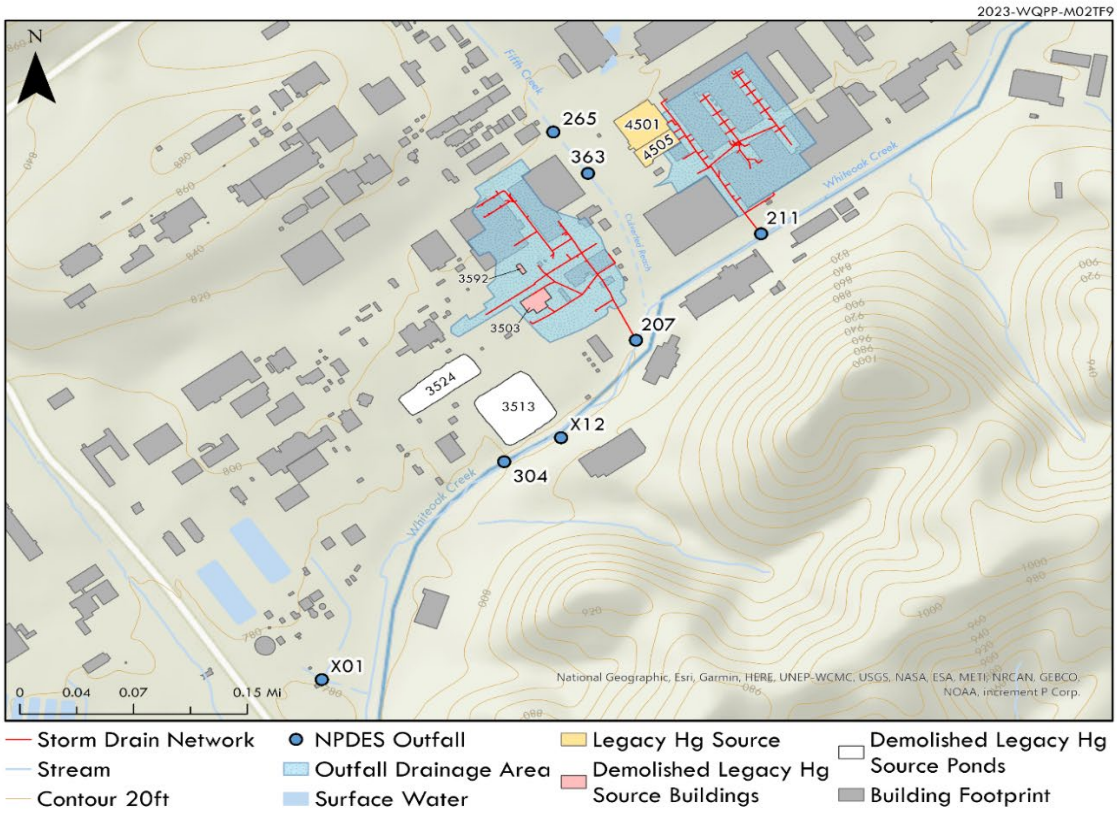


Figure 5.15. Outfalls and associated storm drain connections that are potential mercury sources, 2024

5.5.4.1. Mercury in Ambient Water

Aqueous Hg monitoring in WOC continued in 2024 as part of bioaccumulation studies in the WOC watershed. Quarterly grab sampling was performed at five instream sites: White Oak Creek kilometer (WCK) 1.5, WCK 2.3, WCK 3.4, WCK 4.1, and WCK 6.8 (Figure 5.16). Samples were collected to be representative of seasonal base flow conditions (dry weather, clear flow). Historical sampling results show that Hg concentrations are typically higher under those conditions.

In 2024, the average concentration of Hg in WOC upstream from ORNL (WCK 6.8) was less than 3 ng/L, and the highest value was 3.4 ng/L. Waterborne Hg concentrations in WOC downstream of ORNL (Figure 5.17) were above Tennessee recreational-use water quality criteria (WQCs) from 1997 to 2007 but declined abruptly in 2008 as a result of actions to reduce Hg discharges to WOC at Outfall 211 (sump reroutes to the PWTC) and to reduce Hg discharges from the PWTC. Since 2008, the results from WQPP Hg monitoring have met Tennessee Hg WQCs for recreational use (51 ng/L), with only a few exceptions. Applying recreational-use WQCs to the WOC watershed is very conservative because the watershed is on ORR and is not accessible to the public. Ambient concentrations have remained low since 2008, with a few exceptions. In 2024, Hg concentrations were well below WQCs at all the instream sites that were monitored (Figure 5.17). The average aqueous Hg concentration at WOD (WCK 1.5) was 21.48 ng/L in 2024 compared with 27.45 ng/L in 2023.

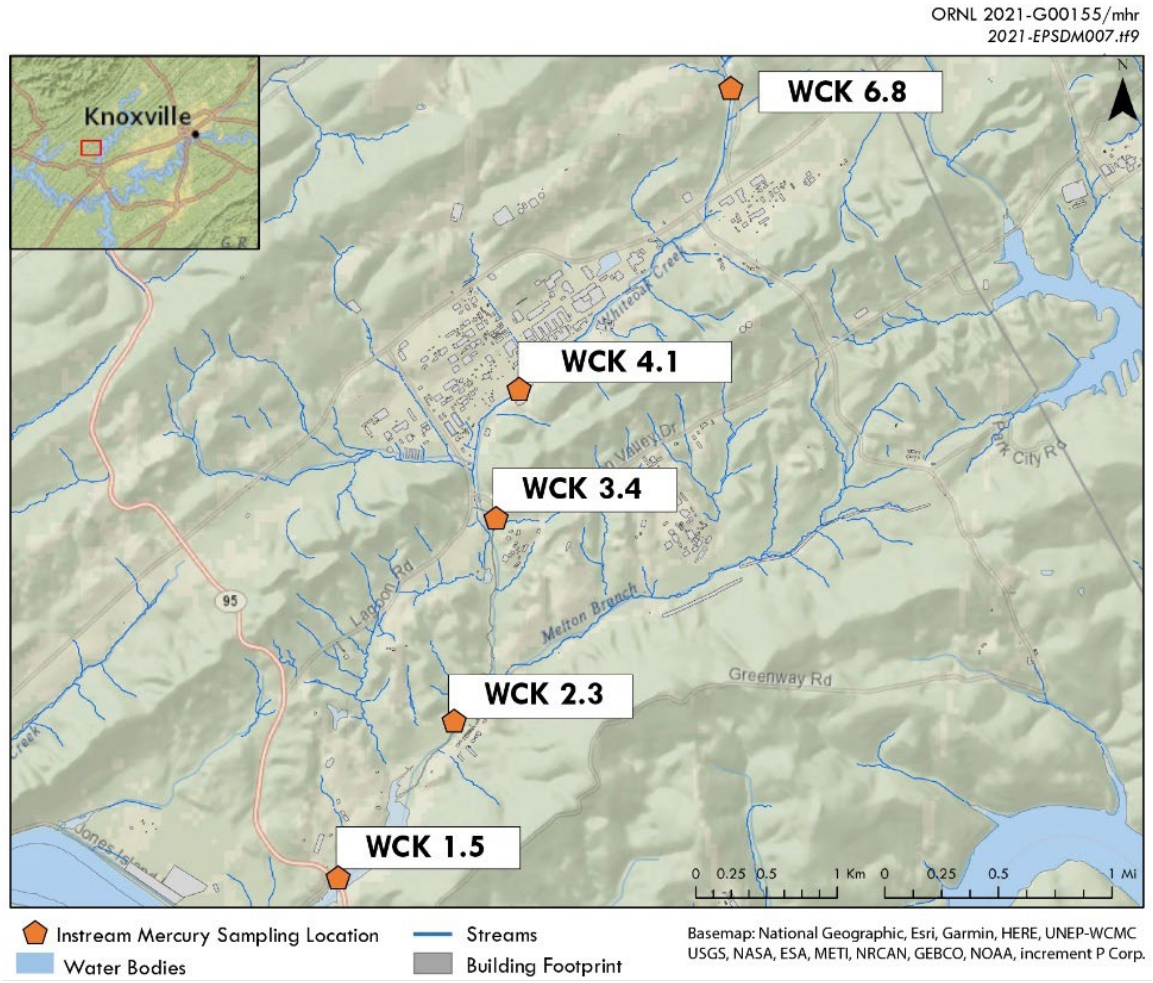
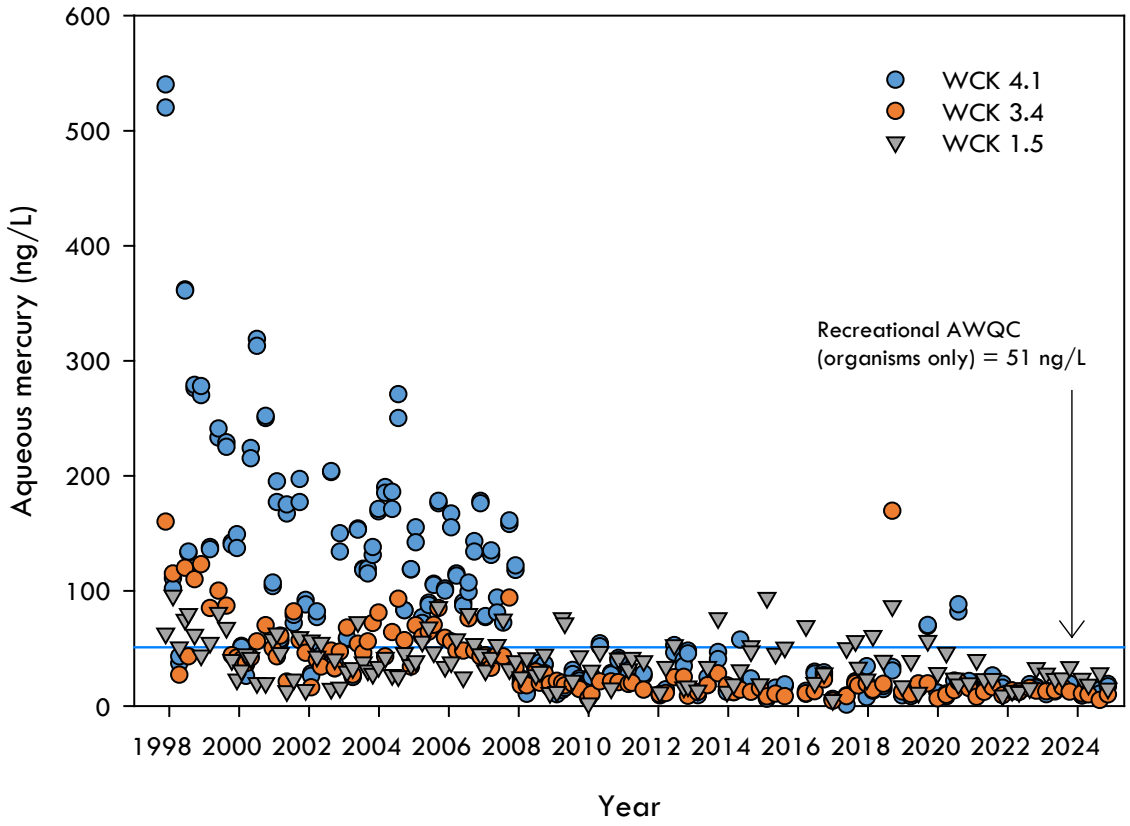


Figure 5.16. Instream mercury monitoring and data locations, 2024



Note: *The blue line at 51 ng/L shows the recreational water quality criterion for organisms.*

Acronyms:

AWQC = ambient water quality criterion *WCK = White Oak Creek kilometer*

Figure 5.17. Aqueous mercury concentrations of grab samples at sites in White Oak Creek downstream from ORNL, 1998–2024

5.5.4.2. Water Quality Protection Plan Mercury Investigation—Treatment Plants

The STP and the PWTC (Outfalls X01 and X12, respectively) are monitored quarterly for Hg, and results are reported to TDEC in monthly discharge monitoring reports required by the NPDES permit. Twenty-four-hour composite samples are taken at both locations, and flow rates are also measured and recorded.

Concentrations of Hg in discharges from the STP (X01) averaged 1.9 ng/L in 2024, and Hg concentrations in discharges from the PWTC (X12) averaged 51.25 ng/L. Trends in total Hg concentrations are shown in Figure 5.18 for the STP (Outfall X01) from 2012 to 2024 and in Figure 5.19 for the PWTC (Outfall X12) from 2009 to 2024.

The 2024 quarterly dry-weather sampling at X01 and X12 was coordinated with Hg sampling at instream locations WCK 4.4 (upstream of the two treatment plant outfalls), WCK 3.4 (7500 Bridge monitoring station downstream of the ORNL central campus and both wastewater treatment plant outfalls), and WCK 1.5 (X15) at WOD. These data are presented in Figure 5.20.

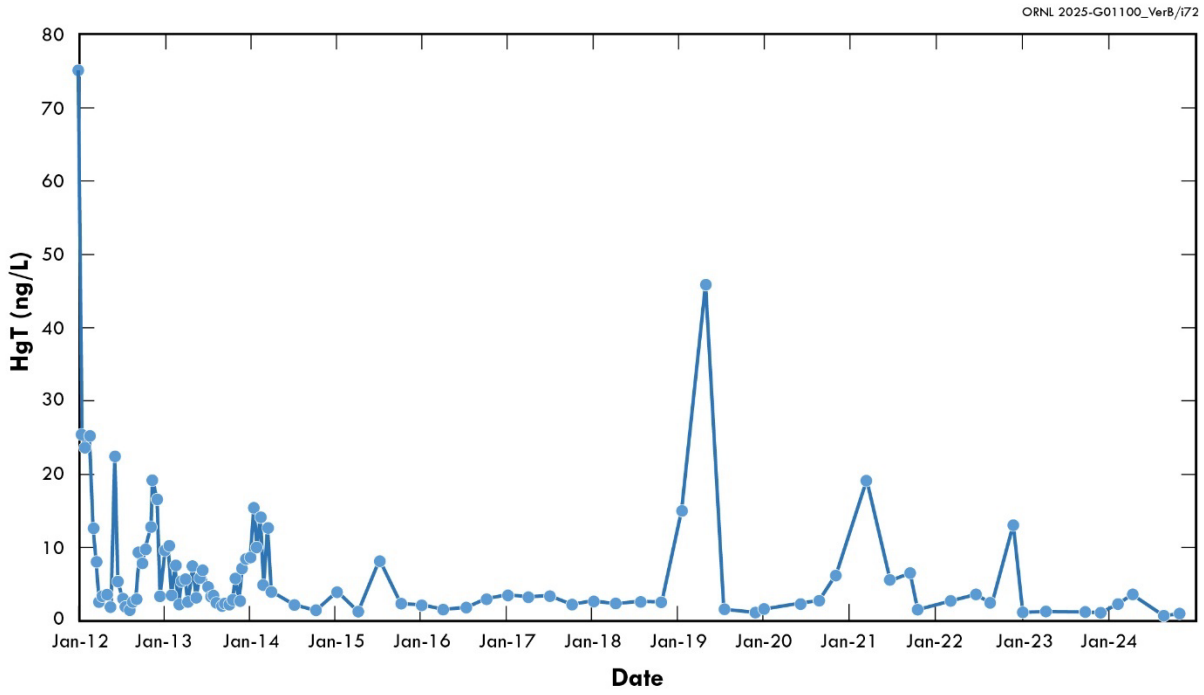


Figure 5.18. Total mercury concentrations in discharges to Outfall X01 from the Sewage Treatment Plant, 2012–2024

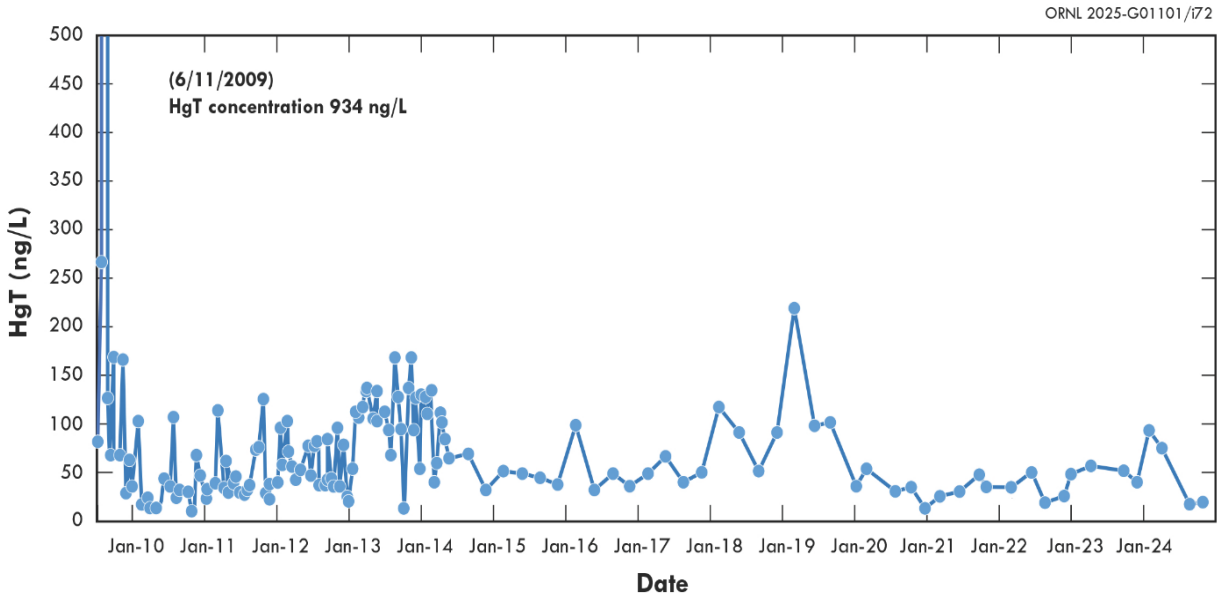
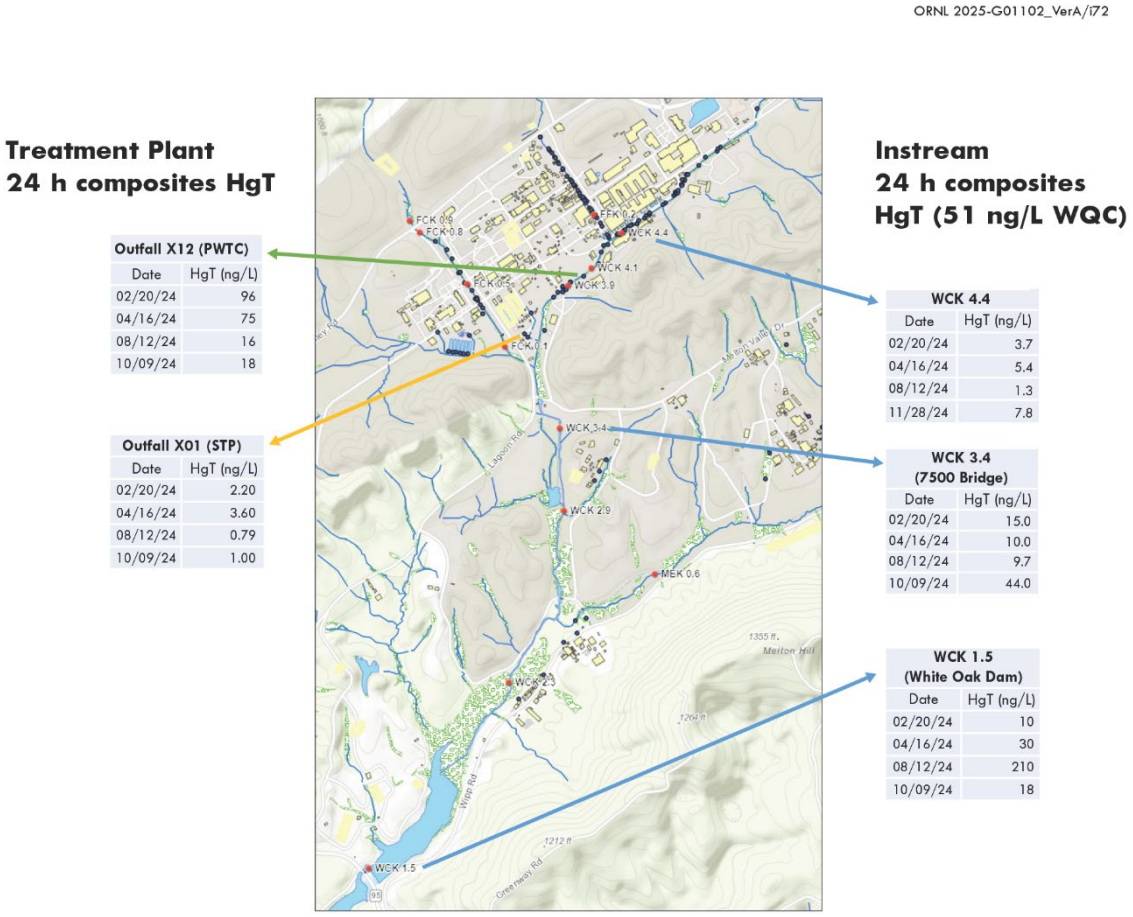


Figure 5.19. Total mercury concentrations in discharges to Outfall X12 from the Process Waste Treatment Complex, 2009–2024



Acronyms:

PWTC = Process Waste Treatment Complex
STP = Sewage Treatment Plant
WCK = White Oak Creek kilometer
WQC = water quality criterion

Figure 5.20. Coordination of treatment plant sampling with instream sampling sites at ORNL, 2024

5.5.4.3. Legacy Outfall Point Source and Non-Point Source Investigation

Legacy Hg outfalls are investigated as part of the WQPP to better delineate Hg sources and to help prioritize future abatement actions. WQPP Hg monitoring includes both point source outfalls and non–point source storm water runoff but focuses mainly on several outfalls in the central part of the main ORNL campus known to be contaminated with legacy Hg.

In 2024, most of the WQPP dry-weather Hg monitoring was conducted along WOC and portions of Fifth Creek at Outfalls 207, 211, 265, 304, and 363 (Figure 5.15). As in past years, 2024 WQPP legacy Hg point source monitoring focused on Outfalls 207 and 211, which historically have had the highest Hg concentrations. In 2024, discharged water volumes, and therefore Hg fluxes, from Outfall 211 were higher than those from Outfall 207. This is consistent with previous volume and flux measurements from these locations. Figures 5.21 and 5.22 show trends in dry-weather Hg sampling from Outfalls 207 and 211, respectively. In 2024, point source Hg investigations and monitoring (if flow was present) were also performed at Outfalls 265, 304, and 363, where Hg has been detected at levels of interest in the past, likely due to the prevalence of Hg used historically in nearby buildings and from other legacy sources in these areas. In 2024, no

dry-weather flow was recorded at Outfall 265, and the average dry-weather Hg concentrations at Outfalls 304 and 363 were low (15.5 and 31.0 ng/L, respectively).

WQPP non–point source Hg monitoring was also undertaken in 2024. Semiannual wet-weather sampling at Outfalls 207, 211, 265, 304, and 363 was completed. Trends in wet-weather unfiltered Hg sampling results at Outfalls 207 and 211 are presented in Figures 5.23 and 5.24, respectively. In 2024, the average wet-weather sampling results were approximately 7.65 ng/L at Outfall 265, 14.0 ng/L at Outfall 304, and 12.0 ng/L at Outfall 363. Dry- and wet-weather Hg fluxes at Outfalls 207 and 211 either declined in 2024 or were comparable to fluxes in previous years (Figures 5.21–5.24).

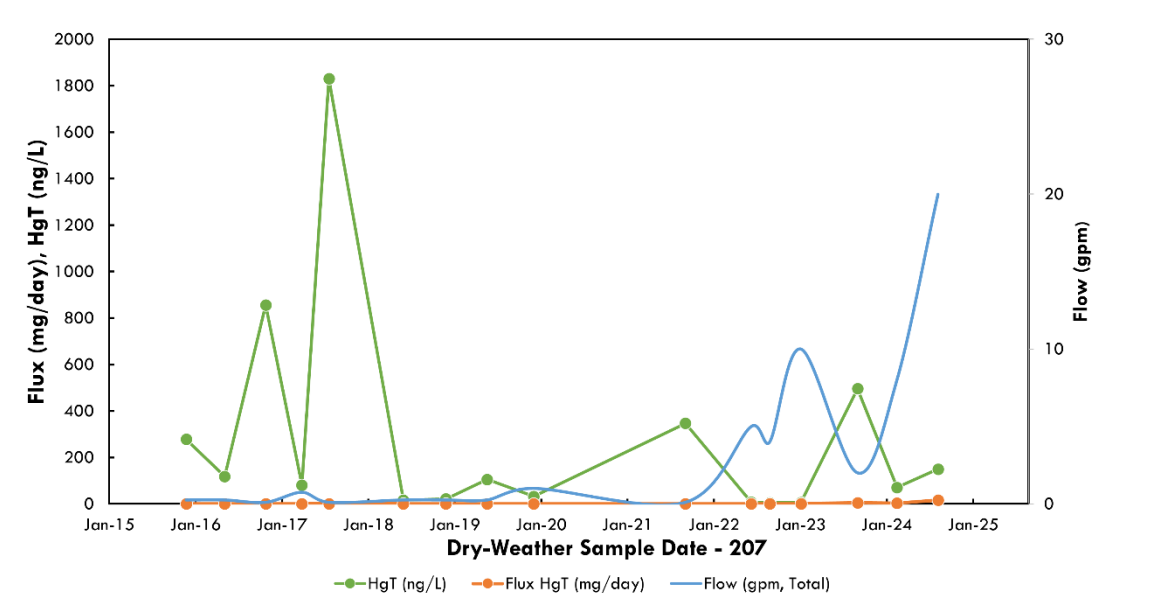


Figure 5.21. Outfall 207 dry-weather flow rate, total mercury concentration (unfiltered), and flux, 2016–2024

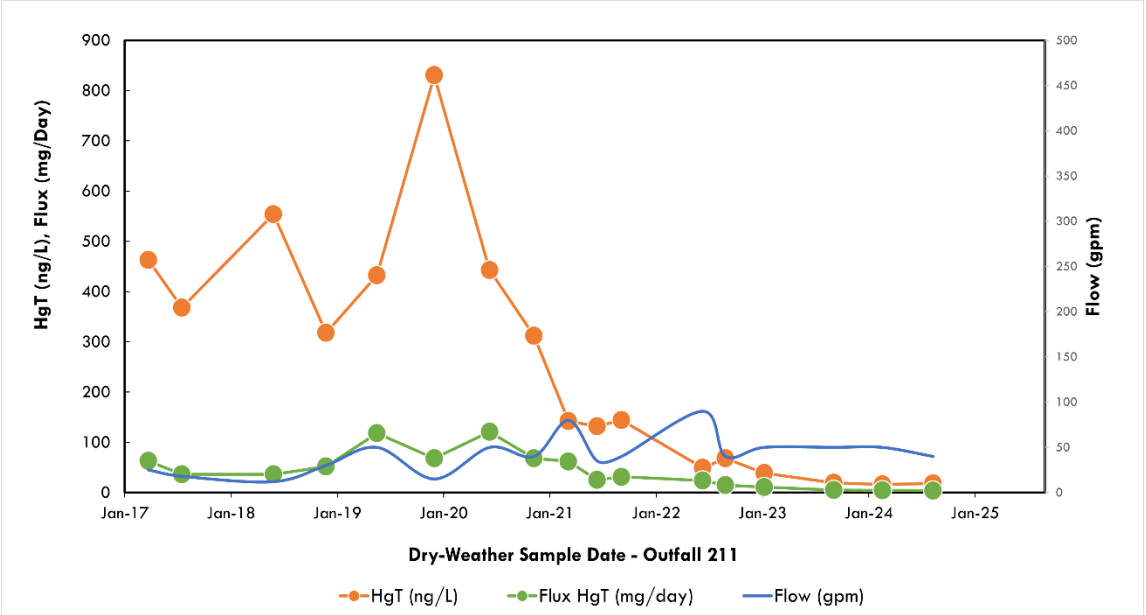


Figure 5.22. Outfall 211 dry-weather flow rate, total mercury concentration (unfiltered), and flux, 2017–2024

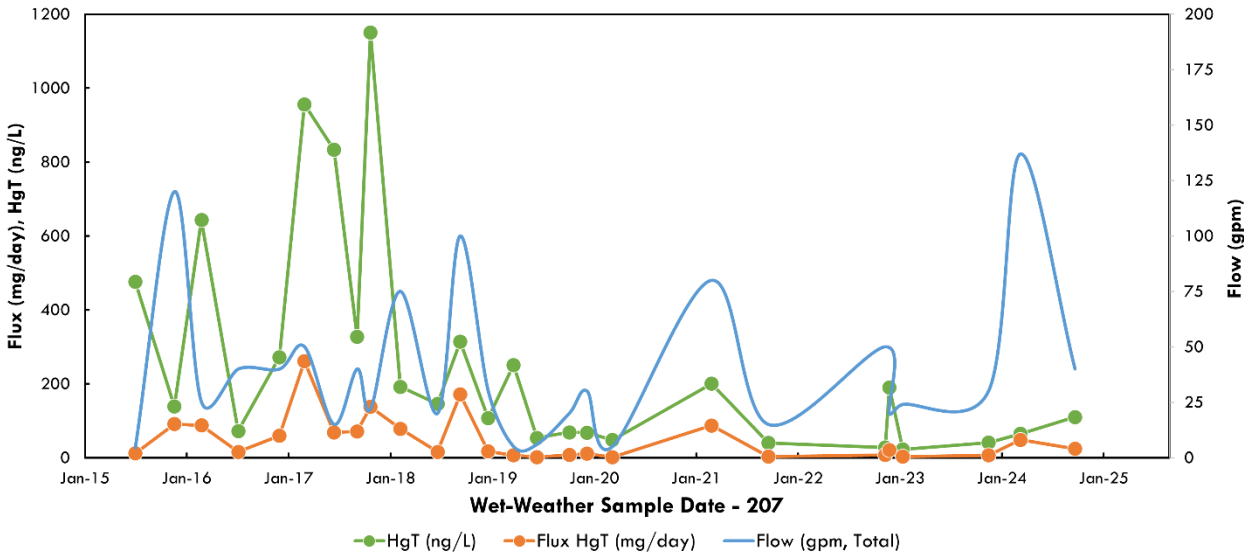


Figure 5.23. Outfall 207 wet-weather flow rate, total mercury concentration (unfiltered), and flux, 2015–2024

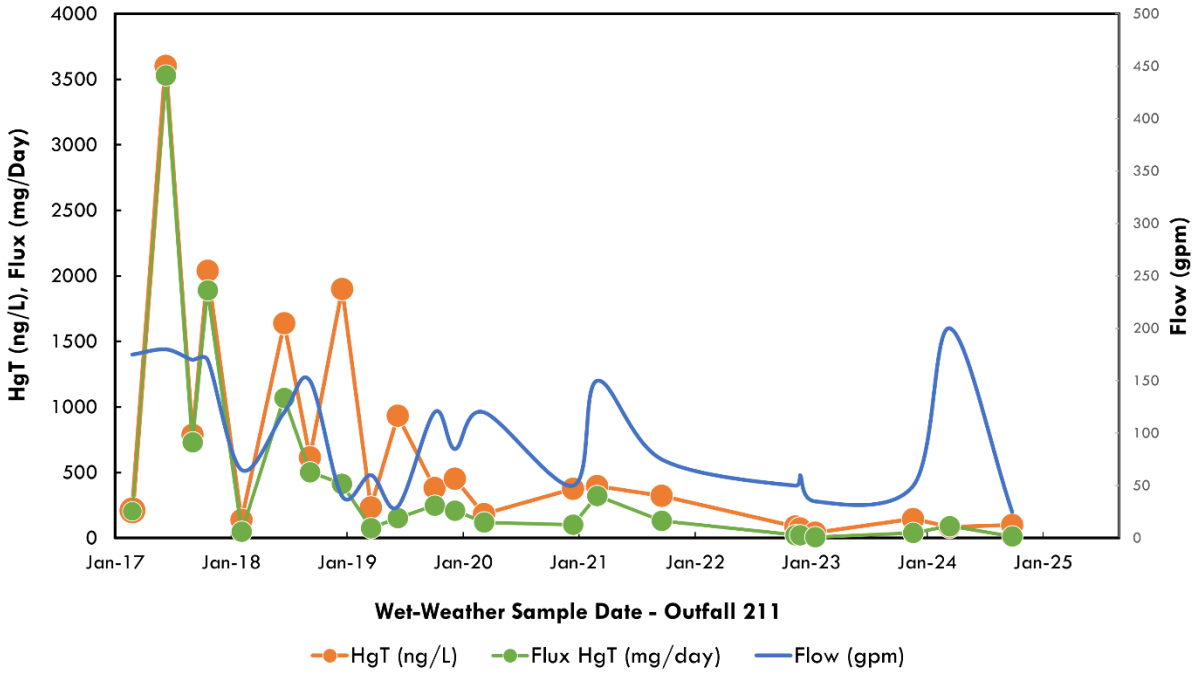


Figure 5.24. Outfall 211 wet-weather flow rate, total mercury concentration (unfiltered), and flux, 2017–2024

5.5.5. Storm Water Surveillances and Construction Activities

Storm water drainage areas at ORNL are inspected semiannually in accordance with WQPP requirements. These areas encompass typical office, industrial, and research settings with surface features such as laboratories, support facilities, paved areas, and grassy lawns. ORNL maintains a robust safety materials management system, ensuring proper tracking, handling, and storage of materials to mitigate potential impacts to storm water. Additionally, ORNL adheres to various regulations governing materials handling, storage, and disposal and waste management, minimizing the risk of environmental release.

ORNL also has a storm water best management practice plan that outlines approved actions and guidance to minimize storm water runoff impacts.

Although outdoor materials are temporarily located throughout the ORNL campus, most movement and storage activities occur in the 7000 area, which is situated on the east end of the site and houses craft and maintenance shops. Smaller outdoor storage areas are dispersed across the site, including loading docks and material delivery areas at laboratory and office buildings. Outdoor materials typically are finished metal items; equipment awaiting use, disposal, or repair; aging infrastructure; and construction equipment and materials, as observed during field inspections. Results of drainage area inspections are documented in electronic map files by the Water Quality Protection group.

Any construction project exceeding 1 acre is required to be permitted under the Tennessee General NPDES Permit for Storm Water Discharges Associated with Construction Activity, necessitating routine inspections by Tennessee-certified erosion and sedimentation control inspectors throughout the project duration. As a best management practice, ORNL mandates routine inspections by Tennessee-certified erosion and sedimentation control inspectors for subcontracted construction projects that are smaller than 1 acre and not covered under the Tennessee General NPDES Permit for Storm Water Discharges Associated with Construction Activity.

Storm water discharges from current ORNL research laboratory operations contain minimal pollutants primarily originating from ongoing site construction, grounds maintenance, and utility operations. Despite ORNL being an active cleanup site with legacy contamination regulated under CERCLA and the Atomic Energy Act for radiological constituents, historical storm water pollutants at ORNL have been limited.

5.5.6. Biological Monitoring

Biological monitoring programs conducted at ORNL in 2024 included bioaccumulation studies in the WOC watershed; benthic macroinvertebrate monitoring in WOC, First Creek, and Fifth Creek; and fish community monitoring in WOC and its major tributaries. The following sections summarize the biological monitoring programs at ORNL and the results for 2024.

5.5.6.1. Bioaccumulation Studies

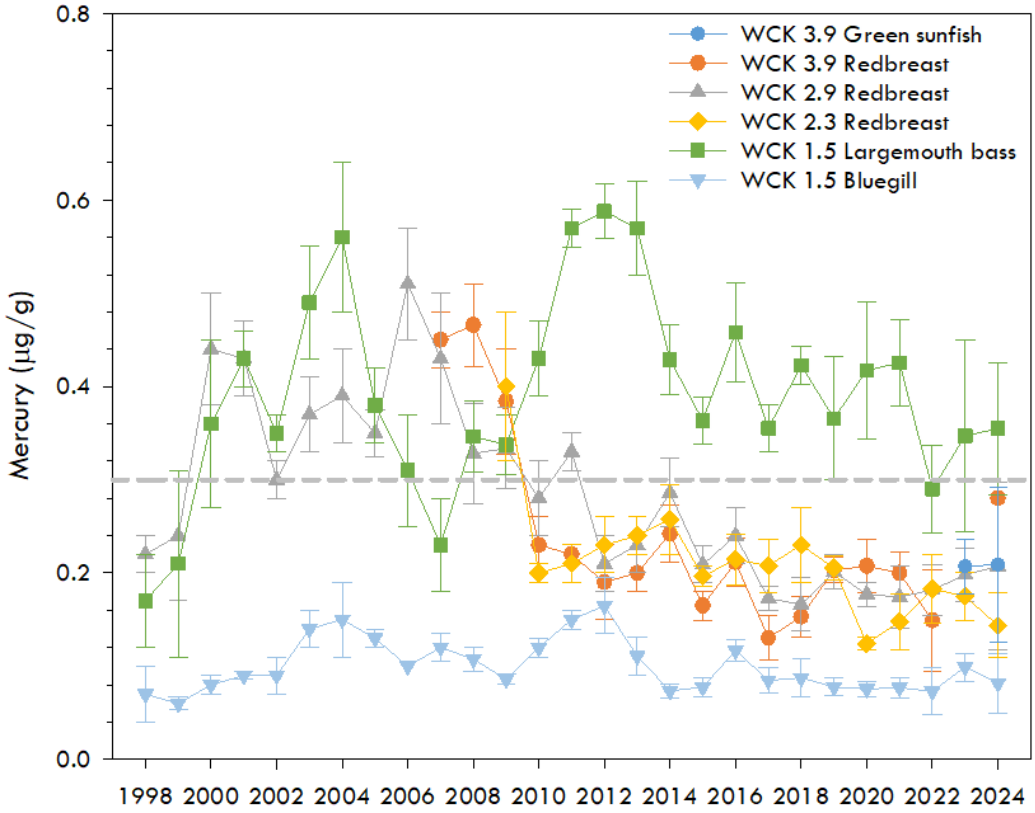
Bioaccumulation tasks for the biological monitoring and abatement plan address two NPDES permit requirements at ORNL: (1) evaluate whether Hg at the site is contributing to streams at a level that will adversely affect fish and other aquatic life or that will violate the recreational criteria and (2)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

Bioaccumulation in fish

Mercury concentrations in fish have been below human health risk thresholds (e.g., EPA-recommended fish-based AWQCs [0.3 µg/g for Hg]) in the stream portions of WOC for a decade due to actions taken in 2007 to treat the water in a Hg-contaminated sump (Figure 5.25). In 2024, Hg concentrations in fish collected throughout WOC remained similar to those seen in 2023. In 2024, Hg concentrations in bluegill and redbreast sunfish samples collected throughout the WOC watershed remained below the AWQC for Hg in fish; Hg concentrations in largemouth bass samples from WCK 1.5 were slightly above this AWQC. Largemouth bass are larger, longer-lived fish at the top of the food web and are therefore expected to have higher Hg concentrations than other sunfish species, but longer-term trends suggest a significant decrease in Hg concentrations over the past decade in this species.

In 2024, PCB concentrations (defined as the sum of Aroclors 1248, 1254, and 1260) in fish collected throughout the WOC watershed remained within historical ranges at all stream sites, averaging below 0.45 µg/g (Figure 5.26).

While these concentrations are above concentrations seen in fish collected from reference sites off ORR, there are no federal guidelines for fish advisories for PCBs. PCB advisories may consider either acute, chronic noncancer, or chronic cancer health risks, which leads to a wide range of difference across states (Cleary et al. 2021). Most recently, the AWQC has been used to calculate the fish tissue concentration triggering impairment and a total maximum daily load; this concentration is 0.02 µg/g in fish fillets (TDEC 2010a,b,c). The average PCB concentrations in fish in WOC (and across ORR) exceed this conservative guideline (Figure 5.26), but recent work has shown that PCB concentrations have generally been declining in WOC sites at rates of up to approximately 1 percent per year through natural attenuation (Matson et al. 2022). Work to mitigate sources of PCBs within ORNL facilities (Section 5.5.7) may increase these attenuation rates.



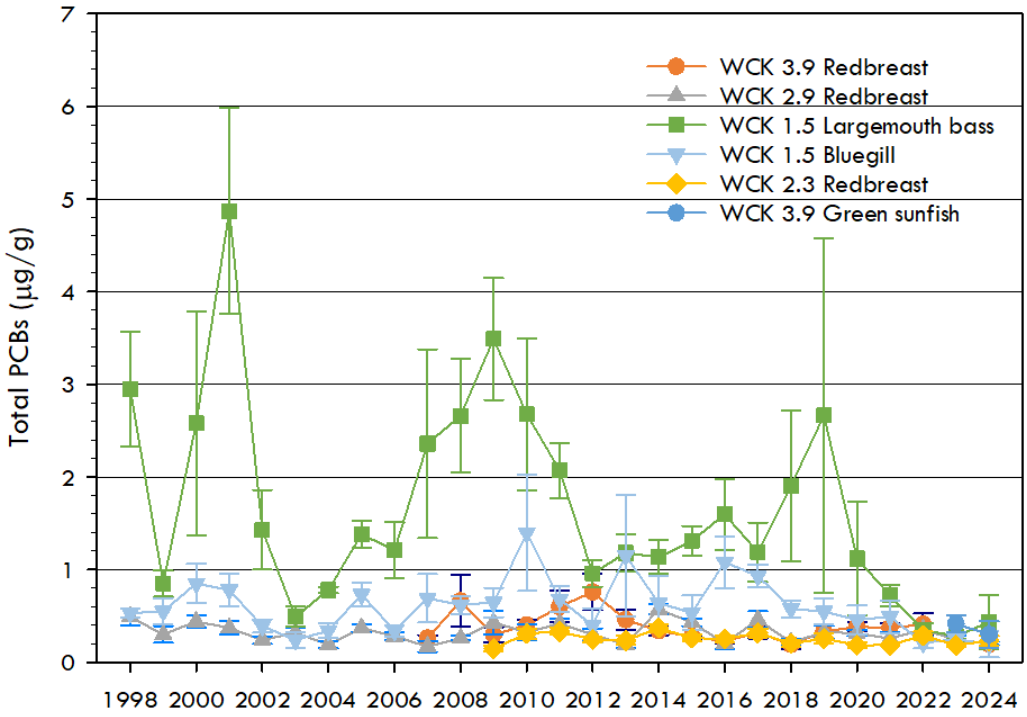
Notes:

1. *Mean concentrations of mercury (± standard error, n = 6) in tissue taken from sampled fish.*
2. *The dashed grey line at 0.3 µg/g indicates the US Environmental Protection Agency ambient water quality criterion for mercury in fish tissue.*

Acronym:

WCK = White Oak Creek kilometer

Figure 5.25. Mean mercury concentrations in muscle tissue of sunfish and bass sampled from the White Oak Creek watershed, 1998–2024



Note: *Mean total PCB concentrations (± standard error, n = 6) found in fish fillets.*

Acronyms:

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

Figure 5.26. Mean total PCB concentrations in fish sampled from the White Oak Creek watershed, 1998–2024

5.5.6.2. Benthic Macroinvertebrate Communities

Monitoring of benthic macroinvertebrate communities in WOC, First Creek, and Fifth Creek continued in 2024. Additionally, monitoring of the macroinvertebrate community in lower Melton Branch (Melton Branch kilometer [MEK] 0.6) continued under the OREM Water Resources Restoration Program (WRRP). Benthic macroinvertebrate samples have been collected annually following TDEC protocols since 2009 and following protocols developed by ORNL staff since 1987. The protocols developed by ORNL staff provide a long-term record (38 years) of spatial and temporal trends in invertebrate communities from which the effectiveness of pollution abatement and remedial actions taken at ORNL can be evaluated. The ORNL protocols also provide quantitative results that can be used to statistically evaluate changes in trends relative to historical conditions. The TDEC protocols provide a qualitative estimate of the condition of a macroinvertebrate community relative to a state-defined reference condition.

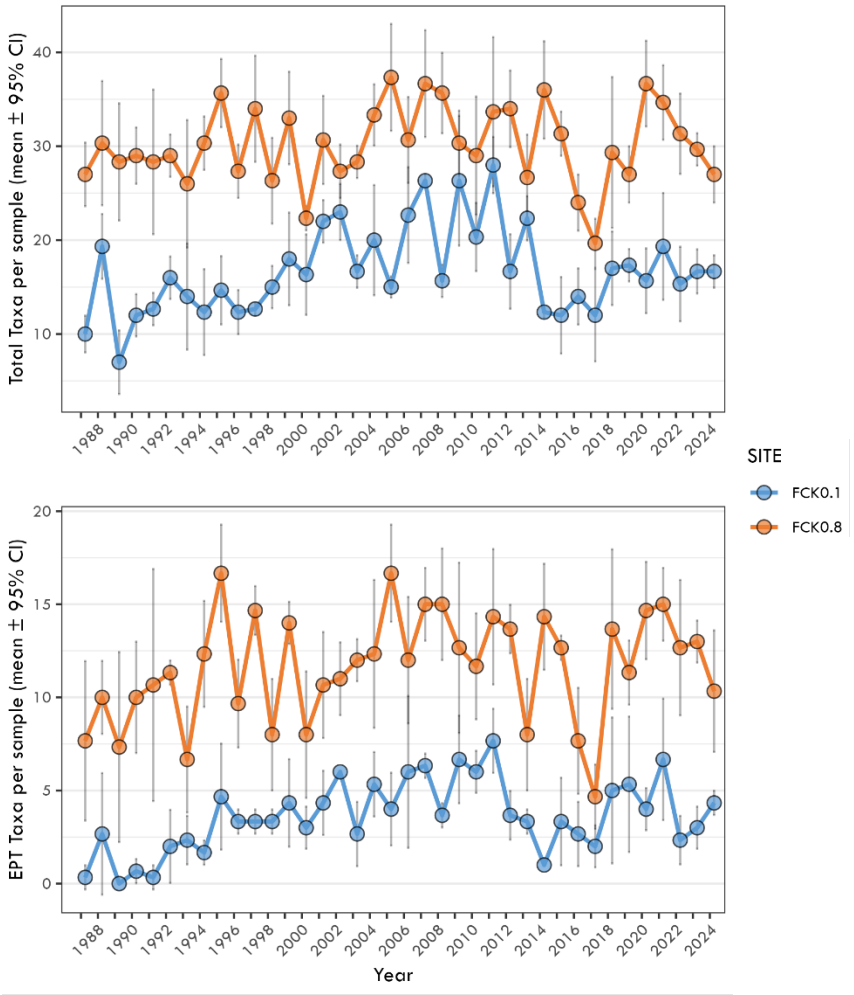
General trends in the results obtained using ORNL protocols indicate significant recovery in benthic macroinvertebrate communities since 1987, but community characteristics suggest that ecological impairment remains (Figures 5.27, 5.28, and 5.29). In 2024, total taxonomic richness (i.e., the number of different species per sample) and richness of the pollution-intolerant taxa (i.e., the number of different mayfly, stonefly, and caddisfly species per sample, or Ephemeroptera, Plecoptera, and Trichoptera [EPT] taxa richness) continued to be lower at downstream sites relative to respective upstream reference sites.

In lower First Creek (First Creek kilometer [FCK] 0.1), total taxa richness increased gradually in the 1990s and 2000s but was then lower for

4 years beginning in 2014 (Figure 5.27). Total taxa richness then increased at FCK 0.1 from 2018 to 2024, reaching values not observed prior to 2014. Similarly, the number of pollution-intolerant EPT taxa decreased in 2012, and in 2014, EPT taxa richness was the lowest it had been since the early 1990s (Figure 5.27). After 2021, when values were the highest they had been in the past 10 years, EPT taxa richness values fell sharply in 2022 but improved in 2023 and 2024. In upper First Creek (FCK 0.8), which serves as a reference for FCK 0.1, total taxa richness and EPT taxa richness declined for 3 consecutive years, from 2015 to 2017, and then increased until they peaked in 2020. Since 2020, total taxa richness and EPT taxa richness at FCK 0.8 have both sharply declined but remain similar to the long-term average (Figure 5.27). Low EPT taxa richness values observed over a 6-year period (2012 to 2017) at FCK 0.1 were mirrored only in some years at FCK 0.8 (i.e., EPT taxa richness was low at both sites in 2013, 2016, and 2017). This suggests that while climate or hydrological change may have influenced conditions within the entire stream (both FCK 0.1 and FCK 0.8), a more localized change may have also occurred in lower First Creek. If a change has occurred, it is not known whether it is related to a change in chemical conditions (e.g., change in water quality or the possible presence of a toxicant), physical conditions (e.g., unstable substrate, increased frequency of high-discharge events), or natural variation. The increase in EPT taxa richness and the stability in total taxa richness at FCK 0.1 in 2024 suggest conditions may be improving, though further monitoring is necessary to determine whether the previously mentioned decline was due to an acute or a longer-term impact to the system.

Total taxa richness at Fifth Creek kilometer (FFK) 0.2 increased in the late 1980s and early 1990s and then was fairly consistent until decreasing significantly between 2007 and 2008 (Figure 5.28), suggesting that conditions changed at the site during that time. Total taxa richness returned to predecline levels over a period of about 5 years, decreased again from 2019 to 2021, and then improved from 2022 to 2024 (Figure 5.28). EPT taxa richness at FFK 0.2 increased slowly from the late 1980s to early 2000s before decreasing for several years (~2003–2011). From 2011 to 2018, EPT taxa richness remained steady at about five EPT taxa per sample but decreased in 2019 and remained low in 2020 and 2021 before increasing in 2022 and 2023. In 2024, EPT taxa richness remained relatively high at this site, similar to levels seen from 2012 to 2018. It is not known whether this represents an upper bound for EPT richness or instead reflects interannual variation in invertebrate community composition. Total and EPT richness values at FFK 1.0 (which serves as a reference for FFK 0.2) have remained higher than at FFK 0.2 since sampling began in 1987 despite exhibiting varying levels of interannual variability from 1987 to 2024.

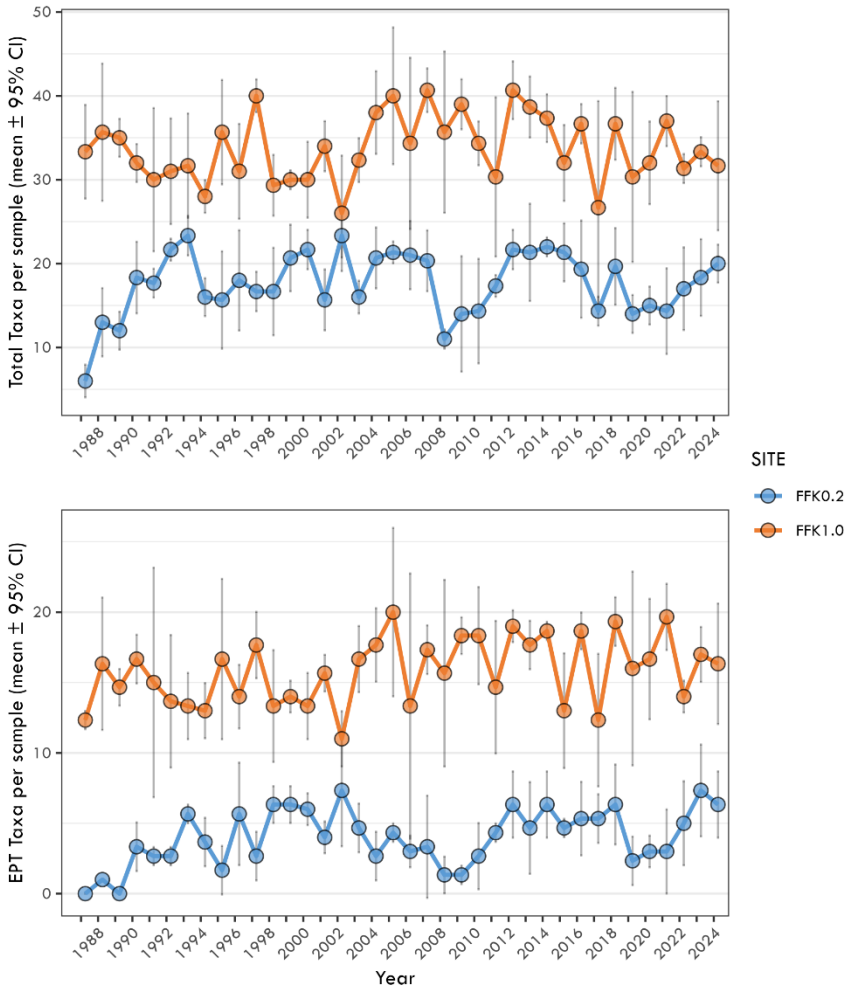
Invertebrate metric values for WCK 2.3 and WCK 3.9 remained within the ranges of values found since the late 1990s and early 2000s, although total taxa richness and EPT taxa richness decreased during the mid-2010s and early 2020s. The EPT taxa richness at WCK 2.3 and WCK 3.9 continued to be notably lower than at the reference site, WCK 6.8. In 2024, total and EPT taxa richness at WCK 3.9 increased for the first time since the large decline that began in 2015. The cause of the initial decline in 2015 and what has prevented recovery are unknown, though changes in the chemical and physical conditions at WCK 3.9 may be contributing to these observed patterns. Since 2001 (except for one sampling event in 1987), Walker Branch kilometer (WBK) 1.0 has served as an additional reference site for WOC main-stem sites downstream of Bethel Valley Road (Figure 5.29). Comparisons of WCK 6.8 with WBK 1.0 show that communities in WCK 6.8 represent ideal reference conditions, though significant declines in both total and EPT taxa richness were observed at WBK 1.0 in 2024, similar to the lowest values previously recorded in 2017, and richness values for WCK 6.8 declined but still remained near their long-term averages.



Note: *Taxonomic richness (number of taxa per sample), 1987–2024. FCK 0.8 serves as a reference site.*
Top: Total taxonomic richness.
Bottom: Taxonomic richness of the pollution-intolerant taxa Ephemeroptera, Plecoptera, and Trichoptera (EPT).

Acronyms:
CI = confidence interval
FCK = First Creek kilometer

Figure 5.27. Benthic macroinvertebrate communities in First Creek, 1987–2024



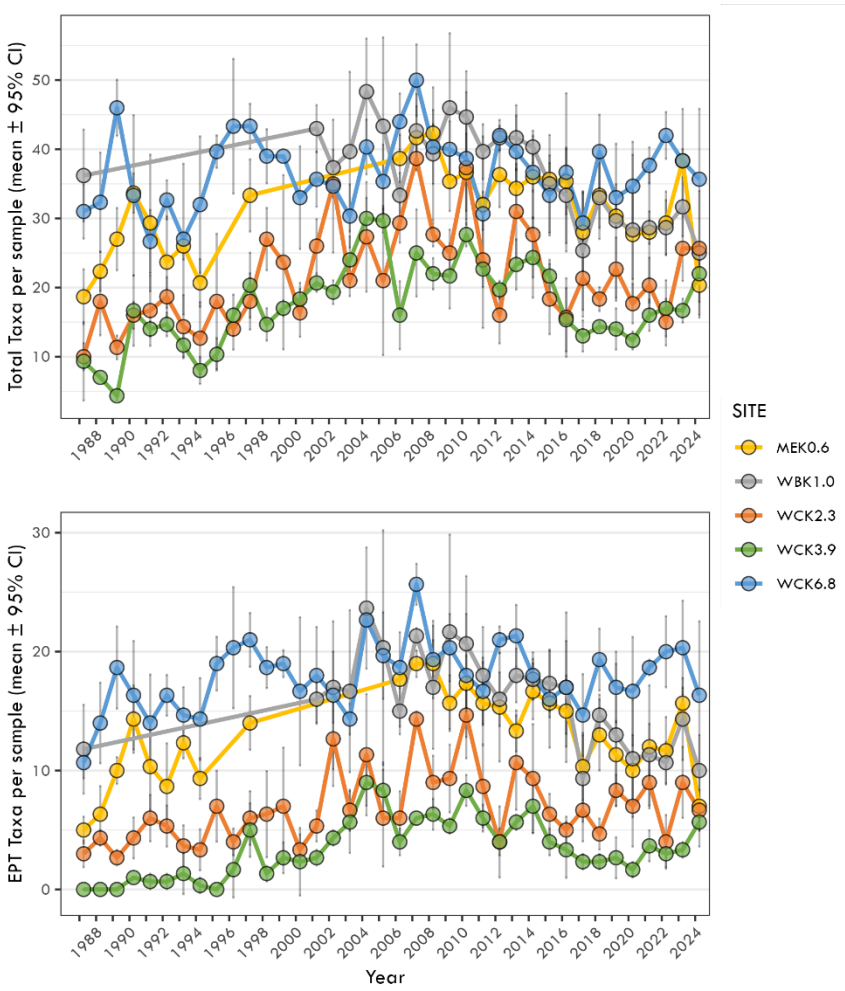
Note: *Taxonomic richness (number of taxa per sample), 1987–2024. FFK 1.0 serves as a reference site.*
Top: Total taxonomic richness.
Bottom: Taxonomic richness of the pollution-intolerant taxa Ephemeroptera, Plecoptera, and Trichoptera (EPT).

Acronyms:

CI = confidence interval

FFK = Fifth Creek kilometer

Figure 5.28. Benthic macroinvertebrate communities in Fifth Creek, 1987–2024



Note: *Taxonomic richness (number of taxa per sample), 1987–2024. WCK 6.8 and WBK 1.0 serve as reference sites.*
Top: Total taxonomic richness.
Bottom: Taxonomic richness of the pollution-intolerant taxa Ephemeroptera, Plecoptera, and Trichoptera (EPT).

Acronyms:

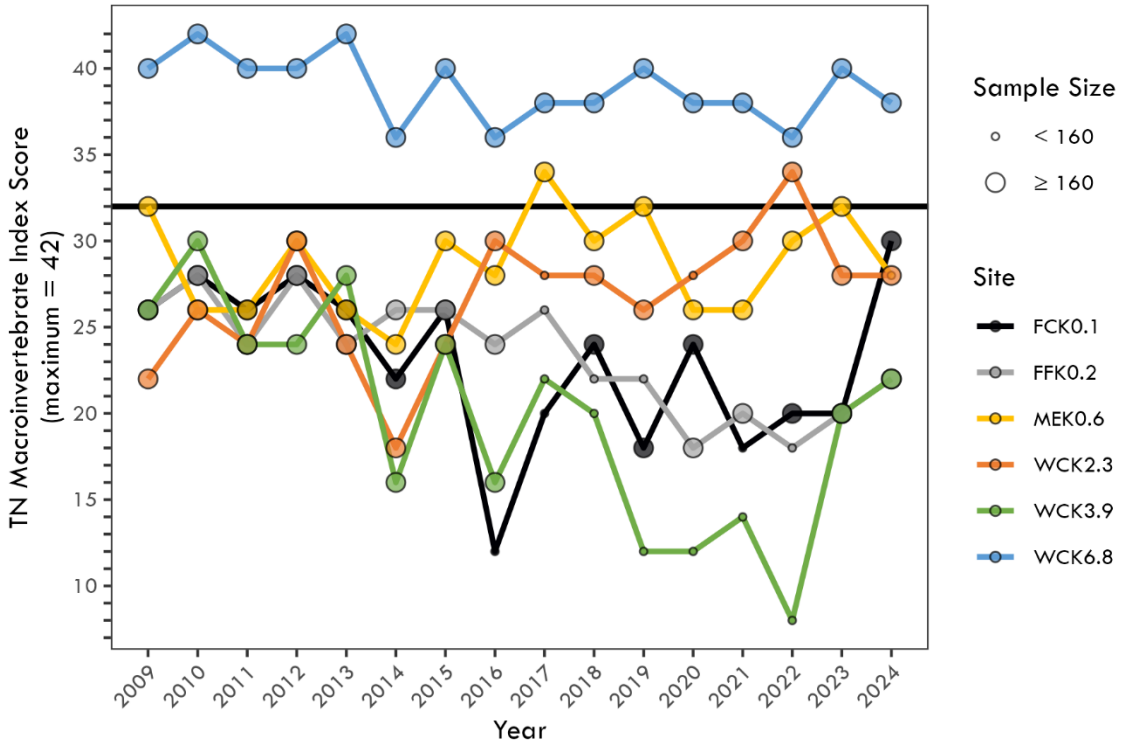
CI = confidence interval
MEK = Melton Branch kilometer
WBK = Walker Branch kilometer
WCK = White Oak Creek kilometer

Figure 5.29. Benthic macroinvertebrate communities in Walker Branch, Melton Branch, and White Oak Creek, 1987–2024

Macroinvertebrate metrics for Melton Branch (MEK 0.6) suggested that total taxa richness and EPT taxa richness were similar to those in reference sites from 2006 through 2023, but significant declines in both metrics similar to declines at WBK 1.0 were observed in 2024 (Figure 5.29). However, other invertebrate community metrics at MEK 0.6, such as the density of pollution-intolerant and pollution-tolerant species (not shown), continued to fluctuate annually between comparable values and values below those of the reference sites. For the past 9 years (2016–2024), EPT density has generally been lower in MEK 0.6 than in WCK 6.8 and WBK 1.0, whereas the density of pollution-tolerant species (oligochaetes and chironomids [worms and nonbiting midges]) has been higher in MEK 0.6 than in those two reference sites.

Based on TDEC protocols (TDEC 2021b), scores for the TDEC Tennessee Macroinvertebrate Index (TMI) in 2024 rated the invertebrate community at the reference site, WCK 6.8, as passing biocriteria guidelines, while scores from FCK 0.1, FFK 0.2, WCK 3.9, and MEK 0.6 were below these guidelines. However, the score for MEK 0.6 should be interpreted with caution given the small (<160 individuals) sample size (Figure 5.30, Table 5.14). Scores improved at three sites (WCK 3.9, FFK 0.2, and FCK 0.1), remained the same at one site (WCK 2.3), and declined at one site (MEK 0.6).

Low TMI scores in FFK 0.2, WCK 2.3, and WCK 3.9 were primarily due to low values for EPT percentage and EPT taxa richness (Table 5.14). However, all these sites had low percentages of oligochaetes and chironomids and thus received high scores for this category. The improvement at FCK 0.1 was primarily due to an increased percent abundance of taxa that build fixed retreats or otherwise attach to substrate surfaces in flowing water and increased total and EPT richness (Table 5.14). WCK 6.8 received the highest attainable scores for all categories except for total and EPT taxa richness (Table 5.14).



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

Acronyms:

FCK = First Creek kilometer
FFK = Fifth Creek kilometer
MEK = Melton Branch kilometer
WCK = White Oak Creek kilometer

Figure 5.30. Temporal trends in Tennessee Department of Environment and Conservation Tennessee Macroinvertebrate Index scores for White Oak Creek watershed streams, August sampling, 2009–2024

Table 5.14. Tennessee Macroinvertebrate Index metric values, metric scores, and index scores for White Oak Creek, First Creek, Fifth Creek, and Melton Branch streams, August 27, 2024[a,b]

Site	Metric values							Metric scores							TMI[c]
	Taxa rich	EPT rich	EPT (%)	OC (%)	NCBI	Cling (%)	TN Nuttol (%)	Taxa rich	EPT rich	EPT (%)	OC (%)	NCBI	Cling (%)	TN Nuttol (%)	
WCK 2.3	29	6	17.9	39.8	4.7	41.3	50.5	6	2	2	4	6	4	4	28
WCK 3.9	17	3	56.9	5.3	5	10.5	29.2	2	0	6	6	4	0	4	22
WCK 6.8	28	10	60.3	2.9	2.5	82.4	9.3	4	4	6	6	6	6	6	38 [pass]
FCK 0.1	21	6	5.3	5.8	3.9	68.1	17.4	4	2	0	6	6	6	6	30
FFK 0.2	12	6	24.8	5.4	5	33.8	44.1	2	2	2	6	4	2	4	22
MEK 0.6	25	9	23.1	5.1	4.8	50.4	29.9	4	4	2	6	4	4	4	28

[a] *TMI metric calculations and scoring and index calculations are based on TDEC protocols for Ecoregion 67f (TDEC 2021b).*

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

[c] *TMI is the total index score. Higher index scores indicate higher quality conditions. A score of ≥32 is considered to pass biocriteria guidelines.*

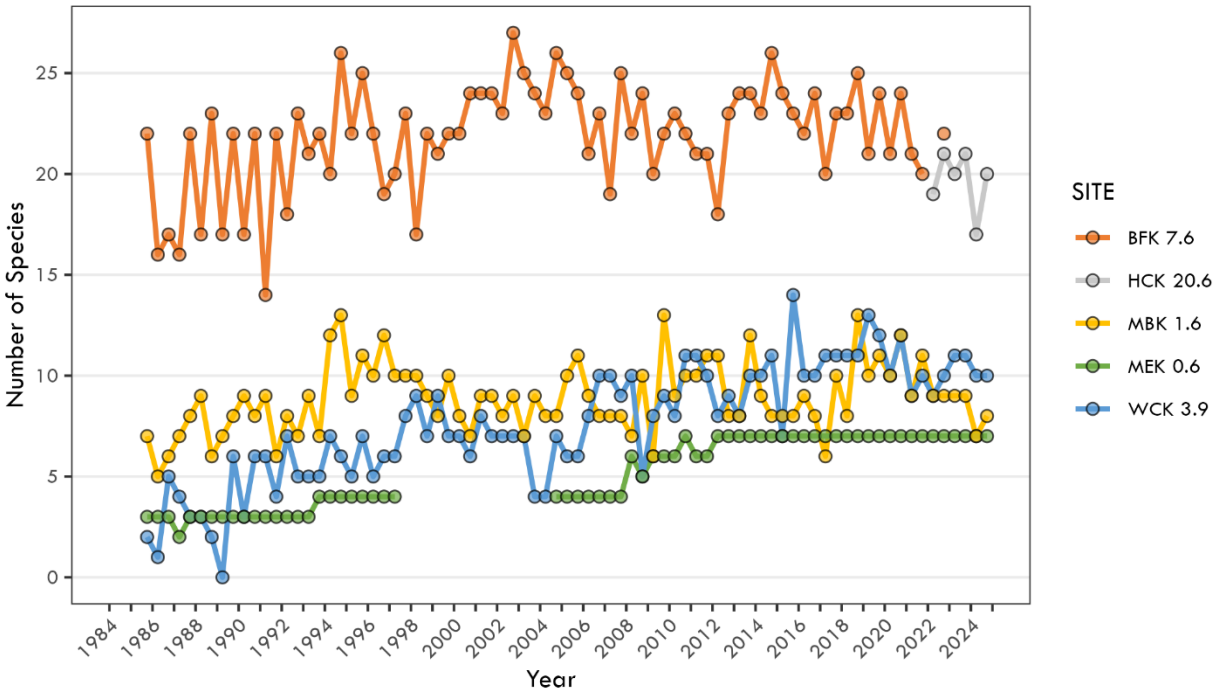
Acronyms:

EPT = Ephemeroptera, Plecoptera, and Trichoptera
FCK = First Creek kilometer
FFK = Fifth Creek kilometer
MEK = Melton Branch kilometer
TDEC = Tennessee Department of Environment and Conservation
TMI = Tennessee Macroinvertebrate Index
WCK = White Oak Creek kilometer

5.5.6.3. Fish Communities

Monitoring of the fish communities in WOC and its major tributaries continued in 2024. 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 Hinds Creek) were also sampled as reference sites for comparison.

In the WOC watershed, the fish community continued to be slightly degraded in 2024 compared with communities in reference streams. Sites closest to outfalls within the ORNL campus had lower species richness (number of species) (Figure 5.31) and fewer pollution-sensitive species than a slightly larger reference site and more closely resembled values found in a smaller reference reach. WOC sites also had more pollution-tolerant species and elevated densities (number of fish per square meter) of pollution-tolerant species compared with reference streams. Seasonal fluctuations in diversity and density are expected and may explain some of the variability seen at these sites. However, the combination of these factors indicates degraded water quality and/or habitat conditions. Overall, the fish communities in tributary sites adjacent to and downstream of ORNL outfalls continued to be negatively affected in 2024 relative to reference streams and upstream sites. These impacts may be related to effluent from outfalls, poor or altered habitat conditions, or barriers to fish passage within the watershed.



Note: *BFK 7.6 was not surveyed after 2023 because of lack of access to the site and was replaced with HCK 20.6.*

Acronyms:

BFK = Brushy Fork kilometer
HCK = Hinds Creek kilometer
MBK = Mill Branch kilometer
MEK = Melton Branch kilometer
WCK = White Oak Creek kilometer

Figure 5.31. Fish species richness (number of species) in upper White Oak Creek and lower Melton Branch compared with reference streams (Brushy Fork, Hinds Creek, and Mill Branch), 1985–2024

A project to introduce fish species that were not found in the WOC watershed but that exist in similar systems on ORR and that may have historically existed in WOC was initiated in 2008 with the stocking of seven such native species. Continuing reproduction has been noted for six of the species, and several species have expanded their ranges downstream and upstream from initial introduction sites to establish new reproducing populations. In general, introduced species have had more difficulty establishing populations at upstream sites in both WOC and Melton Branch. This is likely due to numerous structures located within the watershed that act as barriers to upstream fish migration. In response, introductions to supplement the small populations of those fish species were continued at sites within the watershed until 2019.

Several exceptions to the apparent difficulty of expansion have been observed, including the striped shiner (*Luxilus chrysocephalus*), which has expanded into upper Melton Branch, upper WOC, and lower First Creek, although established populations have not been observed in all those locations. The introductions have enhanced species richness at almost all sample locations within the watershed. This may indicate the capacity of this watershed to support increased fish diversity, which seems to be limited by impassible barriers such as dams, weirs, and culverts and by limited access to source populations downstream in the Clinch River below White Oak Lake.

5.5.7. Polychlorinated Biphenyls in the White Oak Creek Watershed

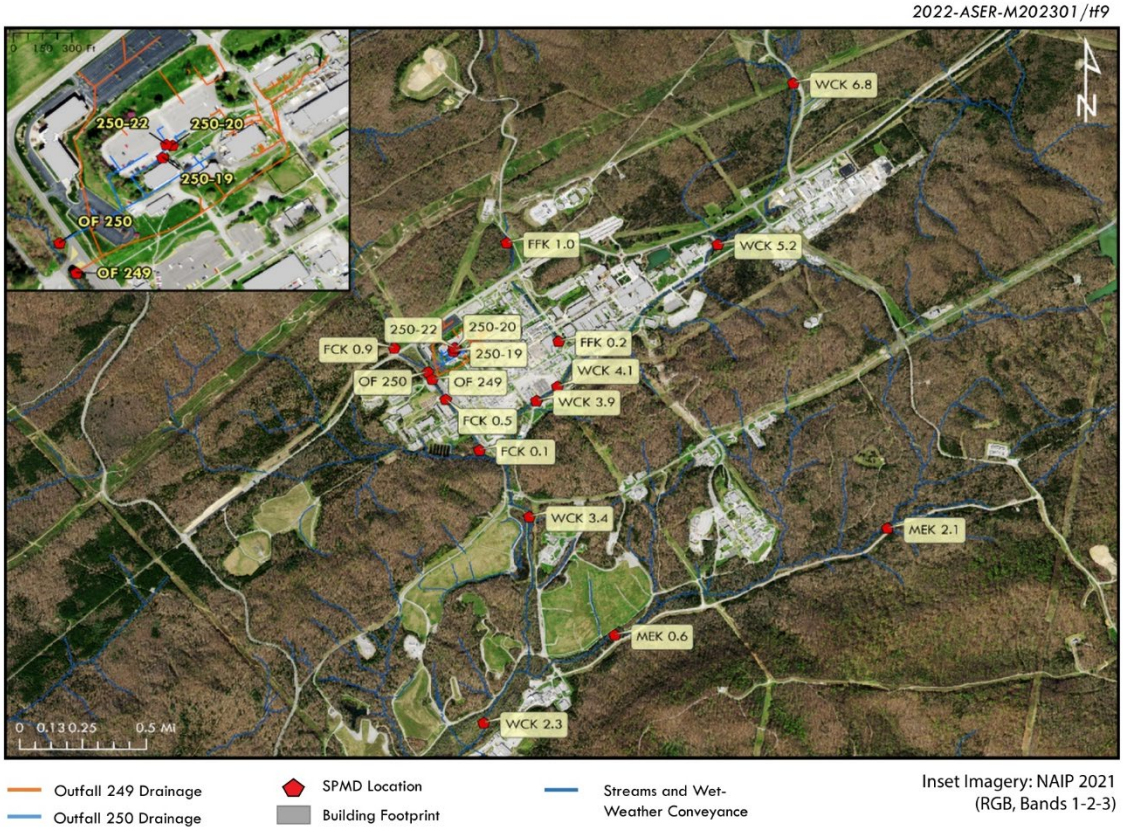
The original objective of the PCB investigation in the WOC watershed was to identify the stream reaches, outfalls, or sediment areas that were contributing to elevated PCB levels. Past ORNL PCB monitoring efforts have identified upper parts of First Creek, particularly the storm drain network leading to Outfall 250, as sources of PCBs to the WOC watershed. Because PCBs are hydrophobic and do not readily dissolve in water, concentrations in samples from the WOC watershed analyzed by conventional methods have historically been below detection limits. However, PCB concentrations in largemouth bass in White Oak Lake have been above levels recommended by TDEC and EPA for frequent consumption, confirming elevated levels at this site. Because fish are mobile, source identification is not possible from the data.

Semipermeable membrane devices (SPMDs), thin plastic sleeves filled with oil in which PCBs are soluble, have proven to be useful tools to identify sources of PCBs. Because SPMDs are deployed at a given site for 4 weeks and have a high affinity for PCBs, they overcome the limitations associated with conventional analytical methods and allow for a time-integrated semiquantitative index of the relative PCB concentrations in the water column (compared to a snapshot value that would be obtained from a conventional surface water grab sample).

The most recent PCB monitoring was done in 2022, when SPMDs were deployed in the same locations monitored in 2009 and 2010 (Figure 5.32) to determine whether changes in PCB sources had occurred. Forage fish were also collected at three sites in First Creek to examine PCB exposure to biota in the stream. Spatial patterns from the 2022 SPMD deployment were very similar to those from the 2009 and 2010 deployments, with First Creek being the greatest contributor to aqueous PCBs in the WOC watershed (Figure 5.33). The Outfall 250 storm drain network, particularly the location at 250-19, remained the greatest contributor of PCBs to the First Creek watershed. PCB concentrations in forage fish in First Creek decreased with downstream distance from this outfall. While SPMDs are semiquantitative, allowing for a relative assessment of PCB sources to the stream, the overall concentrations in the SPMDs were comparable to those in previous years, suggesting no major changes have occurred in aqueous PCB concentrations in the WOC watershed over the past decade.

The upper reaches of the Outfall 250 storm drain network lie beneath a parking lot where two buildings with known PCB materials were once located. A closed-circuit television investigation of

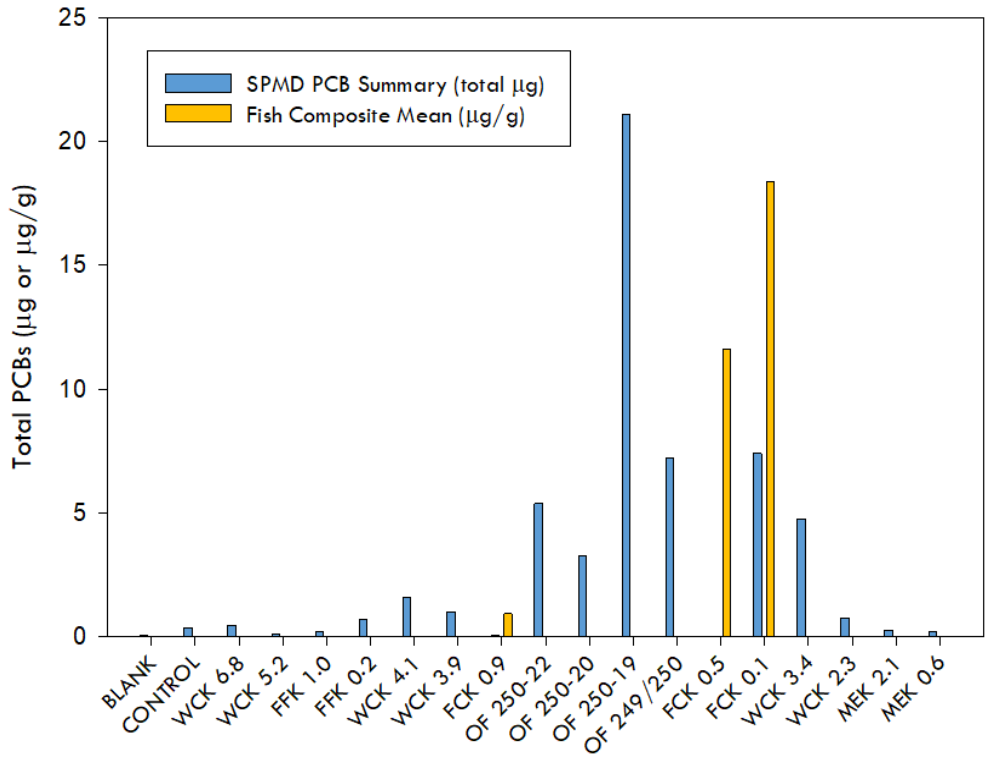
the Outfall 250 storm drain system was completed in 2024 and revealed that underground storm lines beneath the parking lot with no surface connections contain significant amounts of soil and rocky debris. These underground lines are likely legacy storm drains from the demolished buildings that remain connected to the larger Outfall 250 storm drain network. Based on the camera investigation, a sampling strategy was implemented in late 2024 to determine whether the legacy lines are a source of PCBs to the Outfall 250 network. Results will be available in 2025.



Acronyms:

FCK = First Creek kilometer
FFK = Fifth Creek kilometer
MEK = Melton Branch kilometer
OF = outfall
SPMD = semipermeable membrane device
WCK = White Oak Creek kilometer

Figure 5.32. Locations of monitoring points for First Creek source investigations, 2009 and 2022



Acronyms:

FCK = First Creek kilometer
FFK = Fifth Creek kilometer
MEK = Melton Branch kilometer
OF = outfall
PCB = polychlorinated biphenyl
SPMD = semipermeable membrane device
WCK = White Oak Creek kilometer

Figure 5.33. Total polychlorinated biphenyl content (µg) in semipermeable membrane devices in the White Oak Creek watershed and in First Creek forage fish composite samples (*n* = 3), 2022

5.5.8. Oil Pollution Prevention

Requirements for the prevention of oil discharges at specific nontransportation-related facilities are set forth in 40 CFR 112, "Oil Pollution Prevention." Discharges include any spilling, leaking, pumping, pouring, emitting, emptying, or dumping but exclude permitted discharges (e.g., via an NPDES permit). To contain oil discharges and to prevent them from reaching navigable waters or adjoining shorelines, these facilities are required to follow procedures and methods established in 40 CFR 112 to prevent oil spills and clean up spills that do occur; to develop and implement spill prevention, control, and countermeasure (SPCC) plans; and to provide annual training for oil-handling personnel.

Currently, separate SPCC plans are implemented for the ORNL main campus and for the HVC, which is located off ORR. An SPCC plan is not required for the CFTF, which is also located away from ORNL in the Horizon Center Business Park. The ORNL and HVC SPCC plans were revised in 2023. Oil inventories for both SPCC plans are maintained electronically in the ORNL geographic information system and are updated throughout each year as SPCC inventories change. No regulatory actions related to oil pollution prevention were taken at ORNL or the HVC in 2024.

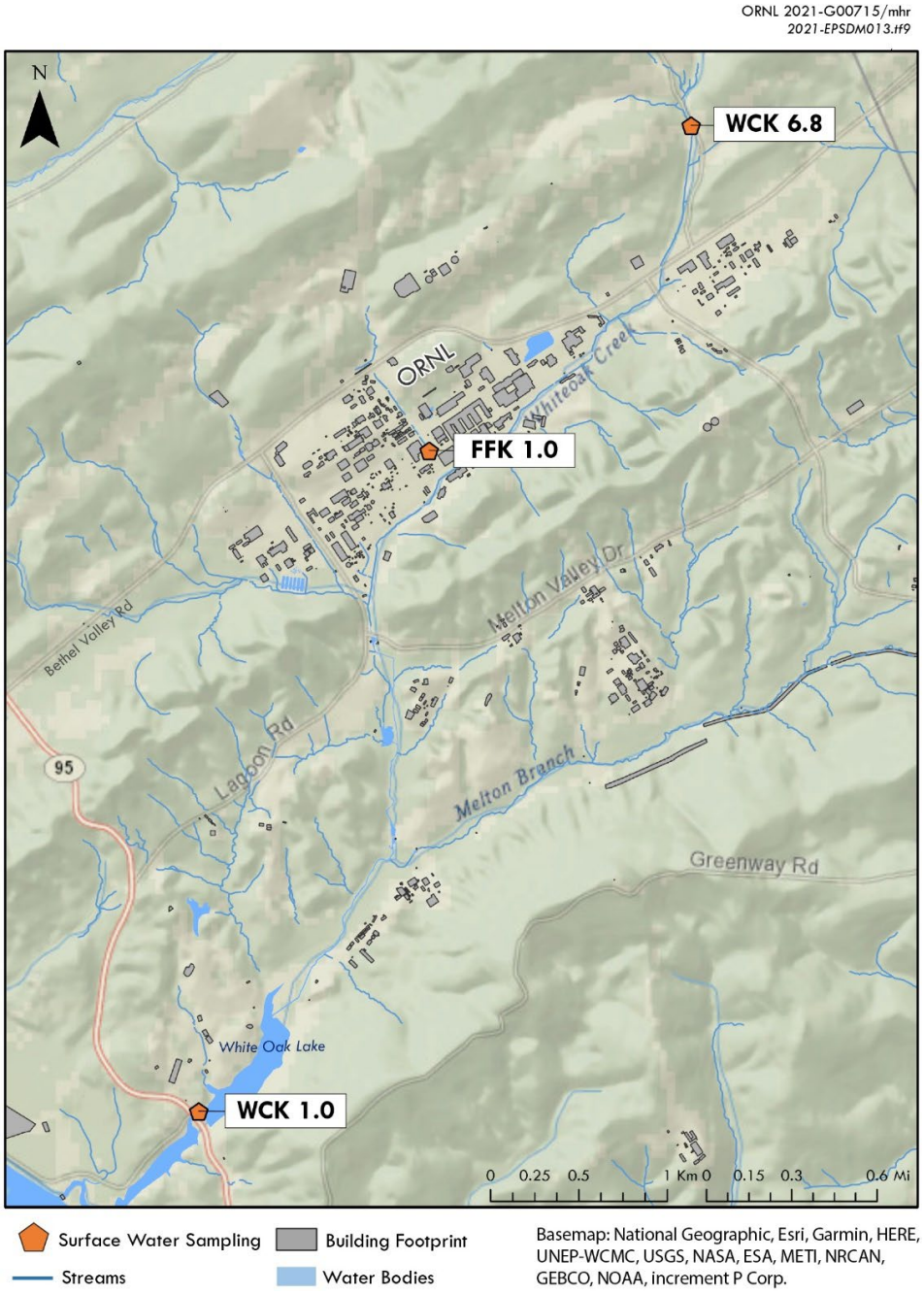
5.5.9. Surface Water Surveillance Monitoring

The ORNL surface water monitoring program is conducted in conjunction with the ORR surface

water monitoring activities discussed in Section 6.4 to assess the impacts of ongoing DOE operations on the quality of local surface water. The sampling locations (Figure 5.34) 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 5.15. Monitoring at WCK 1.0 is conducted monthly for radiological parameters and quarterly for Hg under the ORNL WQPP (Section 5.5.4); therefore, those parameters are not duplicated by this program. Radiological monitoring at WCK 6.8 is also conducted monthly under the ORNL WQPP and therefore is not included in the ORNL surface water monitoring program.

Samples are collected and analyzed for general water quality parameters and are screened for radioactivity at all locations (as part of this program or the WQPP). Samples are further analyzed for specific radionuclides when general screening levels are exceeded. Samples from WCK 1.0 are analyzed for volatile organic compounds (VOCs) and PCBs. Samples from WCK 6.8 are also analyzed for PCBs. The State of Tennessee has designated use classifications for all surface water bodies in the state. Each classification has different WQCs to protect water bodies according to their designated uses. WCK 1.0 and WCK 6.8 are classified for freshwater fish and aquatic life (TDEC 2024a). Tennessee WQCs associated with these classifications are used as references where applicable (TDEC 2024b). The Tennessee WQCs do not include criteria for radionuclides. Four percent of the DOE DCS (DOE 2021) is used for radionuclide comparison.



Acronyms:

FFK = Fifth Creek kilometer

ORNL = Oak Ridge National Laboratory

WCK = White Oak Creek kilometer

Figure 5.34. ORNL surface water sampling locations, 2024

Table 5.15. ORNL surface water sampling locations, frequencies, and parameters, 2024

Location[a]	Description	Frequency and type	Parameters
WCK 1.0[b]	White Oak Lake at WOD	Quarterly, grab	Volatiles, PCBs, field measurements[c]
WCK 6.8[d]	WOC upstream from ORNL	Quarterly, grab	PCBs, field measurements[c]
FFK 0.1	Fifth Creek just upstream of WOC (ORNL)	Semiannually, grab	Gross alpha, gross beta, total radioactive strontium, gamma scan, ^{3}H, field measurements[c]

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

[b] *For this location, radiological parameters and mercury are monitored under another program (the WQPP) and therefore are not included in this program.*

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

[d] *Radiological monitoring is performed at this location as part of the WQPP.*

Acronyms:

FFK = Fifth Creek kilometer
ORNL= Oak Ridge National Laboratory
PCB = polychlorinated biphenyl
WCK = White Oak Creek kilometer
WOC = White Oak Creek
WOD = White Oak Dam
WQPP = water quality protection plan

No radionuclides were reported above 4 percent of the DCS at the Fifth Creek location (FFK 0.1) in 2024. Beta activity and $^{89/90}Sr$ were detected in samples from both sampling events at the Fifth Creek location and are related to known sources in the middle of the ORNL main campus. No $^{89/90}Sr$ results above 4 percent of the DCS were reported for samples collected at the upstream WOC sampling location (WCK 6.8). The other radionuclide results from WCK 6.8 and from samples collected at WOD (before WOC empties into the Clinch River) are discussed in Section 5.5.3.

No PCBs were detected at WCK 1.0 in 2024. Two VOCs were detected in samples from WCK 1.0 during 2024: chloroform was detected in the sample collected in February, and acetone was detected in the samples collected in February and May. All VOC detections were at low estimated values. Acetone was also detected at a low estimated value in the associated trip blank in February and was detected quantitatively in the May trip blank. Chloroform was not detected in any associated trip blank. All VOCs detected in 2024 have previously been detected at WCK 1.0. In addition, acetone and chloroform have occasionally been detected in at least one on-site groundwater well in past monitoring. Acetone and chloroform are common laboratory contaminants.

5.5.10. Carbon Fiber Technology Facility Wastewater Monitoring

Wastewaters from activities at the CFTF are discharged to the City of Oak Ridge sanitary sewer system under conditions established in City of Oak Ridge Industrial Wastewater Discharge Permit 1-12. Permit limits, parameters, and the 2024 compliance status for this permit are summarized in Table 5.16.

Table 5.16. Industrial and commercial user wastewater discharge permit compliance at the ORNL Carbon Fiber Technology Facility, 2024

Effluent parameters	Permit limits		Permit compliance		
	Daily max (mg/L)	Monthly avg (mg/L)	Number of noncompliances	Number of samples	Compliance rate (%)[a]
Outfall 01 (Underground Quench Water Tank)					
Cyanide	3.9	0.1	0	0	100
pH (standard units)	6–9	—	0	0	100
Outfall 02 (Electrolytic Bath Tank)					
pH (standard units)	6–9	—	0	2	100
Outfall 03 (Sizing Bath Tank)					
Copper	0.87	0.10	0	6	100
Zinc	1.24	0.60	0	6	100
Total phenol	4.20	—	0	6	100
pH (standard units)	6–9	—	0	6	100
Outfall 04 (Steam Stretcher Condensate)					
Copper	0.87	0.10	0	0	100
Zinc	1.24	0.60	0	0	100
Total phenol	4.20	—	0	0	100
pH (standard units)	6–9	—	0	0	100

[a] *Compliance rate = 100 − (number of noncompliances/number of samples) × 100*

5.6. ORNL Groundwater Monitoring Program

Groundwater monitoring at ORNL was conducted under two sampling programs in 2024: OREM monitoring and DOE Office of Science (SC) surveillance monitoring. The OREM groundwater monitoring program was conducted by UCOR in 2024. The SC groundwater monitoring surveillance program was conducted by UT-Battelle.

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

Monitoring was performed as part of an ongoing comprehensive CERCLA cleanup effort in Bethel and Melton Valleys, the two administrative watersheds on the ORNL site. Groundwater monitoring is conducted as part of the WRRP to enable baseline and trend evaluation and to measure the effectiveness of completed CERCLA RAs. The WRRP is managed by UCOR for the OREM program. The results of CERCLA monitoring on ORR for FY 2024, including monitoring at ORNL, are evaluated and reported in the *2025 Remediation Effectiveness Report* (DOE 2025) as required by the ORR Federal Facility Agreement.

Groundwater monitoring conducted as part of the OREM program at ORNL includes routine sampling and analysis of groundwater in Bethel Valley to measure performance of several RAs and to continue contaminant and groundwater quality trend monitoring. In Melton Valley, where CERCLA RAs were completed in 2006 for the extensive waste management areas, the groundwater monitoring program includes monitoring groundwater levels to evaluate the effectiveness of hydrologic isolation of buried waste units. Additionally, groundwater is sampled

and analyzed for a wide range of general chemical and contaminant parameters in 46 wells within the interior portion of the closed waste management area.

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

During FY 2024, post-remediation monitoring continued at Solid Waste Storage Area (SWSA) 3 to evaluate the effectiveness of the 2011 hydrologic isolation of the area that included construction of a multilayer cap and an upgradient storm flow and shallow groundwater diversion drain. RAs and monitoring were specified in a CERCLA RA work plan that was developed by DOE and approved by EPA and TDEC before the project was started.

5.6.1.1. Bethel Valley

During FY 2011, construction was completed for RAs at SWSA 1 and SWSA 3, two former waste storage sites that were used for disposal of radioactively contaminated solid wastes between 1944 and 1950. Wastes disposed of at SWSA 1 originated from the earliest operations of ORNL; those at SWSA 3 originated from ORNL, Y-12, the K-25 Site (ETTP), and off-site sources. Although most of the wastes disposed of at SWSA 3 were solids, some were containerized liquid wastes. Some wastes were encapsulated in concrete after placement in burial trenches, but most of the waste was covered with soil. The Bethel Valley record of decision (ROD) (DOE 2002) selected hydrologic isolation using multilayer caps and groundwater diversion trenches as the RA for the waste burial grounds and construction of soil covers over the former contractor's landfill and contaminated soil areas near SWSA 3. The baseline monitoring conducted during FY 2010 included measurement of groundwater levels to obtain baseline data to allow evaluation of post-remediation groundwater-level suppression. Sampling and analysis to evaluate groundwater quality and contaminant concentrations were also conducted. Post-remediation 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 synoptic groundwater-level monitoring in 42 wells in addition to 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.

Monitoring results for 2024 showed that the cap has enabled the attainment of the groundwater-level goals established in the post-remediation completion report. Drinking water standards are used to screen water quality concentrations to evaluate the site response to remediation. Following completion of the remedial actions, concentrations of ^{90}Sr, a signature contaminant at SWSA 3, decreased significantly in groundwater and at the adjacent surface water monitoring sites at Raccoon Creek and the Northwest Tributary. Trend evaluations using the Mann–Kendall test were conducted on ^{90}Sr results from the four wells where ^{90}Sr concentrations exceeded the 8 pCi/L maximum contaminant level derived concentration in 2024. The trend evaluations showed that ^{90}Sr concentrations for the most recent 10-year evaluation period decreased and were stable at three wells for the most recent 5-year evaluation period. No significant trend was identified for the fourth well.

Concentrations of benzene, potentially from natural sources, exhibited a stable trend for the most recent 5-year evaluation period for two wells where benzene results were equal to the 0.005 mg/L maximum contaminant level screening concentration during 2024. The data are presented in the *2025 Remediation Effectiveness Report* (DOE 2025).

Groundwater monitoring continued at the ORNL 7000 area during 2024 to evaluate treatability of the VOC plume at that site. Site characterization testing of the endemic microbial community showed that microbes present at that site are capable of fully degrading trichloroethylene and its degradation products if sufficient electron donor compounds are present in the subsurface environment. During FY 2011, a mixture of emulsified vegetable oil and a hydrogen-releasing compound was injected into four existing monitoring wells in the 7000 area as part of a biostimulation test. Ongoing monitoring of VOC concentrations shows that the effects of the test continue to be apparent, although at decreasing levels.

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

Strontium-90 is a principal CERCLA contaminant of concern in surface water in WOC. The ROD established a 37 pCi/L goal for the annual average concentration of ^{90}Sr at the 7500 Bridge Weir to be attained after completion of all ROD-specified RAs. In 2024, this goal was not attained. Over the past several years, various problems have occurred in Bethel Valley that have caused the failure to meet the ^{90}Sr concentration goal. Belowground infrastructure deterioration related to process liquid wastewater handling in the aging ORNL central campus area is suspected to contribute to nonpoint very shallow groundwater contaminant migration into WOC.

5.6.1.2. Melton Valley

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

Groundwater-level monitoring shows that the hydrologic isolation component of the Melton Valley remedy is effectively minimizing the amount of percolation water contacting buried waste and is reducing contaminated leachate formation. The total amount of rainfall at ORNL in 2024 was about 49 in., which is about 7 in. less than the long-term annual average for ORR. In a few areas, groundwater levels within capped areas continue to respond to groundwater fluctuations imposed from areas outside the caps, but contact of groundwater with buried waste is minimal. Overall, the hydrologic isolation systems are performing as designed.

Groundwater quality monitoring in the interior of Melton Valley shows that in general, groundwater contaminant concentrations are declining or are stable following RAs. At SWSA 6, groundwater quality monitoring that is substantively equivalent to the former RCRA monitoring continues. Several VOCs continue to be detected in wells along the eastern edge of the site at essentially stable concentrations.

During the past 10 years of groundwater monitoring in the Melton Valley exit pathway, several site-related contaminants have been detected in groundwater near the Clinch River. Low concentrations of strontium, ^{3}H, uranium, and VOCs have been detected intermittently in several of the multizone sampling locations. Groundwater in the exit pathway wells has high alkalinity, high sodium, and elevated pH. During FY 2020, an off-site groundwater monitoring well array west of the Clinch River and adjacent to Melton Valley was monitored as part of the OREM program. Monitoring included groundwater-level monitoring to evaluate potential flowpaths near the river and sampling and analysis for a wide array of metals, anions, radionuclides, and VOCs. Groundwater-level monitoring showed that natural head gradient conditions cause groundwater seepage to converge toward the

Clinch River from both the DOE (eastern) and off-site (western) sides of the river. Monitoring results are summarized in the *2025 Remediation Effectiveness Report* (DOE 2025).

5.6.2. DOE Office of Science Groundwater Surveillance Monitoring

DOE Order 458.1 (DOE 2020) is the primary requirement for a sitewide 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 SC groundwater surveillance monitoring are reported in the following sections.

Exit pathway and active-sites groundwater surveillance monitoring points sampled during 2024 included seep/spring and surface water monitoring locations in addition to groundwater surveillance monitoring wells. Seep/spring and surface water monitoring points located in appropriate groundwater discharge areas were used in the absence of monitoring wells.

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

5.6.2.1. Exit Pathway Monitoring

During 2024, exit pathway groundwater surveillance monitoring was performed in accordance with the exit pathway sampling and analysis plan (Bonine 2013). Groundwater exit pathways at ORNL include areas from watersheds or subwatersheds 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 originally included four discharge zones identified by a data quality objectives process. One of the original exit pathway zones was split into two zones for geographic expediency: the Southern Discharge Area Exit Pathway was carved from the East End Discharge Area Exit Pathway. The five zones are listed below. Figure 5.35 shows the locations of the exit pathway monitoring points targeted for sampling in 2024:

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

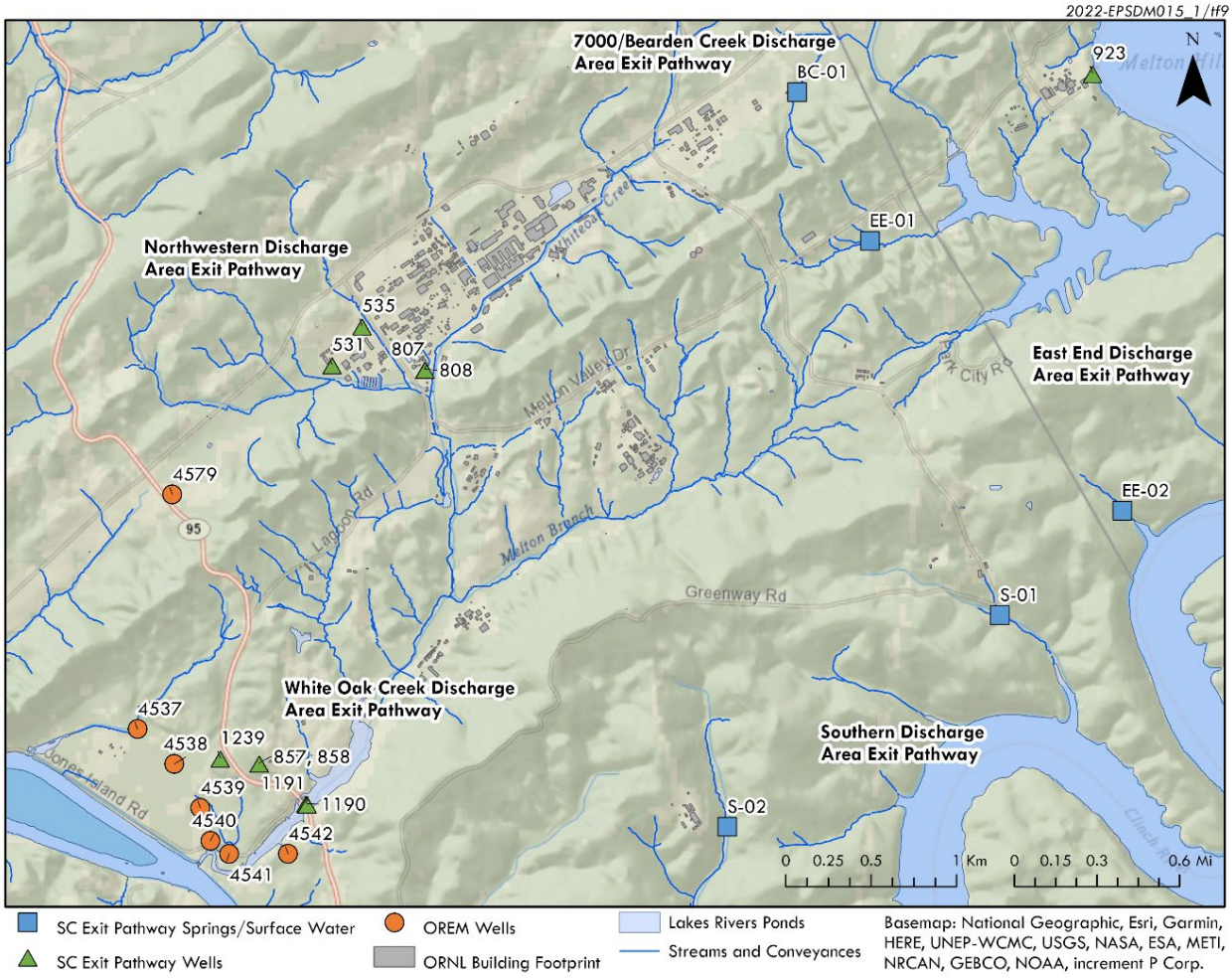
The efficacy of the exit pathway monitoring program was reviewed in late 2011. As a result, the groundwater monitoring program was modified through an optimization approach that included frequency analysis of parameters and their concentrations based on an exhaustive review of historical groundwater sampling data. The modification resulted in a staggered groundwater monitoring schedule and analytical suite selection. This approach was initiated in 2012. The groundwater monitoring that was conducted in 2024 is summarized in Table 5.17.

Unfiltered samples were collected. The organic suite comprised VOCs and semivolatile organic compounds; the metallic suite included heavy and nonheavy metals; and the radionuclide suite comprised gross alpha/gross beta activity, gamma emitters, $^{89/90}Sr$, and ^{3}H. In 2024, dry-season samples were collected in October and November, and wet-season samples were collected in March and April.

Exit pathway monitoring results

Table 5.18 summarizes radiological parameters detected in samples collected from exit pathway monitoring points during 2024. No radiological parameters were detected in 2024 samples from the 7000/Bearden Creek Discharge Area.

Metals are ubiquitous in groundwater exit pathways and are not summarized in the table.



Acronyms:
OREM = DOE Oak Ridge Office of Environmental Management
ORNL = Oak Ridge National Laboratory
SC = DOE Office of Science

Figure 5.35. UT-Battelle exit pathway groundwater monitoring locations at ORNL, 2024

Table 5.17. Exit pathway groundwater monitoring conducted in 2024

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

[a] *Locations EE-02 and S-01 (stream locations) were not sampled in the 2024 dry season because of lack of water flow.*

Table 5.18. Radiological parameters detected in 2024 exit pathway groundwater monitoring[a]

Monitoring location	Parameter	Concentration (pCi/L)		
		Wet season[b]	Dry season[b]	Reference value[c]
East End Discharge Area				
Well 923	Beta	3.2	3.08	50
Stream EE-01	Beta	U2.16	3.2	50
Northwestern Discharge Area				
Well 531	Beta	4.98	4.1	50
Well 807	Beta	4.69	4.57	50
Well 808	Beta	5.08	10.7	50
Southern Discharge Area				
Stream S-01	^{212}Bi	37.8	NF	
Stream S-01	^{214}Bi	5.24	NF	40,000
Stream S-02	Beta	3.04	2.78	50
White Oak Creek Discharge Area				
Well 857	Alpha	11.9	ND	15
Well 857	Beta	11.5	3.27	50
Well 1190	Alpha	U0.226	3.44	15
Well 1190	Beta	U1.91	6.44	50
Well 1190	^{208}Tl	ND	2.05	
Well 1190	^{3}H	11,200	11,500	20,000
Well 1191	Alpha	2.22	3.3	15
Well 1191	Beta	178	223	50
Well 1191	^{214}Bi	11.3	ND	40,000
Well 1191	$^{89/90}$Sr	91.4	107	68
Well 1191	^{3}H	4,480	6,050	20,000
Well 1239	Alpha	U0.291	3.34	15
Well 1239	Beta	U0.286	4.16	50

[a] *No radiological parameters were detected in the 7000/Bearden Creek Discharge Area in 2024.*

[b] *NF = there was no flow at the spring or stream sampling location during sampling attempts.*
ND = the analyte was not detected in the gamma scan that was performed.
U = the analyte was measured but not detected above the practical quantitation limit/contractor-required detection limit.

[c] *Current federal and state standards are used as reference values. If no federal or state standard exists for the analyte, 4 percent of the DOE derived concentration standard is used as the reference value.*

Exit pathway groundwater surveillance summary

Concentrations of metals and man-made radionuclides observed in groundwater exit pathway discharge areas in 2024 at ORNL were generally consistent with observations reported in past annual site environmental reports for ORR.

Based on the results of the 2024 monitoring effort, there is no indication that current SC operations are significantly introducing contaminants to the groundwater at ORNL.

Eight radiological contaminants were detected in exit pathway groundwater samples collected in

2024. Gross beta and $^{89/90}$Sr were the only radiological parameters that exceeded reference values at any of the discharge areas. Consistent with previous monitoring, these parameters were observed at concentrations above their respective reference values in the WOC Discharge Area. During the wet season, alpha activity was detected just above the normal range at well 857. Although below the reference value, this detection is the highest concentration recorded at this location to date.

Twenty-four metallic parameters were detected in exit pathway groundwater samples collected in 2024. Only three metals, aluminum, iron, and manganese, were detected at concentrations exceeding reference values. These metals are commonly found in groundwater at ORNL.

No organic compounds were detected at concentrations above the analytical method practical quantitation limit in exit pathway groundwater monitoring during 2024. Three organic compounds were detected at estimated concentrations (i.e., concentrations between the method analytical detection level and the practical quantitation limit). Acetone was detected during wet-season monitoring in samples from wells 1190 and 1191. Bis(2-ethylhexyl) phthalate and toluene were also detected in the sample from well 1191 in wet-season monitoring. Methylene chloride was detected at an estimated concentration below the detection limit during dry-season monitoring at wells 807 and 1191. Acetone, methylene chloride, toluene, and some phthalate compounds are common laboratory contaminants (EPA 2014).

5.6.2.2. Active-Sites Monitoring—High Flux Isotope Reactor

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

5.6.2.3. Active-Sites Monitoring—Spallation Neutron Source

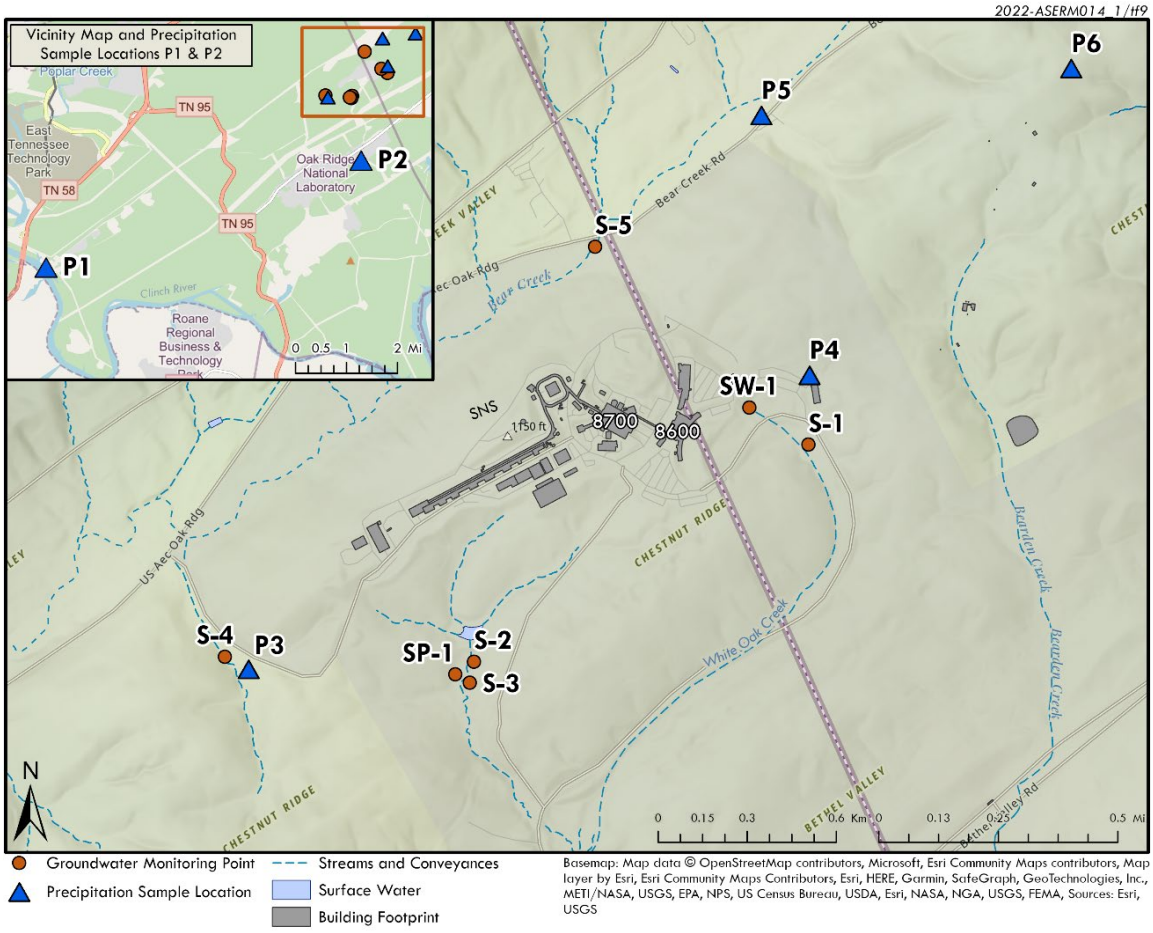
Active-sites groundwater surveillance monitoring was performed in 2024 at the SNS site under the SNS operational monitoring plan (Bonine, Ketelle, and Trotter 2007) because of the potential for adverse impact on groundwater resources at ORNL should a release occur.

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 consistent with 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, 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 transport characteristics of neutron activation products produced, diffusion and advection, and the presence of karst geomorphic features on the SNS site. These uncertainties led to the initiation of the groundwater surveillance monitoring program at the SNS site. Objectives of the

groundwater monitoring program outlined in the operational monitoring plan include maintaining compliance with applicable DOE contract requirements and environmental quality standards and providing uninterrupted monitoring of the SNS site.

A total of seven springs, seeps, and surface water sampling points were routinely monitored as analogues to, and in lieu of, groundwater monitoring wells. Locations were chosen based on hydrogeological factors and proximity to the beam line. Since 2016, precipitation samples have also been collected for ^{3}H analysis at six of the springs, seeps, and surface water locations. Figure 5.36 shows the locations of the specific monitoring points sampled during 2024.



Acronyms:

P = precipitation monitoring point
S = spring
SP = seep
SW = surface water sampling area

Figure 5.36. Groundwater and precipitation monitoring locations at the Spallation Neutron Source, 2024

A modified SNS operational monitoring plan was implemented in 2012 and was based on statistical evaluations of data collected between 2004 and 2011.

Quarterly sampling at each monitoring point continued in 2024. In 2024, all sampling was performed in conjunction with rainfall events, with samples being collected during rising or falling (recession) limb flow conditions. Table 5.19 shows the sampling and parameter analysis schedule followed in 2024.

Table 5.19. Spallation Neutron Source monitoring program schedule, 2024

Monitoring location	Quarter 1 January–March	Quarter 2 April–June	Quarter 3 July–September	Quarter 4 October–December
SW-1	^{3}H	^{3}H	^{3}H and expanded suite[a]	^{3}H
S-1	^{3}H	^{3}H	^{3}H and expanded suite[a]	^{3}H
S-2	^{3}H	^{3}H	^{3}H and expanded suite[a]	^{3}H
S-3	^{3}H	^{3}H	^{3}H	^{3}H and expanded suite[a]
S-4	^{3}H and expanded suite[a]	^{3}H	^{3}H	^{3}H and expanded suite[a]
S-5	^{3}H and expanded suite[a]	^{3}H	^{3}H	^{3}H
SP-1	^{3}H	^{3}H	^{3}H and expanded suite[a]	^{3}H

[a] *The expanded suite includes gross alpha and gross beta activity, ^{14}C, and gamma emitters.*

Acronyms:

S = spring

SP = seep

SW = surface water sampling area

Spallation Neutron Source site results

Sampling at the SNS site occurred quarterly in 2024. Low concentrations of alpha and beta activities were detected at spring S-5 and are attributed to CERCLA contaminants in Bear Creek Valley associated with legacy waste management practices at the Y-12 facility. Very low beta activity was detected at spring S-2. Table 5.20 summarizes SNS sampling locations and radionuclide detections for 2024. Analytical results were compared with current federal or state standards or 4 percent of the DCS. None of the radiological constituents detected in the SNS groundwater and surface water sample locations exceeded reference values in 2024.

In addition to SNS surface water sampling, precipitation monitoring for ^{3}H has been conducted at six locations since 2016. The precipitation sampling is conducted contemporaneously with the surface water sampling. Tritium can be an airborne constituent that is released from several DOE facilities at ORNL, from Tennessee Valley Authority reactor sites, and from commercial radiological waste processing facilities in the area. The precipitation sampling locations are shown in Figure 5.36, and the results are summarized in Table 5.21. Thirty-six sampling events have been conducted at each of the precipitation monitoring locations. The highest ^{3}H concentrations and frequencies of detection were at sample location P1, approximately 6 miles southwest of the SNS site. The second-highest concentrations and detection frequency occurred at location P4, which is located within 2,000 ft northeast of the SNS target facility. Tritium rainout from atmospheric ^{3}H releases from sources including DOE facilities, Tennessee Valley Authority facilities, and commercial radiological waste-handling and waste-processing facilities creates a regional background of ^{3}H in some surface water and groundwater samples.

Table 5.20. Radiological concentrations detected in samples collected at the Spallation Neutron Source, 2024[a]

Parameter	Concentrations (pCi/L)				Reference value[b]
	March	July	September	December	
			SW-1[c]		
^{3}H	1,630	3,120	2,700	1,190	20,000
			S-1[c]		
^{3}H	1,030	588	209	403	20,000
			S-2[c]		
Beta			4.25		50
^{3}H	980	913	600	661	20,000
			S-3[d]		
^{3}H	608	412		417	20,000
			S-4[e]		
Beta				2.28	50
^{3}H	337	816	866	417	20,000
			S-5[f]		
Alpha	11.9				15
Beta	10.7				50
^{3}H	277	241		207	20,000
			SP-1[a]		
^{3}H	441	337	440	454	20,000

[a] *In addition to ^{3}H analyses, an extended suite of parameters was analyzed at each location during one 2024 sampling event. The extended suite included gross alpha, gross beta, gamma scan, and ^{14}C. Results for ^{3}H and detected concentrations from the extended suite are listed in the table.*

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

[c] *Analysis of extended suite completed in September.*

[d] *Analysis of extended suite completed in December.*

[e] *Analysis of extended suite completed in March and December.*

[f] *Analysis of extended suite completed in March.*

Acronyms:

S = spring

SP = seep

SW = surface water sampling area

Table 5.21. Summary of precipitation ^{3}H monitoring results, 2016–2024

Sample location	Total samples	Total detects	Maximum detect (pCi/L)	Date of maximum detect	Date of most recent detect
P1	36	10	4,930	05/21/2016	9/26/2024
P2	36	2	1,070	05/21/2016	12/10/2024
P3	36	7	1,230	05/21/2016	12/10/2024
P4	36	9	3,560	10/07/2023	12/10/2024
P5	36	6	908	05/21/2016	12/10/2024
P6	36	5	1,240	02/07/2018	12/10/2024

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

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

Perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) have been produced in large amounts in the United States and have been studied more than other PFAS compounds. Through 2001, PFOS and other PFAS were used in the manufacture of aqueous film-forming foams, and use of such foams, including in firefighting training activities, may have contributed to environmental releases. The information contained in this and the previous paragraph is summarized from EPA's *Technical Fact Sheet—Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA)* (EPA 2017).

On June 21, 2022, EPA published updated health advisories for PFOA and PFOS of 0.004 and 0.02 ng/L, respectively (EPA 2022b). These replaced the final health advisory of 70 ng/L for combined PFOA and PFOS that was issued in 2016. At the same time, the EPA also issued final health advisories for hexafluoropropylene oxide dimer acid and its ammonium salt (collectively referred to as GenX chemicals) and perfluorobutane sulfonic acid and the related compound potassium perfluorobutane sulfonate (together referred to as PFBS) of 10 and 2,000 ng/L, respectively.

In April 2022, EPA proposed the first CWA aquatic life criteria for PFAS (Table 5.22), which focus on PFOA and PFOS chemical groups. These draft recommendations reflect the latest peer-reviewed scientific knowledge regarding the toxicological effects of PFOA and PFOS on freshwater aquatic organisms.

Historically, firefighter training at ORNL included training in the use of aqueous film-forming foams, and the foams that were used in past training activities may have contained PFAS. The discharges of these foams are suspected to be the most significant potential source of PFAS in environmental media at ORNL. Most of the training was conducted at four locations: adjacent to the ORNL Fire Station (Building 2500), at the Fire Training and Test Facility (Building 2648), on the southeast corner of First Street and Bethel Valley Road (near where Building 2040 was later constructed), and at a location on the north side of Old Bethel Valley Road in the Bearden Creek watershed. A sampling and analysis plan was developed and was implemented in 2023 and 2024 to assess these areas for the presence of PFAS in groundwater and surface water bodies in these areas.

Table 5.22. Draft recommended freshwater aquatic life water quality criteria for PFOA and PFOS (EPA 2022c)

Criteria component	Acute water column (CMC)	Chronic water column (CCC)	Invertebrate whole-body	Fish whole-body	Fish muscle
PFOA magnitude	49 mg/L	0.094 mg/L	1.11 mg/ kg ww	6.10 mg/ kg ww	0.125 mg/ kg ww
PFOS magnitude	3.0 mg/L	0.0084 mg/L	0.937 mg/ kg ww	6.75 mg/ kg ww	2.91 mg/ kg ww
Duration	1 h average	4-day average	Instantaneous[a]		
Frequency	Not to be exceeded more than once in 3 years, on average	Not to be exceeded more than once in 3 years, on average	Not to be exceeded more than once in 10 years, on average		

[a] *Tissue data provide instantaneous point measurements that reflect integrative accumulation of PFOA or PFOS over time and space in aquatic life population(s) at a given site.*

Acronyms:

CCC = criterion continuous concentration
CMC = criterion maximum concentration
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonate
ww = wet weight

The sampling and analysis plan also includes monitoring surface water locations in other parts of the ORNL campus, including former waste storage areas, to assess whether PFAS from non–aqueous film-forming foam sources are present and reaching surface waters. Surface water monitoring includes the use of passive sampling devices, which are deployed in stream environments for extended periods (typically 4 weeks) and accumulate PFAS that might not be measurable with traditional water sampling techniques. In 2024, surface water grab samples were taken in First Creek downstream of Building 2500 and in WOC upstream of the Fire Training and Test Facility. Samples were analyzed with EPA Method 537.1. Some PFAS analytes were detected in these areas, consistent with past aqueous film-forming foams use.

Neither groundwater nor surface water at ORNL is a direct source of drinking water. ORNL's water supply is municipal water purchased from the City of Oak Ridge. DOE owns the water distribution system on the ORNL site, and limited sampling of this system for PFAS was conducted in 2024 as part of fifth Unregulated Contaminant Monitoring Rule efforts. No PFAS were detected in samples from the ORNL water distribution system.

To enable tracking of any current use and operational needs for PFAS-containing materials, the ORNL Hazardous Materials Management Information System generates reports to notify environmental protection staff when new PFAS-containing materials enter the system. This system also supports tracking of Toxics Release Inventory–reportable PFAS inventory. In 2024, the total inventory of these PFAS remained below the reportable threshold.

5.7. Quality Assurance Program

The UT-Battelle Quality Management System (QMS) has been developed to implement the requirements defined in DOE Order 414.1D, Quality Assurance (DOE 2011b). The methods used for successful implementation of the QMS rely on the integration and implementation of quality elements and criteria flowed down through multiple management systems and daily operating processes. These management systems and processes are described in SBMS, where basic requirements are communicated to UT-Battelle staff. Additional or specific customer requirements are addressed at the project or work activity level. The QMS provides a graded

approach to implementation based on 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 perform work safely and effectively. SBMS translates laws, orders, directives, policies, and best management practices into laboratory-wide subject areas and procedures.

5.7.1. Work/Project Planning and Control

UT-Battelle's work/project planning and control directives establish the processes and requirements for executing work activities at ORNL. All environmental sampling tasks are performed following the four steps required in the work control subject areas:

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

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

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

5.7.2. Personnel Training and Qualifications

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

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

5.7.3. Equipment and Instrumentation

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

5.7.3.1. Calibration

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

In addition, a continuous monitor used for CAA compliance monitoring at ORNL Boiler 6 is subject to rigorous QA protocols as specified by EPA methods. A relative accuracy test audit is performed annually to certify the Predictive Emissions Monitoring System for nitrogen oxides and oxygen. The purpose of a relative accuracy test audit is to provide a rigorous QA assessment in accordance with *Performance Specification 16* (EPA 2009b). The results of the QA tests are provided to TDEC quarterly, semiannually, or annually, as applicable.

5.7.3.2. Standardization

EPSD sampling procedures are maintained in the Enterprise Document and Records Management System and include requirements and instructions for the proper standardization and use of monitoring equipment. Requirements include the use of traceable standards and measurements; performance of routine, before-use equipment standardizations; and actions to perform 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 5.3 lists environmental audits and assessments performed at ORNL in 2024 and the number of findings identified. EPSD also conducts internal assessments of UT-Battelle environmental monitoring activities. Surveillance results, recommendations, and completion of corrective actions, if required, are also documented and tracked in the UT-Battelle Assessment and Commitment Tracking System.

Independent audits, surveillances, and internal management assessments are performed at TWPC and Building 3019 to verify that requirements have been accurately specified and that activities that have been performed conform to expectations and requirements. Corrective actions at TWPC, if required, are documented and tracked using the UCOR Quality Assurance and Corrective Action Management Systems, and Isotek corrective actions for Building 3019 are tracked in its Assessment and Commitment Tracking System.

5.7.5. Analytical Quality Assurance

Laboratories that analyze environmental samples collected for EPSD environmental sampling programs are required to have documented QA/QC programs, trained and qualified staff, appropriately maintained equipment and facilities, and applicable certifications. The laboratories also participate in accreditation, certification, and performance evaluation programs such as the National Environmental Laboratory Accreditation Program (NELAP), Mixed Analyte Performance Evaluation Program (MAPEP), Discharge Monitoring Report Quality Assurance Study (DMRQA), and DOE Environmental Management Consolidated Audit

Program (DOECAP), which evaluate laboratories according to stringent and widely accepted criteria for quality, accuracy, reliability, and efficiency. Any issues identified through accreditation or certification programs or through performance evaluation testing are addressed with analytical laboratories and are considered when determinations are made on data integrity. Blank and duplicate samples are submitted along with environmental samples to provide an additional check on analytical laboratory performance.

Environmental samples collected in support of EPSD environmental monitoring programs in 2024 were analyzed by one of two contracted commercial laboratories (GEL Laboratories or Eurofins) or by the UT-Battelle Radiochemical Materials Analytical Laboratory (RMAL) or the UT-Battelle Environmental Toxicology Laboratory. Contracts with analytical laboratories include statements of work that specify the scope of work, data deliverables, turnaround times, required methods, and detection limits.

GEL Laboratories, a contracted commercial radiochemistry and environmental laboratory in Charleston, South Carolina, holds more than 40 federal and state certifications, accreditations, and approvals, including for ISO/IEC 17025 (which contains general requirements for the competence of testing and calibration laboratories) and from the US Department of Defense Environmental Laboratory Accreditation Program (DOD-ELAP), DOECAP, and NELAP. Seven external audits were performed on-site in 2024. No issues were identified that would affect analytical data reported to clients. In 2024, GEL Laboratories reported results from 5,752 performance test analyses (including DMRQA, MAPEP, DOECAP, and NELAP). Of these, 5,670 (98.6 percent) fell within acceptance ranges. Those that did not meet acceptance criteria were found to have no effect on data reported to clients. Eurofins, a contracted environmental laboratory in Tacoma, Washington, is accredited, licensed, or approved by 11 third-party programs, including ISO 17025, DOD-ELAP, DOECAP, NELAP, and several state licensing or accrediting programs. In 2024, Eurofins participated in MAPEP and DMRQA, and all applicable test results were within acceptable ranges.

RMAL received ISO/IEC 17025:2017 (ISO 2017) accreditation in April 2023. Additionally, RMAL operates in compliance with the US Department of Defense/DOE *Consolidated Quality Systems Manual* (DOD/DOE 2018) and with the requirements of DOE 414.1D (DOE 2011b) and 10 CFR 830 Subpart A, "Quality Assurance Requirements." The UT-Battelle Chemical Sciences Division's QA plan also meets applicable requirements of the American Society of Mechanical Engineers' Nuclear Quality Assurance Program. In 2024, RMAL participated in several external audits, including the annual TDEC Waste Compliance Audit and an annual ISO/IEC 17025:2017 surveillance audit performed by A2LA, and 13 internal assessments, that focused on adherence to approved analytical methods, waste management, and record keeping. No issues that required reanalysis or data corrections related to environmental sampling results were identified. In 2024, RMAL participated in MAPEP and DMRQA, and all results for analyses that RMAL performed in support of EPSD environmental monitoring programs were within acceptable ranges except for hexane extractable materials and mercury in soil. Remedial proficiency samples were analyzed for hexane extractable materials, and results of these analyses were acceptable. Analyses of remedial samples for mercury in soil are ongoing.

The Environmental Toxicology Laboratory does not hold any outside accreditations, but it operates in compliance with all methods required by EPA, TDEC, NPDES, and the UT-Battelle Environmental Sciences Division's Quality Assurance Management Program. In 2024, nine internal assessments focused on adherence to approved analytical methods and data analysis were performed. No issues requiring reanalysis or data corrections related to standard toxicity testing results were identified. Updates of all standard operating procedures, reference toxicity control charts, and training requirements were completed in 2021. All standard operating

procedures and lab methods comply with EPA's acute (EPA 2002a) and chronic (EPA 2002b) testing requirements for freshwater species. In 2024, the Environmental Toxicology Laboratory participated in the DMRQA program for whole effluent toxicity testing of *Pimephales promelas* (the fathead minnow, a freshwater fish) and *Ceriodaphnia dubia* (the water flea, a freshwater invertebrate). Results for *C. dubia* were in acceptable ranges, but *P. promelas* results initially were not. Corrective actions were implemented, and a retest was passed in November 2024.

5.7.6. Data Management and Reporting

Data collected by UT-Battelle in conjunction with ORR and ORNL environmental surveillance programs and CWA activities at ORNL are managed 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 the 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.

EPSD is committed to continual improvement in processes and activities and is pursuing opportunities to modernize and improve environmental data management strategies. Implementation of a multiyear database modernization plan is underway to improve data integrity, modernize data delivery, support compliance with cybersecurity and other DOE requirements, and increase program resilience. In 2024, ORNL staff interfaced with other DOE sites to benchmark environmental data management strategies, identify preferred software, and consider lessons learned from similar data modernization efforts undertaken at other DOE sites. These inputs were incorporated into the ORNL database modernization initiative, and the sharing of information across sites continues to optimize efforts.

The ORNL data management team takes part in a community of practice that connects DOE data management teams to discuss data management topics on a quarterly basis. ORNL staff have also joined the Office of Sustainable Environmental Stewardship environmental monitoring working group, which facilitates collaboration among DOE sites and establishes benchmarks for their monitoring programs; this group discusses data management topics and is another avenue for sharing data management best practices across DOE sites.

5.7.7. Records Management

The UT-Battelle Requirements, Documents, and Records Management System provides the requirements for managing all UT-Battelle records, including requirements for creating, maintaining, and using records; scheduling, protecting, and storing records; and destroying records. Records management programs for TWPC and Building 3019 include the requirements for creating and identifying record

material, protecting and storing records in applicable areas, and destroying records.

5.8. Environmental Management and Waste Management Activities at ORNL

The three campuses on ORR have a rich history of research, innovation, and scientific discovery that shaped the course of the world. Unfortunately, today, despite their vitally important missions, they are hindered by environmental legacies of past operations. The contaminated portions of ORR are on the EPA National Priorities List, which includes hazardous waste sites across the nation that are to be cleaned up under CERCLA. Areas that require cleanup or further action on ORR have been clearly defined, and OREM is working to clean those areas under the Federal Facility Agreement with EPA and TDEC. The *FY 2024 Cleanup Progress: Annual Report on Oak Ridge Reservation Cleanup* (UCOR 2024) provides detailed information on OREM's 2024 cleanup activities (**here**).

5.8.1. Wastewater Treatment

At ORNL, OREM operates PWTC and the Liquid Low-Level Waste Treatment Facility. In 2024, 442.9 million L of wastewater was treated and released at PWTC. In addition, the liquid LLW system at ORNL received 427,199 L of waste. The waste treatment activities of these facilities support both OREM and SC mission activities, ensuring that wastewaters from activities associated with projects of both offices are managed in a safe and compliant manner.

5.8.2. Newly Generated Waste Management

ORNL is the largest, most diverse 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 by-products of performing research and operational activities and must be managed to ensure that the environment is protected from associated hazards. As the prime contractor for the management of ORNL, UT-Battelle is responsible for managing most of the wastes generated from R&D activities and from operation of the R&D facilities. If possible, waste streams are treated by on-site liquid or gaseous waste treatment facilities operated by OREM. 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 2024, ORNL performed 120 waste and recycle shipments to off-site hazardous, radiological, or mixed-waste treatment or disposal vendors.

5.8.3. Transuranic Waste Processing Center

TRU waste processing activities performed for DOE in 2024 by UCOR addressed both contact-handled and remotely handled solids and debris. These activities involved processing, treating, and repackaging waste. All TRU waste is transported to the Waste Isolation Pilot Plant for disposal. LLW and mixed LLW are transported to the Nevada National Security Site or to another approved off-site facility for disposal.

In 2024, 68.3 m^3 of contact-handled TRU waste was shipped from TWPC in 12 shipments (643 containers). During 2024, 11.78 m^3 of contact-handled waste was processed; 0.21 m^3 of remotely handled waste was processed, and 126.6 m^3 of mixed LLW (TRU waste that was recharacterized as LLW) was shipped off-site.

5.9. References

10 CFR 830. "Nuclear Safety Management." *US Code of Federal Regulations*, Washington, DC. Retrieved May 5, 2021, from https://www.govinfo.gov/content/pkg/CFR-2011-title10-vol4/pdf/CFR-2011-title10-vol4-part830.pdf.

40 CFR 112. "Oil Pollution Prevention." *US Code of Federal Regulations,* Washington, DC. Retrieved June 4, 2020, from https://www.epa.gov/sites/production/files/2014-04/documents/b_40cfr112.pdf.

40 CFR 141.86. "Monitoring Requirements for Lead and Copper in Tap Water." *US Code of Federal Regulations*, Washington, DC. Retrieved April 30, 2025, from https://www.ecfr.gov/current/title-40/chapter-I/subchapter-D/part-141/subpart-I/section-141.86.

40 CFR 280. "Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (UST)." *US Code of Federal Regulations,* Washington, DC. Retrieved June 9, 2020, from https://www.ecfr.gov/cgi-bin/text-idx?SID=165cbbe4db4970349d085d9840b78873&mc=true&node=pt40.29.280&rgn=div5.

40 CFR 60, Appendix A-1. "Method 2—Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)." *US Code of Federal Regulations*, Washington, DC.

40 CFR 82. "Protection of Stratospheric Ozone." *US Code of Federal Regulations*, Washington, DC. Retrieved June 3, 2020, from https://www.ecfr.gov/cgi-bin/text-idx?rgn=div6;node=40%3A18.0.1.1.2.6.

40 CFR 84. "Phasedown of Hydrofluorocarbons." *US Code of Federal Regulations*, Washington, DC. Retrieved April 30, 2025, from https://www.ecfr.gov/current/title-40/chapter-I/subchapter-C/part-84.

42 U.S.C. 8253. "Energy and Water Management Requirements." US Code, Washington, DC. https://uscode.house.gov/view.xhtml?req=(title:42%20section:8253%20edition:prelim).

42 U.S.C. 17143. "Government Efficiency Status Reports." US Code, Washington, DC. https://https://uscode.house.gov/view.xhtml?req=granuleid:USC-prelim-title42-section17143&num=0&edition=prelim.

AIM 2020. *American Innovation and Manufacturing Act*. Title 42 US Code §7675.

ANSI 1969. *Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities*. ANSI N13.1-1969R. American National Standards Institute, Washington, DC.

ANSI 1999. *Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities.* ANSI/HPS N13.1-1999. American National Standards Institute, Health Physics Society, New York, New York.

Bonine 2013. Bonine, T. M. *UT-Battelle Sampling and Analysis Plan for Surveillance Monitoring of Exit Pathway Groundwater at Oak Ridge National Laboratory*. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Bonine, Ketelle, and Trotter 2007. Bonine, T. M., R. H. Ketelle, and S. M. Trotter. *Operational Groundwater Monitoring Plan for the Spallation Neutron Source Site*. SNS 102040000-ES0001-R01, ORNL/TM-2004/118, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

CAA 1970. *Clean Air Act.* Title 42 US Code §7401 et seq.

CERCLA 1980. *Comprehensive Environmental Response, Compensation, and Liability***.** Title 42 US Code Chapter 103.

Cleary et al. 2021. Cleary, B.M., M. E. Romano, C. Y. Chen, W. Heiger-Bernays, and K. A. Crawford, "Comparison of Recreational Fish Consumption Advisories across the USA." *Current Environmental Health Reports* 8(2), 71–88.

CWA 1972. *Clean Water Act.* Title 33 US Code §1251 et seq.

DOD/DOE 2018. *Department of Defense (DoD)/Department of Energy (DOE) Consolidated Quality Systems Manual (QSM) for Environmental Laboratories*. DoD/DOE QSM 5.5.1, US Department of Defense and US Department of Energy, Washington, DC. Retrieved April 30, 2021, from https://denix.osd.mil/edqw/documents/documents/qsm-version-5-1-1-final/.

DOE 1992. *Federal Facility Agreement for the Oak Ridge Reservation*. FFA-PM/18-011, DOE/OR-014, January 1, 1992, or latest revision, US Environmental Protection Agency Region IV, US Department of Energy, and Tennessee Department of Environment and Conservation, Oak Ridge, Tennessee. Retrieved August 18, 2022, from https://www.energy.gov/sites/prod/files/em/2001_Agreements/ORR_FFA_1-1-92.pdf.

DOE 2000. *Record of Decision for Interim Actions for the Melton Valley Watershed at the Oak Ridge National Laboratory, Oak Ridge, Tennessee*. DOE/OR/01-1826&D3, US Department of Energy, Washington, DC.

DOE 2002. *Record of Decision for Interim Actions in Bethel Valley Watershed, Oak Ridge, Tennessee*. DOE/OR/01-1862&D4, US Department of Energy, Washington, DC.

DOE 2008. *Environmental Protection Program.* DOE Order 450.1A. Approved June 4, 2008. US Department of Energy, Washington, DC.

DOE 2011a. *Final Draft ^{233}U Alternatives Analysis, Phase I Report: Screening of Alternative Disposition Approaches.* US Department of Energy, Washington, DC.

DOE 2011b. *Quality Assurance.* DOE Order 414.1D. Approved April 25, 2011. US Department of Energy, Washington, DC.

DOE 2012. *Phased Construction Completion Report for the Bethel Valley Burial Grounds at the Oak Ridge National Laboratory, Oak Ridge, Tennessee*. DOE/OR/01-2533&D2. UCOR, Oak Ridge, Tennessee.

DOE 2020. *Radiation Protection of the Public and the Environment.* DOE Order 458.1, Change 4. Approved September 15, 2020. US Department of Energy, Washington, DC.

DOE 2021. *Derived Concentration Technical Standard*. DOE-STD-1196-2021. US Department of Energy, Washington, DC. July 2021. https://www.standards.doe.gov/standards-documents/1100/1196-astd-2021.

DOE 2025. *2025 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Site Oak Ridge, Tennessee*. DOE/OR/01-2989&D1, US Department of Energy, Washington, DC.

EAct 2020. *The Energy Act of 2020*. Public Law 116-260, Division Z.

EISA 2007. *Energy Independence and Security Act of 2007*. Public Law 110-140.

EPA 2000. *Stressor Identification Guidance Document.* EPA-822-B-00-025, US Environmental Protection Agency, Office of Water, Washington, DC.

EPA 2002a. *Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms*. EPA-821-R-02-012, US Environmental Protection Agency, Washington, DC. Retrieved April 17, 2021, from https://www.wbdg.org/FFC/EPA/EPACRIT/epa821_r_02_012.pdf.

EPA 2002b. *Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms*. EPA-821-R-02-013, US Environmental Protection Agency, Washington, DC. Retrieved April 17, 2021, from https://www.epa.gov/sites/production/files/2015-08/documents/short-term-chronic-freshwater-wet-manual_2002.pdf.

EPA 2009a. *Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act*. EPA 841-B-09-001, US Environmental Protection Agency, Washington, DC. https://www.epa.gov/sites/default/files/2015-09/documents/eisa-438.pdf.

EPA 2009b. *Performance Specification 16 for Predictive Emissions Monitoring Systems and Amendments to Testing and Monitoring Provisions*. US Environmental Protection Agency, Washington, DC. https://www.federalregister.gov/documents/2009/03/25/E9-6275/performance-specification-16-for-predictive-emissions-monitoring-systems-and-amendments-to-testing.

EPA 2014. *Laboratory Data Review for the Non-Chemist*. US Environmental Protection Agency, Region 9, San Francisco, California. https://clu-in.org/conf/tio/rcraexpert_100516/slides/Data-Review-Manual- 110114.pdf.

EPA 2017. *Technical Fact Sheet—Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA)*. EPA 505-F-17-001, US Environmental Protection Agency. https://www.epa.gov/sites/production/files/2017-12/documents/ffrrofactsheet_contaminants_pfos_pfoa_11-20-17_508_0.pdf.

EPA 2022a. *Phasedown of Hydrofluorocarbons: Establishing the Allowance Allocation and Trading Program under the AIM Act.* US Environmental Protection Agency, Washington, DC. Retrieved April 6, 2022, from https://www.federalregister.gov/documents/2021/10/05/2021-21030/phasedown-of-hydrofluorocarbons-establishing-the-allowance-allocation-and-trading-program-under-the.

EPA 2022b. "Lifetime Drinking Water Health Advisories for Four Perfluoroalkyl Substances." US Environmental Protection Agency, Federal Register, Vol. 87, No. 118. Approved June 21, 2022. Retrieved March 19, 2023, from https://www.govinfo.gov/app/details/FR-2022-06-21/summary.

EPA 2022c. "Fact Sheet: Draft 2022 Aquatic Life Ambient Water Quality Criteria for Perfluorooctanoic acid (PFOA) and Perfluorooctane Sulfonic Acid (PFOS)." EPA 842-D-22-005, US Environmental Protection Agency, Office of Water. Retrieved March 25, 2024, from https://www.epa.gov/system/files/documents/2022-04/pfoa-pfos-draft-factsheet-2022.pdf.

EPA 2024. *Criteria Air Pollutants*. US Environmental Protection Agency. February 2024. https://www.epa.gov/criteria-air-pollutants.

EPAct 2005. *Energy Policy Act of 2005*. Public Law 109-58.

EPCRA 1986. *Emergency Planning and Community Right-to-Know Act*. Title 42 US Code Chapter 116.

ISO 2004. *Environmental Management Systems—Requirements with Guidance for Use*. ISO 14001:2004, International Organization for Standardization. http://www.iso.org.

ISO 2015. *Environmental Management Systems—Requirements with Guidance for Use*. ISO 14001:2015, International Organization for Standardization. http://www.iso.org.

ISO 2017. *General Requirements for the Competence of Testing and Calibration Laboratories*. ISO/IEC 17025, International Organization for Standardization. Retrieved April 17, 2021, from https://www.iso.org/publication/PUB100424.html.

Matson et al. 2022. Matson, P. G., L. M. Stevenson, R. A. Efroymson, R. T. Jett, M. W. Jones, M. J. Peterson, and T. J. Mathews, "Variation in Natural Attenuation Rates of Polychlorinated Biphenyls (PCBs) in Fish from Streams and Reservoirs in East Tennessee Observed over a 35-Year Period." *Journal of Hazardous Materials* 438, 129427.

NEPA 1969. *National Environmental Policy*. Title 42 US Code Chapter 55.

NHPA 1966. *National Historic Preservation Act*. Public Law 89-665; Title 54 US Code §300101 et seq.

NRC 2000. *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*. NUREG-1575, Rev. 1/EPA 402-R-97-016, Rev. 1/DOE/EH-0624, Rev. 1, US Nuclear Regulatory Commission, US Environmental Protection Agency, US Department of Defense, and US Department of Energy, Washington, DC.

NRC 2009. *Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual (MARSAME)*. NUREG-1575, Supplement 1/EPA 402-R-09-001/DOE/HS-0004. US Nuclear Regulatory Commission, US Environmental Protection Agency, US Department of Defense, and US Department of Energy, Washington, DC.

Pelletier 1995. Pelletier, R. F., "Application of DOE 5400.5 Requirements for Release and Control of Property Containing Residual Radioactive Material," correspondence to distribution. US Department of Energy, Office of Environmental Policy and Assistance, Washington, DC.

RCRA 1976. "Resource Conservation and Recovery Act." *US Code of Federal Regulations* Title 40 Parts 239–282.

SARA 1986. *The Superfund Amendments and Reauthorization Act.* Public Law 99-499. https://www.congress.gov/bill/99th-congress/house-bill/2005.

Souza et al. 2001. Souza, P. A., G. D. DuVall, and M. J. Hart. *Cultural Resource Management Plan, DOE Oak Ridge Reservation, Anderson and Roane Counties, Tennessee.* DOE/ORO/2085, US Department of Energy, Washington, DC.

TDEC 2010a. *Proposed Total Maximum Daily Loads (TMDLs) for Polychlorinated Biphenyls (PCBs) and Chlordane in Melton Hill Reservoir: Lower Clinch River Watershed (HUC 06010207), Anderson, Knox, Loudon, and Roane Counties, Tennessee*. Tennessee Water Pollution Control Board, Division of Water Pollution Control, Nashville, Tennessee.

TDEC 2010b. *Proposed Total Maximum Daily Loads (TMDLs) for Polychlorinated Biphenyls (PCBs) and Chlordane in Watts Bar Reservoir: Watts Bar Lake Watershed (HUC 06010201), Lower Clinch River Watershed (HUC 06010207), and Emory River Watershed (HUC 06010208), Loudon, Meigs, Morgan, Rhea, and Roane Counties, Tennessee*. Tennessee Water Pollution Control Board, Division of Water Pollution Control, Nashville, Tennessee.

TDEC 2010c. *Proposed Total Maximum Daily Loads (TMDLs) for Polychlorinated Biphenyls (PCBs) in Fort Loudoun Reservoir: Fort Loudoun Lake Watershed (HUC 06010201), Blount, Knox, and Loudon Counties, Tennessee*. Tennessee Water Pollution Control Board, Division of Water Pollution Control, Nashville, Tennessee.

TDEC 2020. "Public Water Systems." *Rules of Tennessee Department of Environment and Conservation Division of Water Resources*. Chapter 0400-45-01. Tennessee Department of Environment and Conservation, Bureau of Environment, Division of Water Supply, Nashville, Tennessee. https://publications.tnsosfiles.com/rules/0400/0400-45/0400-45-01.20190217.pdf.

TDEC 2021a. "Underground Storage Tank Program." *Rules of Tennessee Department of Environment and Conservation*. Chapter 0400-18-01. Tennessee Department of Environment and Conservation, Division of Underground Storage Tanks, Nashville, Tennessee.

TDEC 2021b. *Quality System Standard Operating Procedure for Macroinvertebrate Stream Surveys.* DWR-WP-P-01-QSSOP-Macroinvert-122821, Tennessee Department of Environment and Conservation, Division of Water Resources, Nashville, Tennessee. https://www.tn.gov/content/dam/tn/environment/water/policy-and-guidance/DWR-PAS-P-01-Quality_System_SOP_for_Macroinvertebrate_Stream_Surveys-122821.pdf.

TDEC 2024a. "Use Classifications for Surface Waters." *Rules of the Tennessee Department of Environment and Conservation.* Chapter 0400-40-04. Tennessee Department of Environment and Conservation, Bureau of Environment, Division of Water Supply, Nashville, Tennessee. https://publications.tnsosfiles.com/rules/0400/0400-40/0400-40-04.20240317.pdf.

TDEC 2024b. "General Water Quality Criteria." *Rules of the Tennessee Department of Environment and Conservation.* Chapter 0400-40-03. Tennessee Department of Environment and Conservation, Bureau of Environment, Division of Water Supply, Nashville, Tennessee. https://publications.tnsosfiles.com/rules/0400/0400-40/0400-40-03.20240317.pdf.

TSCA 1976. *Toxic Substances Control Act.* Title 15 US Code §2601 et seq. https://www.epa.gov/laws-regulations/summary-toxic-substances-control-act).

UCOR 2024. *FY 2024 Cleanup Progress: Annual Report on Oak Ridge Reservation Cleanup.* OREM-23-7632, US Department of Energy Oak Ridge Office of Environmental Management, Oak Ridge, Tennessee. Retrieved April 26, 2025, from https://ucor.com/wp-content/uploads/2024/12/Cleanup_Progress_2024.pdf.



The Tennessee Wildlife Resources Agency has conducted annual turkey hunts on the Oak Ridge Reservation since 1997. Harvested turkeys are screened before release to evaluate potential radiation doses to consumers. Since 1977, less than 0.34 percent of harvested turkeys have been retained because of potential radiation contamination.

6

Oak Ridge Reservation Environmental Monitoring Program

ORR environmental surveillance is conducted to comply with DOE requirements to protect the public and the environment against undue risks associated with DOE activities. These requirements are established in DOE Order 458.1, *Radiation Protection of the Public and the Environment* (DOE 2020), and related guidance is provided in *Environmental Radiological Effluent Monitoring and Environmental Surveillance* (DOE 2015). The objective of the ORR environmental surveillance program is to characterize environmental conditions in areas outside the ORR facility boundaries, both on and off ORR.

6.1. Meteorological Monitoring

Eight meteorological towers provide data on meteorological conditions and on the transport and diffusion qualities of the atmosphere on ORR. Data collected at the towers are used in routine dispersion modeling to predict impacts from facility operations and as input to emergency response atmospheric models, which are used for simulated and actual accidental releases from a facility. Data from the towers are also used to support various research and engineering projects. Additionally, ORNL and Y-12 operate three wind profilers on ORR to better characterize upper-level winds (winds higher than 60 m above ground level).

6.1.1. Data Collection and Analysis

The eight meteorological towers on ORR are described in Table 6.1 and depicted in Figure 6.1. In this document, ORR towers are designated by "MT" followed by a numeral. Other commonly used names for these towers are provided in Table 6.1. Meteorological data are collected at different heights above the ground (1, 2, 3, 10, 15, 30, 33, 35, and 60 m) to assess the vertical structure of the atmosphere, particularly with respect to wind shear and stability. Stable boundary

layers and significant wind shear zones associated with the local ridge-and-valley terrain and the Great Valley of Eastern Tennessee (see Appendix B) can significantly affect the movement of a plume after a facility release (Bowen et al. 2000). Data are collected at 10 or 15 m at most towers, but the wind measurement height is 25 m for MT11 and 20 m for MT13. Data are collected at some towers at 30, 33, 35, and 60 m. Temperature, relative humidity, and precipitation are measured at most sites at 2 m, but wind speed and wind direction typically are not. Atmospheric stability (a measure of the vertical mixing properties of the atmosphere) is measured at most towers; however, measurements involving vertical temperature profiles (i.e., measurements made by the solar radiation delta-T method) limit accurate determination of nighttime stability to the 60 m towers. The solar radiation delta-T method is a stability calculation that involves the temperature difference between 15 and 30 m heights, 15 m wind speeds, and the solar radiation value. Stability is also calculated for most sites using the sigma phi method, which relies heavily on the measurement of the standard deviation of vertical wind speed using 3D sonic wind monitors. Barometric pressure is measured at one or more of the towers at each ORR site (MT2, MT4, MT6, MT9, MT12, and MT13). Precipitation is measured at MT6 and MT9 at the Y-12 Complex; at MT13 at ETTP; and at MT2, MT3, MT4, and MT12 at ORNL. Solar radiation is measured at MT6 and MT9 at the Y-12 Complex and at MT2, MT4, and MT12 at ORNL. Instrument calibrations are managed by UT-Battelle, LLC, and are performed every 6 months by qualified instrument technicians. Additionally, Holian Environmental audits the Y-12-owned towers (MT6, MT9, and MT11) every 3 months.

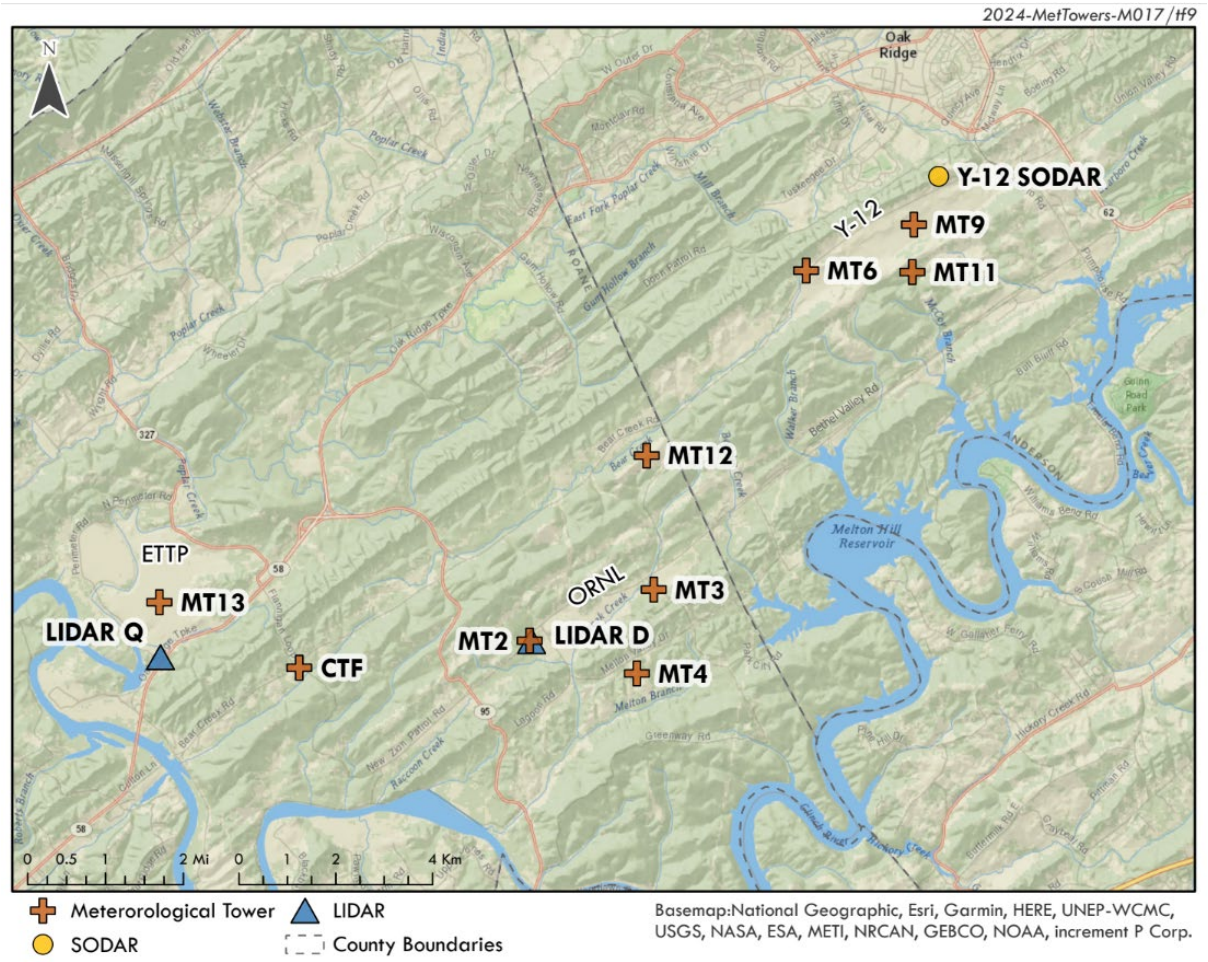
Table 6.1. ORR meteorological towers

Tower	Alternate tower names	Location (latitude, longitude)	Altitude above MSL (m)	Measurement heights (m)
		ETTP		
MT13	J, YEOC	35.93043N, −84.39346W	237	20
		ORNL		
MT2	D,[a] 1047	35.92559N, −84.32379W	261	1, 2, 15, 35, 60
MT3	B, 6555	35.93273N, −84.30254W	256	15, 30
MT4	A, 7571	35.92185N, −84.30470W	266	1, 3, 15, 30
MT12	F	35.95285N, −84.30314W	354	10
		Y-12 Complex		
MT6	W, West	35.98058N, −84.27358W	326	2, 10, 30, 60
MT9	Y, PSS Tower	35.98745N, −84.25363W	290	2, 15, 33
MT11	S, South Tower	35.98190N, −84.25504W	352	25

[a] *Tower "C" before May 2014.*

Acronyms:

ETTP = East Tennessee Technology Park
MSL = mean sea level
ORNL = Oak Ridge National Laboratory
ORR = Oak Ridge Reservation
PSS = plant shift superintendent
Y-12 Complex = Y-12 National Security Complex
YEOC = Y-12 Complex Emergency Operations Center



Acronyms:

CTF = Central Training Facility
ETTP = East Tennessee Technology Park
LIDAR = light detection and ranging
ORNL = Oak Ridge National Laboratory
ORR = Oak Ridge Reservation
SODAR = sonic detection and ranging
Y-12 = Y-12 National Security Complex

Figure 6.1. The ORR meteorological monitoring network, including light and sonic detection and ranging devices and the Central Training Facility sensor

Sonic detection and ranging (SODAR) devices have been installed at the east end of the Y-12 Complex (Pine Ridge). The SODAR devices use acoustic waves to estimate wind direction, wind speed, and turbulence at altitudes higher than the reach of meteorological towers (40–800 m above ground level). Although SODAR measurements are somewhat less accurate than measurements made on the meteorological towers, the SODAR devices provide useful information regarding stability, upper-air winds, and mixing depth. Mixing depth is the thickness of the air layer adjacent to the ground over which an emitted or entrained inert nonbuoyant tracer could be mixed by turbulence within 1 h. Similar to SODAR but slightly more accurate, light detection and ranging (LIDAR) is a remote sensing technology that uses lasers to measure meteorological conditions.

Meteorological data are collected in real time from the meteorological towers at 2 min, 15 min, and 1 h average intervals for emergency response purposes and for dispersion modeling at the ORNL and Y-12 Complex Emergency Operations Centers.

Annual dose estimates are calculated using the archived hourly data. Data quality is checked continuously against predetermined data constraints, and out-of-range parameters are marked as invalid and excluded from compliance modeling. Appropriate substitution data are identified when possible. Quality assurance records of missing and erroneous data are routinely kept for the eight ORR towers.

6.1.2. Results

Prevailing winds generally flow up-valley from the southwest and west-southwest or down-valley from the northeast and east-northeast, patterns that typically result from channeling effects produced by the parallel ridges flanking the ORR sites. Winds in the valleys tend to follow the ridge axes, limiting cross-ridge flow within local valley bottoms. These conditions dominate over most of ORR, but flow variation is greater at ETTP, which is located within a less constrained open valley bottom.

On ORR, low wind speeds dominate near the valley surfaces largely because of the decelerating influence of nearby ridges and mountains. Wind acceleration is sometimes observed at ridgetop level, particularly when flow is not parallel to the ridges (see Appendix B).

The atmosphere over ORR is often characterized by stable conditions at night and for a few hours after sunrise. These conditions, when coupled with low wind speeds and channeling effects in the valleys, result in poor dilution of emissions from the facilities. However, high roughness values (caused by terrain and obstructions such as trees and buildings) may significantly mitigate these factors by increasing turbulence (atmospheric mixing). These features are captured in dispersion model data input and are reflected in modeling studies conducted for each facility.

Precipitation data from MT2 have previously been used in streamflow modeling and in certain research efforts. The data indicate the variability of regional precipitation: the high winter rainfall resulting from frontal systems and the uneven but occasionally intense summer rainfall associated with frequent air mass thunderstorms. The total precipitation at ORNL during 2024 (1,227.9 mm, or 48.34 in.) was about 15 percent below the long-term 1991–2020 average of 1,417.8 mm (55.80 in.). The average annual wind data recovery rates (a measure of acceptable data) during 2024 were greater than 96 percent for MT3, MT4, and MT12. Tower MT2 was down a portion of the year because of maintenance and updates but still recorded a recovery rate greater than 70 percent in 2024. Missing data at tower MT2 were corrected through profiling and substitution along with consideration of ambient meteorological measurements and synoptic weather by on-site meteorologists.

6.2. Ambient Air Monitoring

In addition to exhaust stack monitoring conducted at ORR installations (see Chapters 3, 4, and 5), ambient air monitoring is performed to measure radiological parameters directly in the ambient air adjacent to the facilities (Figure 6.2). Ambient air monitoring provides a means to verify that contributions of fugitive and diffuse sources are insignificant, serves as a check on dose-modeling calculations, and would enable the determination of contaminant levels at monitoring locations in the event of an emergency.



Figure 6.2. ORR ambient air station

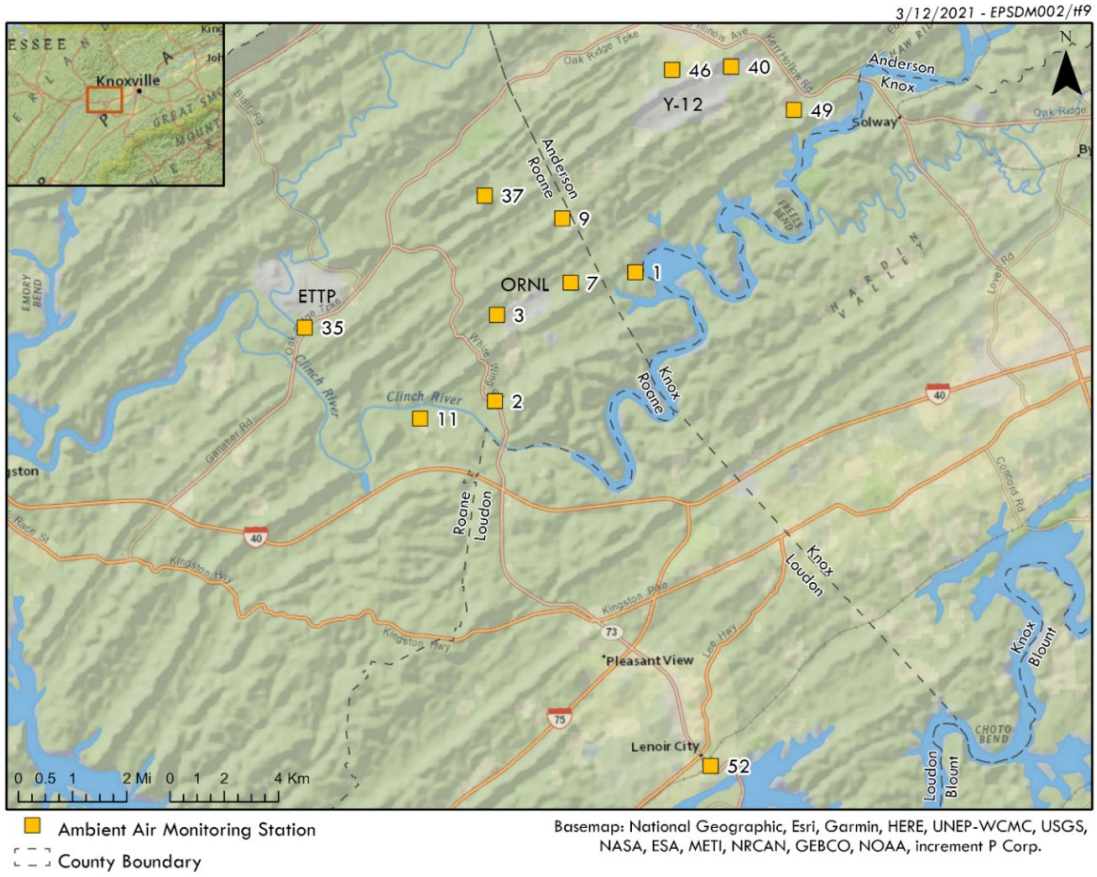
6.2.1. Data Collection and Analysis

Ambient air monitoring conducted by individual site programs is discussed in Chapters 3, 4, and 5. The ORR ambient air monitoring program complements the individual site programs and enables the impacts of ORR operations to be assessed on an integrated basis.

The objectives of the ORR ambient air monitoring program are to perform surveillance of airborne radionuclides at the reservation perimeter and to collect reference data from a location not affected by activities on ORR. The perimeter air monitoring network was established in the early 1990s and was modified in 2016 in response to changes in DOE activities and operations since the 1990s. The stations monitored in 2024 are shown in Figure 6.3. Reference samples are collected at Station 52 (Fort Loudoun Dam). Sampling was conducted at each ORR station during 2024 to quantify levels of alpha-, beta-, and gamma-emitting radionuclides.

Atmospheric dispersion modeling was used to select appropriate sampling locations likely to be affected most by releases from the Oak Ridge facilities. Therefore, in the event of a release, no residence or business near ORR should receive a radiation dose greater than doses calculated at the sampled locations.

The sampling system at each ambient air monitoring station consists of two separate instruments. Particulates are captured by a high-volume air sampler equipped with a glass-fiber filter. The filters are collected weekly, composited quarterly, and then submitted to an analytical laboratory to quantify gross alpha and gross beta activity and to determine the concentrations of specific isotopes of interest on ORR. The second instrument is designed to collect tritiated water vapor. The sampler consists of a prefilter followed by an adsorbent trap that contains indicating silica gel. The samples are collected weekly or biweekly, composited quarterly, and then submitted to an analytical laboratory for ^{3}H analysis.



Notes:

1. *Reference samples are collected at Station 52 (Fort Loudoun Dam).*
2. *Station 7 is an ORNL site-specific monitoring location and is not part of the ORR perimeter network.*

Acronyms:

ETTP = East Tennessee Technology Park
ORNL = Oak Ridge National Laboratory
ORR = Oak Ridge Reservation
Y-12 = Y-12 National Security Complex

Figure 6.3. Locations of ORR perimeter air monitoring stations

6.2.2. Results

Data from the ORR ambient air network are analyzed to assess the impact of DOE operations on the local air quality. Each measured radionuclide concentration (Table 6.2) is compared with derived concentration standards (DCSs) for air established by DOE as guidelines for controlling exposure to members of the public (DOE 2021a). All radionuclide concentrations measured at the ORR ambient air stations during 2024 were less than 1 percent of applicable DCSs.

6.3. External Gamma Radiation Monitoring

Members of the public could hypothetically be exposed directly to gamma radiation from radionuclides released into the environment, from previously released radionuclides deposited on soil and vegetation or in sediments, from radiation-generating facilities (especially high-energy accelerators), and from the storage of radioactive materials (DOE 2021b). Continuous direct radiation levels are monitored at locations around ORR to complement the sample data collected as part of the ORR ambient air monitoring program (see Section 6.2).

Table 6.2. Radionuclide concentrations at ORR perimeter air monitoring stations sampled quarterly, 2024

Station	Average concentration (pCi/mL)[a] (Number detects/*n*)											
	^{7}Be	^{214}Bi	^{3}H	^{40}K	^{210}Pb	^{212}Pb	^{214}Pb	^{99}Tc	^{208}Tl	$^{233/234}$U	$^{235/236}$U	^{238}U
01[b]	3.02E-08 (4/4)		5.38E-06 (3/4)	2.13E-10 (1/4)	1.58E-08 (3/4)					4.06E-11 (4/4)	2.37E-12 (2/4)	3.59E-11 (4/4)
02	2.68E-08 (4/4)	6.62E-11 (1/4)	6.36E-06 (4/4)	2.31E-10 (0/4)	1.83E-08 (4/4)	3.42E-11 (1/4)				3.31E-11 (4/4)	2.24E-12 (2/4)	3.89E-11 (4/4)
03	2.92E-08 (4/4)	9.01E-11 (1/4)	1.44E-05 (3/4)	9.32E-10 (2/4)	1.59E-08 (3/4)	3.80E-11 (1/4)	4.86E-11 (1/4)		2.44E-11 (1/4)	3.98E-11 (4/4)	4.11E-12 (2/4)	3.61E-11 (4/4)
09	2.81E-08 (4/4)	1.03E-10 (1/4)	1.77E-05 (4/4)	1.64E-09 (3/4)	2.22E-08 (4/4)		9.59E-11 (1/4)			4.10E-11 (4/4)	3.35E-12 (3/4)	3.49E-11 (4/4)
11	2.85E-08 (4/4)		5.83E-06 (3/4)	1.06E-09 (2/4)	2.23E-08 (4/4)					3.47E-11 (4/4)	2.20E-12 (2/4)	3.61E-11 (4/4)
35	2.73E-08 (4/4)		5.61E-06 (3/4)	7.22E-10 (1/4)	4.99E-09 (1/4)			1.62E-09 (1/4)	1.50E-11 (1/4)	4.49E-11 (4/4)	2.40E-12 (1/4)	3.33E-11 (4/4)
37	2.91E-08 (4/4)		2.66E-06 (3/4)	9.21E-10 (2/4)	1.78E-08 (4/4)					3.42E-11 (4/4)	3.23E-12 (1/4)	3.94E-11 (4/4)
40	2.74E-08 (4/4)		2.70E-06 (3/4)	1.60E-09 (4/4)	1.99E-08 (3/4)					4.36E-11 (4/4)	3.15E-12 (3/4)	3.71E-11 (4/4)
46	3.07E-08 (4/4)		3.27E-06 (3/4)	1.16E-09 (2/4)	1.94E-08 (3/4)					3.50E-11 (4/4)	2.65E-12 (2/4)	3.66E-11 (4/4)
49	2.82E-08 (4/4)		1.89E-06 (2/4)	1.57E-09 (3/4)	1.88E-08 (4/4)					3.86E-11 (4/4)	2.06E-12 (1/4)	3.75E-11 (4/4)
52[c]	2.61E-08 (4/4)		1.46E-06 (1/4)	1.18E-09 (3/4)	1.08E-08 (2/4)			-4.36E-10 (0/4)		3.67E-11 (4/4)	2.67E-12 (2/4)	3.63E-11 (4/4)

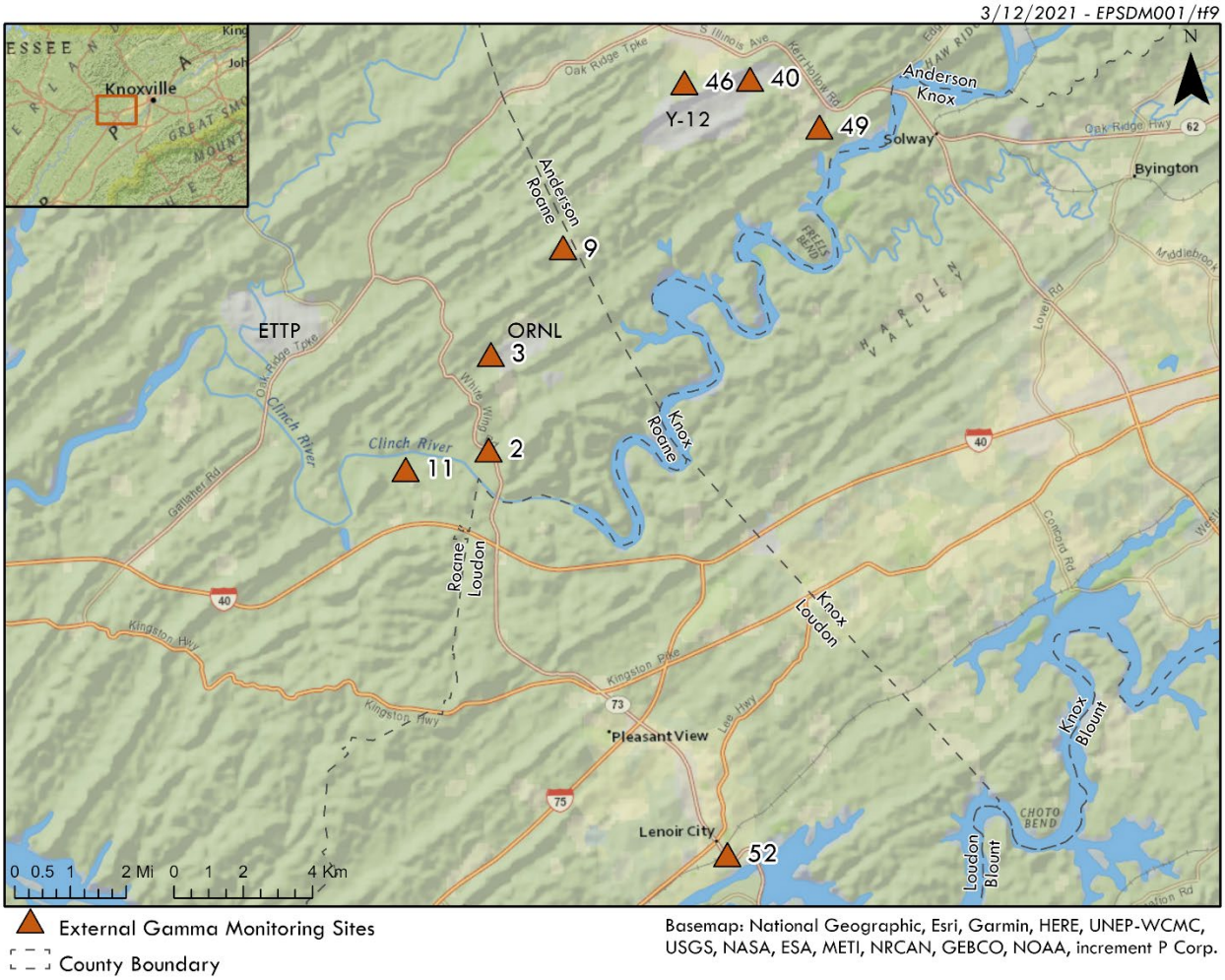
[a] *1 pCi = 3.7E-02 Bq.*
[b] *In one quarter of 2024, ^{60}Co was also detected at Station 01. The average concentration was 5.49E-11 pCi/mL.*
[c] *Station 52 is the reference location.*

6.3.1. Data Collection and Analysis

External gamma exposure rates are continuously recorded every minute by dual-range Geiger–Müller tube detectors colocated with ORR ambient air stations 2, 3, 9, 11, 40, 46, 49, and 52 (see Section 6.2). The data are downloaded weekly and are averaged for the entire year. Figure 6.4 shows locations that were monitored during 2024; Table 6.3 summarizes the data for each station.

6.3.2. Results

The mean exposure rate for the reservation network in 2024 was 9.3 µR/h, and the mean rate at the reference location (Fort Loudoun Dam) was 8.4 µR/h. Background direct radiation exposure rates have been collected at the Fort Loudoun Dam (Station 52) reference location for many years. From 2014 through 2023, the exposure rates at the reference location ranged from 8.0 to 11.4 µR/h and averaged 9.2 µR/h.



Note:
Reference samples are collected at Station 52 (Fort Loudoun Dam).

Acronyms:
ETTP = East Tennessee Technology Park
ORNL = Oak Ridge National Laboratory
ORR = Oak Ridge Reservation
Y-12 = Y-12 National Security Complex

Figure 6.4. External gamma radiation monitoring locations on ORR

Table 6.3. External gamma exposure rate averages for ORR, 2024

Air station number	Number of data points (daily)	Measurement (µR/h)[a]		
		Min	Max	Mean
02	359	7.6	9.8	8.4
03	359	8.0	10.2	8.8
09	366	8.0	16	9.0
11	360	8.5	11.3	9.8
40	366	8.3	10.7	9.5
46	362	9.1	11.5	10.2
49	365	8.3	11.1	9.3
52	366	7.6	9.8	8.4

[a] *To convert microroentgens per hour (µR/h) to milliroentgens per year, multiply by 8.760.*

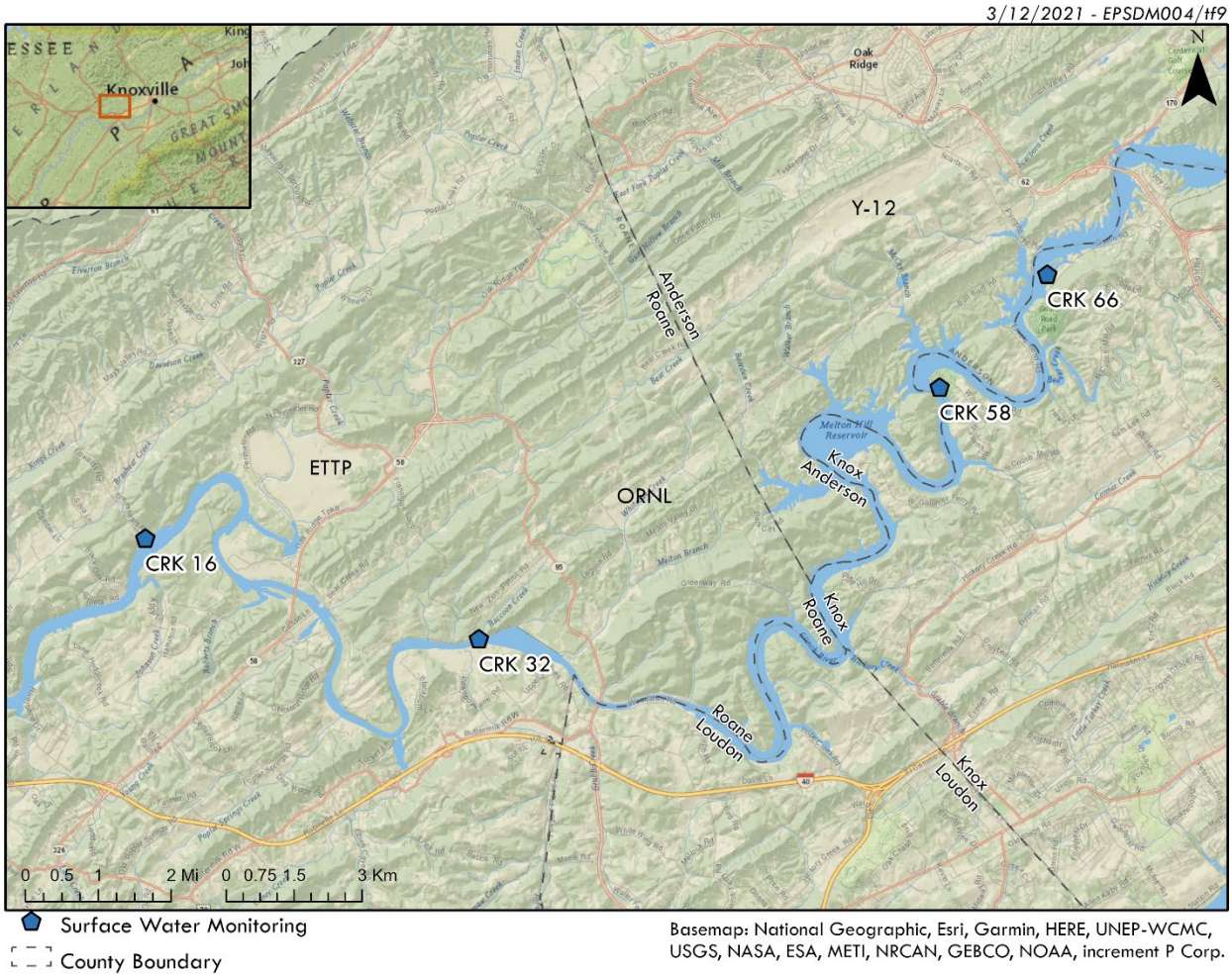
6.4. Surface Water Monitoring

The ORR surface water monitoring program consists of sample collection and analysis from four locations on the Clinch River, including public water intakes (Figure 6.5). The program is conducted in conjunction with site-specific surface water monitoring activities to enable an assessment of the impacts of past and current DOE operations on the quality of local surface water.

6.4.1. Data Collection and Analysis

Grab samples are collected quarterly at all four locations and are analyzed for general water quality parameters, screened for radioactivity, and analyzed for mercury and specific radionuclides when appropriate. Table 6.4 lists the locations and associated sampling frequencies and parameters.

In 2022, a more sensitive analytical method for determining mercury concentrations in surface water samples was adopted. The new method can detect concentrations near 0.2 ng/L, whereas the detection limit for the previous method is about 67 ng/L. As expected, the ability to detect mercury at much lower levels resulted in detections in 8 of the 12 surface water samples collected for mercury analyses in 2024, while in the past, with the less sensitive method, mercury was rarely detected. At the sampling locations, the Clinch River is classified by the State of Tennessee for multiple uses, including recreation and domestic water supply (TDEC 2024a). These two designated uses have numeric Tennessee water quality criteria (WQCs) related to protection of human health. The WQCs are used as references where applicable (TDEC 2024b). The Tennessee WQCs do not include criteria for radionuclides. Four percent of the DOE DCS is used as the criterion for radionuclide comparison (DOE 2021a).



Acronyms:

CRK = Clinch River kilometer
ETTP = East Tennessee Technology Park
ORNL = Oak Ridge National Laboratory
ORR = Oak Ridge Reservation
Y-12 = Y-12 National Security Complex

Figure 6.5. ORR surface water surveillance sampling locations

6.4.2. Results

In 2024, as has been the case since 2009, no statistical differences were found in the concentrations of routinely monitored radionuclides in surface water samples collected from the Clinch River upstream and downstream of DOE inputs. No radionuclides were detected above 4 percent of the respective DCSs.

Mercury was detected in 8 of the 12 samples collected in 2024, including one sample from the location upstream of DOE inputs (Clinch River kilometer [CRK] 66). Results from one sample collected from CRK 32 were below the method detection level. The annual mean mercury concentration at the location downstream of DOE inputs (CRK 16) was statistically significantly higher than the mean concentration at the location upstream of DOE inputs (CRK 66). However, detected mercury results at all locations were well below the Tennessee mercury WQC for recreational use (51 ng/L).

Table 6.4. ORR surface water sampling locations, frequencies, and parameters, 2024

Location[a]	Description	Frequency	Parameters
CRK 16	Clinch River downstream from all DOE ORR inputs	Quarterly	Mercury, gross alpha, gross beta, gamma scan, ^{3}H, field measurements[b]
CRK 32	Clinch River downstream from ORNL	Quarterly	Mercury, gross alpha, gross beta, gamma scan, total radioactive strontium, ^{3}H, field measurements[b]
CRK 58	Water supply intake for Knox County	Quarterly	Gross alpha, gross beta, gamma scan, ^{3}H, field measurements[b]
CRK 66	Melton Hill Reservoir above City of Oak Ridge water intake	Quarterly	Mercury, gross alpha, gross beta, gamma scan, total radioactive strontium, ^{3}H, field measurements[b]

[a] *Locations indicate the water body and distances upstream of the confluence of the Clinch and Tennessee Rivers (e.g., CRK 16 is 16 km upstream from the confluence of the Clinch River with the Tennessee River in the Watts Bar Reservoir).*

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

Acronyms:
CRK = Clinch River kilometer
DOE = US Department of Energy
ORNL = Oak Ridge National Laboratory
ORR = Oak Ridge Reservation

6.5. Groundwater Monitoring

Work continued in 2024 to implement key recommendations from the *Groundwater Strategy for the U.S. Department of Energy Oak Ridge Reservation* (DOE 2013), which was agreed to in 2014 by DOE, EPA, and the Tennessee Department of Environment and Conservation (TDEC). Work performed during 2024 under the ORR Groundwater Program included preparation of a report on the installation of and data obtained during the first year of sampling from three multizone exit pathway groundwater monitoring wells in west Bethel Valley adjacent to the Clinch River (DOE 2024a). Work continued on site-scale groundwater flow models for ETTP.

6.5.1. Off-Site Groundwater Assessment

During fiscal year (FY) 2024, the Oak Ridge Office of Environmental Management 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 Oak Ridge Office of Environmental Management program, including sampling at six multiport monitoring wells in western Melton Valley (wells 4537, 4538, 4539, 4540, 4541, and 4542). The results of this monitoring are summarized in the *2025 Remediation Effectiveness Report* (DOE 2025).

DOE completed an off-site groundwater assessment project and issued a final report in October 2017 (DOE 2017). The project was a cooperative effort among the parties to the ORR Federal Facility Agreement to investigate off-site groundwater quality and potential movement. To follow up on work from the off-site groundwater assessment, DOE conducts annual sampling and analysis of groundwater from several off-site residential wells and springs. Off-site groundwater data are summarized in the *2025 Remediation Effectiveness Report* (DOE 2025).

6.5.2. Regional and Site-Scale Flow Model

During FY 2017, DOE completed a project to construct and calibrate a regional-scale groundwater flow model that encompasses ORR and adjacent areas. The regional model provides a framework to support creation of smaller, site-scale groundwater flow models for use in planning and monitoring the effectiveness of future cleanup decisions and actions. During FY 2024, DOE continued developing a groundwater flow and

solute transport model for the ETTP site to support Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA 1980) groundwater decision-making and conducted groundwater flow modeling for the Molten Salt Reactor Experiment site to support the development of a CERCLA decision for components of that facility not included in a previous CERCLA decision.

6.6. Food

Food sources are analyzed to evaluate potential radiation doses to consumers of local food crops, fish, and harvested game and to monitor trends in environmental contamination and possible long-term accumulation of radionuclides. Samples of hay, vegetables, milk, fish, deer, Canada geese, and turkeys are usually collected every year from areas that could be affected by activities on the reservation and from off-site reference locations. Milk was not collected in 2024 because no dairies were found in potential ORR deposition areas. Surveys are conducted annually to determine whether any dairies are operating in areas of interest.

The wildlife administrative release limits associated with deer, turkeys, and geese harvested on ORR are conservative and were established based on the "as low as reasonably achievable" principle to ensure that doses to consumers are managed at levels well below regulatory dose thresholds. This concept is not a dose limit but rather a philosophy that has the objective of maintaining exposures to workers, members of the public, and the environment below regulatory limits and as low as can be reasonably achieved. The administrative release limit of 5 pCi/g ^{137}Cs is based on the assumption that one person consumes all of the meat from a maximum-weight deer, goose, or turkey. This limit ensures that members of the public who harvest wildlife on the reservation will not receive significant radionuclide doses from that consumption pathway. In addition, a conservative administrative limit of 1.5 times background for gross beta activity has been established. This threshold is near the detection limit for field measurements of $^{89/90}$Sr in deer leg bone.

6.6.1. Hay

Eating beef and drinking milk obtained from cattle that eat hay are potential radiation exposure pathways to humans. Hay is sampled annually to characterize possible doses from this pathway.

6.6.1.1. Data Collection and Analysis

Hay from the eastern edge of ORR, which historically has been cut for off-site use, has been sampled since 2015 but was not harvested there in 2024. Therefore, a sample was collected from a location southwest of ORNL when hay was cut for off-site use there in December 2024. Analyses for gross alpha, gross beta, gamma emitters, and uranium isotopes were performed.

6.6.1.2. Results

No gamma-emitting radionuclides were detected above the minimum detectable activity except for the naturally occurring radionuclide ^{40}K. Uranium isotopes were not detected above minimum detectable activities in any of the samples. Analytical results for hay samples are provided in Table 6.5.

6.6.2. Vegetables

Contaminants may reach vegetation by deposition of airborne materials, uptake from soil, and deposition of materials contained in irrigation water. As available, food crops are sampled annually from garden locations that have the potential to be affected by airborne releases from ORR to evaluate possible radiation doses to consumers. Vegetables are also sampled from a reference location for comparison. If available, crops that represent broad-leaf systems (e.g., lettuce, turnip greens), root-plant-vegetable systems (e.g., tomatoes), and root-system vegetables (e.g., turnips, potatoes) are obtained from each location and analyzed for radionuclides. Vegetable availability varies greatly from year to year.

Table 6.5. Concentrations of radionuclides detected in hay,[a] December 2024 (pCi/kg)[b]

Radionuclide	Result
Gross alpha	c
Gross beta	11,900
^{7}Be	c
^{40}K	14,000
^{234}U	c
^{235}U	c
^{238}U	c

[a] *Detected radionuclides are those at or above minimum detectable activity.*
[b] *1 pCi = 3.7 × 10^{-2} Bq.*
[c] *Value was less than or equal to minimum detectable activity.*

6.6.2.1. Data Collection and Analysis

In 2024, tomatoes were purchased from farms near ORR and from a reference location, and a mixture of kale, turnip greens, and cabbages was collected to represent broad-leaf systems. No root vegetables were available in 2024. The locations were chosen based on availability and the likelihood of being affected by routine releases from the Oak Ridge facilities. All vegetable samples were analyzed for gross alpha, gross beta, gamma emitters, and uranium isotopes.

6.6.2.2. Results

Analytical results for vegetable samples are provided in Table 6.6. No gamma-emitting radionuclides were detected above the minimum detectable activity except for the naturally occurring radionuclides ^{40}K and ^{7}Be.

6.6.3. Milk

Milk is a potentially significant exposure pathway to humans for some radionuclides deposited from airborne emissions because of the relatively large surface area on which a cow can graze daily, the rapid transfer of milk from producer to consumer, and the importance of milk in the diet. Since 2016, no dairies in potential ORR deposition areas have been located, and no milk samples have been collected. Surveys to identify dairies in potential deposition areas are conducted each year, and milk sampling will resume when dairy operations in appropriate areas are located.

6.6.4. Fish

Members of the public could be exposed to contaminants originating from DOE ORR activities by consuming fish caught in area waters. This potential exposure pathway is monitored annually by collecting fish from three locations on the Clinch River and by analyzing edible flesh for specific contaminants. The locations are as follows (Figure 6.6):

- Clinch River upstream from all DOE ORR inputs (CRK 70)
- Clinch River downstream from ORNL (CRK 32)
- Clinch River downstream from all DOE ORR inputs (CRK 16)

6.6.4.1. Data Collection and Analysis

Sunfish (*Lepomis macrochirus*, *L. auritus*, and *Ambloplites rupestris*) and catfish (*Ictalurus punctatus*) are collected from each of the three locations to represent both top-feeding and bottom-feeding predator species. In 2024, a composite sample of each of those species at each location was analyzed for selected metals; polychlorinated biphenyls (PCBs); ^{3}H; gross alpha; gross beta; gamma-emitting radionuclides; total radioactive strontium; and isotopes of americium, neptunium, plutonium, and thorium. To accurately estimate exposure levels to consumers, only edible portions of the fish were submitted for analysis. Once every 5 years, additional radiological analyses are performed to confirm the dose calculations (Chapter 7). In 2024, additional radionuclides analyzed in fish samples included uranium isotopes and ^{99}Tc. Results are presented in Table 6.7.

TDEC issues advisories on consumption of certain fish species caught in specified Tennessee waters. The advisories apply to fish that could contain potentially hazardous contaminants. TDEC has issued a "do not consume" advisory for catfish in

the entire Melton Hill Reservoir, not just in areas that could be affected by ORR activities, because of PCB contamination. Similarly, TDEC has issued a precautionary advisory for catfish in the Clinch River arm of Watts Bar Reservoir because of PCB contamination (TDEC 2023). TDEC also issues precautionary advisories for consumption of fish when mercury levels exceed 0.3 ppm (Denton 2007). As of 2023, the three locations on the Clinch River where ORR fish are collected do not have mercury "do not consume" advisories.

Table 6.6. Concentrations of radionuclides detected in tomatoes and leafy greens, 2024 (pCi/kg)[a]

Location	Gross alpha	Gross beta	^{7}Be	^{40}K	^{234}U	^{235}U	^{238}U
			Leafy greens[b]				
North of Y-12	c	2,060	314	2,450	c	c	0.784
East of ORNL	c	4,590	c	5,750	c	c	c
West of ETTP	c	4,210	c	5,740	c	c	c
South of ORNL	c	4,340	c	4,950	c	c	c
Reference location	c	11,400	c	14,100	16.3	c	c
			Tomatoes				
North of Y-12	c	1,960	c	3,090	c	c	c
East of ORNL	c	2,040	c	2,250	c	c	c
West of ETTP	c	1,760	c	2,630	c	c	c
South of ORNL	c	1,820	c	2,280	c	c	c
Reference location	c	2,340	c	2,760	c	c	c

[a] *Detected radionuclides are those at or above minimum detectable activity. 1 pCi = 3.7 × 10^{-2} Bq.*

[b] *Cabbage was collected at the North of Y-12 and West of ETTP locations, and a mixture of kale and turnip greens was collected at the East of ORNL, South of ORNL, and reference locations.*

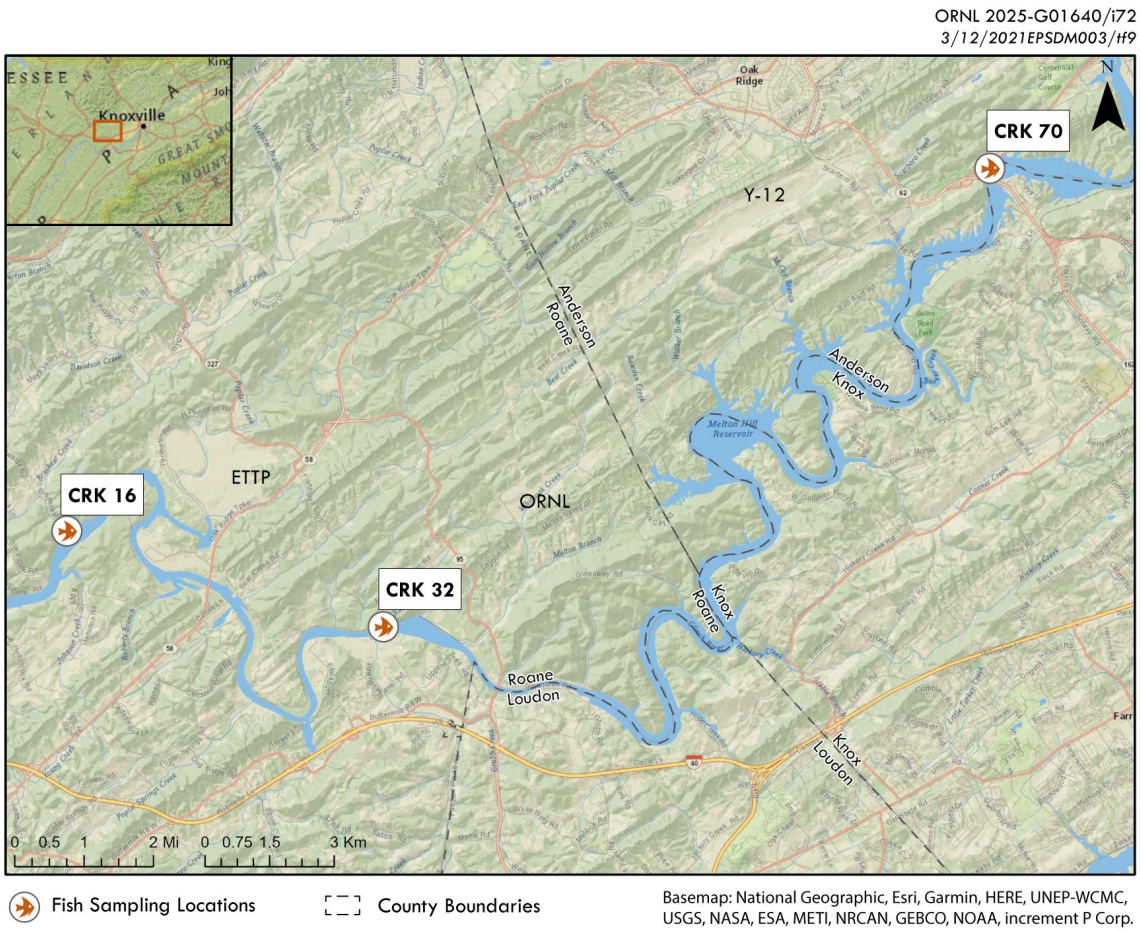
[c] *Value was less than or equal to minimum detectable activity.*

Acronyms:

ETTP = East Tennessee Technology Park

ORNL = Oak Ridge National Laboratory

Y-12 = Y-12 National Security Complex



Acronyms:

CRK = Clinch River kilometer
ETTP = East Tennessee Technology Park
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Figure 6.6. Fish sampling locations for the ORR surveillance program

Table 6.7. Tissue concentrations in catfish and sunfish for detected PCBs and radionuclides, 2024[a]

	CRK 16 Downstream		CRK 32		CRK 70 Upstream	
	Catfish	**Sunfish**	**Catfish**	**Sunfish**	**Catfish**	**Sunfish**
Metals (mg/kg)						
Mercury	c	c	c	c	B0.195[b]	c
PCBs (µg/kg)						
Aroclor 1248	28.7	c	c	c	c	c
Aroclor 1254	87.1	J9.11[d]	J17[d]	c	33.2	c
Aroclor 1260	70.5	J9.5[d]	22.7	c	44.6	c
Radionuclides (pCi/g)						
Beta activity	3.43	3.16	2.61	3.52	2.58	3.49
^{40}K	2.99	3.32	3.33	3.41	3.5	4.22

[a] *Only parameters that were detected for at least one species are listed in the table.*
[b] *"B" indicates that the analyte was detected in the associated method blank.*
[c] *Value was less than or equal to minimum detectable activity.*
[d] *"J" indicates that the result is an estimated value.*
Acronyms:
CRK = Clinch River kilometer
PCB = polychlorinated biphenyl

6.6.4.2. Results

PCBs, specifically Aroclors 1260 and 1254, were detected in sunfish at CRK 16 and in catfish at CRK 32 in 2024. Mercury was detected in catfish at CRK 70 upstream of DOE inputs; the lab reported that mercury was detected in the associated method blank, indicating this result may be biased high. Mercury was not detected above the minimum detectable level at any other location in 2024. These results are consistent with the TDEC advisories. Detected PCBs, mercury, and radionuclide concentrations are shown in Table 6.7.

6.6.5. White-Tailed Deer

In 2024, three quota deer hunts were conducted on ORR: November 2 and 3, November 9 and 10, and December 14 and 15. Each hunt was limited to 450 shotgun/muzzleloader permittees and 600 archery permittees. UT-Battelle staff; Tennessee Wildlife Resources Agency personnel; and student members of the Wildlife Society, University of Tennessee chapter, performed most of the necessary operations at the checking station.

6.6.5.1. Data Collection and Analysis

In 2024, approximately 23,000 acres were available to deer hunters in the Oak Ridge Wildlife Management Area, which encompasses some properties not owned by DOE, including Haw Ridge Park (City of Oak Ridge) and the University of Tennessee Arboretum.

6.6.5.2. Results

The total ORR deer harvest in 2024 was 192, of which 114 (~59.4 percent) were bucks and 78 (~40.6 percent) were does. The heaviest buck weighed 185 lb, the heaviest doe weighed 121 lb, and the greatest number of antler points was 11. No deer were retained for exceeding the administrative release limit of 1.5 times background for beta activity in bone (~20 pCi/g $^{89/90}$Sr) or for exceeding 5 pCi/g ^{137}Cs in edible tissue.

Compared with the deer harvests from 2020 to 2023, the 2024 total harvest of 192 was more consistent with prepandemic numbers. In 2019, the total harvest was 221 deer (~56.6 percent

bucks and ~43.4 percent does), the heaviest buck was 181 lb, the heaviest doe was 112 lb, and greatest number of antler points was 13.

Since 1985, 14,070 deer have been harvested from the Oak Ridge Wildlife Management Area, of which 220 (~2 percent) have been retained because of potential radiological contamination. The heaviest buck ever harvested weighed 218 lb (1998), and the heaviest doe ever harvested weighed 139 lb (1985). The average weight of all harvested deer is approximately 87 lb. (All weights are field-dressed weights.) The oldest deer harvested was a doe estimated to have been 12 years old (1989); the average age of all harvested deer is approximately 2 years. See the ORR hunt information website **here** for more information.

6.6.6. Waterfowl

The consumption of waterfowl is a potential pathway for exposing members of the public to radionuclides released from ORR operations. During the fall statewide season in 2024, Canada goose hunting was allowed on the Three Bend Area of ORR (shorelines only, excluding Gallaher Bend) 0.5 h before sunrise until noon on September 5, 10, 11, 17, and 18 and on October 8, 9, 15, and 16. Hunting was allowed for wood duck and teal on September 9 and 10.

6.6.6.1. Data Collection and Analysis

Canada geese are rounded up each summer for noninvasive gross radiological surveys to characterize concentrations of gamma-emitting radionuclides accumulated by waterfowl that feed and live on ORR.

6.6.6.2. Results

During the June 13, 2024, roundup on ORR, 22 geese (16 adults; 6 juveniles) were captured. All 22 captured geese were subjected to live whole-body gamma scans. Gamma scan results showed that all were well below the administrative release limit of 5 pCi/g ^{137}Cs.

6.6.7. Wild Turkey

Two wild turkey quota hunts were conducted April 13–14 and April 20–21. None of the 37 (34 adults; 3 juveniles) total turkeys harvested was retained for potential radiological contamination.

Since 1997, 1,007 turkeys have been harvested on spring turkey hunts. Twelve additional turkeys have been harvested since 2012 by archery hunters during fall deer hunts. The largest turkey ever harvested on ORR weighed 25.7 lb (harvested in 2009). Of all turkeys harvested, only three (less than 0.34 percent) have been retained because of potential radiological contamination: one in 1997, one in 2001, and one in 2005. Additional information is available on the ORR hunt website **here**.

6.7. Habitat Quality Improvement

Maintaining ecosystems; protecting natural areas; and ensuring functioning of support infrastructure, such as power and communications rights-of-way, roadways, and waterways, through active management are important not only in natural areas but in developed areas as well. ORR conservation needs include control of invasive, non-native plants and animals; restoration of pollinator habitats; forest restoration and conservation; and creation and management of mitigation areas. DOE created the *Conservation Action Plan* (DOE 2021c) to be updated annually; this plan includes climate adaptation and resilience research, fish and wildlife habitat conservation and restoration, and invasive plant and animal management, among other projects.

6.7.1. Invasive Plant Management

Invasive, non-native plant species are among the greatest ecological threats to the United States and around the world. Invasive plants can threaten forests, wetlands, cultural resources, and other resources by increasing the risk of fire and storm damage and by encroaching onto roads, railroads,

power structures, waterways, and agricultural sites. To address these threats, the Federal Noxious Weed Act (1974) was amended and incorporated into the Federal Plant Protection Act (2000). This act mandates federal agencies to develop and coordinate management programs to control invasive plants on lands under their respective jurisdictions and to adequately fund integrated pest management plans. The ORNL Natural Resources Management Program has maintained an invasive plant management plan for ORR since 2004. Details of federal and state laws and regulations driving this plan can be found in technical manuscripts ORNL/TM-2004/98 (Parr et al. 2004), ORNL/TM-2004/98/R1 (Quarles et al. 2011), and ORNL/TM-2004/98/R2 (McCracken and Giffen 2017).

ORNL/TM-2001/113, *Assessment of Nonnative Invasive Plants in the DOE Oak Ridge National Environmental Research Park* (Drake et al. 2002), details the results of extensive survey efforts. These and subsequent surveys have been performed to identify invasive plant problems on ORR. Data from the surveys are used to develop control plans identifying which invasive species to target and in which locations.

More than 1,100 species of plants are found on ORR, and of these, approximately 179 plant species are non-native. Fifty-nine aggressive non-native (invasive) plant species have been identified on ORR, but control efforts have been primarily focused on the subset of 12 species shown in Table 6.8. These target species have been found across ORR in disturbed areas; on power line and gas line rights-of-way; throughout riparian buffer zones; and along state highways, railroad lines, and remote-access fire roads. They have invaded natural areas to varying degrees, causing vast ecological harm in plant and animal communities. In concert with efforts to control the 12 highly invasive species, other invasive plant species are also targeted for control using *Early Detection and Rapid Response* (DOI 2020). In 2023 and 2024, two new incursions of aggressively invasive plant species, cogon grass (*Imperata cylindrical*) and coltsfoot (*Tussilago farfara*), were identified and treated on ORR. The locations where these incursions occurred were marked for future surveys and treatments.

Table 6.8. Twelve most problematic invasive plants on ORR

Common name	Scientific name
Japanese grass, Nepal grass	*Microstegium vimineum*
Japanese honeysuckle	*Lonicera japonica*
Chinese privet	*Ligustrum sinense*
Kudzu	*Pueraria montana*
Multiflora rose	*Rosa multiflora*
Tree of heaven	*Ailanthus altissima*
Autumn olive	*Elaeagnus umbellate*
Oriental bittersweet	*Celastrus orbiculatus*
Princess tree	*Paulownia tomentosa*
Winter creeper	*Euonymus hederaceus*
Bradford/Callery pear	*Pyrus calleryana*
Mimosa	*Albizia julibrissin*

The 32,800-acre DOE ORR consists mostly of undeveloped land, including forests, wetlands, open waterways, riparian buffer zones, and several hundred acres of grassland communities and fallow fields. Three major developed facilities lie within ORR boundaries—ORNL, the Y-12 Complex, and ETTP. Surrounding these developed facilities and interspersed throughout ORR are safety and security areas, utility corridors, access roads, research and education areas, cultural and historic preservation sites, waste burial grounds, monitoring sites, fire roads, emergency evacuation corridors, new facility construction and laydown areas, and public use areas. This multiplicity of land uses presents challenges for effectively preventing and managing invasive species.

Numerous DOE contractors have responsibilities for managing portions of ORR land, as do other federal and state agencies such as the Tennessee Valley Authority and the Tennessee Wildlife Resources Agency. A portion of the ORR Natural Resources Management Team's annual funding is designated for creation and implementation of an invasive plant management plan, which focuses mainly on control efforts in natural areas and

reference areas. However, efforts also include controlling specific invasive plant incursions into locations within and surrounding the campuses of developed facilities on ORR. The *Invasive Plant Management Plan for the Oak Ridge Reservation* (Parr et al. 2004) and its two subsequent revisions (Quarles et al. 2011; McCracken and Giffen 2017) explain options for addressing the problem of invasive plants on ORR and discuss selection of appropriate control measures. Areas selected for invasive plant control tend to cover several acres or are spread out across portions of ORR. Use of select herbicides is the most cost-effective treatment method in most cases, and the invasive plants present determine which herbicides will be most effective without harming surrounding native plant and animal habitats. Controlled burns are used in combination with herbicide applications to clear native grasslands, forest understory, kudzu infestations, and other select vegetation. Clearing these areas allows native plant regeneration and facilitates herbicide spot treatments in subsequent years. ORR fire protection and management programs are discussed in Section 6.8.

Invasive plant control on ORR has been conducted annually since 2003. Table 6.9 indicates the extent of annual invasive plant treatments.

Table 6.9. Annual invasive plant control on ORR, 2003–2024

Year	Area treated
2003	98 acres
2004	136 acres
2005	125 acres
2006	254 acres
2007	236 acres
2008	427 acres
2009	526 acres
2010	884 acres
2011	806 acres
2012	615 acres
2013	329 acres
2014	950 acres
2015	629 acres
2016	952 acres
2017	542 acres + 47 road miles
2018	507 acres + 53 road miles
2019	450 acres + 57 road miles
2020	400 acres + 65 road miles
2021	400 acres + 51 road miles
2022	266 acres + 77 road miles
2023	260 acres + 84 road miles
2024	348 acres + 75 road miles

Invasive plant management activities were completed in 2024 at the following ORR locations:

- Portions of First Creek and White Oak Creek riparian buffer zones, including the White Oak Lake weir
- Bethel Valley Road and Old Bethel Valley Road
- Haw Ridge former 3rd Street steam line and utility right-of-way access roads
- Fire protection roads across ORR
- Bethel Valley Road native grasslands
- Three Bend Wildland and Conservation Area fields, field edges, and roads, including the Gallaher Bend kudzu area
- Tower Shielding Facility roadsides and forest edges
- Pine Ridge and Chestnut Ridge overlooking the Y-12 campus (kudzu control)
- Midway Turnpike
- Gum Branch Road, McNew Hollow Road, Old County Road, and Watson Road
- Filled coal ash pond and slough kudzu area
- Wheat Church vista and trails
- Black Oak Ridge Conservation Easement roads, North Boundary Greenway, Raby Road, Gheen Road, North Boundary Road, and Poplar Creek Road
- McKinney Ridge kudzu and Blair Quarry kudzu areas
- Black Oak Ridge kudzu areas, including Black Oak Ridge Conservation Easement east and west kudzu areas
- Melton Valley Drive kudzu area
- Portions of the ETTP Perimeter Road kudzu area
- Other roads and areas

6.7.2. Wetlands

Wetland determinations and delineations are conducted to facilitate compliance with TDEC and US Army Corps of Engineers wetland protection requirements. In 2024, two determinations and delineations were completed on the ORNL campus to ensure project activities did not adversely affect wetlands. One was included in an Aquatic Resource Alteration Permit. A third wetland determination and delineation was completed off-site at the Black Oak Ridge Conservation Area to help facilitate and support ORNL research.

6.8. Fire Protection Management and Planning

Wildland fire management is an important part of DOE's overall management of ORR. A comprehensive wildfire management program has been established and implemented for the entire ORR. The *Oak Ridge Reservation Wildland Fire Management Plan* (WFMP) (DOE 2024b) assigns responsibilities for wildland fire management and is reviewed every 3 years and revised as needed. The *Oak Ridge Reservation Wildland Fire Implementation Plan* (DOE 2024c) contains details on program implementation. The WFMP was prepared to satisfy the requirements of DOE Order 420.1C, Change 3, *Facility Safety* (DOE 2019); DOE-STD-1066-2023, *Fire Protection* (DOE 2023); and relevant portions of Chapters 19 through 23 in National Fire Protection Association 1140, *Standard for Wildland Fire Protection* (NFPA 2022).

The WFMP outlines the overall goals and strategies necessary to manage, plan for, and respond to fire in the wildland areas of ORR and to reduce the risk of wildland fire to personnel and facilities on ORR and to the public. The WFMP is reviewed at least annually.

The WFMP applies to all DOE employees, contractors, and subcontractors working on ORR and to all DOE ORR tenant activities. The DOE ORR federal manager is responsible for ORR wildland fire management activities.

The primary goal of the WFMP is to lower the overall risk of wildland fire on ORR by conducting fire prevention activities and actions to reduce the spread of a fire should one start. Another goal of

the WFMP is to contain wildfires that do start to the ORR unit of origin by conducting suppression activities.

The WFMP is implemented by multiple organizations, including non-DOE entities such as the City of Oak Ridge and the Tennessee Department of Agriculture Division of Forestry. Memorandums of understanding that ensure collaboration among organizations are maintained for each organization that provides firefighting support on ORR.

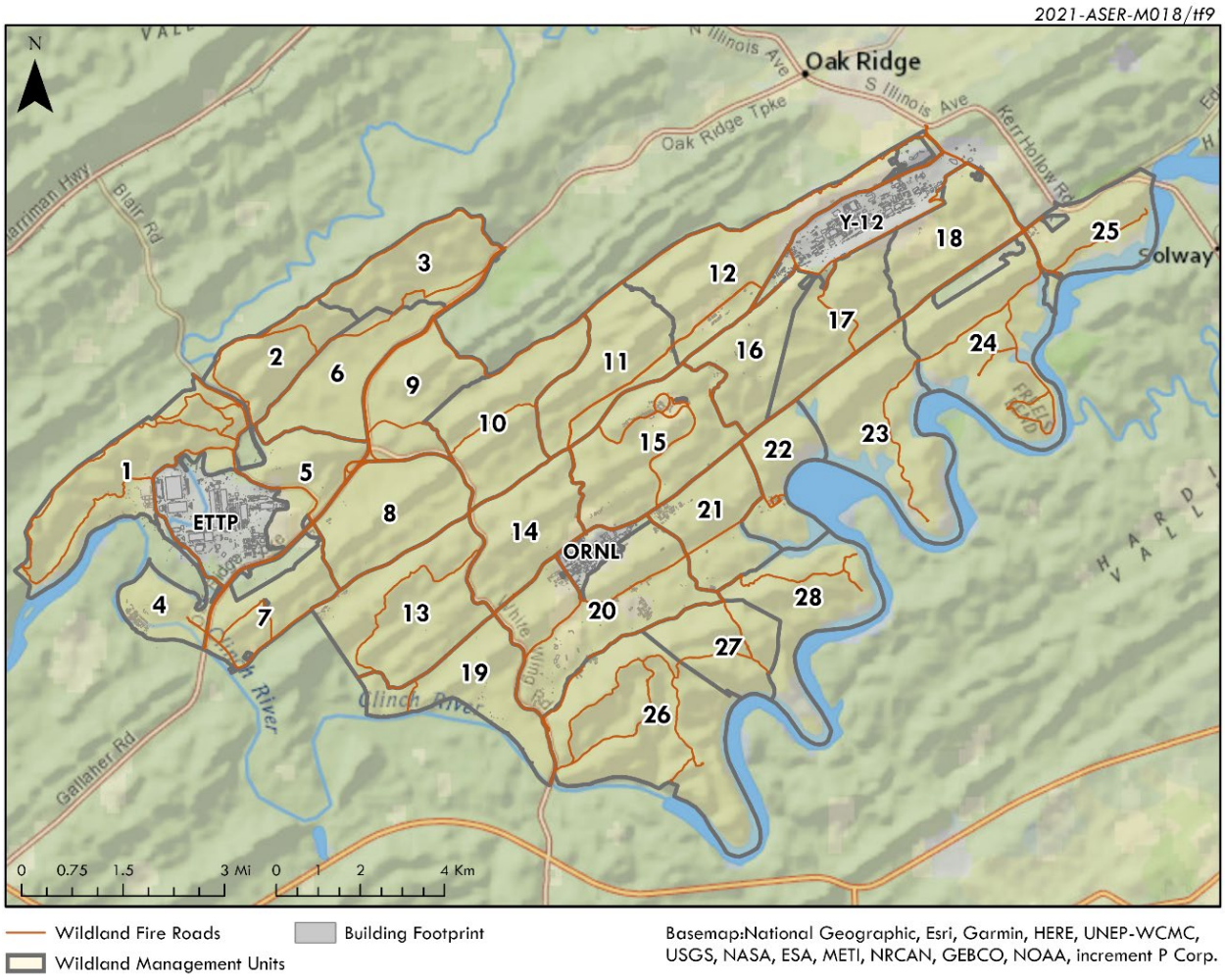
DOE actions associated with wildland fire management include the following:

- Controlling ignition sources in the wildland areas, particularly on days when fire danger is forecasted
- Managing wildfire fuels in and near developed areas
- Developing and implementing controlled burning plans authorized by the DOE ORR federal manager
- Preparing and updating wildland fire preplans that include maps of fuel types, topographic features, roads, cultural resources, sensitive natural resources, contamination areas, and potential hazards
- Developing stakeholder involvement plans in support of the wildland fire program
- Reviewing current data to determine the potential for wildland fire, including indications of wildland fire risk
- Preparing a wildland fire risk report, including a wildland fire hazard severity analysis based on the *Standard for Wildland Fire Protection* (NFPA 2022)
- Maintaining a wildland fire road grid to support fire detection, containment, and suppression
- Conducting tabletop wildland fire exercises at least once every 3 years and full-scale exercises at least once every 5 years
- Incorporating wildland fire mitigation and response activities and procedures into the ORR land-use planning process

The DOE roads and grounds contractor is responsible for establishing and maintaining the wildland fire roads, many of which delineate wildland management units (Figure 6.7), and for maintaining barricades that control access to ORR secondary roads. The management contractors at ORNL and Y-12 are responsible for providing personnel and equipment for initial response to wildland fire events and for establishing incident command. The City of Oak Ridge at Heritage Center has entered into a mutual aid agreement with DOE to provide assistance for wildland fire activities. The Tennessee Division of Forestry has entered into a memorandum of understanding to provide trained personnel and heavy equipment, including fire plows, when requested to assist with wildland fires on ORR.

Because ORR is a large (32,258.54 acres), mostly forested property with access restrictions, it is a challenge for site emergency personnel to maintain familiarity with all remote areas and back roads and to recognize and assess concerns associated with those areas quickly. Wildland management unit prefire plans are designed to aid responders who may or may not be familiar with an area.

The prefire plans are concise documents for each of the 28 ORR wildland management units (Figure 6.7) that summarize access issues, assets, and hazard concerns. Each plan includes the wildland management unit's name and identification number, its general location within ORR, and its boundaries and size. Important information and hazard descriptions are listed early in the document, followed by guidance on tactics, access, vegetation and fuels, water sources, topographic considerations, and hazard controls. Plan maps depict access points, utilities, hazards, research areas, fuel types, water sources, urban interface areas, and sensitive resources. Prefire plans are reviewed on a 3-year cycle and are updated as significant changes occur.



Acronyms:

ETTP = East Tennessee Technology Park
ORNL = Oak Ridge National Laboratory
ORR = Oak Ridge Reservation
Y-12 = Y-12 National Security Complex

Figure 6.7. Wildland management units on ORR

Copies of the plans are kept in responder vehicles for immediate reference during remote events and are available to site fire departments and emergency operations centers, shift superintendent offices, and appropriate management staff. The plans are easily updated, stored, and shared electronically. They are meant to enable quick decisions but not to dictate tactics. The ORR forester is the point of contact for plan distribution.

The 2016 Great Smoky Mountains wildfires, also known as the Gatlinburg wildfires, demonstrated that large fires, although more frequent in western states, can occur on or near ORR. Issues related to wildland and urban interface areas are a growing concern. These areas may be characterized by relatively high housing density and increasing recreational use by the public. DOE has prioritized interface areas and has conducted controlled wildfire fuel reduction burns to limit the spread of fire to and from the community. The presence of dense pine forests increases community vulnerability to potential high-intensity wildfires. Actions to protect these areas include thinning or replacing dense pine growth, mechanical treatments to thin younger pine proactively, and mulching heavy logging slash and insect-damaged timber to interrupt fuel beds.

During 2024, collaborative efforts were undertaken to reduce wildfire fuel hazards near developed areas at the ORR border. DOE partnered with the Tennessee Division of Forestry and one of its incident management teams to safely remove accumulations of woody storm debris and standing hazard trees and install additional firebreaks. The 2-week collaboration involved more than 50 state forestry personnel, 15 pieces of heavy equipment, and 40 support vehicles. The Tennessee Division of Forestry installed over 15 miles of firebreaks, removed 48 truckloads of wood debris, and performed 38 acres of fuel reduction. This effort also enabled Tennessee Division of Forestry staff to practice emergency preparedness and gain familiarity with ORR, where the division is a mutual-aid firefighting partner. These actions supplemented an ongoing series of controlled burns to proactively reduce fuel loads in the nearby forest.

6.9. Quality Assurance

UT-Battelle performs the activities associated with administration, sampling, data management, and reporting for ORR environmental surveillance programs. Project scope is established by a task team whose members represent DOE, UT-Battelle, Consolidated Nuclear Security LLC, and UCOR. UT-Battelle integrates quality assurance, environmental, and safety considerations into every aspect of ORR environmental monitoring. (See Chapter 5, Section 5.7, for a detailed discussion of UT-Battelle quality assurance program elements for environmental monitoring and surveillance activities.)

6.10. References

Bowen et al. 2000. Bowen, B. M., J. A. Baars, and G. L. Stone, "Nocturnal Wind Shear and Its Potential Impact on Pollutant Transport." *Journal of Applied Meteorology* 39(3), 437–45.

CERCLA 1980. *Comprehensive Environmental Response, Compensation, and Liability Act.* Title 42 US Code Chapter 103.

Denton 2007. Denton, G. M., *Mercury Levels in Tennessee Fish.* Tennessee Department of Environment and Conservation, Nashville, Tennessee. https://www.tn.gov/content/dam/tn/environment/water/documents/fishmercurylevels.pdf.

DOE 2013. *Groundwater Strategy for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee*. Volume 1. Main Text. DOE/OR/01-2628/V1&D1, US Department of Energy Office of Environmental Management, Washington, DC. (PDF version available through online catalog at http://doeic.science.energy.gov/.)

DOE 2015. *Environmental Radiological Effluent Monitoring and Environmental Surveillance*. DOE-HDBK-1216-2015, US Department of Energy, Washington, DC. Retrieved May 18, 2021, from https://www.standards.doe.gov/standards-documents/1200/1216-bhdbk-2015.

DOE 2017. *Offsite Groundwater Assessment Remedial Site Evaluation, Oak Ridge, Tennessee*. DOE/OR/01-2715&D2_R, US Department of Energy Office of Environmental Management, Washington, DC.

DOE 2019. *Facility Safety*. DOE Order 420.1C, US Department of Energy, Washington, DC. Retrieved June 15, 2021, from https://www.directives.doe.gov/directives-documents/400-series/0420.1-BOrder-C-chg3-ltdchg.

DOE 2020. *Radiation Protection of the Public and the Environment***.** DOE Order 458.1, US Department of Energy, Washington, DC.

DOE 2021a. *Derived Concentration Technical Standard*. DOE-STD-1196-2021, US Department of Energy, Washington, DC. Retrieved March 28, 2022, from https://www.standards.doe.gov/standards-documents/1100/1196-astd-2021/@@images/file.

DOE 2021b. *Environmental Monitoring Plan for the Oak Ridge Reservation, Calendar Year 2021*. DOE/ORO-228/R12, US Department of Energy Office of Science, Washington, DC. Retrieved April 11, 2021, from https://doeic.science.energy.gov/ASER/ORR_EMP_CY2021_Final.pdf.

DOE 2021c. *U.S. Department of Energy Conservation Action Plan: Report to the White House Council on Environmental Quality*. US Department of Energy, Washington, DC.

DOE 2023. *Fire Protection*. DOE-STD-1066-2023, US Department of Energy, Washington, DC. https://www.standards.doe.gov/standards-documents/1000/1066-astd-2023/@@images/file.

DOE 2024a. *Melton Valley/Bethel Valley Exit Pathway Phase 1 Remedial Investigation Completion Report for the U.S. Department of Energy Oak Ridge Site Oak Ridge, Tennessee*. DOE/OR/01-2953&D2, US Department of Energy, Oak Ridge Office of Environmental Management, Oak Ridge, Tennessee.

DOE 2024b. *Oak Ridge Reservation Wildland Fire Management Plan.* US Department of Energy Office of Science, Washington, DC.

DOE 2024c. *Oak Ridge Reservation Wildland Fire Implementation Plan.* US Department of Energy Office of Science, Washington, DC.

DOE 2025. *2025 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Site Oak Ridge, Tennessee: Data and Evaluations*. DOE/OR/01-2989&D1, Prepared by the Water Resources Restoration Program, UCOR for the US Department of Energy Office of Environmental Management, Oak Ridge, Tennessee.

DOI 2020. *Early Detection and Rapid Response.* National Invasive Species Council, US Department of the Interior, Washington, DC. Retrieved April 20, 2021, from https://www.doi.gov/invasivespecies/early-detection-and-rapid-response.

Drake et al. 2002. Drake, S. J., J. F. Weltzin, and P. D. Parr, *Assessment of Nonnative Invasive Plants in the DOE Oak Ridge National Environmental Research Park.* ORNL/TM-2001/113, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Federal Noxious Weed Act of 1974. Public Law 93-629 (7 U.S.C. 2801 et seq.; 88 Stat. 2148).

Federal Plant Protection Act of 2000. Public Law 106-224, Title IV (7 U.S.C. 7701 et seq). https://www.govinfo.gov/content/pkg/STATUTE-114/pdf/STATUTE-114-Pg358.pdf#page=1.

McCracken and Giffen 2017. McCracken, M. K., and N. R. Giffen, *Invasive Plant Management Plan for the Oak Ridge Reservation*. ORNL/TM-2004/98/R2, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

NFPA 2022. *Standard for Wildland Fire Protection*. NFPA 1140, National Fire Protection Association, Quincy, Massachusetts. https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=1140.

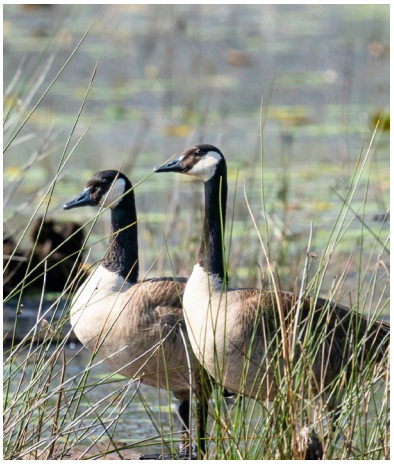
Parr et al. 2004. Parr, P. D., M. G. Ryon, H. D. Quarles, N. R. Giffen, M. S. Salk, and J. W. Webb, *Invasive Plant Management Plan for the Oak Ridge Reservation*. ORNL/TM-2004/98, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Quarles et al. 2011. Quarles, H. D., M. S. Salk, P. D. Parr, M. G. Ryon, and N. R. Giffen, *Invasive Plant Management Plan for the Oak Ridge Reservation.* ORNL/TM-2004/98/R1, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

TDEC 2023. *Posted Streams, Rivers, and Reservoirs in Tennessee*. Tennessee Department of Environment and Conservation, Division of Water Resources, Nashville, Tennessee. https://www.tn.gov/content/dam/tn/environment/water/watershed-planning/wr_wq_fish-advisories.pdf.

TDEC 2024a. "Use Classifications for Surface Waters." *Rules of the Tennessee Department of Environment and Conservation.* Chapter 0400-40-04. Tennessee Department of Environment and Conservation, Bureau of Environment, Division of Water Supply. https://publications.tnsosfiles.com/rules/0400/0400-40/0400-40-04.20240317.pdf.

Rules of the Tennessee Department of Environment and Conservation. Chapter 0400-40-03. Tennessee Department of Environment and Conservation, Bureau of Environment, Division of Water Supply. https://publications.tnsosfiles.com/rules/0400/0400-40/0400-40-03.20240317.pdf.



Radionuclides discharged to surface waters on ORR can potentially reach members of the public who use the Clinch and Tennessee Rivers for fishing, swimming, boating, or drinking water. Water and fish samples are collected at several locations on the Clinch River and are analyzed to ensure that members of the public are not exposed to harmful levels of radioactivity.

Photo by Carlos Jones

7

Dose

Activities on ORR can result in the release of small quantities of radionuclides and hazardous chemicals into the environment that have the potential to expose members of the public. Monitoring of materials released from ORR and environmental monitoring and surveillance on and around the reservation provide data used to show that doses from released radionuclides and chemicals are in compliance with applicable laws and regulations.

In 2024, a hypothetical maximally exposed individual (MEI) would have received an effective dose (ED) of about 0.6 mrem from radionuclides emitted to the atmosphere from all ORR sources; this is well below the National Emission Standards for Hazardous Air Pollutants for Radionuclides standard of 10 mrem/year for protection of the public (40 CFR Part 61, Subpart H).

A worst-case analysis of exposures to waterborne radionuclides for all pathways combined gives a maximum possible individual ED of about 0.3 mrem. This dose is based on a person eating 42 kg/year (93 lb/year) of fish, drinking 953 L/year (252 gal/year) of drinking water, using the shoreline for 60 h/year, swimming 30 h/year, boating 63 h/year, and irrigating food or feed crops.

In addition, if a person consumed one maximum-weight harvested deer, one maximum-weight harvested turkey, and three maximum-weight harvested geese, all containing the maximum ^{137}Cs concentration, that person could have received an ED of about 3 mrem. This calculation provides an estimated upper-bound ED from consuming wildlife harvested from ORR.

Therefore, the annual dose for 2024 to an MEI from the combined exposure pathways is estimated to have been about 4 mrem. No significant doses from discharges of radioactive constituents from ORR other than those reported are known. DOE Order 458.1, *Radiation Protection of the Public and the Environment* (DOE 2020), limits the ED that a member of the public may receive from all radionuclide exposure pathways during 1 year to no more than 100 mrem. The 2024 maximum ED from ORR is about 4 percent of the DOE Order 458.1 limit.

The potential doses to aquatic and terrestrial biota from contaminated soil and water were evaluated using a graded approach. Results of the screening calculations indicate that contaminants released from ORR site activities do not have a significant adverse impact on aquatic or terrestrial biota.

7.1. Radiation Dose

Small quantities of radionuclides were released to the environment from operations at ORR facilities in 2024. Those releases are described, characterized, and quantified in previous chapters of this report. This chapter presents estimates of potential radiation doses to the public from the releases. Dose estimates were obtained using measured and estimated release data, environmental monitoring and surveillance data, estimated exposure conditions that tend to maximize calculated doses, and environmental transport and dosimetry codes that may also overestimate the calculated doses. Therefore, dose calculations are likely overestimates of the doses received by actual people in the ORR vicinity.

7.1.1. Terminology

Exposures to radiation from nuclides located outside the body are called *external exposures*; exposures to radiation from nuclides deposited inside the body are called *internal exposures*. This distinction is important because external exposures occur only when a person is near or in a radionuclide-containing medium, whereas internal exposures continue while the radionuclides remain inside a person. Also, external exposures may result in uniform irradiation of the entire body, including all organs, whereas internal exposures usually result in nonuniform irradiation of the body and organs because most radionuclides deposit preferentially in specific organs or tissues. Several specialized terms and units used to characterize exposures to ionizing radiation are defined in Appendix E.

ED is a risk-based dose equivalent that is used to estimate health effects or risks to exposed persons. It is a weighted sum of dose equivalents to specified organs and is expressed in rem or sieverts (1 rem = 0.01 Sv). Regardless of radiation type or method of delivery, 1 rem of ED has the same total radiological (and biological) risk effect. Because the doses discussed here are very small, EDs are expressed in millirem (mrem), which is one one-thousandth of a rem. (See Appendix E for a comparison and description of various dose levels.)

7.1.2. Methods of Evaluation

The following sections summarize the pathways evaluated and methods used to determine potential EDs to members of the public and to aquatic and terrestrial biota from radionuclides originating from ORR. Dose estimates were calculated using radionuclide concentrations measured in samples collected on or near ORR, estimated release data, and computer models.

7.1.2.1. Airborne Radionuclides

The radiological consequences of radionuclides released into the atmosphere from ORR operations during 2024 were characterized by calculating EDs to maximally exposed on- and off-site members of the public and to the entire population residing within 80 km (50 miles) of the center of ORR. The calculations were performed for each major facility and for the entire ORR. The dose calculations were performed using the Clean Air Act Assessment Package—1988 (CAP-88 PC) Version 4 (EPA 2015), a software program developed under EPA sponsorship to demonstrate compliance with 40 *Code of Federal Regulations* (CFR) Part 61, Subpart H, which governs the emissions of radionuclides other than radon from DOE facilities. CAP-88 PC implements a steady-state Gaussian plume atmospheric dispersion model to calculate concentrations of radionuclides in the air and on the ground and uses food chain models to calculate radionuclide concentrations in foodstuffs (e.g., vegetables, meat, and milk) and subsequent intakes by humans.

In this assessment, adult dose coefficients were used to estimate doses in CAP-88 PC. The coefficients are weighted sums of equivalent doses to 12 specified tissues or organs plus a remainder

term that accounts for the rest of the tissues and organs in the body.

A total of 28 emission points on ORR were modeled during 2024: 3 (2 combined) points at Y-12, 24 points at ORNL, and 1 point at ETTP. Table 7.1 lists the emission point parameter values and receptor locations used in the dose calculations.

Meteorological data used in the calculations for 2024 were in the form of joint frequency distributions of wind direction, wind speed class, and atmospheric stability category. (See Table 7.2 for a summary of tower locations used to model the various sources.) During 2024, rainfall, as averaged over the six rain gauges located on ORR, was about 119 cm (47 in.). The average air temperature was 15.7°C (60.2°F) at the 10 to 15 m levels. The average mixing layer height (i.e., the depth of the atmosphere adjacent to the surface within which air is mixed) was 591.6 m (1,941 ft) for ETTP, 569.6 m (1,869 ft) for ORNL, and 591.6 m (1,941 ft) for Y-12. For occupants of residences, the dose calculations assumed that the occupant remained at home during the entire year and obtained food according to the rural pattern. This pattern specifies that 70 percent of the vegetables and produce, 44 percent of the meat, and 40 percent of the milk consumed are produced in the local area (e.g., a home garden). The remaining portion of each food category was assumed to have been produced within 80 km (50 miles) of ORR. The same assumptions were used for occupants of businesses, but the resulting doses were divided by 2 to compensate for the fact that businesses are occupied for less than half a year and less than half of a worker's food intake occurs at work. For collective ED estimates, production of beef, milk, and crops within 80 km (50 miles) of ORR was calculated using the production rates provided with CAP-88 PC Version 4.

Table 7.1. Emission point parameters and receptor locations used in the dose calculations, 2024

Source	Stack height (m)	Stack diameter (m)	Effective exit gas velocity (m/s)[a]	Distance (m) and direction to the maximally exposed individual			
				From each site		From ORR	
			ORNL				
X-laboratory hoods							
X-1000	15	0.5	0	4,490	SW	11,260	NE
X-2000	15	0.5	0	4,840	SW	10,910	NE
X-3000	15	0.5	0	5,240	SW	10,510	NE
X-4000	15	0.5	0	5,430	SW	10,360	NE
X-6000	15	0.5	0	6,010	SW	9,800	NE
X-7000	15	0.5	0	5,560	WSW	10,750	NNE
X-2026	22.9	1.05	6.38	4,940	SW	10,790	NE
X-2099	3.66	0.18	7.05	4,940	SW	10,800	NE
X-3001	6.86	0.44	13.06	5,140	SW	10,590	NE
X-3020	61	1.22	15.07	5,100	SW	10,630	NE
X-3026-East	0.81	0.97	0[b]	5,170	SW	10,580	NE
X-3026-West	0.81	0.97	0[b]	5,170	SW	10,580	NE
X-3039	74.68	2.53	4.99	5,180	SW	10,570	NE
X-3525	17.25	0.35	9.39	5,120	SW	10,650	NE
X-3571	3.35	0.29	0b	5,080	SW	10,700	NE
X-3608 filter press	8.99	0.36	9.27	5,110	SW	10,720	NE

Table 7.1. Emission point parameters and receptor locations used in the dose calculations, 2024 (continued)

Source	Stack height (m)	Stack diameter (m)	Effective exit gas velocity (m/s)[a]	Distance (m) and direction to the maximally exposed individual			
				From each site		From ORR	
ORNL (continued)							
X-4501	23.47	0.69	15.34	5,370	SW	10,410	NE
X-7503	30.5	0.91	13.24	5,560	WSW	10,600	NNE
X-7830 group	4.6	0.25	9.78	4,230	WSW	12,130	NNE
X-7856-CIP	18.29	0.48	9.37	4,250	WSW	12,190	NNE
X-7877	13.9	0.41	13.56	4,210	WSW	12,180	NNE
X-7880	27.7	1.52	15.50	4,170	WSW	12,200	NNE
X-7911	76.2	1.52	13.05	5,520	WSW	10,810	NNE
X-7935 building stack	15.24	0.51	24.27	5,510	WSW	10,740	NNE
X-7935 glove box	9.14	0.25	0[b]	5,510	WSW	10,740	NNE
X-7966	6.10	0.29	10.82	5,580	WSW	10,660	NNE
X-7977B	5.03	0.02	1.04	5,610	WSW	10,770	NNE
X-8915	104.0	1.22	6.37	8,140	SW	7,580	NE
X-decom areas	15	0.5	0	5,470	SW	10,310	NE
ETTP							
K-1407-AL CWTS	2.74	0.15	0[b]	270	SSW	14,770	ENE
Y-12 Complex							
Y-monitored	20	0.5	0	2,270	NE	2,270	NE
Y-unmonitored processes	20	0.5	0	2,270	NE	2,270	NE
Y-unmonitored lab hoods	20	0.5	0	2,270	NE	2,270	NE

[a] *Exit gas temperatures are ambient air temperatures.*

[b] *The direction of exhaust is horizontal. Therefore, an exit velocity of 0 m/s is used.*

Acronyms:

CIP = Capacity Increase Project
CWTS = Chromium Water Treatment System
decom = decommissioned
ETTP = East Tennessee Technology Park
ORNL = Oak Ridge National Laboratory
ORR = Oak Ridge Reservation
Y-12 Complex = Y-12 National Security Complex

Table 7.2. Meteorological towers and heights used to model atmospheric dispersion from source emissions, 2024

Tower	Height (m)	Source
		Y-12 Complex
MT6 (West Y-12)	30	All Y-12 sources
		ETTP
MT13 (Tower J)	20	K-1407-AL CWTS
		ORNL
MT4 (Tower A)	15	X-7830 group, X-7935 glove box, X-7966, 7977B, and X-7000 lab hoods
	30	X-7503, X-7856-CIP, X-7877, X-7880, X-7911, and X-7935 building stack
MT3 (Tower B)	15	X-6000 lab hoods
MT2 (Tower D)	15	X-2099, X-3001, X-3026-East, X-3026-West, X-3571, X-3608 FP, X-decom hoods, X-1000, X-2000, X-3000, and X-4000 lab hoods
	35	X-2026, X-3525, and X-4501
	60	X-3020 and X-3039
MT12 (Tower F)	10	X-8915

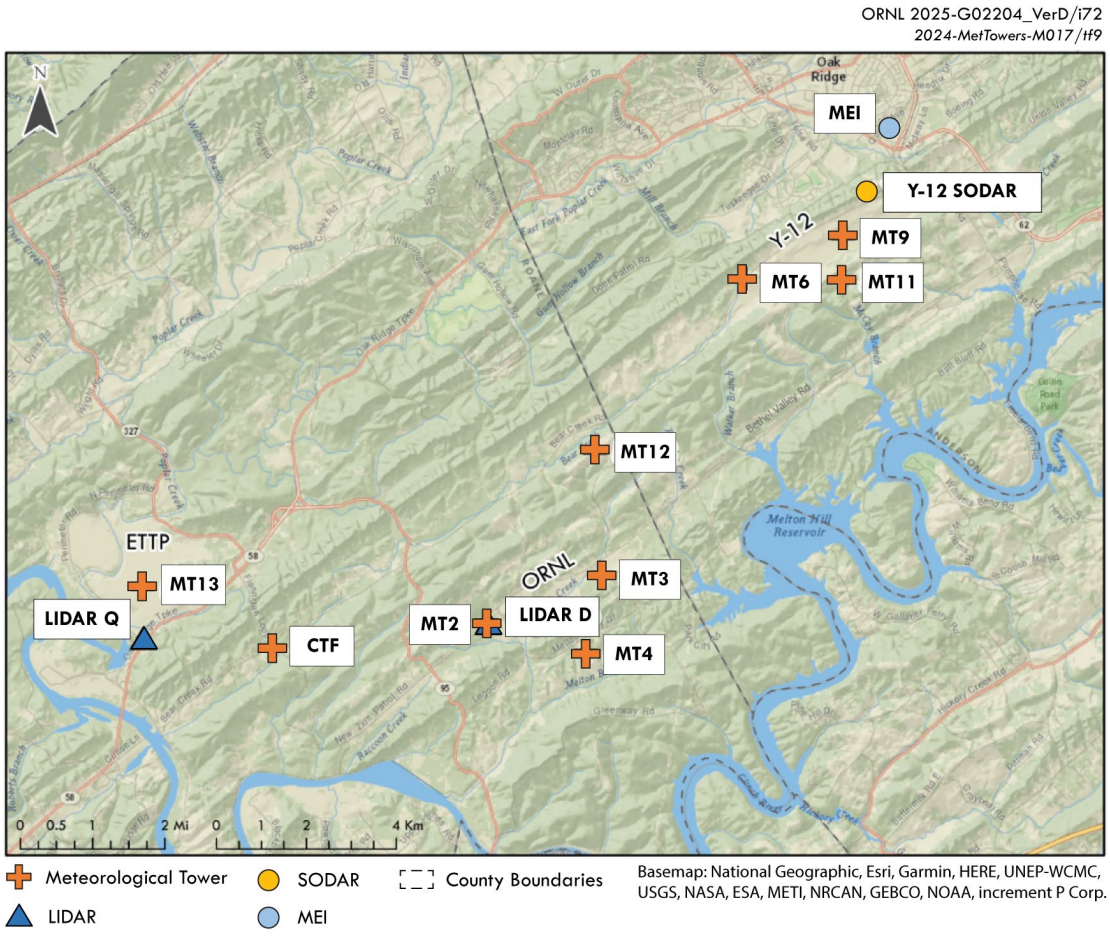
Acronyms:
CIP = Capacity Increase Project
CWTS = Chromium Water Treatment System
decom = decommissioned
ETTP = East Tennessee Technology Park
FP = filter press
ORNL = Oak Ridge National Laboratory
Y-12 Complex = Y-12 National Security Complex

Results

EDs from radionuclides released into the atmosphere from ORR were calculated for ORR as a whole and for each site on ORR for MEIs and for the collective population (1,276,842 persons) residing within 80 km (50 miles) of ORR based on 2020 Census data (Census 2020). CAP-88 PC Version 4 was used in 2024 to calculate individual and collective doses.

The location of the ORR MEI (i.e., the location where a hypothetical individual would receive the maximum ED from radionuclides emitted into the atmosphere from ORR) was about 2,270 m (1.4 miles) northeast of the main Y-12 release point, about 10,810 m (6.7 miles) north-northeast of the 7911 stack at ORNL, and about 14,770 m (9.2 miles) east-northeast of the K-1407-AL Chromium Water Treatment System at ETTP (Figure 7.1). This individual could have received an ED of about 0.6 mrem, which is well below the National Emission Standards for Hazardous Air Pollutants for Radionuclides standard of 10 mrem and is about 0.2 percent of the roughly 300 mrem that the average individual receives from natural sources of radiation (40 CFR Part 61, Subpart H). The maximum individual EDs calculated for each site and for ORR are listed in Table 7.3.

Table 7.4 lists the collective EDs. The calculated collective ED was about 23.9 person-rem, which is about 0.006 percent of the 383,053 person-rem that this population received from natural sources of radiation (based on an individual dose of about 300 mrem/year).



Acronyms:

CTF = Central Training Facility
ETTP = East Tennessee Technology Park
LIDAR = light detection and ranging
MEI = maximally exposed individual
ORNL = Oak Ridge National Laboratory
ORR = Oak Ridge Reservation
SODAR = sonic detection and ranging
Y-12 = Y-12 National Security Complex

Figure 7.1. Location of the maximally exposed individual for ORR, 2024

Table 7.3. Calculated radiation doses to maximally exposed individuals from airborne releases from ORR, 2024

Site	Maximum effective dose, mrem and mSv			
	From each site		From ORR	
	mrem	mSv	mrem	mSv
ORNL[a]	0.3	0.003	0.08	0.0008
ETTP[b]	0.0002	2×10^{-6}	1×10^{-6}	1×10^{-8}
Y-12 Complex[c]	0.5	0.005	0.5	0.005
Entire ORR[d]	e	e	0.6	0.006

[a] *The ORNL MEI was located 5,180 m SW of X-3039 and 5,520 m WSW of X-7911.*

[b] *The ETTP MEI was located 270 m SSW of the K-1407-AL Chromium Water Treatment System.*

[c] *The Y-12 MEI was located 2,270 m NE of the main Y-12 Complex release point.*

[d] *The MEI for the entire ORR was 2,270 m NE of the Y-12 Complex release point, 10,810 m NNE of X-7911, and 14,770 m ENE of the K-1407-AL Chromium Water Treatment System.*

[e] *Not applicable.*

Acronyms:

ETTP = East Tennessee Technology Park
MEI = maximally exposed individual
ORNL = Oak Ridge National Laboratory
ORR = Oak Ridge Reservation
Y-12 Complex = Y-12 National Security Complex

Table 7.4. Calculated collective effective doses from airborne releases, 2024

Site	Collective effective dose[a]	
	Person-rem	Person-Sv
ORNL	13.8	0.138
ETTP	6×10^{-5}	6×10^{-7}
Y-12 Complex	10.1	0.101
Entire ORR	23.9	0.239

[a] *Collective effective dose to the 1,276,842 persons residing within 80 km (50 miles) of ORR (based on 2020 Census data).*

Acronyms:

ETTP = East Tennessee Technology Park
ORNL = Oak Ridge National Laboratory
ORR = Oak Ridge Reservation
Y-12 Complex = Y-12 National Security Complex

The MEI for Y-12 was located at a residence about 2,270 m (1.4 miles) northeast of the main Y-12 release point. This individual could have received an ED of about 0.5 mrem from Y-12 airborne emissions. Uranium radioisotopes (i.e., ^{233}U, ^{234}U, ^{235}U, ^{236}U, and ^{238}U) accounted for about 98 percent, and other radionuclides accounted for about 2 percent of the dose (Figure 7.2). The contribution of Y-12 emissions to the 50-year committed collective ED to the population residing within 80 km (50 miles) of ORR was calculated to be about 10.1 person-rem, which is about 42 percent of the collective ED for ORR.

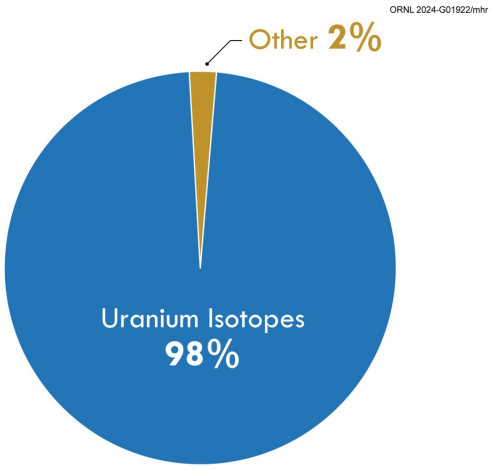


Figure 7.2. Nuclides contributing to effective dose at the Y-12 Complex, 2024

The MEI for ORNL was located at a residence about 5,180 m (3.2 miles) southwest of the 3039 stack and 5,520 m (3.4 miles) west-southwest of the 7911 stack. This individual could have received an ED of about 0.3 mrem from ORNL airborne emissions. Lead-212 contributed about 69 percent, ^{237}Np contributed about 11 percent, and ^{41}Ar, ^{11}C, and ^{138}Cs each contributed about 4 percent to the ORNL ED (Figure 7.3). The total contribution from ^{232}U, ^{233}U, ^{234}U, ^{235}U, ^{236}U, ^{238}U, ^{239}U, and ^{240}U accounted for about 0.09 percent of the dose. Of the uranium isotopes, ^{234}U made the largest contribution. The contribution of ORNL emissions to the collective ED to the population residing within 80 km (50 miles) of ORR was calculated to be about 13.8 person-rem, or about 58 percent of the collective ED for ORR.

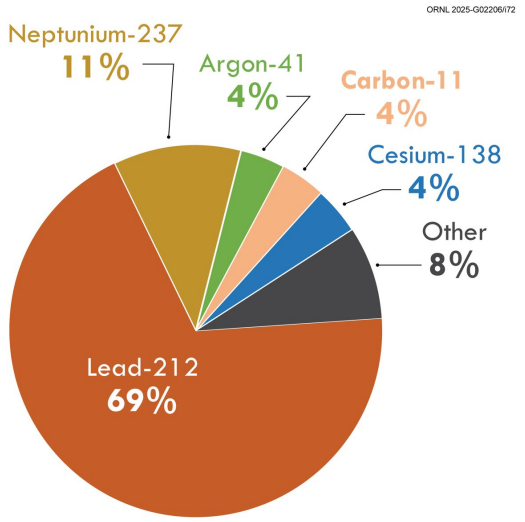


Figure 7.3. Nuclides contributing to effective dose at ORNL, 2024

The MEI for ETTP was located at a business about 270 m (0.17 miles) south-southwest of the K-1407-AL Chromium Water Treatment System. The ED received by this individual from airborne emissions was calculated to have been about 0.0002 mrem. About 82 percent of the dose was from uranium radioisotopes (^{233}U, ^{234}U, ^{235}U, ^{236}U, and ^{238}U), nearly 8 percent of the dose was from progeny of uranium isotopes, and almost 11 percent of the dose was from ^{99}Tc (Figure 7.4). The 2024 contribution of ETTP emissions to the collective ED to the population residing within 80 km (50 miles) of ORR was calculated to have been about 0.00006 person-rem, or about 0.0003 percent of the collective ED for ORR.

To evaluate the validity of the estimated doses calculated using CAP-88 PC Version 4 and emissions data (Table 7.5), the doses were compared to the EDs calculated using radionuclide air concentrations (excluding naturally occurring ^{7}Be and ^{40}K) measured in samples collected at the ORR ambient air locations (Figure 6.3). In 2022, analysis of ambient air samples transitioned to a different laboratory, resulting in possible variations in analytical procedures and reporting methodologies. Analyses included gross alpha, gross beta, gamma emitters, isotopic uranium, ^{3}H, and ^{99}Tc at selected locations.

In 2024, in addition to ^{3}H and uranium isotopes, ^{60}Co, ^{214}Bi, ^{210}Pb, ^{212}Pb, ^{214}Pb, ^{208}Tl, and ^{99}Tc were detected at ORR ambient air stations. Lead-210, a naturally occurring radioisotope, was detected at all ORR ambient air sampling locations listed in Table 7.5 and at the background location, Station 52. On average, the dose contribution from ^{210}Pb at ambient air sampling locations was nearly 4.6 mrem. Measured air concentrations of ^{210}Pb were excluded from calculated EDs because ^{210}Pb is naturally occurring and was emitted from only two sources on ORR at concentration levels significantly below those measured in ambient air samples.

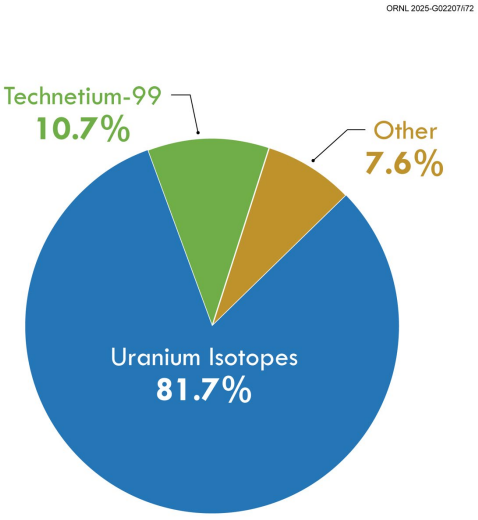


Figure 7.4. Nuclides contributing to effective dose at ETTP, 2024

Based on measured air concentrations, hypothetical individuals assumed to reside at the ambient air stations could have received EDs between 0.02 and 0.07 mrem/year, while EDs calculated using CAP-88 PC Version 4 and emissions data were between 0.1 and 3.2 mrem/year. As shown in Table 7.5, EDs calculated using CAP-88 PC Version 4 and emissions data were greater than EDs calculated using measured air concentrations.

Station 52, located remotely from ORR, gives an indication of potential EDs from background sources. Samples from Stations 35 and 52 were analyzed for ^{99}Tc in 2024. Technetium-99 was detected in one sample at Station 35 but was not

detected at the background location. Based on measured air concentrations (excluding the naturally occurring isotopes ^{7}Be and ^{40}K), the ED at Station 52 was estimated to be 0.02 mrem/year. Based on air concentrations calculated using CAP-88 PC Version 4, the ED was estimated to be 0.06 mrem/year. The measured air concentrations of ^{7}Be at ORR stations were similar to those at the background air monitoring station.

EDs calculated using measured air concentrations of radionuclides at ambient air stations located near the MEIs for each site are significantly less than EDs calculated using source emissions data. Station 11 is located near the off-site MEI for ORNL. The ED calculated with measured air concentrations was 0.03 mrem/year, and the ED estimated using source emissions data was 0.4 mrem/year. Station 40 is located near the offsite MEI for the Y-12 Complex and ORR. The ED calculated with measured air concentrations was 0.02 mrem/year, and the ED estimated using source emissions data was 0.7 mrem/year. Station K11 is located near the on-site MEI for ETTP. The ED calculated with measured air concentrations was 2×10^{-4} mrem/year, and the ED calculated using source emissions data was 0.08 mrem/year.

Table 7.5. Hypothetical effective doses from living near ORR and ETTP ambient air monitoring stations, 2024

Station	Calculated effective doses			
	Using air monitor data		Using CAP-88[a] and emission data	
	mrem/year	mSv/year	mrem/year	mSv/year
		ORR		
1	0.03	0.0003	0.4	0.004
2	0.03	0.0003	0.4	0.004
3	0.05	0.0005	3.2	0.032
11	0.03	0.0003	0.4	0.004
35[b]	0.07	0.0007	0.1	0.001
37	0.02	0.0002	0.3	0.003
40	0.02	0.0002	0.7	0.007
46	0.02	0.0002	0.3	0.003
49	0.02	0.0002	0.3	0.003
52[b,c]	0.02	0.0002	0.06	0.0006
		ETTP		
K11	1×10^{-4}	1×10^{-6}	0.08	0.0008
K12	3×10^{-5}	3×10^{-7}	0.07	0.0007

[a] *CAP-88 PC Version 4 software, developed under US Environmental Protection Agency sponsorship to demonstrate compliance with 40 CFR Part 61, Subpart H.*

[b] *In 2024, analysis for ^{99}Tc in samples from Stations 35 and 52 was performed.*

[c] *Background ambient air monitoring station.*

Acronyms:

CAP-88 PC = Clean Air Act Assessment Package—1988

ETTP = East Tennessee Technology Park

ORR = Oak Ridge Reservation

7.1.2.2. Waterborne Radionuclides

Radionuclides discharged to surface waters from ORR enter the Tennessee River system via the Clinch River. Discharges from Y-12 enter the Clinch River via Bear Creek and East Fork Poplar Creek (EFPC), which both enter Poplar Creek before it enters the Clinch River. Discharges from Rogers Quarry enter McCoy Branch, which flows into Melton Hill Lake. Discharges from ORNL enter the Clinch River via White Oak Creek (WOC) and enter Melton Hill Lake via small drainage creeks. Discharges from ETTP enter the Clinch River either directly or via Poplar Creek. This section discusses the potential radiological impacts of these discharges to persons who get drinking water from the Clinch and Tennessee Rivers and use these rivers for fishing, swimming, boating, and other shoreline activities. For assessment purposes, surface waters potentially affected by ORR are divided into the following seven segments:

- Melton Hill Lake above all possible ORR inputs
- Melton Hill Lake
- Upper Clinch River (from the Melton Hill Dam to the confluence with Poplar Creek)
- Lower Clinch River (from the confluence with Poplar Creek to the confluence with the Tennessee River)
- Upper Watts Bar Lake (from near the confluence of the Clinch and Tennessee Rivers to below Kingston)
- The lower system (from the remainder of Watts Bar Lake and Chickamauga Lake to Chattanooga)
- Poplar Creek (including the confluence with EFPC)

Two methods are used to estimate potential radiation doses to the public. The first method uses radionuclide concentrations in water and fish determined by laboratory analyses of water and fish samples. (See Sections 6.4 and 6.6.4.) The second method calculates possible radionuclide concentrations in water and fish from measured radionuclide discharges with known or estimated streamflows. Both methods use reported concentrations of radionuclides to estimate radiation doses if the reported value is statistically significant or detected.

The advantage of the first method is the use of radionuclide concentrations measured in water and fish; disadvantages are the inclusion of naturally occurring radionuclides (e.g., ^{40}K, uranium and its progeny, thorium and its progeny, and unidentified alpha and beta activities), the possible inclusion of radionuclides discharged from sources not part of ORR, and the possibility that some radionuclides of ORR origin might be present in quantities too low to be measured. The advantages of the second method are that most radionuclides discharged from ORR can be quantified and that naturally occurring radionuclides may not be considered or may be accounted for separately. The disadvantage is the use of models to estimate the concentrations of the radionuclides in water and fish. Both methods use the same models (Hamby 1991) to estimate radionuclide concentrations in media and at locations other than those that are sampled (e.g., downstream), and the doses are calculated using per capita committed ED coefficients for water ingestion (DOE 2022). Utilizing the two methods to estimate potential doses accounts for field measurements and discharge measurements.

Drinking water consumption

Estimated maximum EDs to a person drinking water were calculated using both measured radionuclide concentrations in off-site surface water and measured radionuclide discharges to the off-site surface water, excluding naturally occurring radionuclides such as ^{40}K and ^{7}Be. During fiscal year 2024, the Oak Ridge Office of Environmental Management continued to collect and analyze samples from the off-site groundwater monitoring well array west of the Clinch River adjacent to Melton Valley. Currently, no water is consumed from these off-site groundwater wells.

Water drawn into treatment plants from the Clinch and Tennessee River systems could be

affected by discharges from ORR. Because they are based on radionuclide concentrations in water before it enters a processing plant, the dose estimates given in this section are likely high. (No in-plant radionuclide concentration data are available for the treatment plants.)

Based on a nationwide health and nutrition survey (EPA 2023) and weighted based on the combined population of Anderson, Knox, Loudon, and Roane Counties, which reflects 2020 decennial US Census data (Census 2020; Fryar et al. 2021), the drinking water consumption rate for the MEI is assumed to be 953 L/year (252 gal/year), and the drinking water consumption rate for the average person is 284 L/year (75 gal/year). The average drinking water consumption rate was used to estimate the collective EDs. The EDs for the seven surface water segments were as follows:

- **Upper Melton Hill Lake above all possible ORR inputs.** Based on samples from Melton Hill Lake above possible ORR inputs (at Clinch River kilometer [CRK] 66 near the City of Oak Ridge water intake plant), an MEI drinking water at this location could have received an ED of about 0.04 mrem. The collective ED to the 46,765 persons who drink water from the City of Oak Ridge water plant would have been 0.6 person-rem.
- **Melton Hill Lake.** The only water treatment plant located on Melton Hill Lake that could be affected by discharges from ORR is a Knox County plant. This plant is located near surface water sampling location CRK 58. An MEI could have received an ED of about 0.04 mrem; the collective dose to the 70,666 persons who drink water from this plant could have been 0.9 person-rem.
- **Upper Clinch River.** There are no known drinking water intakes in this river segment.
- **Lower Clinch River.** There are no known drinking water intakes in this river segment (from the confluence of Poplar Creek with the lower Clinch River to the confluence of the lower Clinch River with the Tennessee River).
- **Upper Watts Bar Lake.** The Kingston and Rockwood municipal water plants draw water from the Tennessee River not far from its confluence with the Clinch River. An MEI could have received an ED of about 0.007 mrem. The collective dose to the 34,485 persons who drink water from these plants could have been about 0.07 person-rem.
- **Lower system.** Several water treatment plants are located on tributaries of Watts Bar Lake and Chickamauga Lake. An MEI drinking water from those plants could have received an ED of about 0.006 mrem. The collective dose to the 359,577 persons who drink water from the lower system could have been about 0.5 person-rem.
- **Poplar Creek/lower EFPC.** No drinking water intakes are located on Poplar Creek or on lower EFPC.

Fish consumption

Fishing is common on the Clinch and Tennessee River systems. Based on a nationwide health and nutrition survey (EPA 2023) and weighted based on the combined population of Anderson, Knox, Loudon, and Roane Counties, which reflects 2020 decennial US Census data (Census 2020; Fryar et al. 2021), avid fish consumers were assumed to have eaten 42 kg (93 lb) of fish during 2024. The average person used for collective dose calculations was assumed to have consumed 11 kg (24 lb) of fish in 2024. The average fish consumption value is based on a nationwide food consumption survey (EPA 2023) and is weighted based on the 2020 decennial US Census populations of Anderson, Knox, Loudon, and Roane Counties (Census 2020; Fryar et al. 2021). The maximum ED at each location was estimated using one of the two previously mentioned methods: by using measured radionuclide concentrations in fish or by calculating possible radionuclide concentrations in fish from measured radionuclide discharges and known or estimated streamflows. The number of individuals who could have eaten fish is based on lake creel surveys and commercial fishing reporting conducted annually by the Tennessee Wildlife Resources Agency (TWRA) (TWRA 2019; TWRA 2021; TWRA 2024; TWRA 2025). Routine fish tissue analyses include gross alpha, gross

beta, gamma spectroscopy for gamma emitters, and ^{3}H. Detected or statistically significant radionuclides in 2024 included ^{7}Be, ^{40}K, ^{90}Sr, ^{99}Tc, ^{230}Th, and ^{232}Th.

In 2024, the maximum EDs from fish consumption at upper Melton Hill Lake and both upper and lower Clinch River were determined using measured radionuclide concentrations in samples collected at CRK 70 and CRK 32 (catfish) and CRK 16 (sunfish). However, the maximum fish consumption EDs at the remaining locations were based on the measured radionuclide concentrations in water to estimate radionuclide concentrations in fish.

- **Upper Melton Hill Lake above all possible ORR inputs.** For reference purposes, a hypothetical avid fish consumer who ate fish caught at CRK 70, which is above all possible ORR inputs, could have received an ED of about 0.2 mrem. The collective ED to the 13 persons who could have eaten fish harvested at that location could have been about 0.0007 person-rem.
- **Melton Hill Lake.** An avid fish consumer who ate fish from Melton Hill Lake could have received an ED of about 0.1 mrem. The collective ED to the 119 persons who could have eaten fish harvested at that location could have been about 0.003 person-rem.
- **Upper Clinch River.** An avid fish consumer who ate fish from the upper Clinch River could have received an ED of about 0.2 mrem. The collective ED to the 104 persons who could have eaten fish harvested at that location could have been about 0.004 person-rem.
- **Lower Clinch River.** An avid fish consumer who ate fish from the lower Clinch River could have received an ED of about 0.2 mrem. The collective ED to the 243 persons who could have eaten fish harvested at that location could have been about 0.01 person-rem.
- **Upper Watts Bar Lake.** An avid fish consumer who ate fish from upper Watts Bar Lake could have received an ED of about 0.02 mrem. The collective ED to the 693 persons who could have eaten fish harvested at that location could have been about 0.003 person-rem.
- **Lower system.** An avid fish consumer who ate fish from the lower system could have received an ED of about 0.02 mrem. The collective ED to the approximately 8,235 persons who could have eaten fish harvested at that location could have been about 0.03 person-rem.
- **Poplar Creek/lower EFPC.** An avid fish consumer who ate fish from Poplar Creek/lower EFPC could have received an ED of about 0.1 mrem, but it is considered unlikely that a person would consume fish from those locations. Assuming 200 persons could have eaten fish from lower EFPC and from Poplar Creek, the collective ED could have been about 0.006 person-rem.

Other uses

A highly exposed "other user" was assumed to swim or wade for 30 h/year, boat for 63 h/year, and use the shoreline for 60 h/year. The average individual who is used for collective dose estimates was assumed to swim or wade for 10 h/year, boat for 21 h/year, and use the shoreline for 20 h/year. The potential EDs from these activities were estimated from measured and calculated concentrations of radionuclides in water. The equations that were used were derived from the LADTAP XL code (Hamby 1991) and were modified to account for radioactivity data and shoreline use. The number of individuals who could have been other users is different for each section of water. Recreational activities for Melton Hill Reservoir are based on surveys conducted by the University of Tennessee (Stephens et al. 2006). Another survey was conducted regarding visitor and property owner activities for Chickamauga and Watts Bar Reservoirs (Poudyal et al. 2017). The data from these surveys were used to identify the variety of recreational activities on these water bodies. It was found that respondents often participated in more than one recreational activity.

- **Upper Melton Hill Lake above all possible ORR inputs.** A hypothetical maximally exposed other user of upper Melton Hill Lake above possible ORR inputs (CRK 66) could have received an ED of about 0.002 mrem. The collective ED to the 14,483 other users could have been 0.003 person-rem.
- **Melton Hill Lake.** An individual other user of Melton Hill Lake could have received an ED of about 0.003 mrem. The collective ED to the 40,044 other users could have been about 0.01 person-rem.
- **Upper Clinch River.** An individual other user of the upper Clinch River could have received an ED of about 4×10^{-6} mrem. The collective ED to the 13,114 other users could have been about 4×10^{-6} person-rem.
- **Lower Clinch River.** An individual other user of the lower Clinch River could have received an ED of about 0.001 mrem. The collective ED to the 30,599 other users could have been about 0.006 person-rem.
- **Upper Watts Bar Lake.** An individual other user of upper Watts Bar Lake could have received an ED of about 7×10^{-7} mrem. The collective ED to the 87,424 other users could have been about 4×10^{-6} person-rem.
- **Lower system (Watts Bar and Chickamauga Lakes).** An individual other user of the lower system could have received an ED of about 7×10^{-7} mrem. The collective ED to the 3,173,423 other users could have been about 0.0001 person-rem.
- **Poplar Creek/lower EFPC.** An individual other user of lower EFPC above its confluence with Poplar Creek could have received an ED of about 6×10^{-5} mrem. The collective ED to the 200 other users of Poplar Creek and lower EFPC could have been about 2×10^{-6} person-rem.

Irrigation

Although no known locations use water from water bodies around ORR to irrigate food or feed crops, it was decided to determine whether irrigation could contribute to radiation doses to a member of the public. To make this determination, the method described by the US Nuclear Regulatory Commission (NRC 1977) was used. Based on measured and calculated instream concentrations of radionuclides at CRK 16, which is a location on the lower Clinch River and downstream of ORR, the maximum potential dose (excluding the naturally occurring radionuclides ^{7}Be and ^{40}K) to an individual due to irrigation ranged from 4×10^{-70} to 0.05 mrem in 2024. The average instream dose at CRK 16 was estimated to have been about 0.008 mrem. Based on all water discharges at CRK 16, the sum of doses was estimated to have been 2×10^{-6} mrem. The individual was assumed to have consumed 16 kg (35 lb) of leafy vegetables, 92 kg (203 lb) of produce, 262 L (69 gal) of milk, and 63 kg (139 lb) of meat (beef) during the year. The doses were calculated using per capita committed ED coefficients for water and milk ingestion (DOE 2022).

Summary

Table 7.6 summarizes potential EDs from identified waterborne radionuclides around ORR. The estimated maximum individual ED was about 0.3 mrem to a person who obtained his or her drinking water and annual complement of fish from the water systems in Table 7.6 and who participated in other water uses throughout those systems. The total collective ED from waterborne radionuclides to the population engaging in these activities was estimated to have been about 2.1 person-rem. These doses are small relative to the overall doses from natural sources of radiation; the estimated maximum individual ED from identified waterborne radionuclides is about 0.1 percent of the average individual background dose of roughly 300 mrem/year, and the total collective ED from waterborne radionuclides is about 0.0006 percent of the 383,053 person-rem that the population within 80 km (50 miles) received from natural sources of radiation.

Table 7.6. Summary of annual maximum individual (mrem) and collective (person-rem) effective doses from waterborne radionuclides, 2024[a,b]

Effective dose	Source			Total[c]
	Drinking water	Eating fish	Other uses	
Upstream of all Oak Ridge Reservation discharge locations (CRK 66, City of Oak Ridge water plant)				
Individual	0.04	0.2[d]	0.002	0.3
Collective	0.6	0.0007[d]	0.003	0.6
Melton Hill Lake (CRK 58, Knox County water plant)				
Individual	0.04	0.1	0.003	0.02
Collective	0.9	0.003	0.01	0.9
Upper Clinch River (CRK 23, CRK 32)				
Individual	e	0.2	4×10^{-6}	0.2
Collective	e	0.004	4×10^{-6}	0.004
Lower Clinch River (CRK 16)				
Individual	e	0.2[d]	0.001	0.2
Collective	e	0.01	0.006	0.02
Upper Watts Bar Lake (Kingston municipal water plant)				
Individual	0.007	0.02	7×10^{-7}	0.03
Collective	0.07	0.003	4×10^{-6}	0.07
Lower system (lower Watts Bar Lake and Chickamauga Lake)				
Individual	0.006	0.02	7×10^{-7}	0.02
Collective	0.5	0.03	0.0001	0.6
Lower East Fork Poplar Creek and Poplar Creek				
Individual	e	0.1	6×10^{-5}	0.1
Collective	e	0.006	2×10^{-6}	0.006

[a] *1 mrem = 0.01 mSv.*

[b] *Doses based on measured radionuclide concentrations in water or estimated from measured discharges and known or estimated streamflows.*

[c] *Total doses and apparent sums of individual pathway doses may differ because of rounding.*

[d] *Doses based on measured radionuclide concentrations in fish samples.*

[e] *Not at or near drinking water supply locations.*

Acronym: *CRK = Clinch River kilometer*

7.1.2.3. Radionuclides in Food

The CAP-88 PC computer codes are used to calculate radiation doses from ingestion of meat, milk, and vegetables that could contain radionuclides released from ORR.

Milk, vegetables, hay, wildlife, and fish are sampled and analyzed annually, as available, to characterize doses from radionuclides that could be consumed in food products that originated at local farms and gardens and in game harvested by hunting and fishing on or near ORR.

Milk

Since 2016, no dairies in potential ORR deposition areas have been located, and no milk samples have been collected. Surveys to identify dairies in potential deposition areas are conducted each year. A small dairy operation located in the vicinity of ORR was identified in 2020, but milk

samples could not be obtained. No additional suitable locations were identified in 2024. Milk sampling will resume when dairy operations in appropriate areas are located.

Vegetables

The food crop sampling program is described in Chapter 6. Tomatoes and leafy greens were obtained from four local gardens, and both were obtained from the same distant background location in Putnam County. Samples of root vegetables were not available in 2024. Sample analyses included gross alpha, gross beta, gamma emitters, and isotopic uranium. In samples of leafy greens, statistically significant concentrations of ^{7}Be, ^{40}K, $^{233/234}$U, and ^{238}U were detected. In tomato samples, statistically significant concentrations of ^{40}K and ^{208}Tl were detected. Dose estimates are based on hypothetical consumption rates of vegetables that contain statistically significant or detected concentrations of radionuclides that could have come from ORR. Based on a nationwide food consumption survey (EPA 2011) and weighted based on the combined 2020 decennial US Census population of Anderson, Knox, Loudon, and Roane Counties (Census 2020; Fryar et al. 2021), a hypothetical home gardener was assumed to have eaten a maximum of about 16 kg (35 lb) of homegrown leafy greens and 74 kg (163 lb) of homegrown tomatoes. The hypothetical local gardener could have received an ED of between 0 and 0.03 mrem from leafy greens depending on the garden location. Because ^{40}K and ^{208}Tl do not contribute to dose from ingestion, the hypothetical gardener would have received no additional dose from eating tomatoes. A person eating vegetables from the distant background garden could have received a committed ED of 0.06 mrem from eating leafy greens.

Potassium-40 was detected in tomato and leafy green samples and accounted for most of the beta activity but was excluded from calculated EDs because it is a naturally occurring, fertilizer-introduced radionuclide. Potassium-40 concentrations in tomatoes were similar at all garden locations, including the background location, and were comparable in samples of leafy greens from all of the garden locations except for the background location where it was significantly higher. If the ^{40}K detected in the samples had been included in ED calculations, it would have added about 3 mrem to the hypothetical home gardener's ED. In 2024, gardeners who provided vegetable samples were asked about water sources and fertilizers used. Only natural fertilizers, such as leaf litter, manure, and compost, were used at three of the four garden locations and at the background location. Water sources for the gardens typically include rain or city water. Most of the activity found in vegetables is thought to be due to ^{40}K and to unidentified naturally occurring beta-emitting radionuclides, not emissions from ORR.

Hay

Another environmental pathway that is typically evaluated is eating beef and drinking milk obtained from hypothetical cattle that eat hay harvested from one location on ORR. Hay samples collected on ORR are normally analyzed for gross alpha, gross beta, gamma emitters, and uranium isotopes. In 2024, statistically significant concentrations of ^{40}K and $^{233/234}$U were detected in hay samples. Potassium-40 is naturally occurring and is not included in reported EDs from drinking milk and eating beef; however, it contributed about 17 mrem, primarily from beef, to the total dose. Excluding the dose contributions from ^{40}K, the ED from drinking milk and eating beef was 0.004 mrem.

White-tailed deer

TWRA conducted three 2-day deer hunts on ORR in 2024: November 2 and 3, November 9 and 10, and November 14 and 15. (See Section 6.6.5.) During the hunts, 192 deer were harvested and taken to the TWRA checking station, where a bone sample and a muscle tissue sample were collected from each deer. The samples were field counted for radioactivity to ensure that the deer met the wildlife release criteria of net counts less than 1.5 times background (~20 pCi/g $^{89/90}$Sr) of beta activity in bone and the administrative limit of 5 pCi/g of ^{137}Cs in edible tissue (ORNL 2011;

ORNL 2020).[1] No deer exceeded the wildlife release criteria and were retained in 2024.

The average ^{137}Cs concentration in muscle tissue of the 192 released deer was 0.6 pCi/g; the maximum ^{137}Cs concentration in the released deer was 1.2 pCi/g. The ^{137}Cs activity in most samples was less than minimum detectable levels. The average weight of released deer was approximately 44 kg (97 lb); the maximum weight was 84 kg (185 lb). The EDs attributed to field-measured ^{137}Cs concentrations and actual field weights of the released deer ranged from about 0.04 to 2 mrem, with an average of about 0.7 mrem.

Potential doses from the consumption of deer that might have moved off ORR and been harvested elsewhere were also evaluated. In this scenario, if an individual consumed one average-weight deer (44 kg [97 lb], assuming that 55 percent of the field weight was edible meat) with the 2024 average field-measured concentration of ^{137}Cs (0.6 pCi/g), that individual could have received an ED of about 0.7 mrem. If an individual consumed a deer of maximum weight and ^{137}Cs content, that individual could have received an ED of about 3 mrem.

In 2024, muscle tissue samples from four released deer were collected and analyzed for radionuclides. Analyses included ^{137}Cs, ^{90}Sr, and ^{40}K. Comparison of the released-deer field results with analytical ^{137}Cs concentrations showed that the field concentrations were greater than the analytical results and that all concentrations were less than the administrative limit of 5 pCi/g (ORNL 2011; ORNL 2020).[1] Analytical results for ^{90}Sr concentrations in the muscle tissue of the four released deer ranged from 0 to 0.1 pCi/g. Using the analytical results for ^{137}Cs and ^{90}Sr (excluding ^{40}K, a naturally occurring radionuclide) and actual deer weights, the estimated doses ranged from about 0.2 to 0.3 mrem for the four released deer.

The maximum ED to an individual consuming venison from two or three deer was also evaluated. In 2024, 23 hunters each harvested two or three deer from ORR. Based on ^{137}Cs concentrations determined by field counting and actual field weights, the ED to a hunter who consumed two or more deer was estimated to have been between about 0.5 and 2 mrem.

The collective ED from eating venison from all the deer harvested on ORR in 2024 was estimated to have been about 0.1 person-rem based on the 2024 average field-derived ^{137}Cs concentration of 0.6 pCi/g and an average weight of 44 kg (97 lb). The collective dose is based on the number of harvested deer. Additional individuals may also have consumed the harvested venison, but the collective dose would be essentially the same.

Canada geese

Twenty-nine geese were captured during the 2024 goose roundup and were subjected to live whole-body gamma scans. The geese were field counted for radioactivity to ensure that they met wildlife release criteria (<5 pCi/g of ^{137}Cs in tissue). The average ^{137}Cs concentration was 0.4 pCi/g. The maximum ^{137}Cs concentration in the released geese was 2 pCi/g. All ^{137}Cs concentrations were below minimum detectable activity levels. The average weight of the geese screened during the roundup was about 2.8 kg (6.2 lb), and the maximum weight was about 4.9 kg (11 lb).

The EDs attributed to field-measured ^{137}Cs concentrations of the geese ranged from 0.02 to 0.2 mrem. However, for bounding purposes, if a person consumed a released goose with an average weight of 2.8 kg (6.2 lb) and an average ^{137}Cs concentration of 0.4 pCi/g, the estimated ED would have been approximately 0.03 mrem. About half the weight of a Canada goose was assumed to be edible. The estimated ED was about 0.2 mrem for an individual who consumed a goose with the maximum ^{137}Cs concentration of 2 pCi/g and maximum weight of 4.9 kg (11 lb).

It is possible that a person could have eaten more than one goose that spent time on ORR. The average seasonal goose bag per active hunter from Tennessee in the Mississippi Flyway was 3.4 (±47 percent) geese per hunting season between

[1] The 2020 version of CSD-AM-RML-RA01 supersedes the 2011 version.

2022 and 2023 (US Fish and Wildlife Service 2024). A person who consumed three geese of maximum weight with the highest measured concentration of ^{137}Cs would have received an ED of about 0.7 mrem.

Between 2000 and 2009, 22 samples of goose tissue were analyzed. Potential doses were evaluated based on laboratory-determined concentrations of the following radionuclides: ^{40}K, ^{137}Cs, ^{90}Sr, thorium (^{228}Th, ^{230}Th, and ^{232}Th), uranium ($^{233/234}$U, ^{235}U, and ^{238}U), and transuranic elements (^{241}Am, $^{243/244}$Cm, ^{238}Pu, and $^{239/240}$Pu). The total potential dose, omitting the contribution of naturally occurring ^{40}K, ranged from 0.01 to 0.5 mrem. The average potential dose was 0.2 mrem (EP&WSD 2010).

Eastern wild turkey

Two wild turkey hunts took place on the reservation in 2024: April 13 and 14 and April 20 and 21. Participating hunters are permitted to harvest one turkey per season from the reservation. If a turkey is retained, the hunter is permitted to harvest another turkey. Thirty-seven turkeys were harvested during the turkey hunts, and no additional turkeys were harvested during the deer hunts. No harvested turkeys were retained. The average weight of the released turkeys was about 8.9 kg (19.6 lb). The maximum weight was about 10.8 kg (23.9 lb). Turkeys were field counted for radioactivity to ensure that they met wildlife release criteria (<5 pCi/g of ^{137}Cs in tissue). The average ^{137}Cs concentration in the released turkeys was 0.1 pCi/g, with a maximum concentration of 0.15 pCi/g. All ^{137}Cs concentrations were below minimum detectable activity levels.

The EDs attributed to ^{137}Cs concentrations field measured in the turkeys ranged from 0.02 to 0.04 mrem. However, for bounding purposes, if a person consumed a released turkey with an average weight of 8.9 kg (19.6 lb) and an average ^{137}Cs concentration of 0.1 pCi/g, the estimated ED would have been approximately 0.02 mrem. About half the weight of a turkey was assumed to be edible. The estimated ED to an individual who consumed a hypothetical turkey with the maximum ^{137}Cs concentration of 0.15 pCi/g and maximum weight of 10.8 kg (23.9 lb) was about 0.04 mrem.

The collective ED from eating all the harvested turkeys from ORR with a 2024 average field-derived ^{137}Cs concentration of 0.1 pCi/g and an average weight of 8.9 kg (19.6 lb) is estimated to be about 0.0008 person-rem. The collective dose is based on the number of harvested turkeys. It is possible that additional individuals may have consumed the harvested turkeys; however, the collective dose would be essentially the same.

A tissue sample from one turkey that was collected opportunistically on ORR was analyzed in 2024. Detected or statistically significant radionuclides included ^{241}Am, ^{40}K, ^{90}Sr, and ^{230}Th. The turkey weighed 7.7 kg (17 lb). The estimated ED to a hypothetical individual who consumed this turkey was 0.03 mrem. Earlier evaluations of doses based on laboratory-determined concentrations of radionuclides included ^{40}K, ^{137}Cs, ^{90}Sr, ^{230}Th, ^{3}H, ^{234}U, ^{235}U, ^{238}U, and transuranic elements (^{241}Am, ^{244}Cm, ^{237}Np, and ^{239}Pu). The total dose, omitting the contribution of naturally occurring ^{40}K, ranged from 0.06 to 0.2 mrem (EP&WSD 2010).

7.1.2.4. Direct Radiation

The principal sources of natural external exposure are the penetrating gamma radiations emitted by ^{40}K and the series originating from ^{238}U and ^{232}Th (NCRP 2009). Because of radiological activities on ORR, external radiation exposure rates were measured at six of the ORR ambient air monitoring stations and at Station 52, the reference ambient air station (Figure 6.2). External gamma exposure rates were continuously recorded by dual-range Geiger–Müller tube detectors colocated with ORR ambient air stations. In 2024, exposure rates averaged about 9.4 µR/h and ranged from 7.6 to 11.5 µR/h. These exposure rates correspond to an annual average dose of about 58 mrem with a range of 47 to 71 mrem. At the background ambient air station, the exposure rate averaged about 8 µR/h and ranged from 7.6 to 9.8 µR/h. The resulting average annual dose was about 52 mrem with a

range of 47 to 60 mrem. The annual doses based on measured exposure rates at or near ORR boundaries were typically within the range of the doses measured at the background location; slightly higher exposure rates were observed at ambient air monitoring Stations 11 and 46.

7.1.3. Current-Year Summary

A summary of the maximum EDs to individuals by exposure pathway is given in Table 7.7. In the unlikely event that a person was exposed to all the sources and pathways for the duration of 2024, that person could have received a total ED of about 4 mrem. Of that total, 0.6 mrem would have come from airborne emissions, approximately 0.3 mrem from waterborne emissions (0.04 mrem from drinking water, 0.2 mrem from consuming fish, 0.003 mrem from other water uses along the Clinch River, and 0.05 mrem from irrigation at CRK 16), and about 3 mrem from consuming wildlife. Direct radiation measurements at six ORR ambient air monitoring stations were at or near background levels in 2024. There were no known significant doses from discharges of radioactive constituents from ORR other than those reported.

7.1.4. Five-Year Trends

EDs associated with selected exposure pathways for 2020 through 2024 are given in Table 7.8. In 2024, the air pathway dose was consistent with the dose in 2023, which increased relative to recent years largely due to an increase in calculated emissions from Y-12. Increases in the fish consumption dose and drinking water dose in 2021 were due to the contribution of ^{241}Am detected in the second-quarter water sample taken at CRK 58. Fish consumption and drinking water doses decreased in 2022 and have remained relatively low. Recent direct radiation measurements indicated doses near background levels. Doses from consumption of wildlife have been similar for the past 5 years, although the dose from consumption of deer and geese increased slightly in 2024.

7.1.5. Doses to Aquatic and Terrestrial Biota

The following sections summarize the results of assessments conducted to determine the potential effect of radionuclides originating from ORR on aquatic and terrestrial biota.

7.1.5.1. Aquatic Biota

DOE Order 458.1 (DOE 2020) sets an absorbed dose rate limit of 1 rad/day to native aquatic organisms from exposure to radioactive material in liquid wastes discharged to natural waterways. (See Appendix E for definitions of *absorbed dose* and *rad.*) To demonstrate compliance with this limit, an aquatic organism assessment was conducted using the RESRAD-Biota code (Version 1.8), a companion tool for implementing DOE technical standard DOE-STD-1153-2019, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2019). The code serves as DOE's biota dose evaluation tool and uses the screening (i.e., biota concentration guides [BCGs]) and analysis methods in the technical standard. A BCG is the limiting concentration of a radionuclide in sediment or water that would not cause dose limits for protection of aquatic biota populations to be exceeded.

The intent of the graded approach is to protect populations of aquatic organisms from the effects of exposure to anthropogenic ionizing radiation. Certain organisms are more sensitive to ionizing radiation than others. Therefore, protecting the more sensitive organisms is generally assumed to adequately protect other, less sensitive organisms. Depending on the radionuclide, either aquatic organisms (e.g., crustaceans) or riparian organisms (e.g., raccoons) may be more sensitive and are typically the limiting organisms for the general screening phase of the graded approach for aquatic system evaluations.

Table 7.7. Summary of maximum estimated effective doses from ORR activities to an adult by exposure pathway, 2024

Pathway	Dose to maximally exposed individual		Percentage of DOE mrem/year limit (%)	Estimated collective radiation dose[a]			
				Pathway		Background (person-rem)	Total population
	mrem	mSv		person-rem	person-Sv		
Airborne effluents							
All pathways	0.6	0.006	0.6	23.9	0.239		1,276,842[b]
Liquid effluents							
Drinking water	0.04	0.0004	0.04	2.0	0.02		511,493[c]
Eating fish	0.2	0.002	0.2	0.06	0.0006		9,607[d]
Other activities	0.003	3×10^{-5}	0.003	0.02	0.0002		3,359,287[d]
Irrigation	0.05	0.0005	0.05				
Other pathways							
Eating deer	3[e]	0.03[e]	3	0.1[e]	0.001[e]		192[e]
Eating geese	0.7[f]	0.007[f]	0.07	g	g		
Eating turkeys	0.04[h]	0.0004[h]	0.04	8×10^{-4} [h]	8×10^{-6} [h]		37[h]
Direct radiation	N/A[i]	N/A					
All pathways							
Total	4[i]	0.04	4	26	0.26	383,053	

[a] *Estimated background collective dose is based on the roughly 300 mrem/year individual dose and the population within 80 km (50 miles) of ORR.*

[b] *Population is based on 2020 Census data.*

[c] *Population estimates are based on community and noncommunity drinking water supply data from the Tennessee Department of Environment and Conservation Division of Water.*

[d] *Population estimates for fish are based on creel and commercial fishing data. Fractions of fish harvested from Melton Hill, Watts Bar, and Chickamauga Reservoirs are based on creel survey data. Melton Hill, Watts Bar, and Chickamauga recreational use information was obtained from the Tennessee Valley Authority (Stephens et al. 2006 and Poudyal et al. 2017). Other activities include swimming, boating, and shoreline use; the population estimates include individuals involved in more than one activity and visitors who may live outside the 80 km radius.*

[e] *Estimates for eating deer are based on consuming one hypothetical deer of the heaviest weight measured among the captured deer and with the highest ^{137}Cs concentration measured in the released deer on ORR; collective dose is based on the number of harvested deer.*

[f] *Estimates for eating geese are based on consuming three hypothetical geese, each with the heaviest weight measured among the captured geese and with the highest measured concentration of ^{137}Cs in the released geese.*

[g] *Collective doses were not estimated for the consumption of geese because no geese were harvested for consumption during the goose roundup.*

[h] *Estimates for eating turkey are based on consuming a hypothetical turkey with the heaviest weight measured in the harvested turkeys and with the highest ^{137}Cs concentration measured in the released turkeys on ORR; collective dose is based on the number of harvested turkeys.*

[i] *Current exposure rate measurements at ambient air monitoring stations are at or near background levels.*

[i] *Dose estimates have been rounded.*

Acronyms:

DOE = US Department of Energy

ORR = Oak Ridge Reservation

Table 7.8. Trends in effective dose from ORR activities, 2020–2024 (mrem)[a]

Pathway	2020	2021	2022	2023	2024
Airborne effluents—all pathways	0.4	0.5	0.2	0.6	0.6
Fish consumption (Clinch River)	2	3	0.4	0.7	0.2
Drinking water (Kingston)	0.02	3	0.03	0.006	0.007
Deer	*b*	*b*	2	1	3
Geese	0.07	0.2	0.1	0.08	0.7[c]
Turkeys	*b*	*b*	*b*	0.04	0.04

[a] *1 mrem = 0.01 mSv*

[b] *Wild turkey hunts scheduled on ORR for 2020 through 2022 and deer hunts for 2020 and 2021 were canceled because of the COVID-19 pandemic.*

[c] *In 2024, goose consumption dose was based on consuming three geese, but for previous years, it was based on consuming two geese.*

Acronym: *ORR = Oak Ridge Reservation*

At ORNL, doses to aquatic organisms are based on surface water concentrations at the following instream sampling locations:

- Melton Branch (X13) and Melton Branch Weir
- WOC headwaters (WOC 6.8), WOC (X14), and White Oak Dam (WOD) (X15)
- ORNL Sewage Treatment Plant Wastewater Discharge Point (X01)
- WOC 7500 Bridge
- First Creek
- Fifth Creek
- Northwest Tributary
- Raccoon Weir
- Waste Area Grouping 6 Monitoring Station 3 (tributary to WOC at WOD)
- CRK 16, CRK 32, CRK 58, and CRK 66

Based on the results of the general screening phase, in which the maximum concentrations of radionuclides in water were compared with default BCGs, or second-level screenings at X01, X15, and Northwest Tributary, in which the average concentrations of radionuclides in water were compared with default BCGs, the absorbed dose rates to aquatic organisms at all ORNL locations were below the DOE aquatic dose limit of 1 rad/day for aquatic biota or 0.1 rad/day for riparian biota. Lead-210, a naturally occurring radioisotope, was detected in one water sampling event at each of the following locations: First Creek, Raccoon Weir, and Northwest Tributary. Because ^{210}Pb is naturally occurring, has not typically been reported at these locations, and was only detected during one water sampling event, aquatic biota screenings performed for these locations omitted ^{210}Pb while analytical results are further investigated. Follow-up evaluations will be performed if necessary once results have been confirmed.

At Y-12, doses to aquatic organisms were estimated from surface water concentrations at the following instream sampling locations:

- Surface Water Hydrological Information Support System Station 9422-1 (also known as Station 17)
- Bear Creek at Bear Creek kilometer 9.2
- Discharge Point S24
- Discharge Point S17 (unnamed tributary to the Clinch River)
- Discharge Point S19 (Rogers Quarry)
- Outfall 200 on EFPC

Absorbed dose rates to aquatic organisms at the Y-12 locations were below the DOE aquatic dose limit of 1 rad/day based on general screenings or second-level screenings at Surface Water Hydrological Information Support System Station 9422-1 and Outfall 200.

At ETTP, doses to aquatic organisms were estimated from surface water concentrations at the following instream sampling locations:

- Mitchell Branch at K1700
- Mitchell Branch kilometers 0.45, 0.59, 0.71, and 1.4 (upstream location)
- Poplar Creek at K-716 (downstream)
- K1007-B and K-1710 (upstream location)
- K-702A and K901-A (downstream of ETTP operations)
- CRK 16 and CRK 23

Absorbed dose rates to aquatic organisms were below the DOE aquatic dose limit of 1 rad/day at the ETTP sampling locations based on general screening results.

7.1.5.2. Terrestrial Biota

A terrestrial organism assessment was conducted to evaluate impacts on biota in accordance with requirements in DOE Order 458.1 (DOE 2020). An absorbed dose rate of 0.1 rad/day is recommended as the limit for terrestrial animal exposure to radioactive material in soils. RESRAD-Biota code (Version 1.8), a companion tool for implementing *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2019), was used for the terrestrial organism assessment to demonstrate compliance with this limit. As is the case with aquatic and riparian biota, certain terrestrial organisms are more sensitive to ionizing radiation than others, and protecting the more sensitive organisms is generally assumed to adequately protect other, less sensitive organisms.

Soil sampling for terrestrial dose assessment was initiated in 2007 and was repeated in 2014 and 2021. Additionally, biota sampling in the WOC floodplain was conducted in 2009. White-footed mice (*Peromyscus leucopus*), deer mice (*Peromyscus maniculatus*), and hispid cotton rats (*Sigmodon hispidus)* were selected for sampling because they live and forage in these areas, are food for other mammals, and have relatively small home ranges. The biota sampling locations were at the confluence of Melton Branch and WOC and in the floodplain upstream of White Oak Lake. ORR site-specific bioaccumulation factors were calculated using 2007 and 2014 maximum soil concentrations and radionuclide concentrations in tissue for biota inhabiting the WOC floodplain.

In 2007, 2014, and 2021, soil sampling focused on unremediated areas, such as floodplains and some upland areas. Floodplains are often downstream of contaminant source areas and are dynamic systems where soils are eroding in some places and being deposited in others. This biota sampling strategy was developed using guidance provided in *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2019) and existing radiological information on the concentrations and distribution of radiological contaminants on ORR. In 2021, soil samples were collected from the same general locations as samples collected in 2007 and 2014. Soil sampling locations were as follows:

- **WOC floodplain.** Analytes detected in soil samples at this location in 2021 included ^{241}Am, ^{137}Cs, ^{60}Co, $^{243/244}$Cm, ^{238}Pu, $^{239/240}$Pu, ^{40}K, $^{89/90}$Sr, $^{233/234}$U, ^{235}U, and ^{238}U.
- **Mitchell Branch floodplain.** Analytes detected in soil samples at this location in 2021 included ^{241}Am, $^{239/240}$Pu, ^{99}Tc, $^{233/234}$U, and ^{238}U.
- **Bear Creek Valley floodplain.** Analytes detected in soil samples at this location in 2021 included ^{241}Am, $^{243/244}$Cm, $^{233/234}$U, ^{235}U, and ^{238}U.
- **EFPC floodplain.** Analytes detected in soil samples at this location in 2021 included $^{233/234}$U, ^{235}U, and ^{238}U.
- **Background locations.** Soils were also sampled in 2021 near Gum Hollow Branch, which represents Conasauga Group geologic formations, and near Bearden Creek, which represents Chickamauga Group geologic formations. Analytes detected in soil samples at the background locations in 2021 included ^{241}Am, ^{137}Cs, $^{239/240}$Pu, ^{40}K, $^{89/90}$Sr, $^{233/234}$U, ^{235}U, and ^{238}U.

In 2021, all soil samples except for those collected on the WOC floodplain upstream of WOD passed the general-level screening (a comparison of maximum radionuclide soil concentrations to default BCGs). Cesium-137 was the primary dose contributor to terrestrial biota on the WOC floodplain and was also the primary dose contributor in 2007 and 2014. Strontium-90 also contributed significantly to wildlife dose on the WOC floodplain in 2021 but to a lesser extent than ^{137}Cs. Because of measured concentrations in soil on the WOC floodplain and the results of second-level screening (comparison of average radionuclide soil concentrations to default BCGs), further evaluation was completed using ORR site-specific bioaccumulation factors and average radionuclide soil concentrations. The results of the additional screening evaluation indicated that absorbed dose rates to terrestrial organisms on the WOC floodplain were less than the DOE limit of 0.1 rad/day.

Evaluations of exposure to terrestrial organisms are typically conducted every 5 years or sooner if an abnormal event occurs that could have adverse impacts on terrestrial organisms.

7.2. Chemical Dose

Chemicals released during ORR operations could migrate to off-site locations, resulting in potential exposure of the public. The following sections summarize the results of an informational risk assessment for chemicals found in drinking water and fish on or near ORR.

7.2.1. Drinking Water Consumption

Surface water and groundwater are both potential sources of drinking water for populations in areas adjacent to ORR. Samples of surface water and groundwater are collected from sources near ORR and are analyzed to determine the presence and concentrations of chemicals that could pose a health risk for the local population.

7.2.1.1. Surface Water

To evaluate the drinking water exposure pathway, hazard quotients (HQs) and risks were estimated downstream of ORNL and downstream of ORR discharge points to the Clinch River (Table 7.9).

An HQ is a ratio that compares the estimated exposure dose or intake to a reference dose for noncarcinogens. HQs of less than 1 indicate an unlikely potential for adverse noncarcinogenic health effects. Likewise, risks are evaluated from estimated exposure dose or intake and cancer slope factors. Acceptable risk levels for carcinogens range from 10^{-4} (risk of developing cancer over a human lifetime is 1 in 10,000) to 10^{-6} (risk of developing cancer over a human lifetime is 1 in 1,000,000). (See Appendix F.) Based on a nationwide health and nutrition survey (EPA 2023) and weighted based on the combined population of Anderson, Knox, Loudon, and Roane Counties, which reflects 2020 decennial US Census data (Census 2020; Fryar et al. 2021), the drinking water consumption rate for the MEI is assumed to be 953 L/year (2.6 L/day). This is the same drinking water consumption rate used in the estimation of the maximum exposed radiological dose from consumption of drinking water. Chemical analytes were measured in surface water samples collected at CRK 66, CRK 32, CRK 23, and CRK 16.

Table 7.9. Chemical hazard quotients and estimated risks for drinking water from the Clinch River at CRK 23 and CRK 16, 2024

Analyte	Hazard quotient	
	CRK 23[a]	CRK 16[b]
	Metals	
Chromium	c	5×10^{-2}
Copper	5×10^{-4}	4×10^{-4}
Mercury	7×10^{-5}	6×10^{-4}
Uranium	3×10^{-2}	3×10^{-2}
Risks for carcinogens		
Chromium	c	3×10^{-6}

[a] *CRK 23 is no longer a water intake location.*

[b] *CRK 16 is downstream of all DOE inputs to the Clinch River and not a water intake location.*

[c] *The parameter was undetected.*

Acronym:

CRK = Clinch River kilometer

Calculated HQs for 2024 for CRK 16 and CRK 23 (Table 7.9) were based on detected water concentration values. At all locations, HQs were less than 1 for chemical analytes in water for which there are reference doses. Maximum contaminant levels were also not exceeded (Table 7.9). Beginning in 2022, mercury concentrations at CRK 66, CRK 32, and CRK 16 were measured using a more sensitive analysis method with a lower reporting limit than was used in previous years. HQs were 4×10^{-5} for CRK 66, 1×10^{-4} for CRK 32, 7×10^{-5} for CRK 23, and 6×10^{-4} for CRK 16 in 2024. CRK 16, located downstream of all ORR discharge points, is not a source of drinking water, but data from that location were used as surrogates to evaluate potential exposure to contaminants in drinking water from the Clinch River.

7.2.1.2. Groundwater

During fiscal year 2024, the Oak Ridge Office of Environmental Management continued to collect and analyze samples from the off-site groundwater monitoring well array west of the Clinch River adjacent to Melton Valley. (See Section 6.5.) Currently, no water is consumed from these off-site groundwater wells.

7.2.2. Fish Consumption

Chemicals in water can accumulate in tissues of aquatic organisms that may be consumed by humans. To evaluate the potential health effects from the fish consumption pathway, HQs were estimated for the consumption of noncarcinogens, and risk values were estimated for the consumption of carcinogens detected in sunfish and catfish collected both upstream and downstream of ORR discharge points. Based on a nationwide health and nutrition survey (EPA 2023) and weighted based on the combined population of Anderson, Knox, Loudon, and Roane Counties, which reflects 2020 decennial US Census data (Census 2020; Fryar et al. 2021), avid fish consumers were assumed to have eaten 42 kg (93 lb) of fish during 2024. This fish consumption rate of 115 g/day (42 kg/year) was used for estimating exposure to both noncarcinogenic and carcinogenic chemicals. This is the same fish consumption rate used in the estimation of the radiological dose from consumption of fish.

For consumption of sunfish, HQs of less than 1 were calculated for all detected analytes at all locations. For consumption of catfish, HQs of less than 1 were calculated for all detected analytes except for Aroclor 1248 (CRK 16) and Aroclor 1254 and Aroclor 1260 (CRK 70, CRK 32, and CRK 16) (Table 7.10). For carcinogens, risk values greater than 10^{-6} were calculated for the intake of chromium VI in sunfish at CRK 32 and for Aroclor 1254 and Aroclor 1260 (CRK 16). For catfish, risk values greater than 10^{-6} were calculated for chromium VI (CRK 16), Aroclor 1248 (CRK 16), and Aroclor 1254 and Aroclor 1260 (CRK 70, CRK 32, and CRK 16). The Tennessee Department of Environment and Conservation has issued a fish advisory that states that catfish should not be consumed from the entire Melton Hill Reservoir or from the Tennessee River portion of Watts Bar Reservoir because of polychlorinated biphenyl contamination (TDEC 2023). The Tennessee Department of Environment and Conservation has also issued a precautionary fish consumption advisory for catfish in the Clinch River arm of Watts Bar Reservoir (TDEC 2023).

Table 7.10. Chemical hazard quotients and estimated risks for fish caught and consumed from locations on ORR, 2024[a]

	Sunfish			Catfish		
	CRK 70[b]	CRK 32[c]	CRK 16[d]	CRK 70[b]	CRK 32[c]	CRK 16[d]
Hazard quotients for metals						
Barium			2×10^{-3}			
Chromium		0.5				0.4
Copper	5×10^{-3}	6×10^{-3}	5×10^{-3}	5×10^{-3}	5×10^{-3}	4×10^{-3}
Iron		0.02				
Manganese	3×10^{-3}	1×10^{-2}	8×10^{-3}	3×10^{-3}	4×10^{-3}	2×10^{-3}
Mercury				0.9		
Selenium	0.2		0.1			
Strontium			4×10^{-3}			
Zinc	0.02	0.03	0.04	0.02	0.02	0.02
Hazard quotients for Aroclors						
Aroclor 1248						2
Aroclor 1254			0.6	2	1	6
Aroclor 1260			0.7	3	2	5
Risks for carcinogens						
Chromium		3×10^{-5}				2×10^{-5}
Aroclor 1248						3×10^{-5}
Aroclor 1254			9×10^{-6}	3×10^{-5}	2×10^{-5}	9×10^{-5}
Aroclor 1260			1×10^{-5}	5×10^{-5}	2×10^{-5}	7×10^{-5}
PCBs (mixed)[e]			2×10^{-5}	8×10^{-5}	4×10^{-5}	2×10^{-4}

[a] *Blank space for a location indicates that the parameter was undetected.*

[b] *Melton Hill Reservoir, reference location above the City of Oak Ridge water plant.*

[c] *Clinch River downstream of Oak Ridge National Laboratory.*

[d] *Clinch River downstream of all US Department of Energy inputs.*

[e] *Mixed PCBs comprise the summation of Aroclors detected or estimated.*

Acronyms:

CRK = Clinch River kilometer

ORR = Oak Ridge Reservation

PCB = polychlorinated biphenyl

7.3. References

40 CFR Part 61, Subpart H. "Subpart H—National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities." *US Code of Federal Regulations*, Washington, DC. Retrieved February 25, 2021, from https://www.ecfr.gov/cgi-bin/text-idx?SID=eff89c419f5d1ed63e14b4d1765f4bf9&mc=true&node=pt40.10.61&rgn=div5#sp40.10.61.h.

Census 2020. 2020 Census Results. US Census Bureau, Washington, DC. https://www.census.gov/programs-census-results.html.

DOE 2019. *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*. DOE-STD-1153-2019. US Department of Energy, Washington, DC.

DOE 2020. *Radiation Protection of the Public and the Environment*. DOE Order 458.1, Ltd. Chg. 4. Approved February 11, 2011 (Ltd. Chg. 4 dated September 15, 2020). US Department of Energy, Washington, DC.

DOE 2022. *Derived Concentration Technical Standard*. DOE-STD-1196-2022. US Department of Energy, Washington, DC.

EP&WSD 2010. *Radiological Monitoring and Dose Report for Selected Wildlife Populations Oak Ridge Reservation*. EPWSD-EPS-TP-01, Oak Ridge National Laboratory, Environmental Protection and Waste Services Division, Oak Ridge, Tennessee.

EPA 2011. *Exposure Factors Handbook.* EPA/600/R-090/052F, US Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment, Washington, DC.

EPA 2015. *CAP-88 & CAP-88 PC*. US Environmental Protection Agency, November 2015, Washington, DC. Retrieved February 25, 2021, from https://www.epa.gov/radiation/cap-88-cap-88-pc.

EPA 2023. *What We Eat in America—Food Commodity Intake Database 2005-10*. US Environmental Protection Agency, Office of Pesticide Programs, and University of Maryland. Retrieved April 7, 2024, from https://fcid.foodrisk.org.

Fryar et al. 2021. Fryar, C.D., M.D. Carroll, Q. Gu, J. Afful, and C.L Ogden. *Anthropometric Reference Data for Children and Adults: United States, 2015-2018*. Vital and Health Statistics, Series 3, Number 46. National Center for Health Statistics, Hyattsville, Maryland.

Hamby 1991. Hamby, D.M., "LADTAP XL: An Improved Electronic Spreadsheet Version of LADTAP II." DE93003179, Westinghouse Savannah River Company, Aiken, South Carolina.

NCRP 2009. *Ionizing Radiation Exposure of the Population of the United States.* NCRP Report No. 160, National Council on Radiation Protection and Measurements, Bethesda, Maryland.

NRC 1977. *Regulatory Guide 1.109, Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I*. US Nuclear Regulatory Commission, Washington, DC.

ORNL 2011. *Deer Hunt Radiation Monitoring Guidelines.* CSD-AM-RML-RA01, Oak Ridge National Laboratory, Chemical Sciences Division, Oak Ridge, Tennessee.

ORNL 2020. *Wildlife Monitoring at the TWRA Monitoring Station.* CSD-AM-RML-RA01, Oak Ridge National Laboratory, Chemical Sciences Division, Oak Ridge, Tennessee.

Poudyal et al. 2017. Poudyal, N.C., H. Gotwald, B. English, K. Jensen, J. Menard, C. Caplenor, C. Maldonado, and D. Watkins, "Results from Visitor and Property Owner Surveys on Chickamauga, Norris, and Watts Bar Reservoir in Summer 2016." University of Tennessee Institute of Agriculture, March 24.

Stephens et al. 2006. Stephens, B. et al. *Recreation Use on Melton Hill Reservoir*. Human Dimensions Research Lab, University of Tennessee Agriculture Institute.

TDEC 2023. *Posted Streams, Rivers, and Reservoirs in Tennessee*. Tennessee Department of Environment and Conservation, Division of Water Resources, Nashville, Tennessee. Retrieved April 26, 2024, from https://www.tn.gov/content/dam/tn/environment/water/watershed-planning/wr_wq_fish-advisories.pdf.

TWRA 2019. *Final Report, Report No. 19-06, Tennessee Statewide Creel Survey, 2018 Results*, Fisheries Management Division, Tennessee Wildlife Resources Agency.

TWRA 2021. *Final Report, Report No. 21-06, Tennessee Statewide Creel Survey, 2020 Results*, Fisheries Management Division, Tennessee Wildlife Resources Agency.

TWRA 2024. *Final Report, Report No. 24-04, Tennessee Statewide Creel Survey, 2023 Results*, Fisheries Management Division, Tennessee Wildlife Resources Agency.

TWRA 2025*. Tennessee's Commercial Fish and Mussel Report, Report No. 25-03,* Fisheries Management Division, Tennessee Wildlife Resources Agency.

US Fish and Wildlife Service 2024. *Migratory Bird Hunting Activity and Harvest during the 2022-23 and 2023-24 Hunting Seasons*. US Fish and Wildlife Service.

A

Appendix A Glossary

accuracy—The closeness of the result of a measurement to the true value of the quantity.

aliquot—The quantity of a sample being used for analysis.

alkalinity—The capacity of an aqueous solution to neutralize an acid. Alkalinity measurements are important in determining the sensitivity of a body of water to acid inputs such as acidic pollution from rainfall or wastewater.

alpha particle—A positively charged particle emitted from the nucleus of an atom; it has the same charge and mass as that of a helium nucleus (two protons and two neutrons).

ambient air—The surrounding atmosphere as it exists around people, plants, and structures.

analyte—A constituent or parameter that is being analyzed.

analytical detection limit—The lowest reasonably accurate concentration of an analyte that can be detected; this value varies depending on the method, instrument, and dilution used.

anion—A negatively charged ion.

anthropogenic—Of, relating to, or resulting from the influence of human beings on nature.

aquifer—A saturated, permeable geologic unit that can transmit significant quantities of water under ordinary hydraulic gradients.

aquitard—A geologic unit that inhibits the flow of water.

background radiation—Radiation from cosmic sources; naturally occurring radioactive materials, including radon (except as a decay product of source or special nuclear material), and global fallout as it exists in the environment from the testing of nuclear explosive devices.

beta particle—A negatively charged particle emitted from the nucleus of an atom. It has a mass and charge equal to those of an electron.

biota—The animal and plant life of a particular region considered as a total ecological entity.

blank—A control sample that is identical in principle to the sample of interest, except the substance being analyzed is absent. In such cases, the measured value or signal for the substance being analyzed is believed to be a result of artifacts. Under certain circumstances, that value may be subtracted from the measured value to give a net result reflecting the amount of the substance in the sample. EPA does not permit the subtraction of blank results in EPA-regulated analyses.

calibration—Determination of variance from a standard of accuracy of a measuring instrument to ascertain necessary correction factors.

chemical oxygen demand—Indicates the quantity of oxidizable materials present in water and varies with water composition, concentrations of reagent, temperature, period of contact, and other factors.

closure—Specifically, closure of a hazardous waste management facility under Resource Conservation and Recovery Act (RCRA) requirements.

compliance—Fulfillment of applicable requirements of a plan or schedule ordered or approved by government authority.

concentration—The amount of a substance contained in a unit volume or mass of a sample.

conductivity—A measure of water's capacity to convey an electric current. This property is related to the total concentration of the ionized substances in water and the temperature at which the measurement is made.

confluence—The point at which two or more streams meet; the point where a tributary joins the main stream.

contamination—Deposition of unwanted material on the surfaces of structures, areas, objects, or personnel.

cosmic radiation—Ionizing radiation with very high energies, originating outside the earth's atmosphere.

count—A measure of the radiation from an object or device; the signal that announces an ionization event within a counter.

curie (Ci)—A unit of radioactivity. One curie is defined as 3.7×10^{10} (37 billion) disintegrations per second. Several fractions and multiples of the curie are commonly used:

- **kilocurie (kCi)**—10^{3} Ci, one thousand curies; 3.7×10^{13} disintegrations per second.
- **millicurie (mCi)**—10^{-3} Ci, one-thousandth of a curie; 3.7×10^{7} disintegrations per second.
- **microcurie (µCi)**—10^{-6} Ci, one-millionth of a curie; 3.7×10^{4} disintegrations per second.
- **picocurie (pCi)**—10^{-12} Ci, one-trillionth of a curie; 0.037 disintegrations per second.

daughter—A nuclide formed by the radioactive decay of a parent nuclide.

decay, radioactive—The spontaneous transformation of one radionuclide into a different radioactive or nonradioactive nuclide, or into a different energy state of the same radionuclide.

dense nonaqueous phase liquid (DNAPL)—The liquid phase of chlorinated organic solvents. These liquids are denser than water and include commonly used industrial compounds such as tetrachloroethene and trichloroethene.

derived concentration standard (DCS)—Quantities used in the design and conduct of radiological environmental protection programs at US Department of Energy facilities and sites. These quantities represent the concentration of a given radionuclide in either water or air that results in a member of the public receiving a 1 mSv (100 mrem) effective dose following continuous exposure for 1 year for each of the following pathways: ingestion of water, submersion in air, and inhalation.

disintegration, nuclear—A spontaneous nuclear transformation (radioactivity) characterized by the emission of energy and/or mass from the nucleus of an atom.

dissolved oxygen—A measurement of the amount of gaseous oxygen in an aqueous solution. Adequate dissolved oxygen is necessary for good water quality.

dose—A general term for absorbed dose, equivalent dose, or effective dose.

- absorbed dose—The average energy imparted by ionizing radiation to the matter in a volume element per unit mass of irradiated material. The absorbed dose is expressed in units of rad (or gray) (1 rad = 0.01 gray).
- collective dose/collective effective dose—The sum of the total effective dose to all persons in a specified population received in a specified period of time. It can be approximated by the sum of the average effective dose for a given subgroup i, and Ni is the number of individuals in this subgroup. Collective dose is expressed in units of person-rem (or person-sievert).
- effective dose (E or ED)—The summation of the products of the equivalent dose (HT) received by specified tissues or organs of the body and the appropriate tissue weighting factor (wT). It includes the dose from radiation sources internal and/or external to the body. The effective dose is expressed in units of rems (or sieverts).
- equivalent dose (HT)—The product of average absorbed dose (DT,R) in rad (or gray) in a tissue or organ (T) and a radiation (R) weighting factor (wR).

dosimetry—Measurement and calculation of radiation doses from exposure to ionizing radiation.

drinking water standard (DWS)—Federal primary drinking water standards, both proposed and final, as set forth by the US Environmental Protection Agency.

duplicate samples—Two or more samples collected simultaneously into separate containers.

effluent—A liquid or gaseous waste discharge to the environment.

effluent monitoring—The collection and analysis of samples or measurements of liquid and gaseous effluents for purposes of characterizing and quantifying the release of contaminants, assessing radiation exposures of members of the public, and demonstrating compliance with applicable standards.

energy intensity—Energy consumption per square foot of building space, including industrial or laboratory facilities [EO 13514, Section 19(f)].

Environmental Management—A US Department of Energy program that directs the assessment and cleanup (remediation) of its sites and facilities contaminated with waste as a result of nuclear-related activities.

exposure (radiation)—The incidence of radiation on living or inanimate material by accident or intent. Background exposure is the exposure to natural background ionizing radiation. Occupational exposure is the exposure to ionizing radiation that takes place during a person's working hours. Population exposure is the exposure to the total number of persons who inhabit an area.

external radiation—Exposure to ionizing radiation when the radiation source is located outside the body.

flux—A flow or discharge of a substance (in units of mass, radioactivity, etc.) per unit of time.

gamma ray—High-energy, short-wavelength electromagnetic radiation emitted from the nucleus of an excited atom. Gamma rays are identical to x-rays except for the source of the emission.

grab sample—A sample collected instantaneously with a glass or plastic bottle placed below the water surface to collect surface water samples (also called dip samples).

greenhouse gas (GHG)—Gas that traps heat in the atmosphere. The four major greenhouses gases are carbon dioxide, methane, nitrous oxide, and fluorinated gases.

groundwater—The water located beneath the earth's surface in soil pore spaces and in the fractures of rock formations.

hardness—Water hardness is caused by polyvalent metallic ions dissolved in water. In fresh water, these are mainly calcium and magnesium, although other metals such as iron, strontium, and manganese may contribute to hardness.

hectare—A metric unit of area equal to 10,000 square meters or 2.47 acres.

hydrology—The science dealing with the properties, distribution, and circulation of natural water systems.

internal radiation—Internal radiation occurs when radionuclides enter the body by ingestion of foods, milk, and water, and by inhalation. Radon is the major contributor to the annual dose equivalent for internal radionuclides.

ion—An atom or compound that carries an electrical charge.

irradiation—Exposure to radiation.

isotopes—Forms of an element having the same number of protons in their nuclei but differing in the number of neutrons.

maximally exposed individual (MEI)—A hypothetical individual who, because of proximity, activities, or living habits, could potentially receive the maximum possible dose of radiation from a given event or process.

microbes—Microscopic organisms.

migration—The transfer or movement of a material through the air, soil, or groundwater.

millirem (mrem)—The dose equivalent that is one one-thousandth of a rem.

milliroentgen (mR)—A measure of x-ray or gamma radiation. The unit is one-thousandth of a roentgen.

minimum detectable activity (MDA)—The smallest activity of a radionuclide that can be distinguished in a sample by a given measurement system at a preselected counting time and at a given confidence level.

monitoring—A process whereby the quantity and quality of factors that can affect the environment and/or human health are measured periodically to regulate and control potential impacts.

natural radiation—Radiation arising from cosmic and other naturally occurring radionuclide sources (such as radon) present in the environment.

nuclide—An atom specified by its atomic weight, atomic number, and energy state. A radionuclide is a radioactive nuclide.

outfall—The point of conveyance (e.g., drain or pipe) of wastewater or other effluents into a ditch, pond, or river.

ozone—A gas made up of three oxygen atoms that occurs both in earth's upper atmosphere and at ground level. Ozone can be "good" or "bad" for human health and the environment, depending on its location in the atmosphere. Ozone acts as a protective layer high above the earth, but it can be harmful to breathe.

parts per billion (ppb)—A unit measure of concentration equivalent to the weight/volume ratio expressed as micrograms per liter or nanograms per milliliter.

parts per million (ppm)—A unit measure of concentration equivalent to the weight/volume ratio expressed as milligrams per liter or milligrams per kilogram.

person-rem—Collective dose to a population group. For example, a dose of 1 rem to 10 individuals results in a collective dose of 10 person-rem.

pH—A measure of the hydrogen ion concentration in an aqueous solution. Acidic solutions have a pH from 0 through < 7, basic solutions have a pH > 7, and neutral solutions have a pH = 7.

precision—The degree to which repeated measurements under unchanged conditions show the same results (also called reproducibility or repeatability).

quality assurance (QA)—Any action in environmental monitoring to ensure the reliability of monitoring and measurement data.

quality control (QC)—The routine application of procedures within environmental monitoring to obtain the required standards of performance in monitoring and measurement processes.

rad—The unit of absorbed dose deposited in a volume of material.

radioactivity—The spontaneous emission of radiation, generally alpha or beta particles or gamma rays, from the nucleus of an unstable isotope.

radioisotopes—Radioactive isotopes.

radionuclide—An unstable nuclide capable of spontaneous transformation into other nuclides by changing its nuclear configuration or energy level. This transformation is accompanied by the emission of photons or particles.

reclamation—Recovery of wasteland, desert, etc. by ditching, filling, draining, or planting.

reference material—A material or substance with one or more properties that is sufficiently well established and is used to calibrate an apparatus, to assess a measurement method, or to assign values to materials.

release—Any discharge to the environment. "Environment" is broadly defined as any water, land, or ambient air.

rem—The unit of dose equivalent (absorbed dose in rads × the radiation quality factor). Dose equivalent is frequently reported in units of millirem (mrem), which is one one-thousandth of a rem.

remediation—The correction of a problem. On the Oak Ridge Reservation remediation efforts focus on the safe cleanup of the environmental legacy resulting from research activities and weapons production over the past 5 decades.

roentgen—A unit of radiation exposure equal to the quantity of ionizing radiation that will produce one electrostatic unit of electricity in one cubic centimeter of dry air at 0°C and standard atmospheric pressure. One roentgen equals 2.58 × 10-4 coulombs per kilogram of air. (Note: A coulomb is a unit of electric charge—the SI [International System of Units] unit of electric charge equal to the amount of charge transported by a current of one ampere in one second.)

sensitivity—The capability of a methodology or an instrument to discriminate among samples with differing concentrations or containing varying amounts of analyte.

sievert (Sv)—The SI (International System of Units) unit of dose equivalent; 1 Sv = 100 rem.

spike—The addition of a known amount of reference material containing the analyte of interest to a blank sample.

spiked sample—A sample to which a known amount of some substance has been added.

stable—Not radioactive or not easily decomposed or otherwise modified chemically.

stack—A vertical pipe or flue designed to exhaust airborne gases and suspended particulate matter.

standard reference material (SRM)—A reference material distributed and certified by the National Institute of Standards and Technology.

storm water runoff—Rainfall that flows over the ground surface.

stratospheric ozone—The stratosphere or "good" ozone layer extends upward from about 6 to 30 miles above the earth's surface and protects the earth from the sun's harmful ultraviolet rays.

substrate—The substance, base, surface, or medium in which an organism lives and grows.

Superfund—The Superfund Amendments and Reauthorization Act amended the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) in 1986. CERCLA, the federal program to clean up the nation's uncontrolled hazardous waste, is now known as Superfund.

surface water—All water on the surface of the earth, as distinguished from groundwater.

terrestrial radiation—Ionizing radiation emitted from radioactive materials, primarily potassium-40, thorium, and uranium, in the earth's soils.

total dissolved solids—Dissolved solids and total dissolved solids (generally associated with freshwater systems) consist of inorganic salts, small amounts of organic matter, and dissolved materials.

transect—A line across an area being studied. The line is composed of points where specific measurements or samples are taken.

transuranic (or transuranium)—Of or relating to elements with higher atomic weights than uranium; all 13 known transuranic elements are radioactive and are produced artificially.

transuranic waste—Solid radioactive waste containing primarily alpha-emitting elements heavier than uranium.

trip blank—A sample container of deionized water that is transported to a sampling location, treated as a sample, and sent to the laboratory for analysis; trip blanks are used to check for contamination resulting from transport, shipping, and site conditions.

turbidity—A measure of the concentration of sediment or suspended particles in solution.

volatile organic compounds—Organic chemicals that have a high vapor pressure at ordinary conditions. They include both human-produced and naturally occurring chemical compounds and are used in many industrial processes. Common examples include trichloroethane, tetrachloroethene, and trichloroethene.

watershed—The region draining into a river, river system, or body of water. Large watersheds may be subdivided into smaller units called **subwatersheds**, which collectively flow together to form larger sub-basins and river basins.

wetlands—Lowland areas, such as marshes or swamps, sufficiently inundated or saturated by surface water or groundwater to support aquatic vegetation or plants adapted for life in saturated soils. Wetlands are those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands include swamps, marshes, bogs, and similar areas.

wind rose—A diagram that summarizes statistical information concerning wind direction and speed at a specific location.

B

Appendix B Climate Overview of the Oak Ridge Area

B.1. Regional Climate

The climate of the Oak Ridge area and its surroundings may be broadly classified as humid subtropical. The term *humid* indicates that the region receives an overall surplus of precipitation compared with the level of evaporation and transpiration normally experienced throughout the year. The *subtropical* designation indicates that the region experiences a wide range of seasonal temperatures. Subtropical areas are typified by significant differences in temperature between summer and winter. Also, in humid subtropical climates, at least 4 months have an average temperature above 10°C (50°F). Monthly precipitation does not differ significantly throughout the year, but the types of precipitation may vary.

Oak Ridge winters are characterized by large-scale midlatitude cyclones that produce significant precipitation events roughly every 3 to 5 days. These wet periods are occasionally followed by arctic air outbreaks. Although snow and ice are not associated with many of these systems, occasional snowfall does result. Winter cloud cover tends to be enhanced by the regional terrain due to cold-air wedging and moisture trapping.

Severe thunderstorms, which can occur at any time of the year, are most frequent during spring and rarely occur in winter. The Cumberland Mountains and Cumberland Plateau frequently inhibit the intensity of severe systems that traverse the region to the east, particularly those moving from west to east, because of the downward momentum created as the storms move off higher terrain into the Great Valley. Summers are characterized by very warm, humid conditions. Occasional frontal systems may produce organized lines of thunderstorms and rare damaging tornadoes.

More frequently, however, summer precipitation results from air mass thundershowers that form as a consequence of daytime heating, rising humid air, and local terrain features. Although fall precipitation is usually adequate, August through October often are the driest months of the year. Precipitation during the fall tends to be less cyclical than in other seasons, but it is occasionally enhanced by decaying tropical cyclones. In November, midlatitude cyclones begin to dominate the weather and typically continue to do so until May.

Decadal-scale climate changes regularly affect the East Tennessee region. Most of these changes appear related to the hemispheric temperature and precipitation effects caused by the frequencies and phases of the El Niño–Southern Oscillation (ENSO), the Pacific Decadal Oscillation (PDO), and the Atlantic Multidecadal Oscillation (AMO). The ENSO is a recurring climate pattern involving changes in the temperature of waters in the central and eastern tropical Pacific Ocean. About every 3 to 7 years, the surface waters across a large swath of the tropical Pacific Ocean warm or cool by anywhere from 1°C to 3°C compared to normal. The PDO is a long-term climate pattern that affects the temperature of the Pacific Ocean and the weather patterns around it. The PDO is a naturally occurring phenomenon that shifts between warm and cool phases, with each phase lasting around 20–30 years. The PDO can strongly affect global weather and is important in long-range weather forecasting (Dutton 2021). The AMO is an ongoing series of long-duration changes in the sea surface temperature of the North Atlantic Ocean, with cool and warm phases that may last for 20–40 years each and a difference of about −17.2°C (1.0°F) between extremes. These changes are natural and have been occurring for at least the past 1,000 years.

These medium- and long-range sea surface temperature patterns collectively influence decadal-scale and longer regional temperature and precipitation trends in eastern Tennessee. The AMO shifted from a cold sea surface temperature phase to a warm sea surface temperature phase in the mid-1990s; these warmer temperatures have generally continued through the present. The PDO entered an either cool or transitional sea surface temperature phase around 2000. Although the ENSO pattern frequently caused warmer eastern Pacific sea surface temperatures during the 1990s, that warming subsided somewhat in the 2000s. The El Niño returned to prominence during the 2010s. A very strong El Niño occurred in 2015–2016, causing above-normal temperatures both locally and across much of the globe by 2016. Additionally, evidence exists that human-induced climate change may be affecting local temperatures via well-mixed greenhouse gases, land-cover change, carbon soot, aerosols, and other first-order influences. Solar influences on the jet stream via changes to the stratospheric temperature gradient over the 11-year solar cycle also contribute to interannual climate variability (Ineson et al. 2011). Perhaps in part because of the effects of the AMO and ENSO, the Oak Ridge climate warmed about 1.2°C from the 1970s to the 1990s and through the 2010s increased by less than 0.2°C from the value observed in the 1990s. This slight warming trend has continued into the early 2020s. The late-20th-century warming appears to have lengthened the growing season (i.e., the period with temperatures above 0°C, or 32°F) by about 2 to 3 weeks over the past 30 years, primarily by increasing minimum temperatures. Similar trends were noted through the 2000s and 2010s, with an average of 10 fewer days per year of minimum temperatures below 0°C. This effect is presumably related to changes in the interaction of the surface boundary layer with greenhouse gases and/or aerosol concentration changes. The effects of greenhouse gases on the nocturnal inversion layer (and thus on minimum temperatures) represent a redistribution of heat in the lower portion of the surface atmospheric layer. Temperature averages for individual years may vary significantly, as observed in the more than 1°C difference between the average temperatures for 2014 (14.8°C) and 2015 (16.0°C), largely the result of the recent strong El Niño. During the post-El Niño years of 2017 and 2018, the annual average temperature at ORNL returned to approximately the same level

as in 2014 (i.e., 14.5°C in 2018) but rose again in 2019 under the influence of weak El Niño conditions (15.2°C). The average temperature declined in 2020 to 14.7°C with the onset of La Niña conditions, which persisted into early 2023 before positive sea surface temperature anomalies (i.e., strengthening El Niño conditions) returned and lasted through the early summer of 2024. Through the remainder of the year, conditions were generally neutral.

B.2. Winds

Five major terrain-related wind regimes regularly affect the Great Valley of eastern Tennessee:

- Pressure-driven channeling
- Downward-momentum transport or vertically coupled flow
- Forced channeling
- Along-valley and mountain-valley thermal circulations
- Down sloping

Pressure-driven channeling and vertically coupled flow affect winds on scales comparable to that of the Great Valley (hundreds of kilometers). Forced channeling occurs on similar scales but is also quite important at small spatial scales, such as those characterizing the ridge-and-valley terrain within ORR (Birdwell 2011). Along-valley and mountain-valley circulations are thermally driven and occur within a broad range of spatial scales. Thermally driven flows are more prevalent under conditions of clear skies and low humidity, favoring summer and especially fall months. Down sloping is frequently responsible for a slight temperature elevation when the Cumberland Mountains are on the windward side of ORR. Such windward flow also favors reduced wind speeds.

Forced channeling is defined as the direct deflection of wind by terrain. Because it necessitates some degree of vertical motion transfer, forced channeling is less pronounced during periods when cool air is trapped under warmer air just off the surface (i.e., inversion). Although it may result from interactions between large valleys and mountain ranges (such as the Great Valley and the surrounding mountains), forced channeling is especially important in narrow, small valleys such as those within ORR and the Great Valley (Kossman and Sturman 2002).

Forced channeling is the dominant large-scale wind mechanism within the Central Great Valley, influencing 50–60 percent of all winds observed in the area. For up-valley (southwest to northeast) flow cases, these winds are frequently associated with large wind shifts (45°–90°) when they initiate or terminate. At small scales, ridge-and-valley terrain produces forced-channeled local flow in more than 90 percent of cases.

Large-scale forced channeling occurs regularly within the Great Valley when northwest-to-north winds (perpendicular to the axis of the Central Great Valley) coincide with vertically coupled flow. This sometimes results in a split-flow pattern, with winds southwest of Knoxville moving down valley and those east of Knoxville moving up valley. The causes of such a flow pattern may include the shape characteristics of the Great Valley (Kossman and Sturman 2002) but also may be associated with the specific location of the Cumberland and Smoky Mountains relative to upper-level wind flow (Eckman 1998). A northwest wind flow through the convex shape of the Great Valley may lead to a divergent wind flow pattern in the Knoxville area, resulting in downward air motion. Horizontal flow is also reduced by the windward Cumberland Mountains, which increase buoyancy and the apparent force caused by the earth's rotation, or the Coriolis effect (also known as Froude and Rossby ratios). Consequently, the leeward terrain of the Smoky Mountains becomes more effective at blocking or redirecting the winds.

Vertically coupled winds tend to occur when the atmosphere is unstably or neutrally buoyant. When a strong horizontal wind component is present, as in conditions behind a winter cold front or during strong regional cold-air advection, winds tend to override the terrain, flowing roughly in the same direction as the winds aloft. This is a consequence of the horizontal transport

and momentum aloft being transferred to the surface. However, Coriolis effects may turn the winds to the left by up to 40° (Birdwell 1996).

In the Central Great Valley, vertically coupled winds dominate about 25–35 percent of each occurrence of broader-scale wind events; however, most vertically coupled winds are turned toward an up-valley or down-valley direction when small-scale ridge-and-valley terrain is factored in. Wintertime vertically coupled flow is typically dominated by strong, large-scale pressure forces, whereas summertime cases tend to be associated with a deep mixing depth (greater than 500 m). Most vertically coupled flows are associated with major wind shifts (90°–135°) when they begin or terminate (Birdwell 2011).

Pressure-driven channeling is the redirection of synoptically induced wind flow through a valley channel. The direction of wind flow through the valley is determined by the axis of the pressure gradient superimposed on the valley axis (Whiteman 2000). The process is affected by Coriolis forces, a leftward deflection of winds in the Northern Hemisphere. Eckman (1998) suggested that pressure-driven channeling plays a significant role in the Great Valley. Winds driven purely by pressure-driven channeling shift from up-valley to down-valley flow or in the opposite direction if large-scale pressure systems induce reversals in air pressure gradients across the axis of the Great Valley. Because the processes involved in pressure-driven flow primarily affect the horizontal motion of air, the presence of a temperature inversion enhances this pattern significantly. Weak vertical air motion and momentum associated with such inversions allow different layers of air to slide over one another with varied directions of movement (Monti et al. 2002).

Within the Central Great Valley, and especially within ORR, winds dominated by down-valley pressure-driven channeling range in frequency from 2 to 10 percent of cases, with the lowest values in summer and the highest in winter. Up-valley pressure-driven channeling usually does not dominate winds in the Central Great Valley but co-occurs with forced-channeled winds 50 percent of the time. Winds dominated by pressure-driven channeling often result in large wind shifts (90°–180°) before and after the occurrence of the wind pattern. These wind shifts occur about twice as frequently within and near ORR than in other parts of the Great Valley (Birdwell 2011). Most pressure-driven channeled winds occur in association with moderate (0.006–0.016 mb/km) synoptic pressure gradients.

Thermally driven winds are common in areas of complex terrain. These winds occur because of pressure and temperature differences caused by varied surface–air energy exchanges at similar altitudes along a valley's axis, sidewalls, or slopes. Conditions are ideal for the development of thermally driven winds when synoptic winds are light and when thermal differences are exacerbated by clear skies and low humidity (Whiteman 2000). Ridge-and-valley terrain may be responsible for enhancing or inhibiting such flow, depending on ambient weather conditions. Large-scale thermally driven winds are most frequent during summer and especially fall, when surface heating and low humidity help drive flow patterns (Birdwell 2011).

B.3. Temperature and Precipitation

Temperature and precipitation normals (1991–2020) and extremes (1948–2024) and their durations for the city of Oak Ridge and ORNL are summarized in Table B.1. Decadal temperature and precipitation averages for 5 decades (1970s–2010s) are provided in Table B.2. Hourly freeze data (1985–2024) are given in Table B.3. Overall, at ORNL, 2024 was 0.3°C warmer than normal compared with the 1991–2020 Oak Ridge base period, and precipitation was 15 percent below normal compared with the 1991–2020 mean.

B.3.1. Recent Climate Change with Respect to Temperature and Precipitation

Table B.2 presents a decadal analysis of temperature patterns from 1970 to 2019. In general, temperatures in the Oak Ridge area rose from the 1970s to the 1990s and have nearly stabilized since the 1990s. Based on these average decadal temperatures, temperatures rose 1.2°C between the 1970s and the 1990s, from 13.8°C to 15.0°C (56.8°F to 59.0°F). The warmest decade of the past five was the 2000s at 15.2°C (59.4°F), although temperatures in the 2010s were virtually the same (15.1°C, or 59.2°F). More detailed analysis reveals that these temperature changes have been neither linear nor equal with respect to the seasons.

January and February average temperatures increased by about 2.5°C from the 1970s to the 1990s and have declined by just over 1°C since the 1990s. The peak in the 1990s may be associated with the effects of the AMO, other natural effects, and/or anthropogenic effects. The Arctic has seen the largest increase in temperatures anywhere in the Northern Hemisphere over the past 30 years, and this increase has had a corresponding effect on Oak Ridge temperatures in winter because of the influx of Arctic air masses.

During the winter months of January and February, much of the air entering eastern Tennessee comes from the Arctic. As a result, Oak Ridge temperatures have warmed more dramatically during these months. Changes to average temperatures in December have not been as dramatic as those in January and February. December averages were relatively warm in the 1970s (4.6°C), bottomed out in the 1980s (3.1°C), returned to approximately 1970s levels in the 1990s and 2000s, and finally warmed to about 6.0°C by the 2010s.

Compared with the 1970s, temperatures have warmed 1.0°C, 1.5°C, and 2.1°C during the climatological spring months of March, April, and May, respectively. However, most of the warming in March and April did not occur until the 2000s. The tendency toward warmer springs has slightly lengthened the growing season.

Summer months (June, July, and August) were 1.8°C, 1.3°C, and 0.9°C warmer on average, respectively, in the 2010s than in the 1970s; however, most observed warming during summer can be attributed to a rise in minimum temperatures. In fact, August maximum temperatures have declined about 1.0°C since the 2000s. Warming for June and July has virtually stopped since the 2000s.

Climatological fall months (September, October, and November) generally have had the smallest average temperature increases (0.9°C, 1.3°C, and 0.1°C, respectively) since the 1970s. In fact, average temperatures in September and October have remained fairly consistent since the 1990s, and November has not shown a clear trend across the decades since the 1970s.

The mean annual temperature increased by 1.4°C between the 1970s and the 2000s and then remained about the same in the 2010s (1.3°C warmer than the 1970s). About 90 percent of the increase occurred between the 1980s and 1990s. Mean annual decadal-averaged temperatures have varied by only 0.2°C since the 1990s. Since the 2020 ASER, a base period of 1991–2020 has been used to determine the mean annual temperature. The mean annual temperature increased by about 0.6°C, mainly because the cooler 1980s values were eliminated. Between 2022 and 2024, global temperatures were above average, perhaps in part because of an increase in water vapor within the stratosphere due to the eruption of Hunga Tonga in the South Pacific.

Decadal precipitation averages suggest some important changes in precipitation patterns in Oak Ridge from the 1970s to 2010s. Although overall decadal precipitation averages remained between about 48 and 60 in. annually, some decadal shifts were observed in monthly and seasonal patterns of rainfall. During winter (December, January, and February), precipitation remained fairly constant after the 1970s. However, February precipitation in the 2010s (and for winter overall after the 2000s) increased significantly. Spring precipitation (March, April, and May) declined about 20 percent after the 1970s. Summer (June, July, and August) precipitation changes are mixed.

June values changed little between the 1970s and the 2010s, but July values increased by about 20 percent, and August values declined by about 20 percent. Similar patterns were observed for the fall months. During the 2010s, September precipitation values increased by about 10 percent compared with the 1970s, whereas October values decreased by about 10 percent. Little change occurred in precipitation for November. Overall, annual average precipitation in the 2010s was about 3 percent less than it was in the 1970s (59.68 vs. 58.18 in.). Also, precipitation values in the 1980s and 2000s were 10 to 20 percent less than those in the 2010s, and precipitation levels in the 1990s were similar to levels observed in the 2010s.

The increase in winter temperatures since the 1970s has affected monthly and annual snowfall amounts. During the 1970s and 1980s, snowfall averaged about 25.4 to 28 cm (10 to 11 in.) annually in Oak Ridge. However, during the most recent 2 decades (the 2000s and 2010s), snowfall averaged only 9.8 cm (3.9 in.) per year. This decrease seems to have occurred largely since the mid-1990s. January and February temperatures cooled slightly in the 2010s compared with the 2000s, which seems to have reversed the decrease in snowfall slightly, with annual averages of 13.2 cm (5.2 in.) during the 2010s. Concurrently with the overall decrease in snowfall, the annual number of hours of subfreezing weather generally declined after the 1980s (see Table B.3). However, the number of subfreezing hours during 2010 (1,123 h) was the highest recorded since 1988. January 2014 was the coldest January since 1985, with 371 subfreezing hours, and February 2015 was the coldest February since 1978, also with 371 subfreezing hours.

Table B.3 presents the number of hours of subfreezing temperatures in Oak Ridge for each year from 1985 to 2024. During the mid- to late 1980s, there were about 900 to 1,000 h of subfreezing temperatures during a typical year. In recent years, these values have fallen to about 600 to 700 h, although higher values have occurred relatively recently (e.g., 1,123 h in 2010). However, in some years in the 2010s, only 350 to 500 h of subfreezing weather were observed.

B.4. Moisture

ORR's humid environment results in frequent saturation of the surface layer, especially at night. Average annual relative humidity at ORNL for tower MT2, one of eight DOE-managed ORR meteorological towers, is 75.4 percent (2015–2021) at 2 m above ground level and 72.9 percent at 15 m above the ground. The average annual absolute humidity, a measure of the actual amount of water vapor (moisture) in the air regardless of the air's temperature, for MT2 is 10.3 g/m^3 at both 2 and 15 m above ground level. Absolute humidity varies greatly throughout the year, ranging from a monthly minimum of about 4.7 g/m^3 during winter to a maximum of about 16.9 g/m^3 during summer.

Table B.1. Climate normals (1991–2020) and extremes (1948–2024) for ORNL

Monthly variables	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Temperature, °C													
30-year average max	8.8	11.4	16.5	21.9	26.2	29.8	31.4	31.2	28.1	22.2	15.4	10.3	21.1
2024 average max	5.5	14.1	17.3	20.4	24.5	29.3	30.3	30.3	27.2	23.2	17.7	10.4	20.9
77-year record max	25	27	30	33	35	41	41	39	39	35	28	26	41
30-year average min	-1.5	0.2	3.9	5.8	13.4	17.8	20.1	19.5	15.9	9.1	3.0	0.3	9.0
2024 average min	-3.7	1.3	5.2	9.6	14.6	18.8	21.0	19.0	17.3	10.1	7.8	1.4	10.2
77-year record min	-27	-25	-17	-7	-1	4	9	10	1	-6	-16	-22	-27
30-year average	3.5	5.8	10.2	13.2	19.7	23.7	25.6	25.2	21.8	15.5	9.1	5.2	14.9
2024 average	1.0	7.4	11.0	14.8	19.1	23.9	25.1	24.0	21.8	15.9	12.6	5.6	15.2
2024 departure from average	-2.5	1.6	0.8	1.6	-0.6	0.2	-0.5	-1.2	0	0.4	3.5	0.4	0.3
30-year average heating degree days, °C													
	451	351	252	110	31	1	0	0	9	101	270	399	1,974
30-year average cooling degree days, °C													
	0	0	7	18	80	170	235	221	120	22	1	0	874
Precipitation, mm													
30-year average	132.4	138.7	129.8	131.6	106.5	113.1	141.5	84.6	100.4	80.0	120.7	138.5	1,417.8
2024 totals	133.1	118.1	90.7	73.4	176	57.4	245.1	35.3	118.1	0.3	76.2	104.1	1,227.9
2024 departure from average	0.7	-20.6	-39.1	-58.2	69.5	-55.7	103.61	-49.3	17.71	-79.7	-44.5	-34.36	-189.9
77-year max monthly	337.2	384.7	311.0	356.5	271.9	283	489.6	265.8	257.6	203.8	310.5	321.2	1,939.4
77-year max 24 h	108.0	131.6	120.4	158.5	112.0	94.0	124.8	190.1	160.1	67.6	130.1	130.1	190.1
77-year min monthly	23.6	21.3	54.1	46.2	20.3	13.5	31.3	13.7	Trace	Trace	34.8	17.0	911.4
Snowfall, in.													
30-year average	4.6	5.1	2	0	0	0	0	0	0	0	2.5	2.5	14.5
2024 totals	8.10	0	0	0	0	0	0	0	0	0	Trace	Trace	8.1
77-year max monthly	24.4	43.7	53.4	15	Trace	0	0	0	0	Trace	16.5	53.4	105.2
77-year max 24 h	21.1	28.7	30.5	13.7	Trace	0	0	0	0	Trace	16.5	30.5	30.5

Table B.1. Climate normals (1991–2020) and extremes (1948–2024) for ORNL (continued)

Monthly variables	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Days w/temperature													
30-year max ≥ 32°C	0	0	0	0.1	1.5	7.7	14.4	12.7	4.9	0.1	0	0	41.4
2024 max ≥ 32°C	0	0	0	0	0	5	9	9	2	0	0	0	8
30-year min ≤ 0°C	19.8	15.4	8.7	1.8	0.1	0	0	0	0	0.9	10.3	16.5	73.5
2024 min ≤ 0°C	22	16	4	0	0	0	0	0	0	0	2	16	60
30-year max ≤ 0°C	2.6	0.8	0.1	0	0	0	0	0	0	0	0	0.8	4.3
2024 max ≤ 0°C	6	0	0	0	0	0	0	0	0	0	0	0	6
Days w/precipitation													
30-year avg ≥ 0.01 in.	11.8	11.6	12.4	11.1	11.5	11.4	12.3	9.8	8.1	8.3	9.2	12.2	129.7
2024 days ≥ 0.01 in.	13	9	10	13	17	11	13	2	9	1	11	10	119
30-year avg ≥ 1.00 in.	1.7	1.4	1.4	1.5	1.1	1.2	1.6	0.9	1.2	1	1.7	1.7	16.4
2024 days ≥ 1.00 in.	1	1	1	0	3	0	3	0	2	0	1	0	12

Table B.2. Decadal climate change (1970–2019) for city of Oak Ridge/ORNL, with 2024 comparisons

Monthly variables	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Temperature, °C													
1970–1979 avg max	6.6	9.7	15.6	21.4	24.8	28.5	30.0	29.7	26.8	20.8	14.5	10.0	19.9
1980–1989 avg max	6.9	10.2	15.9	21.0	25.6	29.8	31.6	30.7	27.1	21.3	15.6	8.6	20.3
1990–1999 avg max	9.4	12.3	16.2	21.9	26.2	29.7	32.1	31.4	28.4	22.6	15.2	10.4	21.3
2000–2009 avg max	8.8	11.2	17.0	21.4	25.8	29.8	30.8	31.4	27.6	21.8	15.9	9.8	21.0
2010–2019 avg max	8.1	11.2	16.3	22.6	26.8	30.2	31.2	30.8	28.5	22.3	15.1	11.4	21.2
1980s vs. 2010s	1.2	1.0	0.3	1.6	1.2	0.4	-0.2	0.0	1.4	1.0	-0.5	2.3	0.8
2000s vs. 2010s	-0.7	0.0	-0.8	1.2	1.0	0.4	0.5	-0.6	0.9	0.5	-0.8	1.1	0.2
2024 avg max	5.5	14.1	17.3	20.4	24.5	29.3	30.3	30.3	27.2	23.2	17.7	10.4	20.9
1970–1979 avg min	-3.4	-2.4	3.0	6.7	11.6	15.7	18.3	18.1	15.5	7.5	2.6	-0.8	7.7
1980–1989 avg min	-4.1	-2.1	1.7	6.0	11.4	16.2	19.0	18.4	14.4	7.5	3.1	-2.3	7.4
1990–1999 avg min	-0.9	0.0	2.9	7.2	12.5	17.2	20.0	18.9	15.1	8.2	2.2	0.1	8.6
2000–2009 avg min	-1.4	0.0	4.4	8.6	13.6	18.0	20.0	20.0	16.1	9.5	3.9	-0.4	9.4
2010–2019 avg min	-2.0	0.6	4.2	8.8	14.1	18.2	20.3	19.5	16.4	9.4	2.7	1.2	9.5
1980s vs. 2010s	2.0	2.6	2.5	2.7	2.7	2.1	1.3	1.1	2.0	2.0	-0.4	3.6	2.1

Table B.2. Decadal climate change (1970–2019) for city of Oak Ridge/ORNL, with 2024 comparisons (continued)

Monthly variables	January	February	March	April	May	June	July	August	September	October	November	December	Annual
2000s vs. 2010s	-0.6	0.6	-0.2	0.1	0.5	0.4	0.3	-0.5	0.3	-0.1	-1.2	1.6	0.1
2024 avg min	-3.7	1.3	5.2	9.6	14.6	18.8	21.0	19.0	17.3	10.1	7.8	1.4	10.2
1970–1979 avg	1.6	3.7	9.3	14.1	18.1	22.1	24.1	23.9	21.1	14.2	8.6	4.6	13.8
1980–1989 avg	1.4	4.1	8.8	13.5	18.5	23.0	25.3	24.6	20.8	14.4	9.4	3.1	13.9
1990–1999 avg	4.2	6.2	9.6	14.5	19.4	23.5	26.0	25.2	21.9	15.5	8.8	5.3	15.0
2000–2009 avg	3.7	5.6	10.7	15.3	19.7	23.9	25.4	25.7	21.9	15.6	9.9	4.7	15.2
2010–2019 avg	3.0	5.3	10.3	15.7	20.3	24.0	25.4	24.6	21.9	15.4	8.7	6.4	15.1
1980s vs. 2010s	1.5	1.8	1.5	2.1	1.8	0.9	0.1	0.2	1.2	1.1	-0.7	2.8	1.2
2000s vs. 2010s	-0.7	0.2	-0.4	0.3	0.6	0.0	0.0	-1.0	0.1	-0.2	-1.2	1.2	-0.1
2024 avg	1.0	7.4	11.0	14.8	19.1	23.9	25.1	24.0	21.8	15.9	12.6	5.6	15.2
Precipitation, mm													
1970–1979 avg	143.4	94.6	169.4	118.3	149.8	120.5	130.4	109.8	107.2	99.8	129.6	145.3	1,516.4
1980–1989 avg	100.4	109.1	112.6	88.8	110.6	84.1	120.4	82.6	108.9	79.8	128.0	107.6	1,236.2
1990–1999 avg	141.4	136.5	149.0	126.3	113.4	110.0	134.8	83.6	71.9	67.3	109.8	161.0	1,429.4
2000–2009 avg	116.9	121.8	115.6	125.0	117.8	95.2	138.9	78.4	108.8	74.0	121.4	124.4	1,333.4
2010–2019 avg	130.1	146.6	117.4	131.9	93.8	132.4	156.8	92.5	114.1	91.0	128.0	151.7	1,478.2
1980s vs. 2010s	29.5	37.6	4.6	42.9	-16.8	15.2	36.3	9.9	5.3	11.2	0.0	44.3	239.3
2000s vs. 2010s	13.2	24.9	1.7	6.9	24.1	13.5	17.8	14.0	5.3	17.0	6.7	27.2	146.9
2024 totals	133.1	118.1	90.7	73.4	176	57.4	245.1	35.3	118.1	0.3	76.2	104.1	1,227.9
Snowfall, cm													
1970–1979 avg	11.1	12.5	4.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.5	4.4	35.1
1980–1989 avg	11.4	8.8	2.2	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.5	32.8
1990–1999 avg	6.9	7.8	8.1	Trace	0.0	0.0	0.0	0.0	0.0	0.0	0.3	3.1	10.9
2000–2009 avg	2.1	4.5	Trace	Trace	0.0	0.0	0.0	0.0	0.0	0.0	Trace	1.7	8.3
2010–2019 avg	5.3	6.4	0.3	Trace	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1.4	13.2
1980s vs. 2010s	5.2	1.8	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	2.8	12.4
2000s vs. 2010s	3.6	2.8	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	6.6
2024 totals	20.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Trace	Trace	20.6

Table B.3. Hourly subfreezing temperature data for Oak Ridge, Tennessee, 1985–2024[a] (Hours at or below 0°C, −5°C, −10°C, and −15°C)

Year	January				February				March			April		May		October		November			December				Annual			
	≤0	<-5	<-10	<-15	≤0	<-5	<-10	<-15	≤0	<-5	<-10	≤0	<-5	≤0	<-5	≤0	<-5	≤0	<-5	<-10	≤0	<-5	<-10	<-15	≤0	<-5	<-10	<-15
1985	467	195	103	39	331	127	26	0	105	6	0	43	3	0	0	0	0	22	0	0	431	201	66	2	1,399	532	195	41
1986	308	125	38	10	161	29	3	0	124	28	0	17	0	0	0	0	0	32	10	0	232	34	0	0	874	226	41	10
1987	302	53	7	0	111	19	3	0	95	0	0	55	4	0	0	36	0	103	18	0	151	16	0	0	853	110	10	0
1988	385	182	43	0	294	102	19	0	97	9	0	6	0	0	0	45	0	62	3	0	301	55	0	0	1,190	351	62	0
1989	163	27	0	0	190	66	10	0	35	0	0	18	0	3	0	7	0	125	14	0	421	188	71	30	962	295	81	30
1990	142	13	0	0	115	5	0	0	35	0	0	35	0	0	0	19	0	62	1	0	172	43	5	0	580	62	5	0
1991	186	44	0	0	158	47	15	0	49	0	0	0	0	0	0	4	0	148	16	0	192	38	0	0	737	145	15	0
1992	230	65	8	0	116	22	0	0	116	4	0	27	2	0	0	7	0	100	0	0	166	9	0	0	762	102	8	0
1993	125	11	0	0	245	47	8	0	124	32	9	3	0	0	0	0	0	152	2	0	223	44	0	0	872	136	17	0
1994	337	191	85	26	196	46	3	0	66	0	0	18	0	0	0	0	0	53	1	0	142	0	0	0	812	238	88	26
1995	240	45	6	0	217	84	18	0	37	0	0	0	0	0	0	0	0	142	3	0	288	84	10	0	924	216	34	0
1996	301	91	0	0	225	110	62	27	182	49	6	23	0	0	0	3	0	101	0	0	194	40	4	0	1,029	290	72	27
1997	254	101	24	0	67	0	0	0	25	0	0	6	0	0	0	6	0	96	10	0	232	14	0	0	686	125	24	0
1998	97	10	7	0	25	0	0	0	74	20	0	0	0	0	0	0	0	38	0	0	132	4	0	0	366	34	7	0
1999	181	68	0	0	113	14	0	0	62	0	0	0	0	0	0	4	0	41	0	0	177	23	0	0	578	105	0	0
2000	273	62	5	0	127	30	0	0	18	0	0	8	0	0	0	11	0	94	11	0	345	124	7	0	876	227	12	0
2001	281	60	5	0	79	9	0	0	53	0	0	2	0	0	0	18	0	28	0	0	137	35	0	0	598	104	5	0
2002	185	28	0	0	121	16	0	0	91	17	0	2	0	0	0	0	0	41	0	0	82	6	0	0	522	67	0	0
2003	345	123	26	0	117	12	0	0	19	0	0	0	0	0	0	0	0	37	0	0	102	9	0	0	620	144	26	0
2004	285	50	2	0	76	0	0	0	18	0	0	0	0	0	0	0	0	9	0	0	247	41	4	0	635	91	6	0
2005	151	65	6	0	52	1	0	0	81	1	0	0	0	0	0	1	0	55	0	0	176	28	0	0	516	95	6	0
2006	70	0	0	0	169	19	0	0	44	0	0	0	0	0	0	15	0	37	0	0	126	41	1	0	461	60	1	0
2007	189	30	5	0	283	70	0	0	29	0	0	32	0	0	0	0	0	60	0	0	83	8	0	0	673	111	5	0
2008	242	86	11	0	114	7	0	0	69	6	0	0	0	0	0	15	0	89	18	0	157	34	5	0	686	151	16	0
2009	238	93	29	0	178	64	5	0	55	15	0	5	0	0	0	0	0	8	0	0	178	22	0	0	662	194	34	0
2010	384	181	14	0	289	32	0	0	40	2	0	0	0	0	0	0	0	46	0	0	364	109	11	0	1,123	324	25	0
2011	300	61	0	0	108	14	0	0	2	0	0	0	0	0	0	5	0	29	0	0	91	0	0	0	535	75	0	0
2012	169	27	0	0	78	19	0	0	9	0	0	1	0	0	0	0	0	46	0	0	76	0	0	0	379	46	0	0
2013	245	49	0	0	120	12	0	0	95	7	0	0	0	0	0	11	0	121	0	0	173	6	0	0	765	74	0	0
2014	371	208	76	12	109	5	0	0	68	0	0	5	0	0	0	0	0	122	10	0	94	1	0	0	769	224	76	12

Table B.3. Hourly subfreezing temperature data for Oak Ridge, Tennessee, 1985–2024[a] (continued) (Hours at or below 0°C, −5°C, −10°C, and −15°C)

Year	January				February				March			April		May		October		November			December				Annual			
	≤0	<-5	<-10	<-15	≤0	<-5	<-10	<-15	≤0	<-5	<-10	≤0	<-5	≤0	<-5	≤0	<-5	≤0	<-5	<-10	≤0	<-5	<-10	<-15	≤0	<-5	<-10	<-15
2015	228	52	16	0	371	120	31	6	52	16	0	0	0	0	0	0	0	11	0	0	41	0	0	0	703	188	47	6
2016	333	82	12	0	211	17	0	0	35	0	0	9	0	0	0	0	0	44	3	0	163	32	0	0	795	134	12	0
2017	130	47	11	1	64	5	0	0	82	8	0	0	0	0	0	8	0	67	0	0	252	20	0	0	603	44	10	0
2018	362	199	86	4	67	7	0	0	49	2	0	11	0	0	0	0	0	89	6	0	102	11	0	0	680	225	86	4
2019	146	46	1	0	46	0	0	0	80	9	0	5	0	0	0	0	0	93	11	0	90	0	0	0	466	66	1	0
2020	124	14	0	0	102	11	0	0	20	1	0	12	0	4	0	0	0	30	0	0	210	49	11	0	502	75	11	0
2021	151	1	0	0	144	33	0	0	34	0	0	31	0	0	0	0	0	121	0	0	70	0	0	0	551	34	0	0
2022	271	45	0	0	126	3	0	0	37	11	0	3	0	0	0	8	0	59	3	0	170	75	36	13	674	137	36	13
2023	67	0	0	0	31	3	0	0	53	5	0	0	0	0	0	0	0	77	10	0	130	1	0	0	358	19	0	0
2024	312	118	65	13	114	9	0	0	25	0	0	0	0	0	0	0	0	12	0	0	157	25	0	0	620	152	65	13
Avg	239	74	17	3	147	31	5	1	58	6	0	9	0	0	0	6	0	68	4	0	182	37	6	1	710	151	28	5

[a] *Source: 1985–2014 National Oceanic and Atmospheric Administration, Atmospheric Turbulence and Diffusion Division, KOQT Station, Automated Surface Observing System; 2015–2024 ORNL, Tower "D."*

B.5. Severe Weather

On average, thunderstorms and associated lightning occur in the Oak Ridge area at a rate of 48 days per year, with a monthly maximum of about 11 days occurring in July. About 40 of these thunderstorm days occur during the 7-month period from April through October, with the remainder spread evenly throughout late fall and winter. The highest number of thunderstorm days at ORNL (65) was observed during 2012; the lowest (34) was observed during 2007. A total of 40 thunderstorm days occurred in 2024.

Hailstorms are infrequent on ORR and typically occur in association with severe thunderstorms. Hailstorms are usually caused by high-altitude thunderstorm updrafts, which propel water droplets above the freezing level. Some hail events have been known to occur in association with nonthunder rain showers and low freezing levels (particularly during winter or spring). Most hailstorm occurrences (77 percent) do not produce hailstones larger than 2 cm (about 0.75 in.). From 1961 through 1990, about six hail events (with hailstones larger than about 2 cm) were documented at locations within 40 km (25 miles) of ORNL. Nearly all of these events occurred during the summer and fall seasons. During the 2011 significant tornado outbreak in East Tennessee, large hail (greater than 2 cm) was observed in Farragut, Tennessee, about 15 km (9 miles) southeast of ORNL.

A tornado outbreak occurs in East Tennessee about once every 3 to 6 years on average. The Fujita Tornado Scale, usually referred to as the F-Scale, was developed in 1973 to classify tornadoes based on the resulting damage. The scale ranges from F0 (minimal damage) to F5 (incredible damage). The version used today—the Enhanced Fujita Scale—went into effect in 2007 and ranges from EF0 tornadoes with winds of 65 to 85 mph to EF5 tornadoes with winds exceeding 200 mph. Tornado indices from the National Weather Service in Morristown, Tennessee, show that since 1950, three tornadoes have been documented within 10 km (6 miles) of ORNL: two F0 tornadoes and one F3 (severe damage) tornado. The F3 tornado occurred in February 1993 and moved through Bear Creek Valley near the Y-12 National Security Complex, with winds damaging the roofs of several buildings along Union Valley Road. To date, the February 1993 tornado is the only documented tornado that has occurred within ORR.

Eleven additional tornadoes have been documented since 1950 within 20 km (12 miles) of ORNL, ranging in intensity from F0/EF0 to F2/EF2. The most recent of these was an EF2 that occurred during the afternoon of August 7, 2023, and touched down just west of Pellissippi Parkway before crossing the road and traversing east for a track totaling 6.1 km (3.8 miles). Just days prior, a brief EF0 tornado spun up along Highway 70 in Oral, Tennessee, in Roane County. Both tornadoes formed within passing squall lines, which produced widespread high winds and associated damage across the local area. The remaining tornadoes within 20 km (12 miles) of ORNL affected eastern Roane County to the south and the Edgemoor Road area to the northeast of ORR. Another 10 tornadoes, ranging from F0/EF0 to F3/EF3 in intensity, have occurred within 35 km (22 miles) of ORNL since 1950. Most of them occurred to the east and south of ORR in Knox and Roane Counties; however, a few occurred in the Rocky Top and Norris areas.

The annual probability that a tornado will strike any location in a grid square can be estimated by multiplying the number of tornadoes per year per square kilometer in that particular grid square by the path area of a tornado. The result of this calculation is greatly affected by the assumed path area of a tornado. In total, about 24 tornadoes have been documented within 35 km (22 miles) of ORNL since 1950.

B.6. Stability

The local ridge-and-valley terrain plays a role in the development of stable surface air under certain conditions and influences the dynamics of airflow. Although ridge-and-valley terrain creates identifiable patterns during times of unstable conditions as well, strong vertical mixing and

momentum tend to reduce these effects. *Stability* describes the tendency of the atmosphere to mix (especially vertically) or overturn. Consequently, dispersion parameters are influenced by the stability characteristics of the atmosphere. Stability classes range from A (very unstable) to G (very stable), with D being a neutral state.

The suppression of vertical motions during stable conditions increases the effect of local terrain on air motion. Conversely, stable conditions isolate wind flows within the ridge-and-valley terrain from the effects of more distant terrain features and from winds aloft. These effects are particularly significant with respect to mountain waves, which are downwind oscillations that result from terrain-induced disruption within the horizontal flow. Like water flowing over a boulder, when air is perpendicular to a stationary boundary (e.g., the Cumberland or Smoky Mountains), it tends to stay at the same altitude or sink in a stable air mass. This causes a "ripple" or "wave" on the lee side of the terrain. This effect on mountain-wave formation may be important to the impact that the nearby Cumberland Mountains could have on local airflow.

A second factor that may decouple large-scale wind flow effects from local ones (and thus produce stable surface layers) occurs with overcast sky conditions. Clouds overlying the Great Valley may warm because of direct insolation (i.e., exposure to the sun's rays) on the cloud tops. Warming may also occur within the clouds as latent energy, which is released because of the condensation of moisture. Surface air underlying the clouds may remain relatively cool because the layer remains cut off from direct exposure to the sun. Consequently, the vertical temperature gradient associated with the air mass becomes more stable (Lewellen and Lewellen 2002). Long-wave radiational cooling of fog or low stratus decks has also been observed to help modify stability in the surface layer (Whiteman et al. 2001). This occurs because the emittance of long-wave radiation further cools the surface layer and thus strengthens the associated inversion.

Stable boundary layers typically form as a result of radiational cooling processes near the ground (Van De Weil et al. 2002); however, they are also influenced by the mechanical energy supplied by horizontal wind motion, which in turn is influenced by the large-scale weather-related pressure differences from one location to another (gradient). Ridge-and-valley terrain may significantly block such winds and their associated mechanical energy (Carlson and Stull 1986). Consequently, radiational cooling at the surface is enhanced because less wind energy is available to remove chilled air.

Stable boundary layers also exhibit intermittent turbulence, which is associated with the aforementioned factors. The process results from interactions between the effects of friction and radiational cooling. As a stable surface layer intensifies via a radiational cooling process, it tends to decouple from air aloft, thereby reducing the effects of surface friction. The upper air layer responds with an acceleration in wind speed. Increased wind speed aloft increases mechanical turbulence and wind shear at the boundary with the stable surface layer. Eventually, the turbulence works into the surface layer and weakens it. As the inversion weakens, friction again increases, reducing wind speeds aloft. The reduced wind speeds aloft allow enhanced radiation cooling at the surface, which reintensifies the inversion and allows the process to start again. Van De Weil et al. (2002) have shown that cyclical temperature oscillations up to 4°C (7°F) may result from these processes. Because these intermittent processes are driven primarily by large-scale horizontal wind flow and radiational cooling of the surface, ridge-and-valley terrain significantly affects the intensity of these oscillations.

B.7. References

Birdwell 1996. Birdwell, K. R., "A Climatology of Winds over a Ridge and Valley Terrain within the Great Valley of Eastern Tennessee." Master's thesis, Department of Geosciences, Murray State University, Murray, Kentucky.

Birdwell 2011. Birdwell, K. R., "Wind Regimes in Complex Terrain of the Great Valley of Eastern Tennessee." Doctoral dissertation, Department of Geography, University of Tennessee, Knoxville, Tennessee.

Carlson and Stull 1986. Carlson, M. A., and R. B. Stull, "Subsidence in the Nocturnal Boundary Layer." *Journal of Climate and Applied Meteorology* 25, 1088–99.

Dutton 2021. Dutton, J., "What Is the Pacific Decadal Oscillation (PDO)?" World Climate Service. https://www.worldclimateservice.com/2021/09/01/pacific-decadal-oscillation/.

Eckman 1998. Eckman, R. M., "Observations and Numerical Simulations of Winds within a Broad Forested Valley." *Journal of Applied Meteorology* 37, 206–19.

Ineson et al. 2011. Ineson, S., A. A. Scaife, J. R. Knight, J. C. Manners, N. J. Dunstone, L. J. Grey, and J. D. Haigh, "Solar Forcing of Winter Climate Variability in the Northern Hemisphere." *Nature Geoscience* 4, 753–57.

Kossman and Sturman 2002. Kossman, M., and A. P. Sturman, "Pressure Driven Channeling Effects in Bent Valleys." *Journal of Applied Meteorology* 42, 151–58.

Lewellen and Lewellen 2002. Lewellen, D. C., and W. S. Lewellen, "Entrainment and Decoupling Relations for Cloudy Boundary Layers." *Journal of the Atmospheric Sciences* 59, 2966–86.

Monti et al. 2002. Monti, P., H. J. S. Fernando, M. Princevac, W. C. Chan, T. A. Kowalewski, and E. R. Pardyjak, "Observations of Flow and Turbulence in the Nocturnal Boundary Layer over a Slope." *Journal of the Atmospheric Sciences* 59, 2513–34.

Van De Weil et al. 2002. Van De Weil, B. J. H., A. F. Moene, R. J. Ronda, H. A. R. De Bruin, and A. A. M. Holtslag, "Intermittent Turbulence and Oscillations in the Stable Boundary Layer over Land. Part II: A System Dynamics Approach." *Journal of the Atmospheric Sciences* 59, 2567–81.

Whiteman 2000. Whiteman, C. D., *Mountain Meteorology: Fundamentals and Applications*. Oxford University Press, New York.

Whiteman et al. 2001. Whiteman, C. D., S. Zhong, W. J. Shaw, J. M. Hubbe, and X. Bian, "Cold Pools in the Columbia River Basin." *Weather and Forecasting* 16, 432–47.

C

Appendix C Reference Standards and Data for Water

Table C.1. Reference standards for radionuclides in water

Parameter[a]	National primary drinking water standard[b]	DCS[c]
^{241}Am		740
^{214}Bi		1,000,000
^{109}Cd		42,000
^{143}Ce		210,000
^{60}Co		14,000
^{51}Cr		3,800,000
^{137}Cs		4,100
^{155}Eu		1,000,000
Alpha particles[d,e]	15	
Beta particles and photon emitters (mrem/year)[e]	4	
^{3}H Tritated Water		2,600,000
^{3}H Organic Bound Tritium		1,000,000
^{131}I		2,800
^{40}K		16,000
^{237}Np		1,400
^{234}Pa		300,000
^{238}Pu		430
$^{239/240}$Pu		400
^{226}Ra		280
^{228}Ra		73
^{226}Ra and ^{228}Ra combined[e]	5	
^{106}Ru		19,000
^{90}Sr		1,700
^{99}Tc		390,000
^{228}Th		830
^{230}Th		720
^{232}Th		620
^{234}Th		84,000
^{234}U		1,200

Table C.1. Reference standards for radionuclides in water (continued)

Parameter[a]	National primary drinking water standard[b]	DCS[c]
^{235}U		1,300
^{236}U		1,300
^{238}U		1,400
Uranium, total (µg/L)[e]	30	

[a] *Only the radionuclides included in the Oak Ridge Reservation monitoring programs are listed. Unless labeled otherwise, units are pCi/L.*

[b] *40 Code of Federal Regulations Part 141, National Primary Drinking Water Regulations, Subparts B and G. The drinking water standards are presented strictly for reference purposes and have regulatory applicability only for public water supplies.*

[c] *DOE. "Derived Concentration Technical Standard," DOE-STD-1196-2022, December 2022.*

[d] *Including ^{226}Ra and excluding radon and uranium.*

[e] *Carcinogenic pollutant (EPA uses a 10^{-6} level to determine an increased risk of cancer).*

Table C.2. TDEC and EPA nonradiological water quality standards and criteria (µg/L)

Chemical	TDEC and EPA drinking water standards[a]	TDEC fish and aquatic life criteria		TDEC recreation criteria water + organisms, organisms only[b]
		Maximum	Continuous	
Acenaphthene				670, 990
Acrolein		3.0	3.0	6, 9
Acrylonitrile (c)				0.51, 2.5
Alachlor	2 (E1, T)			
Aldicarb[c]	3 (E1)			
Aldicarb sulfone[c]	2 (E1)			
Aldicarb sulfoxide[c]	4 (E1)			
Aldrin (c)		3.0	–	0.00049, 0.00050
Aluminum	50 to 200 (E2)			
Anthracene				8,300, 40,000
Antimony	6 (E1, T)			5.6, 640
Arsenic (c)	10 (E1, T)			10.0, 10.0
Arsenic(III)		340[d]	150[d]	
Asbestos	7 million fibers/L (MFL) (E1)			
Atrazine	3 (E1, T)			
Barium	2,000 (E1, T)			
Benzene (c)	5 (E1, T)			22, 510
Benzidine (c)				0.00086, 0.0020
Benzo(a)anthracene (c)				0.038, 0.18
Benzo(a)pyrene (PAHs) (c)	0.2 (E1, T)			0.038, 0.18
Benzo(b)fluoranthene (c)				0.038, 0.18

Table C.2. TDEC and EPA nonradiological water quality standards and criteria (µg/L) (continued)

Chemical	TDEC and EPA drinking water standards[a]	TDEC fish and aquatic life criteria		TDEC recreation criteria water + organisms, organisms only[b]
		Maximum	Continuous	
Benzo(k)fluoranthene (c)				0.038, 0.18
Beryllium	4 (E1, T)			
a-BHC (c)				0.026, 0.049
b-BHC (c)				0.091, 0.17
g-BHC (Lindane) (b)	0.2 (E1, T)	0.95	–	0.98, 1.8
Bis(2-chloroethyl) ether (c)				0.30, 5.3
Bis(2-chloro-isopropyl) ether				1,400, 65,000
Bis(2-ethylhexyl) phthalate Di(2-ethylhexyl) phthalate (c)	6 (E1, T)			12, 22
Bis (Chloromethyl) ether (c)				0.0010, 0.0029
Bromate	10 (E1)			
Bromoform (c)				43, 1,400
Butyl Benzyl Phthalate (BBP) (c)				1,500, 1,900
Cadmium	5 (E1, T)	1.8[e]	0.72[e]	
Carbaryl		2.1	2.1	
Carbofuran	40 (E1, T)			
Carbon tetrachloride (c)	5 (E1, T)			2.3, 16
Chloramines (as Cl_2)	4,000 (E1)			
Chlordane (b) (c)	2 (E1, T)	2.4	0.0043	0.0080, 0.0081
Chloride	250,000 (E2)	860,000	230,000	
Chlorine (as Cl_2)	4,000 (E1)			
Chlorine (total residual chlorine)		19	11	
Chlorine dioxide (as ClO_2)	800 (E1)			
Chlorite	1,000 (E1)			
Chlorobenzene (Monochlorobenzene)	100 (E1, T)			130, 1,600
Chlorodibromomethane (Dibromochloromethane) (c)				4.0, 130
Chloroform (c)				57, 4,700
2-Chloronaphthalene				1,000, 1,600
2-Chlorophenol				81, 150
Chlorpyrifos		0.083	0.041	
Chromium (total)	100 (E1, T)			
Chromium(III)		570[e]	74[e]	
Chromium(VI)		16[d]	11[d]	

Table C.2. TDEC and EPA nonradiological water quality standards and criteria (µg/L) (continued)

Chemical	TDEC and EPA drinking water standards[a]	TDEC fish and aquatic life criteria		TDEC recreation criteria water + organisms, organisms only[b]
		Maximum	Continuous	
Chrysene (c)				0.038, 0.18
Coliforms	630/100 mL (geometric mean) (T); no more than 5% of samples per month can be positive for total coliforms (E1)	630/100 mL, *E. coli* (geometric mean); 2880/100 mL, maximum, *E. coli* (single sample)	630/100 mL, *E. coli* (geometric mean); 2880/100 mL, maximum, *E. coli* (single sample)	126/100 mL (geometric mean), *E. coli;* 487/100 mL, maximum lakes/ reservoirs/state scenic river/Exceptional Tennessee Water/ Outstanding Natural Resource Water, *E. coli;* 941/100 mL, maximum, other water bodies, *E. coli*
Color	15 color units (E2)			
Copper	1,300 (E1 "Action Level") 1,000 (E2)	13[e]	9.0[e]	
Cyanide (as free cyanide)	200 (E1, T)	22[f]	5.2[f]	140, 140
2,4-D (Dichlorophenoxyacetic acid)	70 (E1, T)			
4,4'-DDD (b) (c)				0.0031, 0.0031
4,4'-DDE (b) (c)				0.0022, 0.0022
4,4'-DDT (b) (c)		1.1	0.001	0.0022, 0.0022
Dalapon	200 (E1, T)			
Demeton		–	0.1	
Diazinon		0.17	0.17	
Dibenz(a,h)anthracene (c)				0.038, 0.18
1,2-dibromo-3-chloropropane (DBCP) (c)	0.2 (E1, T)			
1,2-Dichlorobenzene (*ortho*-)	600 (E1, T)			420, 1,300
1,3-Dichlorobenzene (*meta*-)				320, 960
1,4-Dichlorobenzene (*para*-)	75 (E1, T)			63, 190
3,3-Dichlorobenzidine (c)				0.21, 0.28
Dichlorobromomethane (c)				5.5, 170
1,2-Dichloroethane (c)	5 (E1, T)			3.8, 370
1,1-Dichloroethylene	7 (E1, T)			330, 7,100
Cis-1,2-Dichloroethylene	70 (E1, T)			
Trans-1,2-Dichloroethylene	100 (E1, T)			140, 10,000
2,4-Dichlorophenol				77, 290
1,2-Dichloropropane (c)	5 (E1, T)			5.0, 150
1,3-Dichloropropene (c)				3.4, 210
Dieldrin (b)(c)		0.24	0.056	0.00052, 0.00054

Table C.2. TDEC and EPA nonradiological water quality standards and criteria (µg/L) (continued)

Chemical	TDEC and EPA drinking water standards[a]	TDEC fish and aquatic life criteria		TDEC recreation criteria water + organisms, organisms only[b]
		Maximum	Continuous	
Diethyl phthalate				17,000, 44,000
Di (2-ethylhexyl) adipate	400 (E1, T)			
Dinoseb	7 (E1, T)			
Dimethyl phthalate				270,000, 1,100,000
Dimethylphenol				380, 850
Di-n-butyl phthalate				2,000, 4,500
Dinitrophenols (DNP)				69, 5,300
2,4-Dinitrotoluene (DNT) (c)				1.1, 34
Dioxin (2,3,7,8-TCDD) (b) (c)	3 E-5 (E1, T)			0.000001[g], 0.000001[g]
Diquat	20 (E1, T)			
1,2-Diphenylhydrazine (Hydrazobenzene) (c)				0.36, 2.0
a-Endosulfan		0.22	0.056	62, 89
b-Endosulfan		0.22	0.056	62, 89
Endosulfan sulfate				62, 89
Endothall	100 (E1, T)			
Endrin	2 (E1, T)	0.086	0.036	0.059, 0.06
Endrin aldehyde				0.29, 0.30
Ethylbenzene	700 (E1)			530, 2,100
Ethylene dibromide (1,2-Dibromoethane, EDB)	0.05 (E1, T)			
Fluoranthene				130, 140
Fluorene				1,100, 5,300
Fluoride	4,000 (E1) 2,000 (E2)			
Foaming agents	500 (E2)			
Glyphosate	700 (E1, T)			
Guthion		–	0.01	
Haloacetic acids (HAA5) (c)	60 (E1)			
Heptachlor (c)	0.4 (E1, T)	0.52	0.0038	0.00079, 0.00079
Heptachlor epoxide (c)	0.2 (E1, T)	0.52	0.0038	0.00039, 0.00039
Hexachlorobenzene (b)(c)	1 (E1, T)			0.0028, 0.0029
Hexachlorobutadiene (b)(c)				4.4, 180
Hexachlorocyclohexane-Technical (HCH) (b)(c)				0.123, 0.414
Hexachlorocyclopentadiene	50 (E1, T)			40, 1,100

Table C.2. TDEC and EPA nonradiological water quality standards and criteria (µg/L) (continued)

Chemical	TDEC and EPA drinking water standards[a]	TDEC fish and aquatic life criteria		TDEC recreation criteria water + organisms, organisms only[b]
		Maximum	Continuous	
Hexachloroethane (c)				14, 33
Hexafluoropropylene oxide dimer acid (HFPO-DA, C3 Dimer Acid)	0.01 (E1)			
Indeno(1,2,3-cd)Pyrene (c)				0.038, 0.18
Iron	300 (E2)			
Isophorone (c)				350, 9,600
Lead	5 (T) 10 (E1 "Action Level")	65[e]	2.5[e]	
Malathion		–	0.1	
Manganese	50 (E2)			
Mercury (b)	2 (T) 2 (E1 inorganic)	1.4[d]	0.77[d]	0.05, 0.051
Methoxychlor	40 (E1, T)	–	0.03	
Methyl bromide				47, 1,500
2-Methyl-4,6-dinitrophenol (4,6-Dinitro-O-cresol, DNOC)				13, 280
Methylene chloride (Dichloromethane) (c)	5 (E1, T)			46, 5,900
Nickel	100 (T)	470[e]	52[e]	610, 4,600
Nitrate as N	10,000 (E1,T)			
Nitrite as N	1,000 (E1, T)			
Nitrobenzene				17, 690
Nitrosamines				0.0008, 1.24
N-Nitrosodibutylamine (NDBA) (c)				0.063, 2.2
N-Nitrosodiethylamine (NDEA) (c)				0.008, 2.4
N-Nitrosopyrrolidine (NPYR) (c)				0.16, 340
N-Nitrosodimethylamine (NDMA) (c)				0.0069, 30
N-Nitrosodi-n-propylamine (c)				0.05, 5.1
N-Nitrosodiphenylamine (c)				33, 60
Nonylphenol		28.0	6.6	
Odor	3 Threshold Odor Numbers (E2)[h]			
Oxamyl (Vydate)	200 (E1, T)			
Parathion		0.065	0.013	

Table C.2. TDEC and EPA nonradiological water quality standards and criteria (µg/L) (continued)

Chemical	TDEC and EPA drinking water standards[a]	TDEC fish and aquatic life criteria		TDEC recreation criteria water + organisms, organisms only[b]
		Maximum	Continuous	
Pentachlorobenzene (b)				1.4, 1.5
Pentachlorophenol (c)	1 (E1, T)	19[i]	15[i]	2.7, 30
Perfluorohexanesulfonic acid (PFHxS)	0.01 (E1)			
Perfluorooctanesulfonic acid (PFOS)	0.004 (E1)			
Perfluorooctanoic acid (PFOA)	0.004 (E1)			
Perfluorononanoic acid (PFNA)	0.01 (E1)			
pH	6.5 to 8.5 units (E2) 6.0 to 9.0 units (T)	6.0 to 9.0 units for wadeable streams; 6.5 to 9.0 units for larger rivers, lakes, reservoirs, and wetlands		6.0 to 9.0 units
Phenol				10,000, 860,000
Picloram	500 (E1,T)			
Polychlorinated biphenyls (PCBs), total (b)(c)	0.5 (E1, T)	–	0.014	0.00064, 0.00064
Pyrene				830, 4,000
Selenium	50 (E1, T)			170, 4,200
Selenium (lentic)[j]		20	1.5[k]	
Selenium (lotic)[l]		20	3.1[k]	
Silver	100 (E2)	3.2[e]	–	
Simazine	4 (E1, T)			
Styrene	100 (E1, T)			
Sulfate	250,000 (E2)			
1,2,4,5-Tetrachlorobenzene (b)				0.97, 1.1
1,1,2,2-Tetrachloroethane (c)				1.7, 40
Tetrachloroethylene (Perchloroethylene, PCE) (c)	5 (E1, T)			6.9, 33
Thallium	2 (E1, T)			0.24, 0.47
Toluene	1,000 (E1, T)			1,300, 15,000
Total dissolved solids	500,000 (E2, T)			
Toxaphene (b)(c)	3 (E1, T)	0.73	0.0002	0.0028, 0.0028
Tributyltin (TBT)		0.46	0.072	
1,2,4-Trichlorobenzene (1,2,4-TCB)	70 (E1, T)			35, 70
1,1,1-Trichloroethane (Methyl Chloroform)	200 (E1, T)			

Table C.2. TDEC and EPA nonradiological water quality standards and criteria (µg/L) (continued)

Chemical	TDEC and EPA drinking water standards[a]	TDEC fish and aquatic life criteria		TDEC recreation criteria water + organisms, organisms only[b]
		Maximum	Continuous	
1,1,2-Trichloroethane (c)	5 (E1, T)			5.9, 160
Trichloroethylene (TCE) (c)	5 (E1, T)			25, 300
2,4,5-Trichlorophenol				1,800, 3,600
2,4,6-Trichlorophenol (c)				14, 24
2,4,5 Trichlorophenoxyprioponic acid (2,4,5-TP, Silvex)	50 (E1, T)			
Trihalomethanes (total) (TTHMs) (c)	80 (E1)			
Vinyl chloride (c)	2 (E1, T)			0.25, 24
Xylenes (total)	10,000 (E1, T)			
Zinc	5,000 (E2)	120[e]	120[e]	7,400, 26,000

[a] *E1 = EPA Primary Drinking Water Standards; E2 = EPA Secondary Drinking Water Standards; T = TDEC domestic water supply criteria.*

[b] *For each parameter, the first recreational criterion is for "water and organisms" and is applicable on the Oak Ridge Reservation (ORR) only to the Clinch River, because it is the only stream on ORR classified for both domestic water supply and for recreation. The second criterion is for "organisms only" and is applicable to the other streams on ORR. TDEC uses a 10^{-5} risk level for recreational criteria for all carcinogenic pollutants (designated as (c) under the "Chemical" column). Recreational criteria for noncarcinogenic chemicals are set using a 10^{-6} risk level. (Note: All federal recreational criteria are set at a 10^{-6} risk level.)*

[c] *Administrative stay of the effective date.*

[d] *Criteria are expressed as dissolved.*

[e] *Criteria are expressed as dissolved and are a function of total hardness (mg/L). Criteria displayed correspond to a total hardness of 100 mg/L.*

[f] *Criteria may be applied as free cyanide if Standard Methods 4500-CN, 4500-CN G, or OIA-1677 are used.*

[g] *Total dioxin in the sum of the concentrations of all dioxin and dibenzofuran isomers after multiplication by Toxic Equivalent Factors.*

[h] *Threshold Odor Numbers (TON) are whole numbers that indicate how many dilutions it takes to produce odor-free water.*

[i] *Criteria are expressed as a function of pH; values shown correspond to a pH of 7.8.*

[i] *Lentic – Still water aquatic ecosystems such as ponds, lakes, or reservoirs.*

[k] *The numeric water criteria are applicable for all purposes, but for water quality assessment, fish tissue values may be used to confirm or refute impacts to aquatic life in accordance with and using values from EPA's Final Criterion: Aquatic Life Ambient Water Quality Criterion for Selenium – Freshwater (June 30, 2016).*

[l] *Lotic – Flowing water aquatic ecosystems such as streams and rivers.*

Acronyms and other definitions:

EPA = US Environmental Protection Agency

TDEC = Tennessee Department of Environment and Conservation

(b) = bioaccumulative parameter (TDEC)

(c) = carcinogenic pollutant (TDEC uses a 10^{-5} risk level and EPA uses a 10^{-6} level to determine an increased risk of cancer)

D

Appendix D National Pollutant Discharge Elimination System Noncompliance Summaries for 2024

D.1. East Tennessee Technology Park

In 2024, the East Tennessee Technology Park program was 100 percent compliant with the numerical permit limits. ETTP's NPDES storm water permit in effect during 2024 (TN0002950) was issued on February 4, 2022, and became effective on April 1, 2022. Compliance was determined by field measurements, flow estimates, and more than 110 laboratory analyses.

D.2. Y-12 National Security Complex

In 2024, the Y-12 National Security Complex was 100 percent compliant with the NPDES permit limits. Approximately 4,200 data points were obtained from sampling required by the NPDES permit. Y-12's NPDES permit (TN0002968) was issued on August 5, 2022, and became effective on October 1, 2022. The new permit is currently under appeal in part, and settlement negotiations are ongoing.

On July 17, 2024, a Notice of Violation was received from TDEC for a fish kill resulting from a potable water line break on June 20, 2024.

On October 1, 2024, a fish kill occurred when controlled low-strength material (concrete mix) from UCOR pre-demolition activities entered East Fork Poplar Creek through an abandoned drain line from the basement of Building 9201-02. The discharge resulted in high turbidity, elevated pH and the death of approximately 1,300 fish and other aquatic organisms.

D.3. Oak Ridge National Laboratory

In 2024, compliance with the Oak Ridge National Laboratory NPDES permit was determined by field measurements and 1,736 laboratory analyses. ORNL wastewater treatment facilities achieved a numeric

permit compliance rate of 100 percent in 2024. The Carbon Fiber Technology Facility also achieved 100 percent compliance with the UT-Battelle City of Oak Ridge Industrial and Commercial User Discharge Pre-Treatment Permit in 2024. In May 2019, TDEC issued a renewed NPDES permit for ORNL. Several conditions in the permit were appealed, and others were addressed in permit modifications issued in December 2022 and February 2023. Another minor modification was scheduled to become effective on March 1, 2023; however, some conditions were appealed and remained unresolved in 2024. An NPDES permit renewal application was submitted to TDEC in June 2023. Until a new permit is issued, the February 2023 permit (which expired December 31, 2023) has been administratively extended.

E

Appendix E Radiation

This appendix presents basic information about radiation. The information is intended to serve as a basis for understanding the potential doses associated with releases of radionuclides from the Oak Ridge Reservation, not as a comprehensive discussion of radiation and its effects on the environment and on biological systems.

Radiation comes from natural and anthropogenic (human-produced) sources. People are constantly exposed to naturally occurring radiation. For example, cosmic radiation, radon in air, potassium in food and water, and uranium, thorium, and radium in the earth's crust are all sources of radiation. The following discussion describes important aspects of radiation and its types, sources, and pathways, as well as radiation measurement and dose information.

E.1. Atoms and Isotopes

All matter is made up of atoms. An atom is "a unit of matter consisting of a single nucleus surrounded by a number of electrons equal to the number of protons in the nucleus" (Alter 1986). The number of protons in the nucleus determines an element's atomic number or chemical identity. Except for hydrogen, the nucleus of each type of atom also contains at least one neutron. Unlike protons, the neutrons may vary in number among atoms of the same element. The number of neutrons and protons determines the atomic weight. Atoms of the same element that have different numbers of neutrons are called isotopes. In other words, isotopes have the same chemical properties but different atomic weights, as illustrated in Figure E.1.

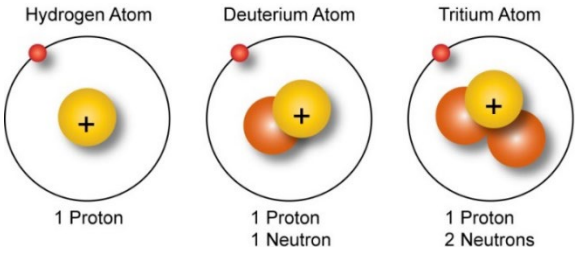


Figure E.1. The hydrogen atom and its isotopes

For example, the element uranium has 92 protons. All isotopes of uranium, therefore, have 92 protons. However, each uranium isotope has a different number of neutrons:

- Uranium-234 has 92 protons and 142 neutrons
- Uranium-235 has 92 protons and 143 neutrons
- Uranium-238 has 92 protons and 146 neutrons

Some isotopes are stable, or nonradioactive, and some are radioactive. Radioactive isotopes are called radionuclides or radioisotopes. To become stable, radionuclides emit energy in the form of rays or particles. This emission of energy is known as radioactive decay. Each radioisotope has a radioactive half-life, which is the average time required for half of a specified number of atoms to decay. Half-lives can be very short (fractions of a second) or very long (millions of years), depending on the isotope. Table E.1 shows the half-lives of selected radionuclides.

Table E.1. Selected radionuclide half-lives

Radionuclide	Symbol	Half-life (in years unless otherwise noted)	Radionuclide	Symbol	Half-life (in years unless otherwise noted)
Americium-241	^{241}Am	432.2	Plutonium-238	^{238}Pu	87.74
Americium-243	^{243}Am	7.37E+3	Plutonium-239	^{239}Pu	2.411E+4
Argon-41	^{41}Ar	1.827 hours	Plutonium-240	^{240}Pu	6.564E+3
Beryllium-7	^{7}Be	53.22 days	Potassium-40	^{40}K	1.251E+9
Californium-252	^{252}Cf	2.645	Radium-226	^{226}Ra	1.6E+3
Carbon-11	^{11}C	20.39 minutes	Radium-228	^{228}Ra	5.75
Carbon-14	^{14}C	5.70E+3	Ruthenium-103	^{103}Ru	39.26 days
Cerium-141	^{141}Ce	32.508 days	Samarium-153	^{153}Sm	46.5 hours
Cerium-144	^{144}Ce	284.91 days	Strontium-89	^{89}Sr	50.53 days
Cesium-134	^{134}Cs	2.0648	Strontium-90	^{90}Sr	28.79
Cesium-137	^{137}Cs	30.167	Technetium-99	^{99}Tc	2.111E+5
Cesium-138	^{138}Cs	32.41 minutes	Thorium-228	^{228}Th	1.9116
Cobalt-58	^{58}Co	70.86 days	Thorium-230	^{230}Th	7.538E+4
Cobalt-60	^{60}Co	5.271	Thorium-232	^{232}Th	1.405E+10
Curium-242	^{242}Cm	162.8 days	Thorium-234	^{234}Th	24.1 days
Curium-244	^{244}Cm	18.1	Tritium	^{3}H	12.32
Iodine-129	^{129}I	157E+7	Uranium-234	^{234}U	2.455E+5
Iodine-131	^{131}I	8.02 days	Uranium-235	^{235}U	7.04E+8
Krypton-85	^{85}Kr	10.756	Uranium-236	^{236}U	2.342E+7
Krypton-88	^{88}Kr	2.84 hours	Uranium-238	^{238}U	4.468E+9
Lead-212	^{212}Pb	10.64 hours	Xenon-133	^{133}Xe	5.243 days
Manganese-54	^{54}Mn	312.12 days	Xenon-135	^{135}Xe	9.14 hours
Neptunium-237	^{237}Np	2.144E+6	Yttrium-90	^{90}Y	64.1 hours
Niobium-95	^{95}Nb	34.991 days	Zirconium-95	^{95}Zr	64.032 days

Source: ICRP 2008

E.2. Radiation

Radiation is energy in the form of waves or particles moving through space. Visible light, heat, radio waves, and alpha particles are examples of radiation. When people feel warmth from sunlight, they are actually absorbing the radiant energy emitted by the sun.

Electromagnetic radiation is a form of energy that travels in waves. It comes from natural and anthropogenic sources and includes gamma rays, x-rays, ultraviolet light, and radio waves. Particulate radiation consists of particles that have mass and energy, such as alpha and beta particles. Radiation is also characterized as ionizing or nonionizing by its energy and the way it interacts with matter.

Ionizing radiation

Normally an atom has an equal number of protons (positively charged) and electrons (negatively charged), but atoms can lose or gain electrons in a process known as ionization. Ionizing radiation removes bound electrons from an electrically neutral atom, leaving the atom with a net positive charge. Examples of ionizing radiation include alpha and beta particles, gamma rays, and x-rays (World Health Organization 2016).

Ionizing radiation is capable of changing the chemical state of matter and subsequently causing biological damage. By this mechanism, it is potentially harmful to human health.

Nonionizing radiation

Nonionizing radiation is described as a series of energy waves composed of oscillating electric and magnetic fields traveling at the speed of light and is lower in energy than ionizing radiation (Department of Labor 2025). It includes the spectrum of ultraviolet light, visible light, infrared radiation, microwaves, radio waves, and other extremely low frequency fields. Lasers commonly operate in the ultraviolet, visible, and infrared frequencies. Microwave radiation is absorbed near the skin, while radio frequency radiation may be absorbed throughout the body. At high enough intensities, both will damage tissue through heating. Damage to the eyes and skin may occur from excessive exposure to visible light (Department of Labor 2025).

In the discussion that follows, the term "radiation" is used to describe ionizing radiation.

E.3. Measuring Ionizing Radiation

To determine the possible effects of exposure to radiation on the health of the environment and the public, the radiation must be measured. By quantifying the levels of exposure, its potential to cause damage may be estimated.

Activity

To determine the level of radiation in the environment, the rate of radioactive decay or activity is measured. The rate of decay varies widely among radioisotopes. For that reason, 1 gram of a radioactive substance may contain the same amount of activity as several tons of another material. This activity is expressed in a unit of measure known as a curie (Ci). More specifically, 1 Ci equals 3.7×10^{10} (37,000,000,000) nuclear disintegrations per second (dps). In the International System of Units, 1 dps equals 1 becquerel (Bq).

Absorbed dose

The total amount of energy absorbed per unit mass of an exposed material as a result of exposure to radiation is expressed in a unit of measure known as a rad, short for "radiation absorbed dose." The amount of radiation, or number of rads, humans or biota are exposed to is used to estimate the effect of the absorbed energy and the potential biological damage that may occur. In the International System of Units, 100 rads equal 1 gray (Gy).

Effective dose

The measure of potential biological damage to the body caused by exposure to and subsequent absorption of radiation is expressed in a unit of measure known as a rem, an abbreviation for

"roentgen equivalent man." For radiation protection purposes, 1 rem of any type of radiation has the same damaging effect. Because a rem represents a fairly large dose, the measure is usually expressed in millirem (mrem), which is 1/1000 of a rem. In the International System of Units, 1 sievert (Sv) equals 100 rems; 1 millisievert (mSv) equals 100 mrem. The effective dose (ED) is the tissue-weighted sum of equivalent dose, which accounts for type of radiation absorbed via a radiation weighting factor in specified tissues or organs. The ED is based on tissue-weighting factors for 12 specific tissues or organs plus a weighting factor for the remaining organs and tissues. In addition, the ED is based on the recently developed lung model, gastrointestinal absorption fractions, and biokinetic models used for selected elements. Specific types of EDs are defined as follows (ICRP 2007):

- Committed ED – the weighted sum of the committed organ or tissue equivalent doses in the human body during the 50-year period following intake (70 years for children)
- Collective ED – the product of the mean ED for a population and the number of persons exposed

E.4. Radiation Exposure Pathways

People can be exposed to radionuclides in the environment through a number of routes, as shown in Figure E.2. Potential routes for internal and external exposure are referred to as pathways. For example, radionuclides in air could be inhaled directly or could fall on grass in a pasture. If the grass were then consumed by cows, it would be possible for the radionuclides to impact the cow's milk and subsequently the people drinking the milk. Similarly, radionuclides in water could be ingested by fish, and fishermen or other consumers could then ingest the radionuclides in the fish tissue. People swimming in the water also would be exposed. Exposure to ionizing radiation varies significantly with geographic location, diet, drinking water source, and building construction.



Figure E.2. Examples of radiation pathways

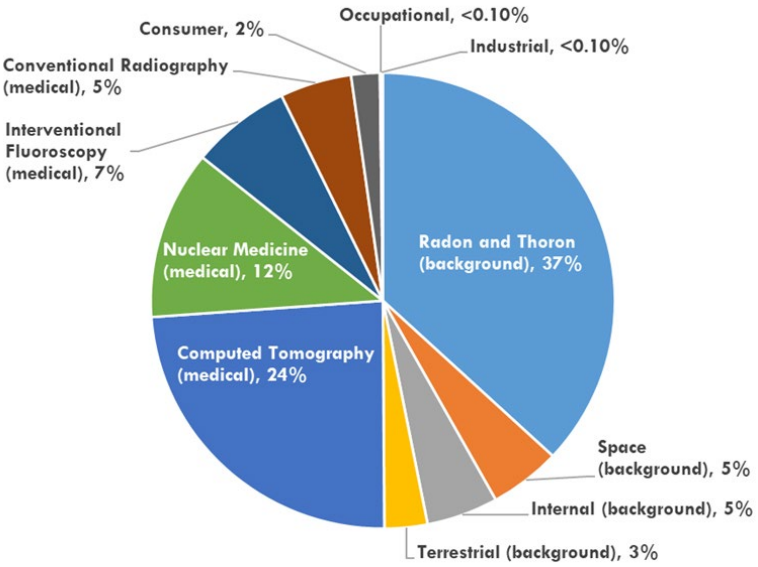
E.5. Radiation Sources and Doses

Basically, the process of radioactive decay generates radiant energy. People absorb some of the energy to which they are exposed, either from external radiation sources or internally deposited radionuclides. The amount of energy absorbed is reflected in an individual's dose. Whether radiation is natural or anthropogenic, it has the same effect on people.

There are five broad categories for radiation exposure to the US population (NCRP 2009):

- Exposure to ubiquitous background radiation, including radon in homes
- Exposure to patients from medical procedures
- Exposure from consumer products or activities involving radiation sources
- Exposure from industrial, security, medical, educational, and research radiation sources
- Exposure to workers that results from their occupations

Figure E.3 shows the percent contributions of various sources of exposure to the total collective dose for the US population in 2006. As shown, the major sources are radon and thoron (37 percent), computed tomography (24 percent), and nuclear medicine (12 percent) (NCRP 2009). Consumer, occupational, and industrial sources contribute about 2 percent to the total US collective dose.



Source: NCRP 2009

Figure E.3. Exposure categories for collective effective dose for 2006

E.5.1. Background Radiation

Naturally occurring radiation is the major source of radiation in the environment. Sources of background radiation exposure include the following:

- External exposure from space or cosmic radiation
- External exposure from terrestrial radiation
- Internal exposure from inhalation of radon, thoron, and their progeny
- Internal exposure from radionuclides in the body

E.5.1.1. External Exposures

Space or cosmic radiation

Energetically charged particles from outer space continuously hit the earth's atmosphere. These particles and the secondary particles and photons they create are called cosmic radiation. Because the atmosphere provides some shielding against cosmic radiation, the intensity of this radiation increases with altitude above sea level as the atmosphere becomes less dense. For example, a person in Denver is exposed to more cosmic radiation than a person in New Orleans.

The average annual effective dose to people in the United States from cosmic radiation is about 33 mrem, or 0.33 mSv (NCRP 2009). Effective dose rates from cosmic radiation depend on geomagnetic latitude and elevation above sea level.

Terrestrial radiation

Terrestrial radiation refers to radiation emitted from radioactive materials in the earth's rocks, soils, and minerals. Radon (Rn), radon progeny (the relatively short-lived decay products from the decay of the radon isotope ^{222}Rn), potassium (^{40}K), isotopes of thorium (Th), and isotopes of uranium (U) are the elements responsible for most terrestrial radiation.The average annual dose from terrestrial gamma radiation is about 21 mrem (0.21 mSv) in the United States, but it varies geographically across the country (NCRP 2009). Typical reported values are about 23 mrem (0.23 mSv) on the Atlantic and Gulf Coasts, about 90 mrem (0.9 mSv) on the Colorado Plateau, and about 46 mrem (0.46 mSv) elsewhere in the United States (EPA 2025).

E.5.1.2. Internal Exposures

Radionuclides in the environment enter the body with the air people breathe and the foods they eat. They can also enter through an open wound. Natural radionuclides that can be inhaled and

ingested include isotopes of uranium and their progeny, especially radon (^{222}Rn) and its progeny, thoron (^{220}Rn) and its progeny, potassium (^{40}K), rubidium (^{87}Rb), and carbon (^{14}C). Radionuclides contained in the body are dominated by ^{40}K and polonium (^{210}Po); others include ^{87}Rb and ^{14}C (NCRP 1987).

Radon and thoron and decay products

The major contributors to the annual effective dose from background radiation sources are radon and thoron and their short-lived decay products. As shown in Figure E.3, 37 percent of the dose from all exposure categories is from radon and thoron and their decay products, which contribute an average dose to an individual of about 228 mrem (2.28 mSv) per year (NCRP 2009). Radon is an inert gas, and a small fraction is retained in the body; however, the dose to the lungs comes from the short-lived radon decay products. Radon levels vary widely across the United States. Elevated levels are most commonly found in the Appalachians, the upper Midwest, and the Rocky Mountain states (NCRP 2009).

Other internal radiation sources

Other sources of internal radiation include ^{40}K, ^{232}Th, and the ^{238}U series. The primary source of ^{40}K in body tissues is food, primarily fruits and vegetables. Sources of radionuclides from the ^{232}Th and ^{238}U series are food and water (NCRP 2009). The average dose from these other internal radionuclides is about 29 mrem (0.29 mSv) per year. This dose is attributed predominantly to the naturally occurring radioactive isotope of potassium, ^{40}K.

E.5.2. Anthropogenic Radiation

In addition to background radiation, most people have been exposed to anthropogenic sources of radiation such as consumer products, medical sources, industrial by-products, and fallout from atmospheric atomic bomb tests. No atmospheric testing of atomic weapons has occurred since 1980 (NCRP 1987).

Consumer products

Some consumer products are sources of radiation. The radiation in these products—which includes smoke detectors, radioluminous products (e.g., self-illuminating exit signs in commercial buildings), and airport x-ray baggage inspection systems—is essential to the performance of the device. In other products, such as tobacco products and building materials, the radiation occurs incidentally to the product's function (NCRP 2009).

The US annual dose to an individual from consumer products and activities averages about 13 mrem (0.13 mSv), ranging between 0.1 and 40 mrem (0.001 and 0.4 mSv). Cigarette smoking accounts for about 35 percent of this dose. Other important sources are building materials (27 percent), commercial air travel (26 percent), mining and agriculture (6 percent), miscellaneous consumer-oriented products (3 percent), combustion of fossil fuels (2 percent), highway and road construction materials (0.6 percent), and glass and ceramics (less than 0.03 percent). Television and display monitors, sewage sludge and ash, and self-illuminating signs contribute negligible doses (NCRP 2009).

Medical sources

Radiation is an important tool in diagnostic medicine and treatment, which are the main sources of exposure to the public from anthropogenic radiation. Exposure is deliberate and is directly beneficial to the patients exposed. In general, medical exposures from diagnostic or therapeutic x-rays result from beams directed to specific areas of the body, so not all organs are uniformly irradiated. Nuclear medicine examinations and treatments involve the internal administration of radioactive compounds, or radiopharmaceuticals, by injection, inhalation, consumption, or insertion. Radiation and radioactive materials also are used in preparing medical instruments, including sterilizing heat-sensitive products such as plastic heart valves.

Nuclear medicine examinations, which internally administer radiopharmaceuticals, account for a significant portion of dose from anthropogenic sources. However, the radionuclides used for specific tests are not uniformly distributed throughout the body. In these cases, the concept of ED, which relates the significance of exposures of organs or body parts to the effect on the entire body, is useful in making comparisons. The average annual ED from medical examinations is roughly 300 mrem (3 mSv), including 147 mrem (1.47 mSv) from computed tomography scans, 77 mrem (0.77 mSv) from nuclear medicine procedures, 43 mrem (0.43 mSv) from interventional fluoroscopy, and 33 mrem (0.33 mSv) from conventional radiography and fluoroscopy (NCRP 2009). Not everyone receives such exams each year.

Other sources

Other sources of radiation include emissions of radioactive materials from nuclear facilities such as uranium mines, fuel-processing plants, and nuclear power plants; transportation of radioactive materials; and emissions from mineral-extraction facilities. The dose to the general public from these sources has been estimated at less than 1 mrem (0.01 mSv) per year (NCRP 1987).

E.6. References

Alter 1986. Alter, H. *A Glossary of Terms in Nuclear Science and Technology*. American Nuclear Society, La Grange Park, Illinois.

Department of Labor 2025. *OSHA Safety and Health Topics: Non Ionizing Radiation.* Retrieved July 15, 2025, from https://www.osha.gov/non-ionizing-radiation.

EPA 2025. *Calculate Your Radiation Dose.* US Environmental Protection Agency. Retrieved July 15, 2025, from https://www.epa.gov/radiation/calculate-your-radiation-dose.

ICRP 2007. *The 2007 Recommendations of the International Commission on Radiological Protection*. ICRP Publication 103. *Annals of the ICRP* 37 (2-4). International Commission on Radiological Protection, Ottawa, Canada.

ICRP 2008. *Nuclear Decay Data for Dosimetric Calculations.* ICRP Publication 107. *Annals of the ICRP* 38(3). International Commission on Radiological Protection, Ottawa, Canada.

NCRP 1987. *Ionizing Radiation Exposure of the Population of the United States*. NCRP Report No. 93. National Council on Radiation Protection and Measurements, Bethesda, MD.

NCRP 2009. *Ionizing Radiation Exposure of the Population of the United States*. NCRP Report No. 160, National Council on Radiation Protection and Measurements, Bethesda, Maryland.

World Health Organization 2016. *Ionizing radiation, health effects and protective measures*. Retrieved July 15, 2025, from https://www.who.int/news-room/fact-sheets/detail/ionizing-radiation-health-effects-and-protective-measures.

F

Appendix F Chemicals

This appendix presents basic information about chemical risk assessment for carcinogens and noncarcinogens. The information is intended to serve as a basis for understanding the toxicity associated with possible releases from the Oak Ridge Reservation (ORR) and is not a comprehensive discussion of chemicals and their effects on human health and the environment.

F.1. Perspective on Chemicals

The lives of modern humans have been greatly improved by the development of chemicals such as those used in pharmaceuticals, building materials, housewares, pesticides, and industry. We can use chemicals to increase food production, cure diseases, build more efficient houses, and send people into space. At the same time, we must be cautious to ensure uncontrolled and over-expanded use of chemicals does not endanger our own existence (Diamanti-Kandarakis et al. 2009, Duruibe et al. 2007, Li et al. 2018, Sunderland et al. 2019).

Just as all humans are exposed to radiation in their normal daily routines, humans are also exposed to chemicals. Some potentially hazardous chemicals exist in the natural environment. In many areas of the country, soils contain naturally elevated concentrations of metals such as selenium, arsenic, or molybdenum, which may be hazardous to humans or animals. Even some of the foods we eat contain natural toxins. Aflatoxins are found in chili peppers, corn, millet, peanuts, rice, sorghum, sunflower seeds, tree nuts, and wheat. Cyanide is found in apple seeds. However, exposure to many more hazardous chemicals results from direct or indirect human actions. Building materials used in home construction may contain chemicals such as formaldehyde (in some insulation materials), asbestos (formerly used in insulation and ceiling tiles), and lead (formerly used in paints and gasoline). Some chemicals are present as a result of applying pesticides and fertilizers to soil. Other chemicals may have been transported long distances through the atmosphere from industrial sources and then deposited on soil or water.

F.2. Pathways of Chemicals from the Oak Ridge Reservation to the Public

Pathways are the routes or ways through which a person can encounter a chemical substance. Chemicals may be released to the air, soil, or water. Chemicals may also be released as liquid wastes, called effluents, which can enter streams and rivers.

People are exposed to chemicals by inhalation (breathing air), ingestion (intake of food, soil, or water), or dermal contact (touching soil or swimming in water). For example, fish that live in a river containing effluents may take in some of the chemicals present in the water. People eating fish and drinking water from the river would then be exposed to the chemicals. The public is not normally exposed to chemicals on ORR because access to the reservation is limited. However, chemicals released as a result of ORR operations can move through the environment to off-site locations, resulting in potential exposure of the public.

F.3. Toxicity

Toxicity refers to an adverse effect of a chemical on human health. Health effects from chemical exposures vary based on the chemical's toxicity. The toxic effect can be acute (a short-term, possible severe health effect) or chronic (a longer-term, persistent health effect). Although we ingest chemicals in food, water, and medications every day, toxic chemicals are typically nontoxic or harmless below certain concentrations or thresholds.

Chemical health effects due to toxicity are divided into two broad categories: adverse or systemic effects from noncarcinogens and cancer from carcinogens. The potential health hazards of noncarcinogens range from mild (e.g., skin irritation) to severe (e.g., death). Carcinogens cause or increase the incidence of malignant neoplasms or cancers. A chemical can have both carcinogenic and noncarcinogenic effects. Toxic effects can result from short-term or long-term chemical exposures.

Concentration limits or advisories are set by government agencies for some chemicals that are known or suspected to have adverse effects on human health. These concentration limits are used to calculate chemical doses that would not be harmful to individuals who are particularly sensitive to a chemical. These chemical doses are converted to slope factors to address carcinogenic risk and to reference doses to address noncarcinogenic hazards (Hayes and Kobets 2023).

F.3.1. Dose Terms for Carcinogens

A slope factor is a plausible upper-bound estimate of the probability of a response per daily dose of a chemical during a lifetime of exposure (70 years). The slope factor conservatively estimates the probability of cancer due to chemical exposure for an individual's lifetime to a particular concentration. Units are expressed as risk per dose in mg/kg-day.

A slope factor converts the estimated daily dose, averaged over a lifetime exposure, to the incremental risk of an individual developing cancer. Because it is unknown for most chemicals whether a threshold (an intake below which no adverse effect occurs) exists for carcinogens, units for carcinogens are set in terms of risk factors. The US Environmental Protection Agency (EPA) typically uses cancer risk benchmarks that range from 1 in 1,000,000 (10^{-6}) to 1 in 10,000 (10^{-4}), depending on the regulatory context and level of conservatism applied. These values represent the estimated increase in lifetime cancer risk for a single individual exposed continuously to a specific concentration of a carcinogenic substance, rather than predicting cancer incidence in a population.

F.3.2. Dose Term for Noncarcinogens

A reference dose is an estimate of a daily chemical exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a

period of exposure. Units are expressed as milligrams of chemical per kilogram of body weight per day (mg/kg-day). Reference dose values are derived from chemical intakes that resulted in no adverse effect or the lowest dose that showed an adverse effect in humans or laboratory animals.

Uncertainty factors are typically used in deriving reference doses. Uncertainty adjustments may be made to account for (1) interspecies variability in response when extrapolating from animal studies to humans; (2) response variability in humans; (3) uncertainty in estimating a no-effect level from a dose where effects were observed; (4) extrapolation from shorter duration studies to a full life-time exposure; and (5) data deficiencies (Dankovic et al., 2015). The use of uncertainty factors in deriving reference doses is thought to help protect sensitive human subpopulations.

F.3.3. Toxicity Value Sources

The slope factors and reference doses used for ORR calculations are selected from a tiered hierarchy system devised by EPA (EPA 2003). Values in the Integrated Risk Information System database, a Tier 1 toxicity value source, are considered to be validated and have undergone rigorous peer review and an EPA consensus review process. The EPA's Provisional Peer-Reviewed Toxicity Value database is a Tier 2 toxicity value source with values primarily derived for use in EPA's Superfund Program. Provisional Peer-Reviewed Toxicity Values are derived from a review of the relevant scientific literature using EPA methods, sources of data and guidance for value derivation. Tier 2 values have undergone rigorous peer review, but an EPA consensus review has not been performed. Tier 3 toxicity value sources include other sources of information and are used when Tier 1 or 2 values are not available for a contaminant. Multiple Tier 3 toxicity value sources are used on ORR including the Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Levels, the EPA's Office of Pesticide Programs Human Health Benchmarks for Pesticides, EPA's Health Effects Summary Table, and other federal and state sources (ATSDR 2025, EPA 2021, EPA 1997).

F.4. Measuring Chemicals

Environmental samples are collected in areas surrounding ORR and are analyzed for those chemical constituents most likely to be released from ORR. Chemical concentrations in liquids are typically expressed in milligrams or micrograms of chemical per liter of water (mg/L or µg/L, respectively); concentrations in solids, such as soil and fish tissue, are expressed in milligrams or micrograms of chemical per kilogram of sample material (e.g., mg/kg or µg/kg for soil or fish tissue).

The instruments used to measure chemical concentrations are sensitive; however, there are limits below which they cannot detect chemicals of interest. Concentrations below the reported analytical detection limits of the instruments are recorded by the laboratory as estimated values, which have a greater uncertainty than concentrations detected above the detection limits of the instruments. Concentrations that use these estimated values are indicated by the less-than symbol (<), which specifies that the value for a parameter could not be quantified at the analytical detection limit.

F.5. Risk Assessment Methodology

The methods for assessing the cancer risk and noncancer hazard resulting from exposure to a particular chemical are discussed in the following paragraphs.

Exposure assessment

To estimate an individual's potential exposure via a specific exposure pathway, the daily dose of the chemical must be determined. For example, chemical dose (in units of mg of contaminant per kilogram of body weight per day) from drinking water and eating fish from the Clinch River is assessed in the following manner:

1. Clinch River surface water and fish tissue samples are analyzed to measure chemical contaminant concentrations.
2. Estimated daily doses to the public are calculated by multiplying chemical concentrations measured in the samples by the surface water intake rate (liters/day) and fish ingestion rate (kg/day), respectively.
3. The average daily intakes are then multiplied by the exposure duration (in years) and exposure frequency (days/year) and divided by an averaging time (365 days/year multiplied by a lifetime [70 years] for carcinogens or the exposure duration for noncarcinogens).

The default exposure assumptions are conservative and, in many cases, may result in higher estimated daily doses than an individual would actually receive.

Calculation method

Carcinogenic risk calculations use slope factors and daily doses averaged over a lifetime (70 years). To estimate the potential carcinogenic risk from ingestion of water and fish, the estimated average daily dose (mg/kg-day) is multiplied by the slope factor (risk per mg/kg-day), resulting in units of risk. As mentioned earlier, acceptable risk levels for carcinogens range from 10^{-6} (risk of developing cancer over a human lifetime is 1 in 1,000,000) to 10^{-4} (risk of developing cancer over a human lifetime is 1 in 10,000). Carcinogenic risks greater than 10^{-4} indicate a concern for adverse health effects or the need for further study.

Noncarcinogenic hazard calculations use reference doses and daily doses averaged over the exposure duration. To calculate the potential hazard from ingestion of water and fish, the estimated average daily dose (mg/kg-day) is divided by the reference dose (mg/kg-day), resulting in a unitless value called a hazard quotient. Hazard quotient values less than 1 indicate an unlikely potential for adverse noncarcinogenic health effects; hazard quotient values greater than 1 indicate a concern for adverse health effects or the need for further study.

F.6. References

ATSDR 2025. *Minimal Risk Levels (MRLs) for Hazardous Substances*. Retrieved July 15, 2025, from https://wwwn.cdc.gov/TSP/MRLS/mrlsListing.aspx.

Dankovic et al. 2015. Dankovic, D.A, B. D. Naumann, A. Maier, M. L. Dourson, and L. S. Levy. "The Scientific Basis of Uncertainty Factors Used in Setting Occupational Exposure Limits." *Journal of Occupational and Environmental Hygiene*. 12:sup1, S55-S68.

Diamanti-Kandarakis et al. 2009. Diamanti-Kandarakis, E, J.P. Bourguignon, L.C. Giudice, R. Hauser, G.S. Prins, A.M. Soto, R.T. Zoeller, and A.C. Gore. "Endocrine-Disrupting Chemicals: An Endocrine Society Scientific Statement." Endocrine Reviews. 30(4), 293-342.

Duruibe et al. 2007. Duruibe, J.O., M.O.C. Ogwuegbu, and J.N. Egwurugwu. "Heavy metal pollution and human biotoxic effects." International Journal of the Physical Sciences. 2(5), 112-118.

EPA 2003. Human Health Toxicity Values in Superfund Risk Assessment. *OSWER Directive 9285.7-53*. December 5, 2003.

EPA 2021. *2021 Human Health Benchmarks for Pesticides.* Retrieved July 15, 2025, from https://www.epa.gov/sdwa/2021-human-health-benchmarks-pesticides.

EPA 1997. *Health Effects Assessment Summary Tables FY 1997 Update*. EPA-540-R-97-036, July 1997, US Environmental Protection Agency, Washington, DC. Retrieved July 15, 2025, from https://semspub.epa.gov/work/10/100004170.pdf.

Hayes and Kobets 2023. Hayes, A.W. and T Kobets (Eds.) *Hayes' Principles and Methods of Toxicology.* CRC Press, Boca Raton, FL.

Li et al. 2018. Li, J.Y., H.H. Liu, and J.P. Chen. "Microplastics in freshwater systems: A review on occurrence, environmental effects, and methods for microplastic detection." Water Research. 137. 3.

Sunderland et al. 2019. Sunderland, E.M., X.C. Hu, C. Dassuncao, A.D. Tokranov, C.C. Wagner, and J.G. Allen. "A review of the pathways of human exposure to poly- and perfluoroalkyl substances (PFASs) and present understanding of health effects." Journal of Exposure Science and Environmental Epidemiology. 29(2), 131-147.

Appendix G

Radiological Airborne Emissions at Oak Ridge National Laboratory

This appendix presents radiological airborne emissions at ORNL for calendar year 2024. Source term information from the ORNL site is obtained from 9 major and 15 minor emission sources. The nine major emission sources (2026, 3020, 3039, 3525, 4501, 7503, 7880, 7911, and 8915) have the potential to emit radionuclides that could result in a dose equal to or greater than 0.1 mrem/year (0.001 mSv/year) to the most exposed member of the public and require continuous emission sampling. The 15 minor emission sources (point and grouped) do not have the potential to cause any member of the public to receive an effective dose equal to or greater than 0.1 mrem/year (0.001 mSv/year). A variety of approved methods are used to evaluate minor source emissions, including in-stack sampling, the use of health physics data and HEPA filter sampling results, surrogate emission estimates, and inventory data with emission factors provided in 40 CFR Part 61, Appendix D.

Table G.1. Radiological airborne emissions from all major and minor sources at ORNL, 2024 (Ci)[a]

Isotope	Inhalation class[b]	Chemical form	Stack									Total minor sources	ORNL total
			X-2026	X-3020	X-3039	X-3525	X-4501	X-7503	X-7880	X-7911	X-8915		
^{225}Ac	M	particulate										1.12E-07	1.12E-07
^{226}Ac	M	particulate										1.07E-09	1.07E-09
^{227}Ac	M	particulate										1.91E-09	1.91E-09
^{228}Ac	M	particulate										1.55E-20	1.55E-20
^{105}Ag	M	particulate										8.40E-21	8.40E-21
^{108}Ag	B	unspecified										2.45E-12	2.45E-12
^{108m}Ag	M	particulate										2.75E-11	2.75E-11
^{110}Ag	B	unspecified										1.09E-10	1.09E-10
^{110m}Ag	M	particulate										1.73E-08	1.73E-08
^{111}Ag	M	particulate										4.23E-08	4.23E-08
^{112}Ag	M	particulate										5.62E-10	5.62E-10
^{26}Al	M	particulate										2.99E-09	2.99E-09
^{241}Am	M	particulate	6.50E-09	2.74E-05	1.47E-07	2.94E-10	5.40E-09	9.34E-09	9.15E-07	1.95E-09		2.95E-07	2.88E-05
^{242}Am	M	particulate										3.30E-10	3.30E-10
^{242m}Am	M	particulate										3.31E-10	3.31E-10
^{243}Am	M	particulate										3.02E-09	3.02E-09
^{37}Ar	B	unspecified										1.10E-06	1.10E-06
^{39}Ar	B	unspecified										6.33E-04	6.33E-04
^{41}Ar	B	unspecified				7.20E-05				7.94E+02	9.73E+01		8.91E+02
^{73}As	M	particulate										4.83E-24	4.83E-24
^{195}Au	M	particulate										5.78E-22	5.78E-22
^{133}Ba	M	particulate										9.48E-08	9.48E-08
^{137m}Ba	B	unspecified										3.22E-06	3.22E-06
^{139}Ba	M	particulate	5.64E-02							3.90E-01			4.46E-01
^{140}Ba	M	particulate								4.16E-04		4.74E-08	4.16E-04
^{7}Be	M	particulate	2.80E-07	9.68E-08	3.54E-06	8.27E-08	4.19E-06	5.59E-08		4.75E-07		2.84E-06	1.16E-05
^{10}Be	M	particulate										1.07E-15	1.07E-15
^{206}Bi	M	particulate										3.21E-09	3.21E-09
^{207}Bi	M	particulate										1.62E-18	1.62E-18
^{208}Bi	B	unspecified										2.66E-19	2.66E-19
^{210}Bi	M	particulate										1.27E-20	1.27E-20
^{210m}Bi	M	particulate										1.58E-19	1.58E-19
^{212}Bi	M	particulate										1.89E-11	1.89E-11
^{247}Bk	M	particulate										3.66E-24	3.66E-24

Table G.1. Radiological airborne emissions from all sources at ORNL, 2024 (Ci)[a] (continued)

Isotope	Inhalation class[b]	Chemical form	Stack									Total minor sources	ORNL total
			X-2026	X-3020	X-3039	X-3525	X-4501	X-7503	X-7880	X-7911	X-8915		
^{249}Bk	M	particulate										1.00E-11	1.00E-11
^{250}Bk	M	particulate										4.31E-22	4.31E-22
^{82}Br	M	particulate										6.58E-10	6.58E-10
^{11}C	G	dioxide									1.19E+04		1.19E+04
^{14}C	M	particulate										3.76E-10	3.76E-10
^{41}Ca	M	particulate										7.40E-12	7.40E-12
^{45}Ca	M	particulate										6.34E-11	6.34E-11
^{109}Cd	M	particulate										4.56E-10	4.56E-10
^{113}Cd	M	particulate										4.06E-16	4.06E-16
^{113m}Cd	M	particulate										1.02E-09	1.02E-09
^{115}Cd	M	particulate										1.16E-08	1.16E-08
^{115m}Cd	M	particulate										5.88E-16	5.88E-16
^{139}Ce	M	particulate										1.93E-10	1.93E-10
^{141}Ce	M	particulate										5.31E-09	5.31E-09
^{143}Ce	M	particulate										8.38E-10	8.38E-10
^{144}Ce	M	particulate										7.21E-07	7.21E-07
^{248}Cf	M	particulate										4.25E-24	4.25E-24
^{249}Cf	M	particulate										3.43E-14	3.43E-14
^{250}Cf	M	particulate										3.62E-14	3.62E-14
^{251}Cf	M	particulate										1.72E-15	1.72E-15
^{252}Cf	M	particulate										2.71E-09	2.71E-09
^{36}Cl	M	particulate										1.39E-04	1.39E-04
^{242}Cm	M	particulate										2.51E-10	2.51E-10
^{243}Cm	M	particulate	1.45E-08	1.09E-08	5.15E-09		1.17E-08	2.36E-08				1.57E-10	6.59E-08
^{244}Cm	M	particulate	1.45E-08	1.09E-08	5.15E-09		1.17E-08	2.36E-08				2.94E-06	3.01E-06
^{245}Cm	M	particulate										5.50E-11	5.50E-11
^{246}Cm	M	particulate										1.49E-11	1.49E-11
^{247}Cm	M	particulate										1.53E-10	1.53E-10
^{248}Cm	M	particulate										2.53E-12	2.53E-12
^{250}Cm	M	particulate										9.31E-22	9.31E-22
^{56}Co	M	particulate										8.95E-16	8.95E-16
^{57}Co	M	particulate										3.90E-10	3.90E-10
^{58}Co	M	particulate										8.25E-12	8.25E-12
^{60}Co	M	particulate			9.16E-08	5.72E-08			2.97E-07			2.02E-06	2.47E-06
^{60m}Co	M	particulate										9.42E-16	9.42E-16
^{51}Cr	M	particulate										8.34E-12	8.34E-12

Table G.1. Radiological airborne emissions from all sources at ORNL, 2024 (Ci)[a] (continued)

Isotope	Inhalation class[b]	Chemical form	Stack									Total minor sources	ORNL total
			X-2026	X-3020	X-3039	X-3525	X-4501	X-7503	X-7880	X-7911	X-8915		
^{134}Cs	F	particulate				2.05E-06						7.30E-07	2.78E-06
^{135}Cs	F	particulate										2.21E-11	2.21E-11
^{136}Cs	F	particulate										3.84E-09	3.84E-09
^{137}Cs	F	particulate	2.24E-07	1.21E-05	2.42E-05	5.26E-05		1.39E-07		3.97E-06		2.36E-04	3.29E-04
^{138}Cs	F	particulate								4.12E+02			4.12E+02
^{159}Dy	M	particulate										9.59E-16	9.59E-16
^{254}Es	M	particulate										4.31E-22	4.31E-22
^{150}Eu	M	particulate										5.64E-16	5.64E-16
^{152}Eu	M	particulate			7.25E-07							1.85E-07	9.10E-07
^{154}Eu	M	particulate				6.52E-05						2.54E-07	6.55E-05
^{155}Eu	M	particulate										7.79E-08	7.79E-08
^{156}Eu	M	particulate										5.57E-21	5.57E-21
^{55}Fe	M	particulate										2.92E-06	2.92E-06
^{59}Fe	M	particulate										1.00E-11	1.00E-11
^{60}Fe	M	particulate										2.12E-15	2.12E-15
^{148}Gd	M	particulate										1.69E-10	1.69E-10
^{151}Gd	M	particulate										6.68E-22	6.68E-22
^{152}Gd	M	particulate										1.37E-22	1.37E-22
^{153}Gd	M	particulate										4.09E-11	4.09E-11
^{68}Ge	M	particulate										2.91E-15	2.91E-15
^{71}Ge	M	particulate										1.63E-24	1.63E-24
^{3}H	V	vapor			5.01E-01	4.54E-02	8.99E-03	4.63E-01		8.53E+01	9.12E+02	2.75E+00	1.00E+03
^{172}Hf	M	particulate										5.30E-12	5.30E-12
^{175}Hf	M	particulate										8.88E-15	8.88E-15
^{178m}Hf	M	particulate										3.08E-11	3.08E-11
^{179m}Hf	M	particulate										1.08E-28	1.08E-28
^{181}Hf	M	particulate										1.41E-12	1.41E-12
^{182}Hf	M	particulate										9.88E-14	9.88E-14
^{203}Hg	M	inorganic										6.09E-14	6.09E-14
^{163}Ho	B	unspecified										3.68E-16	3.68E-16
^{166m}Ho	M	particulate										1.57E-12	1.57E-12
^{124}I	F	particulate					1.49E-04						1.49E-04
^{125}I	F	particulate										3.17E-23	3.17E-23
^{126}I	F	particulate			1.25E-02		6.35E-03					1.57E-09	1.89E-02

Table G.1. Radiological airborne emissions from all sources at ORNL, 2024 (Ci)[a] (continued)

Isotope	Inhalation class[b]	Chemical form	Stack									Total minor sources	ORNL total
			X-2026	X-3020	X-3039	X-3525	X-4501	X-7503	X-7880	X-7911	X-8915		
^{129}I	F	particulate				8.39E-07				1.44E-04		9.12E-06	1.54E-04
^{131}I	F	particulate				6.47E-05	2.46E-02			4.11E-02		1.68E-08	6.58E-02
^{132}I	F	particulate					3.34E-04			9.60E+00			9.60E+00
^{133}I	F	particulate								2.58E-01			2.58E-01
^{134}I	F	particulate								8.79E-01			8.79E-01
^{135}I	F	particulate								9.15E-01			9.15E-01
^{113m}In	M	particulate										7.64E-12	7.64E-12
^{114}In	B	unspecified										1.88E-15	1.88E-15
^{114m}In	M	particulate										2.96E-15	2.96E-15
^{115}In	M	particulate										6.37E-22	6.37E-22
^{192}Ir	M	particulate										2.86E-16	2.86E-16
^{192m}Ir	M	particulate										2.31E-20	2.31E-20
^{194}Ir	M	particulate										9.50E-19	9.50E-19
^{194m}Ir	M	particulate										3.66E-19	3.66E-19
^{40}K	M	particulate										3.06E-07	3.06E-07
^{81}Kr	B	unspecified										2.01E-07	2.01E-07
^{83m}Kr	B	unspecified										1.73E-09	1.73E-09
^{85}Kr	B	unspecified				3.46E-01				6.82E+02		1.69E+02	8.51E+02
^{85m}Kr	B	unspecified				1.75E-04				6.70E+00	1.11E+02		1.18E+02
^{87}Kr	B	unspecified				2.39E-04				2.40E+01	2.36E+02		2.60E+02
^{88}Kr	B	unspecified				6.93E-05				3.34E+01	8.59E+01		1.19E+02
^{89}Kr	B	unspecified								1.68E+01			1.68E+01
^{137}La	M	particulate										1.27E-17	1.27E-17
^{138}La	M	particulate										5.63E-21	5.63E-21
^{140}La	M	particulate										6.16E-08	6.16E-08
^{173}Lu	M	particulate										3.35E-13	3.35E-13
^{174}Lu	M	particulate										6.21E-12	6.21E-12
^{174m}Lu	M	particulate										7.88E-16	7.88E-16
^{176}Lu	M	particulate										3.29E-21	3.29E-21
^{177}Lu	M	particulate										1.22E-16	1.22E-16
^{177m}Lu	M	particulate										4.05E-14	4.05E-14
^{53}Mn	M	particulate										4.08E-15	4.08E-15
^{54}Mn	M	particulate										2.26E-08	2.26E-08
^{93}Mo	M	particulate										1.93E-09	1.93E-09
^{99}Mo	M	particulate										1.74E-08	1.74E-08
^{100}Mo	*											7.42E-26	7.42E-26

Table G.1. Radiological airborne emissions from all sources at ORNL, 2024 (Ci)[a] (continued)

Isotope	Inhalation class[b]	Chemical form	Stack									Total minor sources	ORNL total
			X-2026	X-3020	X-3039	X-3525	X-4501	X-7503	X-7880	X-7911	X-8915		
^{22}Na	M	particulate										2.05E-11	2.05E-11
^{91}Nb	B	unspecified										1.13E-10	1.13E-10
^{91m}Nb	B	unspecified										4.10E-14	4.10E-14
^{92}Nb	B	unspecified										5.64E-15	5.64E-15
^{92m}Nb	B	unspecified										2.62E-25	2.62E-25
^{93m}Nb	M	particulate										2.42E-09	2.42E-09
^{94}Nb	M	particulate										3.30E-10	3.30E-10
^{95}Nb	M	particulate										1.73E-08	1.73E-08
^{96}Nb	M	particulate										9.67E-11	9.67E-11
^{97}Nb	M	particulate										5.95E-11	5.95E-11
^{144}Nd	B	unspecified										3.78E-20	3.78E-20
^{147}Nd	M	particulate										2.09E-09	2.09E-09
^{150}Nd	*											7.71E-27	7.71E-27
^{59}Ni	M	particulate										9.86E-10	9.86E-10
^{63}Ni	M	particulate										1.12E-02	1.12E-02
^{235}Np	M	particulate										5.29E-15	5.29E-15
^{236}Np	M	particulate										1.24E-16	1.24E-16
^{237}Np	M	particulate										2.40E-03	2.40E-03
^{239}Np	M	particulate										1.10E-07	1.10E-07
^{185}Os	M	particulate										3.43E-14	3.43E-14
^{191}Os	M	particulate					3.12E-02					1.06E-25	3.12E-02
^{194}Os	M	particulate										1.81E-13	1.81E-13
^{32}P	M	particulate										1.05E-15	1.05E-15
^{33}P	M	particulate										2.92E-18	2.92E-18
^{228}Pa	M	particulate										5.50E-11	5.50E-11
^{230}Pa	M	particulate										3.72E-09	3.72E-09
^{231}Pa	M	particulate										1.68E-14	1.68E-14
^{232}Pa	M	particulate										1.40E-10	1.40E-10
^{233}Pa	M	particulate										4.38E-08	4.38E-08
^{234m}Pa	B	unspecified										1.89E-22	1.89E-22
^{205}Pb	M	particulate										7.22E-20	7.22E-20
^{210}Pb	M	particulate										5.79E-12	5.79E-12
^{212}Pb	M	particulate	8.79E+00	3.88E-01	2.70E+00	6.37E-03	1.50E-02	3.99E-01		8.20E-02		7.51E-02	1.25E+01
^{214}Pb	M	particulate		2.00E-03	1.58E+00	3.56E-04	3.32E-03	2.68E-01		5.58E-02		2.05E-01	2.11E+00

Table G.1. Radiological airborne emissions from all sources at ORNL, 2024 (Ci)[a] (continued)

Isotope	Inhalation class[b]	Chemical form	Stack									Total minor sources	ORNL total
			X-2026	X-3020	X-3039	X-3525	X-4501	X-7503	X-7880	X-7911	X-8915		
^{103}Pd	M	particulate										2.23E-21	2.23E-21
^{107}Pd	M	particulate										2.83E-12	2.83E-12
^{143}Pm	M	particulate										2.55E-15	2.55E-15
^{144}Pm	M	particulate										1.98E-15	1.98E-15
^{145}Pm	M	particulate										3.97E-11	3.97E-11
^{146}Pm	M	particulate										6.96E-11	6.96E-11
^{147}Pm	M	particulate										1.63E-04	1.63E-04
^{148}Pm	M	particulate										3.57E-16	3.57E-16
^{148m}Pm	M	particulate										2.74E-10	2.74E-10
^{208}Po	B	unspecified										2.49E-13	2.49E-13
^{209}Po	B	unspecified										7.20E-10	7.20E-10
^{210}Po	B	inorganic										5.13E-12	5.13E-12
^{143}Pr	M	particulate										1.75E-21	1.75E-21
^{144}Pr	M	particulate										6.48E-07	6.48E-07
^{193}Pt	M	particulate										3.45E-12	3.45E-12
^{236}Pu	M	particulate										5.56E-12	5.56E-12
^{237}Pu	M	particulate										3.53E-22	3.53E-22
^{238}Pu	M	particulate	4.54E-09	1.77E-05	4.16E-07	1.65E-10	1.44E-09	2.48E-09	9.37E-08	4.74E-09		3.84E-07	1.86E-05
^{239}Pu	M	particulate	4.59E-09	1.03E-05	2.08E-07	1.14E-10	1.13E-09	6.60E-09	2.77E-08	2.47E-09		2.07E-06	1.26E-05
^{240}Pu	M	particulate	4.59E-09	1.03E-05	2.08E-07	1.14E-10	1.13E-09	6.60E-09	2.77E-08	2.47E-09		1.88E-07	1.07E-05
^{241}Pu	M	particulate										3.37E-06	3.37E-06
^{242}Pu	M	particulate										6.52E-10	6.52E-10
^{243}Pu	M	particulate										1.36E-16	1.36E-16
^{244}Pu	M	particulate										1.19E-10	1.19E-10
^{223}Ra	M	particulate										1.00E-07	1.00E-07
^{224}Ra	M	particulate										4.98E-09	4.98E-09
^{225}Ra	M	particulate										1.05E-08	1.05E-08
^{226}Ra	M	particulate										5.06E-08	5.06E-08
^{228}Ra	M	particulate										1.21E-12	1.21E-12
^{83}Rb	M	particulate										5.82E-19	5.82E-19
^{84}Rb	M	particulate										8.28E-25	8.28E-25
^{86}Rb	M	particulate										2.00E-21	2.00E-21
^{87}Rb	M	particulate										9.19E-16	9.19E-16
^{183}Re	B	unspecified										1.47E-17	1.47E-17
^{184}Re	M	particulate										1.04E-14	1.04E-14
^{184m}Re	M	particulate										6.72E-15	6.72E-15

Table G.1. Radiological airborne emissions from all sources at ORNL, 2024 (Ci)[a] (continued)

Isotope	Inhalation class[b]	Chemical form	Stack									Total minor sources	ORNL total
			X-2026	X-3020	X-3039	X-3525	X-4501	X-7503	X-7880	X-7911	X-8915		
^{186}Re	M	particulate										1.58E-18	1.58E-18
^{186m}Re	M	particulate										3.12E-15	3.12E-15
^{187}Re	M	particulate										1.99E-16	1.99E-16
^{188}Re	M	particulate										3.05E-14	3.05E-14
^{101}Rh	M	particulate										1.19E-15	1.19E-15
^{102}Rh	M	particulate										5.51E-12	5.51E-12
^{102m}Rh	M	particulate										1.34E-16	1.34E-16
^{103m}Rh	M	particulate										5.21E-13	5.21E-13
^{105}Rh	M	particulate										5.44E-09	5.44E-09
^{106}Rh	B	unspecified										4.43E-07	4.43E-07
^{219}Rn	B	unspecified										5.43E-12	5.43E-12
^{222}Rn	B	unspecified										1.29E-11	1.29E-11
^{103}Ru	M	particulate										1.65E-08	1.65E-08
^{106}Ru	M	particulate										5.16E-07	5.16E-07
^{35}S	M	particulate										6.07E-13	6.07E-13
^{120m}Sb	M	particulate										1.46E-09	1.46E-09
^{122}Sb	M	particulate										3.00E-09	3.00E-09
^{124}Sb	M	particulate					3.72E-04					2.06E-09	3.72E-04
^{125}Sb	M	particulate					4.26E-05					1.59E-07	4.28E-05
^{126}Sb	M	particulate					7.25E-04					5.26E-09	7.25E-04
^{126m}Sb	M	particulate										2.42E-11	2.42E-11
^{127}Sb	M	particulate										4.53E-09	4.53E-09
^{46}Sc	M	particulate										5.46E-11	5.46E-11
^{75}Se	F	particulate										7.03E-16	7.03E-16
^{79}Se	F	particulate										1.59E-11	1.59E-11
^{32}Si	M	particulate										3.69E-13	3.69E-13
^{145}Sm	M	particulate										1.01E-11	1.01E-11
^{146}Sm	M	particulate										2.87E-18	2.87E-18
^{147}Sm	M	particulate										1.87E-16	1.87E-16
^{148}Sm	B	unspecified										1.32E-21	1.32E-21
^{151}Sm	M	particulate										3.16E-07	3.16E-07
^{113}Sn	M	particulate										8.61E-12	8.61E-12
^{117m}Sn	M	particulate										9.76E-10	9.76E-10
^{119m}Sn	M	particulate										5.59E-09	5.59E-09

Table G.1. Radiological airborne emissions from all sources at ORNL, 2024 (Ci)[a] (continued)

Isotope	Inhalation class[b]	Chemical form	Stack									Total minor sources	ORNL total
			X-2026	X-3020	X-3039	X-3525	X-4501	X-7503	X-7880	X-7911	X-8915		
^{121}Sn	M	particulate										3.10E-11	3.10E-11
^{121m}Sn	M	particulate										4.84E-11	4.84E-11
^{123}Sn	M	particulate										1.00E-11	1.00E-11
^{125}Sn	M	particulate										3.63E-09	3.63E-09
^{126}Sn	M	particulate										2.42E-11	2.42E-11
^{85}Sr	M	particulate										8.92E-17	8.92E-17
^{89}Sr	M	particulate	1.87E-07	3.66E-06	2.98E-05		1.65E-09	3.13E-08		3.90E-05		3.93E-08	7.26E-05
^{90}Sr	M	particulate	1.87E-07	3.66E-06	2.98E-05		1.65E-09	3.13E-08	1.08E-06	3.90E-05		9.84E-05	1.72E-04
^{91}Sr	M	particulate										1.19E-13	1.19E-13
^{178}Ta	B	unspecified										4.30E-19	4.30E-19
^{179}Ta	M	particulate										8.54E-12	8.54E-12
^{182}Ta	M	particulate										6.27E-11	6.27E-11
^{157}Tb	M	particulate										1.22E-13	1.22E-13
^{158}Tb	M	particulate										9.87E-16	9.87E-16
^{160}Tb	M	particulate										1.01E-12	1.01E-12
^{96}Tc	M	particulate										1.97E-10	1.97E-10
^{97}Tc	M	particulate										4.76E-18	4.76E-18
^{97m}Tc	M	particulate										3.50E-17	3.50E-17
^{98}Tc	M	particulate										8.36E-17	8.36E-17
^{99}Tc	M	particulate							2.86E-06			8.61E-10	2.86E-06
^{121}Te	M	particulate										4.05E-10	4.05E-10
^{121m}Te	M	particulate										5.41E-11	5.41E-11
^{123}Te	M	particulate										1.70E-13	1.70E-13
^{123m}Te	M	particulate										7.39E-12	7.39E-12
^{125m}Te	M	particulate										3.76E-08	3.76E-08
^{127}Te	M	particulate										6.38E-12	6.38E-12
^{127m}Te	M	particulate										6.51E-12	6.51E-12
^{128}Te	*											4.96E-27	4.96E-27
^{129}Te	M	particulate										2.02E-15	2.02E-15
^{129m}Te	M	particulate										3.10E-15	3.10E-15
^{131m}Te	M	particulate										9.13E-10	9.13E-10
^{132}Te	M	particulate										3.03E-09	3.03E-09
^{227}Th	S	particulate										1.54E-08	1.54E-08
^{228}Th	S	particulate	1.15E-08	9.21E-08	8.85E-08	8.07E-10	4.73E-09	1.47E-09		2.25E-08		7.27E-08	2.94E-07
^{229}Th	S	particulate		2.99E-08						1.29E-09		6.31E-10	3.18E-08
^{230}Th	S	particulate	2.19E-09	9.87E-09	1.37E-08	6.89E-11	2.35E-09			5.82E-09		5.56E-09	3.96E-08

Table G.1. Radiological airborne emissions from all sources at ORNL, 2024 (Ci)[a] (continued)

Isotope	Inhalation class[b]	Chemical form	Stack									Total minor sources	ORNL total
			X-2026	X-3020	X-3039	X-3525	X-4501	X-7503	X-7880	X-7911	X-8915		
^{231}Th	S	particulate										1.67E-10	1.67E-10
^{232}Th	S	particulate	4.85E-10	1.41E-08	6.60E-09	1.26E-10	6.28E-10	4.44E-09		7.87E-09		1.63E-06	1.67E-06
^{234}Th	S	particulate										1.97E-11	1.97E-11
^{44}Ti	M	particulate										7.52E-12	7.52E-12
^{204}Tl	M	particulate										4.95E-16	4.95E-16
^{206}Tl	B	unspecified										1.18E-19	1.18E-19
^{208}Tl	B	unspecified										3.32E-14	3.32E-14
^{170}Tm	M	particulate										8.22E-14	8.22E-14
^{171}Tm	M	particulate										1.30E-09	1.30E-09
^{232}U	M	particulate	3.99E-09	2.89E-07								9.35E-13	2.93E-07
^{233}U	M	particulate	3.59E-08	2.20E-06	7.40E-06	2.65E-10	1.56E-09	1.13E-08		5.25E-09		4.84E-07	1.01E-05
^{234}U	M	particulate	3.59E-08	2.20E-06	7.40E-06	2.65E-10	1.56E-09	1.13E-08		5.25E-09		7.95E-05	8.91E-05
^{235}U	M	particulate	4.15E-10	1.02E-08	2.43E-08		6.09E-10			8.08E-10		6.85E-06	6.88E-06
^{236}U	M	particulate										5.74E-08	5.74E-08
^{238}U	M	particulate	2.93E-09	3.40E-08	3.13E-08	4.82E-10	1.73E-09	2.75E-09		1.24E-08		6.10E-05	6.11E-05
^{240}U	M	particulate										1.76E-18	1.76E-18
^{48}V	M	particulate										2.49E-17	2.49E-17
^{49}V	M	particulate										8.05E-11	8.05E-11
^{178}W	M	particulate										4.30E-19	4.30E-19
^{181}W	M	particulate										1.95E-12	1.95E-12
^{185}W	M	particulate										3.44E-11	3.44E-11
^{188}W	M	particulate										3.50E-08	3.50E-08
^{123}Xe	B	unspecified									1.47E+02		1.47E+02
^{125}Xe	B	unspecified									7.92E+01		7.92E+01
^{127}Xe	B	unspecified									3.31E-03	2.72E-06	3.31E-03
^{131m}Xe	B	unspecified				9.51E-03				1.10E+02		2.79E-07	1.10E+02
^{133}Xe	B	unspecified				8.88E-05				4.39E+00			4.39E+00
^{133m}Xe	B	unspecified				2.03E-04				1.71E+01			1.71E+01
^{135}Xe	B	unspecified								3.13E+01			3.13E+01
^{135m}Xe	B	unspecified				2.81E-05				1.62E+01			1.62E+01
^{137}Xe	B	unspecified								3.07E+01			3.07E+01
^{138}Xe	B	unspecified				8.36E-04				8.54E+01			8.54E+01
^{88}Y	M	particulate							3.02E-07			7.17E-13	3.02E-07
^{90}Y	M	particulate										2.76E-06	2.76E-06
^{91}Y	M	particulate										9.75E-12	9.75E-12
^{65}Zn	M	particulate										1.01E-08	1.01E-08

Table G.1. Radiological airborne emissions from all sources at ORNL, 2024 (Ci)[a] (continued)

Isotope	Inhalation class[b]	Chemical form	Stack									Total minor sources	ORNL total
			X-2026	X-3020	X-3039	X-3525	X-4501	X-7503	X-7880	X-7911	X-8915		
^{88}Zr	M	particulate										1.68E-15	1.68E-15
^{93}Zr	M	particulate										1.02E-10	1.02E-10
^{95}Zr	M	particulate										1.47E-08	1.47E-08
^{97}Zr	M	particulate										3.72E-11	3.72E-11
Totals			**8.85E+00**	**3.90E-01**	**4.79E+00**	**4.10E-01**	**9.11E-02**	**1.13E+00**	**5.60E-06**	**2.36E+03**	**1.36E+04**	**1.72E+02**	**1.61E+04**

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

[b] *The designation of F, M, or S refers to the lung clearance type: fast (F), moderate (M), or slow (S) for the given radionuclide. G stands for gaseous, V for vapor, and B for blank, unspecified form. An asterisk (*) indicates that inhalation class information was not available.*